

[COMP24] The Automated Negotiating Agents Competition (ANAC) 2024 Challenges and Results

Demonstration Track

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ABSTRACT

This paper introduces the main research challenges and results of the 15th International Automated Negotiating Agents Competition (ANAC 2024). The main challenges addressed are learning the reservation value in bilateral negotiation and designing a factory agent employing concurrent negotiation in supply chain management. Additionally, it outlines the future directions for the competition.

KEYWORDS

Automated Negotiation; Competition; Supply Chain Management

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1 INTRODUCTION

For a long time, ANAC has played a vital role in innovation and progress in agent-based negotiation research and introduced various negotiation problems and research challenges in multi-agent systems [8]. ANAC started in 2010 with a total of 7 participants [4], but participation has grown over the last 15 editions to a total of 800+ participants [3]. In 2024, two leagues were set up as follows. In **Automated Negotiation League (ANL)**, participants are tasked with designing bilateral negotiating agents that aim to learn their opponent's reservation value throughout the negotiation process

and adapt their bidding and acceptance strategies accordingly. To facilitate this, our framework provides access to both their own utility and their opponent's utility, without revealing the opponent's reservation value. In **Supply Chain Management League (SCML)** [12], the main task is to design factory agents aiming to maximize their profit in a competitive market environment involving strategic decision-making. These agents should decide how, with whom and how to negotiate to acquire the necessary materials for production and sell their manufactured products.

In 2024, ANAC attracted 160 registered international participants, who assembled 43 teams to compete for a total prize pool worth 2850 euros. For both leagues, the **NegMAS** [10] framework was used to develop competing agents and run the tournaments. All participating agents negotiated against every other agent on randomly generated problems. In the ANL league, agents are ranked based on the average scores, focusing on individual utility and the Nash distance, calculated at the tournament's end. Conversely, the SCML agents are assessed based on the accumulated profit they make in the simulated markets. In the following sections, we provide the competition settings and present the results of these leagues.

2 MAIN LEAGUE CHALLENGES & RESULTS

In the main league of 2024, participants design a bilateral negotiating agent that has access both to its own utility and the utility of its opponent. However, the opponent's reservation value remains a secret. The challenge is to estimate the opponent's reservation value as accurately as possible, and design an agent that beats other contestants by conceding efficiently and obtaining the best deals.

All submitted agents participate in a bilateral negotiation tournament. The agents negotiate against each other using the Alternating Offers Protocol [1] where the starting agent makes an opening offer, which is followed by acceptance, a counteroffer, or a walk-away, repeated in a turn-taking fashion. If both agents reach an agreement before the deadline (varying between 10 and 10000 rounds), the



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Table 1: ANAC 2024 Results

League	Track	#	Agent	Score
ANL	Individual Utility	1	Shochan	0.4051
		2	UOAgent	0.4038
		3	AgentRenting2024	0.3939
	Nash	1	Shochan	0.8847
SCML	OnShot	1	CautiousOneShotAgent[9]	1.088
		2	MatchingPennies	1.085
		3	DistRedistAgent	1.080
		3	EpsilonGreedyAgent	1.080
	Standard	1	PenguinAgent[7]	1.057

agent’s score is equal to the utility of the outcome. If the negotiation fails, each agent gets a different private reservation value. The key aspect of the scenarios is the shape of the Pareto Frontier, which can be linear, piece-wise linear, or monotonically decreasing.

In total, 21 teams submitted to ANL 2024, all bringing their strategies and techniques. Most participants opted to wait until the last moment to take action, which was not penalized as the protocol defined no discounting of utility over time. In addition, most participants implemented a non-concession bidding and acceptance strategy. With a shared utility function and unknown reservation values, the challenge narrowed to estimating the opponent’s reservation value, for which the participants implemented techniques such as curve fitting and linear regression (*CARCAgent*), Bayesian Learning (*NayesianNice*), and neural networks (*AgentRenting2024*).

The results of this year are shown in Table 1. Agent *Shochan* won first place in both categories. While adapting to factors such as opponent behavior is part of their strategy, a unique element is to also consider the specific type of scenario encountered. For instance, in a scenario where concessions yield greater benefits for opponents, they use time-dependent concession strategies to seek common ground rather than waiting until the final moment.

3 SUPPLY-CHAIN MANAGEMENT LEAGUE

SCML 2024 featured two tracks: OneShot and Standard. We had 22 qualified teams in total in 2024 (13 for OneShot, and 9 for Standard). Game rules were the same as for SCML 2023 for both tracks. This fact combined with the ability to access the source code and technical reports of all agents submitted to SCML over the years, allowed participants to build upon insights from earlier agents. As a result, all finalists outperformed the winner of SCML 2023. In SCML 2024, we simplified the process of training reinforcement learning agents by providing a standard Gymnasium[13] environment encapsulating the SCML simulation [11].

The main goal of SCML is to bring automated negotiation research nearer to real-world challenges facing the adoption of this technology in business and industrial application. The game is designed as an abstraction of a well-known procurement problem: *How to satisfy production needs of raw materials while minimizing procurement and inventory costs?*

The SCML OneShot world simulates a supply chain consisting of multiple factories that buy raw materials from, and sell final products to, one another. The factories are managed by autonomous

agents. These agents are assigned a target quantity (drawn at random) to either buy or sell. They then negotiate with other agents to reach agreements, which become binding contracts that specify the terms of trade (quantity and price). Agents are penalized for trading more or less than their assigned target quantity. A simulation comprises multiple days, during each of which the OneShot game is played. All agents have the same goal each day, namely to turn as much profit as possible.

In SCML-OneShot, products are perishable, which means profits/losses on a given day are independent of the results of past or future negotiations given the contracts reached on that day. Agents negotiate to sell or to buy but never both. Moreover, price and quantity ranges are small reducing the search space during negotiation. The research challenge in SCML-OneShot is designing effective negotiation strategies for *repeated concurrent negotiation* in a many-to-many negotiation environment.

In SCML-Standard, these limitations are lifted by allowing agents to negotiate delivery dates, making products nonperishable with a storage cost for carried inventory, deepening the production graph resulting in some agents negotiating for both buying and selling and increasing the range of prices and quantities negotiated. These changes lead to a more challenging environment where the research challenge is to design effective strategies for *dependent sequential sets of concurrent negotiations*.

The results of the two tracks are shown in Table 1. The winner of the OneShot track (CautiousOneShotAgent [9]) used a greedy heuristic that tries to minimize excess and shortfall penalties by considering the power set of offers during the negotiation. The winner of the Standard Track (PenguinAgent [7]) used a similar greedy approach inspired from a text-book inventory-control strategy that minimizes carrying inventory over time. Several agents considered opponent modeling (e.g. RTAgent, CCAgent, DistRedistAgent, Group5, epsilonGreedy). Curiously, winners of both tracks did not consider opponent behavior and tried to play the domain.

4 CONCLUSION

In upcoming competition settings, the organizers intend to move towards a multi-deal one-to-many negotiation challenge as outlined in [2] within the ANL league, where agents will encounter multiple opponents in sequence and will be rewarded based on the specific combination of deals achieved in each negotiation. Additionally, for the SCML league, all finalists for this year outperformed the winners from last year, which is a clear sign of progress. Nevertheless, we believe that the challenge of concurrent negotiation within a market simulation is still unmet and plan to reopen the challenge again in ANAC 2025. The source code of all agents and a short description of their strategies are publicly available [5, 6]. Foundational models used for negotiation offer no means for analysing the quality of their results. ANAC offers the continued framework to test negotiating agents for quality and strategic strength.

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