

## Assignment Part 2

### IMPLEMENT A NEGOTIATION STRATEGY

- a) The acceptance strategy of MegatronAgent was carefully developed to adjust in an instant to the specific circumstances of the negotiation. A dynamically modified threshold, originally set at 1.2 times the reserved utility value, serves as the agent's basic factor for accepting an offer. By indicating the minimal utility the agent expects from any acceptable plan, this threshold helps to ensure that the agent enters into talks with realistic yet strong expectations.
- The acceptance threshold is modified to allow for changes in the dynamics of the negotiations as they proceed. The agent reacts by carefully decreasing its acceptance threshold (multiplied by 1.0) if the opponent improves their offer, indicating that it's willing to converge towards the agent's preferences. This creates a friendly negotiating climate and encourages the opponent to make additional sacrifices. On the other hand, the agent significantly reduces the threshold (multiplied by 0.85) as the negotiation gets closer to its deadline (time left < 0.3) in order to prevent deadlock and raise the possibility of achieving an agreement under time restrictions.
- By making these modifications, the agent is able to stay flexible and adaptable to the changing negotiating environment, adjusting its plan of action in response to both the opponent's actions and the length of time. This strategy has a basis in strategic negotiation theories, which support adaptable strategies depending on how valuable offers are viewed and how much time is left in the negotiation.
- b) The aggressive and adaptable bidding approach of MegatronAgent is intended to make careful decisions depending on the state of the negotiation and the quality of the opponent's proposals. By providing one of the highest utility outcomes out of its set of possible choices, the agent gets off to a solid start. The goal of this aggressive start is to create a strong foundation that may influence the environment of this negotiation in an advantageous manner from the very beginning.
- The agent adjusts its bidding strategy in response to the opponent's moves as the negotiation progresses. The agent may continue to take an aggressive stance and re-offer its prior high-utility offer if the opponent's proposals are getting worse or are not getting better. In the event that the opponent makes a more advantageous offer than the one it received previously, the agent will react by selecting offers from its pool that have higher utilities. The use of this strategy not only keeps the negotiation going forward but also lets the other agent know that the agent is willing to cooperate, which could result in an advantageous compromise.

According to strategic negotiation models, which place an importance on flexibility and adaptability in order to maximize negotiation outcomes, this dynamic bidding approach makes sure the agent stays competitive while also being open to the negotiation flow.

- c) MegatronAgent uses an opponent modeling technique that looks at the worth of the offers put out in order to determine the opponent's reservation value. The agent determines its estimate of the opponent's reservation value by taking the lowest utility offer observed and assuming that the offers indicate utilities above the opponent's reservation value. With the use of this model, the agent can modify its approach in response to a constantly changing picture of what the opponent is probably going to accept.

Throughout the negotiation, the agent's bidding and acceptance strategies will need to be adjusted in response to this continuous change of the opponent's reservation value. The agent can strategically adjust its offers in order to push the opponent toward agreements that are advantageous but acceptable given the seeming limits of the opponent's valuation by having a more comprehensive understanding of the opponent's utility value.

Making use of such an advanced opponent model corresponds with skilled strategies for negotiation discussed in the research [33],[34],[35],[36]; where one can greatly improve negotiating results by understanding and adapting the opponent's preferences and limitations. Through strategic modeling, the agent becomes more adaptive and more capable of achieving successful results in negotiations.

#### QUANTIFY THE PERFORMANCE OF YOUR AGENT

The MegatronAgent was tested against itself and several other rival agents in a comprehensive simulation run by NEGMAS in order to assess its performance and negotiating strategies. Boulware, RVFitter, Linear, NashSeeker, Conceder, and MiCRO were among the agents, and they covered a broad range of negotiating strategies from combative to cooperative. The simulation's findings showed that the agents performed differently, with MegatronAgent receiving a significantly lower score than the others. In particular, MegatronAgent scored -0.349009, which is quite different to Boulware, the agent with the highest score, who scored 0.373086. These results point to a significant difference in strategy efficiency, suggesting that MegatronAgent may be using a less effective technique in the reviewed domain.

In general, when we compared Megatron with Boulware, Boulware always had less reservation value and negotiator time. Other than that, most of the times, Boulware ended around 0.8-0.9 utility whereas Megatron ended with 0.15-3 utility. This shows how effective Boulware is against our agent.

In comparison with Conceder, it has significantly less negotiator times(around 0.03) and a little bit lesser reservation value(around 0.2). Most of the time, when it is negotiated with Megatron, it will end up with around 0.63 utility whereas Megatron ends with 0.3. We can also see that Conceder is more effective than Megatron in general. Also those numbers are so close to Linear so we can also say the same things.

Other than RVFilter, Micro and NashSeeker ended around 0.5 utilities while Megatron has 0.4 but RVFilter had 0.8 when Megatron had 0.1 in general. For all of them, reserved values are the same(around 2 and Megatron had 2.6) but for negotiator time, between NashSeeker and Megatron, it is very low that it is not even 0.05. Megatron, RVFilter and Micro had around 1.6(RVFilter and Micro and 0.8(Megatron).

When it comes to negotiating with itself, Megatron had reserved values of 2.6 and 2, also utilities of 2.6 and 2. For negotiator times, it is also nearly the same with 1.6 and 1.5. We can clearly say that they almost got the same results.

Pareto Optimality: The outcomes reached a Pareto efficiency score of approximately 0.929, which shows that the negotiations are generally effective. However, they are not maximized for efficiency since a perfect score is 1.0. Nash Point: At around 0.665, the Nash optimality suggests that there is still opportunity to improve the mutually beneficial options.

Example : MegatronAgent vs. Boulware; MegatronAgent's consistent losses suggest that its strategy might be overly aggressive or poorly aligned with the dynamics of the domain. For instance, in a specific negotiation session against Boulware, MegatronAgent only achieved a utility of 0.1907 compared to Boulware's 0.8093, demonstrating a significant imbalance in benefit. "utilities": [0.19065357442705383,0.8093464255729461]".

Test#1 : Negotiations ----- 100% 0:09:05

	strategy	score
0	Boulware	0.373086
1	RVFitter	0.354971
2	Linear	0.302419
3	NashSeeker	0.257364
4	Conceder	0.230081
5	MiCRO	0.194257
6	MegatronAgent	-0.349009
Finished in 13m37s		

## CONCLUDING: FUTURE PERSPECTIVES

For this project, we used a strategy that tries to understand the opponent's intentions. In order to do that, our agent examines the moves of the opponent and takes actions accordingly. For instance, our agent gets more aggressive towards opponents who try to lower our utility consecutively because they believe that this opponent is trying to exploit us. On the other hand, our agent senses that the opponent can be exploitable due to the moves that keep increasing the agent's utility. Those are some actions that are pre-determined for our agent; however, it is not most likely suitable for real-world negotiations. When it comes to the real world, many more factors are not pre-determined or can be changed at any time. This can be caused by our morals, feelings, moods and psychology. To improve our agent for real-world scenarios, we can make it less rigid. For instance, in the real world, people can get frustrated by the deals that keep getting worse for them and this can lead to disagreements easily. To prevent that, we can be more forgiving and patient about aggressive bid increases in our strategy. For example, we can wait for more before we start to increase bids and we can also increase bids less in both size and number. This can lead to less frustrating negotiations in real life. Also, we shouldn't always start with mimicking our opponent's moves in real life. For instance, if we are negotiating for something we love or important to us, this strategy could lead to failure because if the 2 sides become stubborn, this can lead to a deadlock. These are some changes that could improve our agents in real-life situations; however, if we make those strategies softer than they should, it can be harmful and inefficient for our agents. It is essential to take into account the use of adaptive learning processes that can improve negotiating methods over time based on collected experiences, in order to further increase the MegatronAgent's value and application in real-world circumstances. The agent's efficiency and effectiveness might be increased by implementing machine learning techniques like reinforcement learning, which would allow it to dynamically modify its strategy based on the results of previous agreements. Furthermore, improving the agent's ability to manage complex, multi-party conversations might significantly increase its usefulness in a wider range of negotiation situations, including business mergers and diplomatic discussions.

When it comes to comparing our implemented strategy, we started to compare it with the actions that our agent took when the negotiations came closer to ending. First, we implemented that it will increase the bid no matter what. This resulted in the lowest score of our agent. After that, we decreased the time interval from the last 0.2 of the negotiation to the last 0.1 of the negotiation. That increased our score a little bit when we compared it to the previous one. After that, we just got rid of that function and also decreased our reserved value to agree. This one is the most successful one among them. Other than that, in the first version of our project, we had a static value reserved

value. We first changed it to a dynamic version that keeps increasing the reserved value by some constant if our opponents keep making moves that decrease our utility. This also decreased our score in the tournament so we understand that we should make our agent less strict. In the end, we came up with a solution that decreases the reservation value by 5% when our opponent increases our utility. This was about to show a positive response in order to come to an agreement. Before those changes, we get a score of -1 to 2 but after that, we even get around 0.6 against the Conceder agent.