

# Automated Negotiation for Supply Chain Management

## Industrial Partner: NEC Corporation

NEC <https://www.nec.com>, founded in 1899, is now particularly addressing the development of solutions for society that will help resolve many issues the world is facing and which will engender the creation of a brighter and more prosperous society. Through co-creation initiatives with many stakeholders, including customers, business partners, private individuals, government agencies, and international institutions, we are actively devising new business models to create social value by harnessing our extensive information and communication technology (ICT) assets.

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## Background

Negotiation is one of the most commonly used methods for reaching agreements in human society. With increased automation of business and industrial processes in the past decades, interest in automating the negotiation process between AIs is growing both in the industry and academia [1]. For example, an automated agent representing a consumer (buyer) may negotiate price, quantity and delivery date with another representing supplier (seller). Each agent is trying to maximize the profit of the firm it represents while considering long-term relationships as well. By taking advantage of the computational power and rationality of AI in this case, the buyer and seller may be able to reach agreements that are better for both than what could be achieved through human negotiations. Automated Negotiation is the research field concerned with designing protocols and strategies for reaching agreements between **self-interested** agents that have their own preferences over possible outcomes of the negotiation process.

Automated Negotiation research has a long history. Earliest approaches to Automated Negotiation relied on game-theoretic arguments to achieve theoretical guarantees in simple situation (e.g. known preferences of all players)[6]. Most of this work was geared at understanding the negotiation process as an economic activity that underlies agreements in modern society. Recently, interest has shifted towards building *practical* applications of automated negotiation technologies in several fields including supply chain management, transportation, energy among many others.

Supply Chain Management (SCM) is one of the most important industrial activities without which production cannot proceed. The goal of SCM is to make sure all required supplies are available when needed where they are needed at an appropriate cost. In practice, SCM is done through concurrent closed negotiations between suppliers and consumers, which leads in several instances to inefficiencies in transactions (i.e. money

left on the table). Automating the whole or a part of the SCM negotiation process can improve the efficiency of business activities and industrial production significantly.

Automated Negotiation in SCM is not only an important industrial application but it provides a testbed for advanced research on the edge of automated negotiation including concurrent negotiations [2] and negotiation under uncertainty.

NEC has been engaged for several years in research and development activities related to the application of automated negotiation to supply chain management among other fields. One example is the [NEC-AIST AI Cooperative Research Laboratory](#). Recently, NEC — with its partners — started a company for commercialization of the results of this research activity and transferring it to real world application ([The BIRD Initiative](#)). Moreover, NEC is working with international partners to standardize the automated negotiation process to allow seamless interaction between multiple providers through the [eNegotiation](#) under the UNECE organization.

The growing interest in automated negotiation by academia is shown by the establishment of the Automated Negotiating Agents Competition ([ANAC](#)) since 2010. The competition is conducted every year as part of one of the top AI conferences ([IJCAI](#), [AAMAS](#)). A special league about automated negotiation in SCM has been organized as part of ANAC since 2019 ([SCML](#))[4]. Our team is taking the lead in organizing SCML in cooperation with researchers from MIT, Brown University, and Tokyo University of Agriculture and Technology.

## Project and Expectation

The project is expected to design, build and evaluate negotiation strategies to optimize supply chain management in a business like simulation environment. The strategies are expected to advance the state of the art by providing better performance than recent winners of SCML. Moreover, analysis of existing strategies and their interactions using rigorous game-theoretic approaches can occupy part of the project. Students should also demonstrate the benefits and shortcomings of their strategy in the context of the simulation environment provided by NEC.

Students need not know any details about automated negotiation or supply chain management at the start of the project. They can learn these topics during the program. Development will be conducted using Python so experience in using the Python scientific stack will be a great time-saver.

## The Platform

The platform used in this project is a community-driven, NEC supported open source library developed for automated negotiation in general called NegMAS [3] with over [250,000](#) downloads.

NegMAS is a python library for developing autonomous negotiation agents embedded in simulation environments. The name negmas stands for either NEGotiation

MultiAgent System or NEGotiations Managed by Agent Simulations (your pick). The main goal of NegMAS is to advance the state-of-the-art in situated simultaneous negotiations. Nevertheless, it also can (and was used) in modeling simpler bilateral and multilateral negotiations, preference elicitation, etc.

It is the same platform used for the SCML competition. The source code of the platform is available on [GitHub](#) and detailed documentation is also [available](#). Online tutorials and other resources will be made available to students during the project.

### The Competition

As discussed earlier, the project will lead to the development of negotiation strategies for supply chain management. The strategies generated will be compatible with the SCML allowing students to submit their own agents to the competition in 2024. Details about the competition for 2023 can be found in its official website: <https://scml.cs.brown.edu>.

### Requirements

Programming skills (mainly in Python). Knowledge of reinforcement learning and game theory is an advantage.

### References

1. Tim Baarslag, Michael Kaisers, Enrico Gerding, Catholijn M Jonker, and Jonathan Gratch. 2017. When will negotiation agents be able to represent us? The challenges and opportunities for autonomous negotiators.
2. Yasser Mohammad and Shinji Nakadai. 2022. Concurrent negotiations with global utility functions. In *Proceedings of the 21st international conference on autonomous agents and multiagent systems*, 1947–1949.
3. Yasser Mohammad, Shinji Nakadai, and Amy Greenwald. 2021. NegMAS: A platform for automated negotiations. In *PRIMA 2020: Principles and practice of multi-agent systems: 23rd international conference, nagoya, japan, november 18–20, 2020, proceedings 23*, 343–351.
4. Yasser Mohammad, Enrique Areyan Viqueira, Nahum Alvarez Ayerza, Amy Greenwald, Shinji Nakadai, and Satoshi Morinaga. 2019. Supply chain management world. In *PRIMA 2019: Principles and practice of multi-agent systems*, 153–169.
5. John F Nash Jr. 1950. The bargaining problem. *Econometrica: Journal of the Econometric Society*: 155–162.
6. Ariel Rubinstein. 1982. Perfect equilibrium in a bargaining model. *Econometrica: Journal of the Econometric Society*: 97–109.