MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

University of Ruse “Angel Kanchev”

MULTIAGENT SYSTEM WITH ARTIFICIAL INTELLIGENCE

assoc. prof. Desislava Atanasova

08,2022

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

LECTURE 4

Decisions and planning in solving distributed tasks

1. Negotiation
2. Negotiation Strategy
3. Multi-Agent Negotiations
4. Game theory in negotiation

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action
No 2020-EU-IA-0087, co-financed by the EU CEF Telecom
under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Negotiation - a dialogue between two or more people or parties to reach a desired outcome regarding one or more issues of conflict. It is an interaction between entities who aspire to agree on matters of mutual interest.

Distributed conflict resolution

Decision making

Proposal → accepted, refined, criticized, or refuted

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Negotiate – YES or NO?

- Professor George-J.-Siedel from the university of Michigan, conducted the following experiments:
- Ask the students to go the city, walk into retail stores, fast food restaurants, and try to negotiate a lower price despite a fixed price (not into a market)
- Results: 69% Successful in getting lower prices; 6% to 100% discount, with average 40%
- Total savings: 1580$

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Types of negotiation:

- Distributive (also called Position-based)
- Integrative (also called interest-based)
- Mixed-motive negotiation

Distributive (also called Position-based)

- with them, only one side wins - the other loses
- also called competitive negotiations
- It is used to allocate limited resources
- Each side seeks to improve its position by maximizing its gain at the expense of the opponent's loss
- There is no possibility of winning agreements

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Integrative (also called interest-based)

- The parties are interacting.
- Negotiations in the non-zero sum case can focus on common interests without seeking profit, but on negotiating settlements
- the goal is to exchange relevant information that allows them to integrate their interests and find new ones
- opportunities for cooperation
- in this type, negotiators tend to choose compromises

Mixed-motive negotiation

- According to some authors, it does not exist - the negotiations are purely theoretical in one of the two extremes
- Any other type of negotiation can be located between these two extremes and can be described as mixed motive negotiation
- This type of negotiation occurs when: some negotiation points are better for both parties than others... and the potential for negotiation is to increase the total gain available to both parties
- Negotiators usually combine various compromises and concessions in order to reach an agreement

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Negotiation Strategy

- Negotiation tactic
- The parties must make offers that are consistent with their preferences.
- If they reject the other party's offer, they must make a counteroffer
- A negotiation strategy is an opportunity to generate subsequent offers
- The idea is for the negotiator to decide whether to accept and give in or offer a "counter-offer"

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation Strategy

Tradeoffs

- Many issues are being negotiated
- Each negotiator attempts to shift an issue in the opponent's perceived direction while at the same time shifting the other in their favor
- Each tries to find a joint, win-win solution

Concessions

- It is often the case that both parties or one of them agree to enter into such an agreement
- Pruitt defines the concession as:

«A change in the offer in the assumed direction of that of the other party's interests, which reduces the level of the sought-after benefit»

- Benefits of the concession:
  - Possibility to accelerate the agreement
  - Not allowing one negotiator to leave the negotiations
  - Encouraging the other negotiator to repeat the concession

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Negotiation Strategy

Limit

- A negotiator's ultimate position, the level of utility (or benefits) beyond which he or she is unwilling to concede
- Also called a stored value
- Any agreement lower than this value is considered worse than no agreement

Goal

- the value the negotiator is aiming for because it considered realistically achievable
- It can be taken as a preferred value

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Negotiation Strategy

Influence factor

- In practice, negotiation strategy is influenced by many various and complex factors, including:
  - previous experience of similar negotiations, gender, culture,
  - availability of alternatives, intermediaries, time pressure and reactions to the behavior of the adversary
- However, when it comes to negotiations between autonomous agents, only some of these factors are essential

Time pressure

- The desire of the parties is always to conclude the negotiations as quickly as possible
- The main reason is the costs that may result from ongoing negotiations, the need to obtain end result quickly, pressure from an impending deadline or fear of the opponent leaving the negotiations
- It usually incentivizes negotiators to make concessions more quickly
- Modeled well in MAS

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation Strategy

Reactions to Opponent Behavior

- Basing one's negotiation behavior on that of one's opponent is a common strategy among both humans and autonomous agents
- We distinguish two main types of reactions:
  - Matching : or imitation, where if one party demands more, the other demands become bigger and vice versa. If one side makes important concessions, the other reacts with similar concessions (as in integrative negotiations)
  - Mismatching: concessions made by one side lead the opposing side to believe that the first negotiator is desperate to reach an agreement. This is also called tracking (used in distributive negotiations)

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Multi-Agent Negotiations

- It appeared more than three decades ago.
- Options are:
  - Agent-to-agent
  - Person-to-agent negotiations
- It develops based on the behavior of the person in negotiations
- Agents can outperform humans in the process of search for optimal solutions in negotiations with many issues

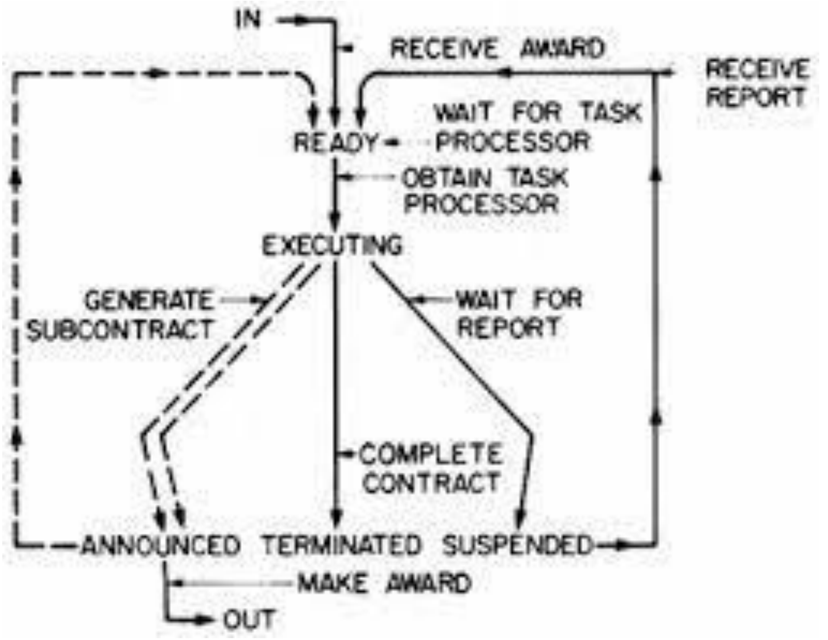
Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Negotiation Protocol

- A negotiation protocol is a set of rules that define the management of interactions between partners during a negotiation session (also called a thread)
- Covers:
  - Types of participants, including third parties (such as brokers)
  - Possible negotiation states: When the negotiation is suspended, ongoing, still open, etc
  - Events that can change negotiation states (e.g. offer accepted)
  - Valid actions by negotiators (eg offering a counter-offer, leaving the negotiation process, etc.)



Smith, "The Contract Net Protocol: High-Level Communication and Control in a Distributed Problem Solver," in IEEE Transactions on Computers, vol. C-29, no. 12, pp. 1104-1113, Dec. 1980, doi: 10.1109/TC.1980.1675516.

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation Protocol

Alternate Offer Protocol

- Many different versions
- Complete and incomplete information
- Upon receiving an offer from the other party, the negotiator may:
  - To exit the negotiation session
  - To accept the offer
  - To offer a counter offer with or without a discount
- Can use deadline, limited time for offer, etc.
- The standard form of the Alternate Offer protocol can be enhanced to support specific application needs. For example, to support one-to-many negotiations

Monotonic Concession Protocol

- At the beginning of the negotiation session, negotiators are required to disclose information about their preferences on the main points of the negotiations:
  - E.g. I'm more interested in delivery time than price
- The offers proposed by each contractor must contain a sequence of discounts, i.e. each subsequent offer having less utility to the negotiator offering it than the previous one
- There is no option to hold a position

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation Protocol

One Step Negotiation Protocols

- It has only one round, where the two agents propose their variants of a deal, and they must accept it

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation Object

- The topic under discussion in the negotiation process or a set of issues on which agreement must be reached
- An object can be composed of a single issue or attribute (e.g. delivery time) or it can cover multiple issues (price, quality, delivery time, etc.)
- The agent makes an offer to the other negotiator when it assigns a value to each of the attributes describing the agreed characteristics of the object
- Whenever the negotiation process is about multiple issues, the negotiators have opportunities to make compromises, and then the importance of an issue can differ from the perspective of one side and the other.
- In some negotiation options, the parties may offer a complete package containing several offers.

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Agent Decision Model

- The negotiation protocol defines what is the set of possible actions that can be taken during a negotiation session.

- The agent's decision model allows him/her to:
  - To assess the value of the offer received by the opponent
  - To decide whether the tender submitted is acceptable
  - To determine what to do as the next step

- Using respectively
  - Utility function/preference relations
  - Condition of acceptance
  - Negotiation strategy

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Agent Decision Model

Utility Function

- A utility function is an idea borrowed from microeconomics that encodes an agent's preferences and quantifies his satisfaction
- It determines the utility that the given agent would have from receiving (or being offered) an offer
- If an agent is interested in several offers, his utility would probably be a weighted sum of the utility functions of all offers.

Preference relationships

- A logic that describes the possible alternatives
  - A+B: A and B are equally preferred by the agent
  - A>B: A is strictly preferred than B by the agent
  - A>=B: A is preferred than B by the agent
  - e.g. I prefer a blue car to a black car, blue and red are equally preferred
- Challenges:
  - These preferences should be complete, they should cover all the possible alternatives
  - Typically it is assumed that these preferences are transitive

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

Negotiation

Agent Decision Model

Condition of acceptance

- In order to accept or reject an offer, an agent relies on its Aspiration Rate AR
- It reflects how much utility an agent expects to obtain at the negotiation cycle

Negotiation strategy

- Concession
  - The agent accepts to reduce its Aspiration Rate
  - Thus, it accepts offers with lower utility
- Several types
  - Time-based Concessions (TBC)
  - Behavior-based Concessions (BBC)
  - Resource-Based concession (RBC)

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

References

1. Adnan, Muhamad Hariz Muhamad; Hassan, Mohd Fadzil; Aziz, Izzatdin; Paputungan, Irving V, "Protocols for agent-based autonomous negotiations: A review". 2016 3rd International Conference on Computer and Information Sciences (ICCOINS). Kuala Lumpur, Malaysia: IEEE: 622–626. doi:10.1109/ICCOINS.2016.7783287.
2. Durfee, Edmund. (2001). Distributed Problem Solving and Planning.. 118-149.
3. Michael Wooldridge, An Introduction to Multiagent Systems, 2009
4. Russel, S. and Norvig, P. Artificial Intelligence: A Modern Approach, fourth edition, Pearson, 2022
5. Smith, "The Contract Net Protocol: High-Level Communication and Control in a Distributed Problem Solver," in IEEE Transactions on Computers, vol. C-29, no. 12, pp. 1104-1113, Dec. 1980, doi: 10.1109/TC.1980.1675516.
6. Davis, R. and Smith, R. Negotiation as a Metaphor for Distributed Problem Solving Artificial Intelligence 20, pp. 63-109, 1983. Winner of the 2006 Influential Paper Award
7. A. M. Mohamed and M. N. Huhns, "Benevolent agents in multiagent systems," Proceedings Fourth International Conference on MultiAgent Systems, 2000, pp. 419-420, doi: 10.1109/ICMAS.2000.858504.
8. David Poole, Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, second edition, Cambridge University Press 2017 (Available at https://artint.info/index.html)

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423