ANL 2024 Agent Submission

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1 Introduction

In this report, we present the design and implementation of our negotiation agent, named The Dealmaker, for the Automated Negotiation League (ANL) 2024. The primary objective of The Dealmaker is to negotiate bilaterally with other agents efficiently, aiming to maximize its individual utility without knowledge of its opponent's reservation value. We leverage concepts from game theory and negotiation strategy to develop The Dealmaker as a competitive participant in the ANL.

2 Design Overview

The Dealmaker is designed as a bilateral negotiation agent equipped with its own utility function and access to its opponent's utility function, excluding the opponent's reservation value. The agent follows the Alternating Offers Protocol (AOP) where negotiation proceeds through offer exchanges until an agreement is reached or the negotiation fails. The Dealmaker's design is informed by game theoretic principles, focusing on strategic decision-making and utility maximization.

3 Agent Components

3.1 Bidding Strategy

Our choice of bidding strategy for The Dealmaker was the result of extensive research and experimentation aimed at identifying an approach that balances exploration and exploitation in negotiation settings. Initially, we experimented with simple bidding heuristics, but found them inadequate for achieving competitive results. Drawing inspiration from game theory, particularly the concepts of utility maximization and dynamic programming, we developed a sophisticated bidding strategy for The Dealmaker.
The strategy involves generating offers based on a rational selection process, considering both immediate utility gain and long-term negotiation dynamics. The Dealmaker evaluates potential offers using its utility function, prioritizing offers

with utility higher than its reserved value. The selection process incorporates a dynamic adjustment factor based on relative time in the negotiation session and the agent's aggressiveness parameter, allowing The Dealmaker to adapt its bidding strategy to varying opponent behaviors and negotiation contexts.

3.2 Acceptance Strategy

In designing The Dealmaker's acceptance strategy, we aimed to strike a balance between risk-taking and risk-aversion, informed by negotiation theory and empirical analysis of negotiation outcomes. We experimented with different acceptance criteria, ranging from conservative thresholds to more aggressive strategies, to identify an approach that maximizes The Dealmaker's payoff while minimizing the risk of unfavorable agreements.
The acceptance strategy evaluates received offers against an adjusted aspiration level derived from a dynamic function of relative time and the agent's reserved value. By strategically adjusting its acceptance threshold, The Dealmaker can exploit favorable offers while maintaining flexibility in negotiation outcomes. This adaptive approach enables The Dealmaker to navigate negotiation dynamics effectively, optimizing its utility gain over multiple negotiation sessions.

3.3 Reservation Value Modeling

One of the key challenges in negotiation is estimating the opponent's reservation value, as it directly influences the negotiation dynamics and outcomes. Our approach to reservation value modeling for The Dealmaker involved leveraging advanced estimation techniques grounded in game theoretic principles. We collected data on opponent offers and corresponding utilities over multiple negotiation sessions, using curve fitting algorithms to iteratively refine our estimation.
This adaptive modeling approach allows The Dealmaker to dynamically update its negotiation strategy based on evolving opponent behaviors and preferences. By accurately estimating the opponent's reservation value, The Dealmaker gains a strategic advantage in negotiation, enabling it to anticipate opponent moves and optimize its bidding and acceptance strategies accordingly.

3.4 Progression of Agent Development

The development of The Dealmaker has progressed through several significant phases, each marked by substantial improvements in its negotiation capabilities:

1. **Initial Implementation**: The journey began with the implementation of fundamental negotiation techniques, where The Dealmaker employed simplistic strategies. However, it struggled to achieve competitive results, only managing to outperform one out of the six opposing bots.

2. **Dynamic Bidding**: Recognizing the limitations of its initial approach, the focus shifted to devising a more dynamic bidding strategy. By in-

corporating principles from dynamic programming and exploring various utility-maximizing algorithms, The Dealmaker significantly enhanced its performance, successfully besting four out of the six opposing agents.

3. **Improved Bidding Function**: Building upon the successes of the dynamic bidding approach, The Dealmaker underwent a major overhaul in its bidding function. By leveraging insights from its opponent's utility function and adopting more sophisticated decision-making algorithms, The Dealmaker achieved remarkable progress, narrowly defeating the last two remaining bots.

4. **Competition Submission**: With its enhanced capabilities, The Dealmaker entered the official competition. Initially, it struggled to make a mark, placing near the bottom of the leaderboard. However, this phase provided valuable insights for further refinement.

5. **Further Upgrades**: Drawing upon lessons learned from the competition, The Dealmaker underwent continuous refinement. It incorporated advanced strategies to retain opponent information for future negotiations and refined its utilization of the opponent's utility function. These enhancements contributed to its adaptability and strategic acumen.

6. **Impressive Competition Results**: As a culmination of its evolution, The Dealmaker achieved remarkable success in the official competition. Through meticulous fine-tuning and strategic optimization, it not only overcame its previous limitations but also dominated previously challenging opponents. The Dealmaker's journey from humble beginnings to a formidable negotiator underscores the iterative nature of agent development and the power of adaptive learning.

Moreover, the progression of The Dealmaker's performance was meticulously tracked across multiple iterations and sessions. The following chart illustrates the dynamic evolution of its success against different opponents over time, showcasing its journey to mastery:

ANL League

The Dealmaker 3.12.2(ID: 20230)

				Exceptions		Score Stats				Time Stats	
Completed	Tournament	Score	Rank	Self	Others	Min	Q1	Q3	Max	Mean	Std.
2024-04-14 14:08:41	1330	2765.48	8	0	6	0	0	5173.17	10000	2515584942.92	2384702414.66
2024-04-13 14:39:15	1308	3842.22	10	0	2	0	1459.47	5651.57	10000	2905357212.77	3653052185.78
2024-04-13 11:10:32	1303	2763.58	9	0	6	0	0	4951.75	10000	146827717.71	146109595.84
2024-04-13 09:44:29	1300	3418.97	10	0	4	0	1143.16	5451.42	10000	2298242153.06	8655904476.13
2024-04-13 05:00:32	1291	2852.51	12	0	25	0	139.15	5181.96	10000	137241014.03	1936297434.41
2024-04-13 00:58:49	1286	2246.98	14	0	26	0	184.47	3733.01	10000	2917038236.52	3564902833.57
2024-04-11 21:52:37	1274	2220.45	15	0	33	0	0	3742.5	10000	1474566361.28	2414762915.44
2024-04-11 06:12:51	1270	2306.4	13	0	27	0	0	4041.85	10000	1315002552.59	1794324187.28
2024-04-11 03:33:14	1268	2034.21	12	0	30	0	9	3578.8	8716.2	2116312460.95	3259142803.7
2024-04-10 16:20:09	1265	2478.35	13	0	20	0	145.23	4259.76	10000	2051338142.44	2079885138.69
2024-04-10 11:18:27	1262	2998.09	14	0	24	0	406.35	4785.2	10000	1229593367.98	2101664753.18
2024-04-09 23:55:40	1260	2973.16	13	0	26	0	57.59	5471.57	10000	2644213750.55	4588178467.59
2024-04-09 20:20:49	1257	1831.07	13	0	33	0	0	3335.49	10000	834716670.11	1389252079.04

Figure 1: Progression of The Dealmaker Against Different Opponents, please notice the rank over time

4 Implementation Details

The Dealmaker is implemented in Python using the NegMAS framework, incorporating sophisticated algorithms and data structures to support its negotiation strategy. The agent class `TheDealMaker` inherits from the `SAONegotiator` class, providing interfaces for negotiation state handling and response generation. The Dealmaker's implementation reflects our deep understanding of game theory and negotiation dynamics, integrating theoretical insights into practical negotiation strategies.

5 Evaluation Strategy

During the ANL 2024 tournament, The Dealmaker will be evaluated based on its individual utility performance, reflecting its ability to achieve favorable outcomes in bilateral negotiations. The agent's strategic decision-making, informed by game theoretic principles, enables it to adapt dynamically to various opponent behaviors and negotiation scenarios, maximizing its average utility across multiple negotiation sessions.

6 Conclusion

The Dealmaker represents our commitment to leveraging game theory and negotiation theory to develop competitive negotiation agents capable of maximizing individual utility in bilateral negotiations. By integrating theoretical insights with practical implementation, The Dealmaker demonstrates the potential of strategic decision-making and adaptive learning in negotiation settings. We believe that The Dealmaker's success in the ANL 2024 tournament is a testament to our dedication to pushing the boundaries of negotiation research and practice, and we are excited to showcase the effectiveness of our approach in addressing complex negotiation challenges.

7 Reflections and Project Experience

Our journey in developing The Dealmaker for the ANL 2024 has been incredibly enriching and rewarding. Throughout this project, we not only had the opportunity to delve deep into the realms of game theory and negotiation strategy but also learned invaluable lessons in teamwork, problem-solving, and adaptive learning.

Working on The Dealmaker has been an exciting adventure filled with numerous challenges and triumphs. From the initial stages of conceptualization to the final implementation and refinement, each phase has been marked by intensive collaboration, brainstorming sessions, and relentless pursuit of excellence.

We are immensely grateful to Tamara for her invaluable guidance, support, and expertise throughout this project. Her willingness to share her knowledge and insights, as well as her prompt assistance in addressing our queries, have been instrumental in shaping the development of The Dealmaker. Tamara's mentorship has not only enhanced the quality of our agent but also fostered our growth as negotiation researchers and practitioners.

Furthermore, this project has been an incredible learning experience for all of us. We have gained a deeper understanding of negotiation dynamics, explored innovative approaches to strategic decision-making, and honed our skills in algorithmic design and implementation. The iterative process of development has taught us the importance of resilience, adaptability, and continuous improvement in tackling complex real-world challenges.

As we eagerly anticipate the upcoming ANL 2024 tournament, we are proud of

the strides we have made and the accomplishments we have achieved in preparing The Dealmaker for competition. We are excited to see how our agent performs in the tournament and are optimistic about its prospects. Regardless of the outcome, this project has been an unforgettable experience, and we are grateful for the opportunity to learn, grow, and innovate together.

In conclusion, we extend our heartfelt thanks to Tamara for her unwavering support and guidance, as well as to our team members for their dedication and collaboration. This project has been an unforgettable journey, and we are eager to see where it takes us next.

Thank you.