This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287.

EJP-CONCERT

European Joint Programme for the Integration of Radiation Protection Research

H2020 – 662287

D9.35 – ABM tool with artificial intelligence: Automated negotiation simulation

Authors: Shan Bai, Tim Mueller, Wolfgang Raskob

Reviewer(s): CONCERT coordination team

Work package / Task	**WP 9 T9.1**	**SST 9.1.6.1**
Deliverable nature:	**Report**	
Dissemination level: (Confidentiality)	**Public**	
Contractual delivery date:	**2018-12 (CONCERT M43)**	
Actual delivery date:	**2018-12 (CONCERT M43)**	
Version:	**1.0**	
Total number of pages:	**16**	
Keywords:	**Agent-based modeling, artificial intelligence, automated negotiation**	
Approved by the coordinator:	**M43**	
Submitted to EC by the coordinator:	**M43**	

Abstract

Agent-based modeling (ABM) is a powerful technique for simulating the actions and interactions of autonomous individuals to assess emerging system level patterns. An ABM consists of a collection of autonomous and heterogeneous agents interacting with attributes or states of other agents and the environment. The agents have also access to past and current values of their own state variables. Negotiation is one of the most common means for resolving conflicts and facilitating individual interactions. This deliverable reports on modelling automated negotiation by using an ABM tool in order to simulate the human negotiation process.

Table of Content

INTRODUCTION ---------- **4**

MULTILATERAL AUTOMATED NEGOTIATION ---------- **4**

STRATEGY ---------- 5
AGENT GROUP ---------- 5
NORMS OF CONVERSATION ---------- 6
AGENDA ---------- 6
CONSENSUS BASIS ---------- 7
PREFERENCE ---------- 7
AGENT ASSESSMENT STRATEGY ---------- 8
ASSESSMENT OF SINGLE-ATTRIBUTE STRATEGY ---------- 8
ASSESSMENT OF MULTI-ATTRIBUTE STRATEGY ---------- 8
AGGREGATE AGENTS ---------- 8
EVALUATION OF A SERIES OF STRATEGIES ---------- 9
PROTOCOL ---------- 9
TACTICS ---------- 9
PREPARE NEGOTIATION ---------- 10
WHEN WILL AGENTS START THE NEGOTIATION? ---------- 10
WHEN WILL AGENTS STOP THE NEGOTIATION? ---------- 11
EXAMPLE ---------- 11

CURRENT WORK ---------- **15**

CONCLUSION AND FUTURE WORK ---------- **15**

REFERENCES ---------- **16**

Introduction

Work package 6 of CONFIDENCE aims to analyze the decision making process in the context of nuclear emergencies by modelling the behavior of decision makers as software agents. Software agents are autonomous computer programs that can interact and negotiate in response to changes in their environment and according to their intentions. The intention of modelling decision makers as software agents is to better understand the decision making process in such groups of decision makers where personal preferences and different views on the same situation may differ. On the one hand, it is of interest to identify the driving criteria, e.g. what criterion is more important than others and why. On the other hand, it is of interest to understand how criteria are weighted against each other, i.e. in which way decision makers find a compromise that is balanced and acceptable for all participants. In this context it is first necessary to define the environment, e.g. a crisis scenario based on parameters like weather and estimated uncertainty. In addition potential measures for the given scenario have to be provided. Secondly the actual software agents need to be defined by determining different types of the crisis managers, e.g. non-governmental organization (NGO) members, politicians, etc. as well as their intentions and behavior during a decision making process. The most important part here is the resolving of conflicts, i.e. the evaluation of the leeway and adaption of preferences in respect to certain criteria e.g. acceptance of costs. Conflicts are resolved by negotiation between the agents and therefore a decent negotiation model is mandatory.

Negotiation has been an important field of study within organizational behavior and management science. It can be defined as a discussion between two or more parties with conflicting interests aiming to reach an agreement (Pruitt et al. 1993). The participants involved may be individuals or groups of people who negotiate over single or multiple attributes simultaneously, or each of which with their own agendas negotiate through multiple modalities. Moreover, the parties involved need not maintain a constant position, but can dynamically vary their goals, strategies to achieve those goals, and agenda for carrying out those strategies as the negotiation proceeds (Traum et al. 2008). The agreement, which might be a mutually acceptable deal, a new allocation of resources or new rules of behavior, has to satisfy all participants to some extent. A negotiation may also fail in case participants have nothing in common to agree on.

In the past few decades, negotiation has been studied to understand the complicated nature of a negotiation process and make it more efficient and reliable in terms of exploring the space of possible agreements, keeping track of negotiation rounds, and discovering negotiators' behavioral patterns. The negotiation of common-pool environmental resources, which are shared by a group of stakeholders and subject to overuse or congestion, have been modelled in the references (Gardner et al., 1994; Bousquet et al., 1998). Involving stakeholders with different viewpoints helps reducing the complexity and uncertainties involved by providing an insight about the stakeholders' goals and preferences, and allows the capture of a diversity of interests to satisfy diverse expectations (Reed, 2008).

Multilateral automated negotiation

When more than two agents come together to negotiate with different constraints and preferences, then the process becomes complicated. The complicated process of automated negotiation is referred to as multilateral automated negotiation, including a range of different utility valuations and relationships among the agents, wherein the relationships may be adversarial, more neutral or cooperative. Several factors should be taken into account, including the roles of agents, the previous

dialogue history, and the utility calculations by using a single fixed negotiation algorithm mapping the value of these factors to a negotiation move.

The key question in the work is how to create a fully general and human-like model of negotiation so that the virtual humans or so-called agents could be acted as role participants in the negotiation environment. The negotiations are taken after the scoring of the strategies by every agent. The scoring model can be extended to be nonlinear to describe more complicated situations. Strategies in this work are designed with multi-attributes. Things are set up so that the results of negotiations can be predicted by computer calculations without human intervention.

Three rules are defined in the following.

- Before negotiation, agents form their own judgements by assessing the utilities of strategies in their view. Judgements are reflected to be scores of strategies and the rank of these scores.
- The negotiation is carried out in the context of a multi-party meeting with multiple individuals involved in a virtual face to face setting. The agents should obey the norms of conversation, including deciding who or what to look at, when to speak or listen, and what to say.
- During negotiation, agents change their judgements by listening to others' opinion and/or also accepting suggestions or offers from the others.

Strategy

We have defined the set of strategies that the agents may choose from as input for our development and testing of the performance of the tool. On the basis of previous European research projects (HARMONE, PREPARE), the strategies have been prepared, which consist of the implementation of emergency actions such as evacuation, sheltering, distribution of iodine tablets in the release phase, the managements of contaminated inhabited areas and food productions for transition and long term phases. One strategy has at least one countermeasure or management option which is defined as an action intended to reduce or avert the exposure of people, or to reduce radioactive contamination of food, agricultural or forestry products etc. For instance, there are 59 potential management options for use in contaminated inhabited areas listed in (EURANOS handbook): 11 cover the pre-release and emergency phase of an incident; 48 are for the recovery phase. To evaluate countermeasures/management options, agents may consider the following factors, such as constraints on its implementation, effectiveness, and requirements, doses received by those implementing the option, waste disposal issues, economic costs, societal and ethical aspects, environmental impact, and protection of workers.

Agent group

The interactions between individuals can be treated as a prototypical social-dilemma game. Individual often profit from selfishness but the group as a whole may lose (Allison et al. 1996). How to organise agents to get agreement to the strategies in order that the whole group get the best long-run profitability rather than agents pursue individual best profits is the core task of negotiations.

The negotiation process is very diverse. In multilateral negotiation, agents may wish to attend the negotiation process for all the strategies, or just partly for certain strategies. They may be interested in discussions on specified attributes but insensible to the others. Some may feel distributive or integrative with individuals, the whole group, or subgroups coalitions. Some may simultaneously be integrative toward certain agents while distributive towards others, and wanting to avoid yet others.

In our work, we assemble agents into several small groups in terms of their occupations or interests. These groups are usually regarded as the fundamental organizations for negotiations. They work together and try to achieve win-win situations during negotiations.

Norms of conversation

The purpose of conversation is to exchange information and opinion within the agents so that the negotiation will be successful. The environment for conversation should be friendly and cohesively. Agents are encouraged to express their own opinion, give explanations of their stands and also give feedbacks to the arguments from the others. The process of conversation is actually also the process of strategy review which should be taken out without any influence by emotions. The discussion can be carried out firstly in these small groups of agents until the agents in the same group get agreements. Then every group chooses one delegate and all delegates sit together to do the final negotiation on behalf of their own groups. The discussion can also be done in another way; all the agents irrespective of groups sit together and discuss strategies one by one. The agents can also choose which attribute to be discussed first, which can be postponed and discussed later and which should be the last one to be discussed.

During negotiations proceeded in the real world, agents usually express a more complex rhetorical argument. They may try to convince the others by explaining in detail why the strategy does not satisfy them. If the listeners give a counter argument, or reinforce the original proposal, the initiators need to be sensitive and give responses to the new situation. They can change their opinions or still insist on their original ones. For example, two people, Tom and Peter, want to go for dinner. There are two restaurants A and B available. Tom selects Restaurant B but Peter selects Restaurant A. In negotiation, Tom explains that he doesn't want to go to Restaurant A only because it is too far away from his apartment. He can accept food in Restaurant A and B. Peter really wants to go to Restaurant A and therefore he offers Tom that he can pick him up on the way to Restaurant A. Tom can accept this offer and then both agree to go to Restaurant A. The negotiation is successful and they go to Restaurant A. But Tom may reject this offer because they might drink alcohol during dinner and then nobody can drive back to home. Then Peter may suggest to order a taxi but unfortunately Tom has his anxiety so that he is against the suggestion. Instead of taking the strategy to go to Restaurant A, Tom tells Peter that there will be a new menu in Restaurant B and it would be nice to try. If Peter does not actually hate food in Restaurant B, he may accept the suggestion from Tom to try new food in Restaurant B. Now the negotiation is successful and they go to Restaurant B.

Agenda

The work is so far concentrated on the management of contaminated inhabited areas and therefore, we want to present results from that activity as example of the application of the ABM tool. However, any other negotiation process in other areas can be treated in a similar way; thus, the tool is universal.

Factors important for the evaluation of a strategy are for example cost, waste, doses and are attributes to be reviewed by agents during negotiations. Each agent can tell which preference he put on each attribute. For some attributes, the agents' preferences are in complete opposition to each other. On the other hand, agents may have different low- and high-priority attributes. They may prefer to negotiate a certain attribute at first and reach consensus to some extent. The preliminary understanding can provide the basis for the next step of the negotiation.

In order to achieve more successful results after negotiations, agents can manage the ordering of the attribute or decide which attribute to be negotiated by setting the agenda and controlling the topic progression. A complex agenda definition protocol can be developed. With the help of the agenda definition protocol, the agents must be reactive to the concerns that the others express and the negotiation must not be too heavy-handed and unilateral for a certain agent. On the other hand, if the agenda is out of control, the agents may agree on an undesirable strategy and refuse to consider other possible strategies.

Consensus basis

Agents in negotiation are suggested to be rational and obey the following instructions (adapted by Carnevale & Probst, 1998): Agents agree to act as professionals, and making rational arguments is a good way to succeed in a negotiation. Thus, agents should stick to the facts, and use rational arguments to explain their positions. It is very important that agents make rational arguments convincingly by referencing to the facts at hand and do not try to manipulate the others. Agents work for their goals in order to come to a better agreement. They can do this by working together with those who have similar positions. In general, the goal of each agent in negotiation is to reach an agreement with the others that is "good" for all of them.

Preference

Preference setting has been studied in decision research for many years. It is considered that decision makers should have stable preferences and preferences should not be affected by the manner in which the options are presented or the method through which the choice is made. However, in practice, the preferences appear to be constructed at the time of judgment, are sensitive to the mode of elicitation, and are susceptible to framing effects (Shaffer et al. 2009).

On the other hand, there is one fundamental question, that is, whether people would forego an option that has a higher consumption utility and to choose one with a lower consumption utility, holding cost constant. The consumption utility of an option is broadly defined here as the benefit the option delivers. There are at least two possible reasons why people may fail to choose the highest consumption utility option. First, they do not accurately predict which option will deliver the highest consumption utility (e.g., Kahneman et al., 1990, 1992). They choose an option with the belief that it has the highest consumption utility, but, when they consume it, they realize it has not. Second, people do not always use their predictions of consumption utility to guide their decisions (Kahneman, 1994). The former reason can be referred to as prediction-consumption inconsistency, and the latter can be referred to as prediction-decision inconsistency.

The uncertainty of preference can be modelled by assigning different probability distributions to agents' preferences. In detail, for each agent group, we can give one suggested interval to a specified criterion and assume the agents from this group can take any number in this given interval by obeying a certain distribution, e.g. Normal distribution N(μ, σ^2), see Figure 1 . By mapping the variables and function values of this distribution into proper ranges and adjudging the parameters respectively, we can realize different phenomena of agents' preferences. For example, N(0, 0.5) can be used to describe that the agents select randomly the preference values close to the mean, while in the

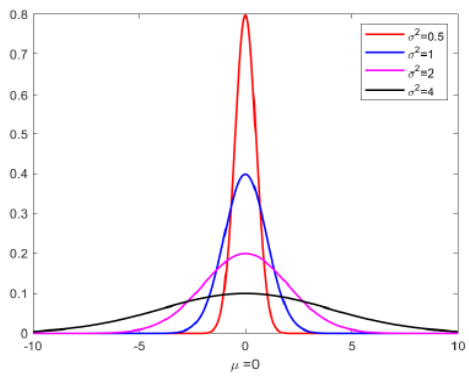

Figure 1: Normal distribution N(μ, σ^2).

distribution N(0, 4), agents select values more uniformly. The different settings of the variances of normal distributions may reflect whether the agents keep an open mind to listen to the opponents or not. There are also many examples of non-symmetric distribution like skew normal distribution or a continuous probability distribution with two or more modes, so-called multimodal distributions. This kind of distribution has always more than one peaks and non-symmetric, e.g. 

Agent assessment strategy

The agents evaluate the strategy according to the following working assumptions:

- Each agent has its own preference for different attributes.
- Reference values of preferences are set in advance for different attributes in each agent group. Each agent can choose a number based on the reference as his own value.
- Different types of weight are introduced to describe that agents can contribute greater or smaller shares in various attributes.

Assessment of single-attribute strategy

Using the notations in (Müller et al. 2018), the utility of i-th agent SU_i to the single-attribute strategy can be defined as,

$$SU_i = \sum_{k=1}^{m} w_k \cdot N_k(C_{k,i}) \quad \forall\, i \in \{1, 2, \dots, n\} \tag{1}$$

where $w_k > 0$ is denoted as the weight of specific normalized criteria and $N_k \,\epsilon [0, 1]$ criteria specific normalization function . The criteria value $C_{k,i}$ can be assigned to be constant but can also be assumed to be a function like e.g. probability.

Assessment of multi-attribute strategy

For multi-attribute strategy, we can extend the equation (1) to be,

$$U_i = \sum_{j=1}^{l} w'_{ij} \cdot SU_{ij} \quad \forall\, i \in \{1, 2, \dots, n\} \tag{2}$$

where U_i is the utility of i-th agent to the single-attribute strategy. $w'_{ij} > 0$ and $\sum_{j=1}^{l} w'_{ij} = 1, \forall\, i \in \{1, 2, \dots, n\}$. $SU_{ij} \,\epsilon [0, 1]$ represents the share of the i-th agent in the utility function U_i and satisfies the condition, $\sum_{i=1}^{m} SU_{ij} = 1$ for each j.

Aggregate agents

Due to several objective factors, agents may not always contribute equally to the assessment of the strategies. Therefore, we introduce the weights of agents $w''_i > 0$ $(i = 1, \dots, n)$ to describe the various shares of agents where $\sum_{i=1}^{n} w''_i = 1$.

The normalized score of one strategy for all the agents can be given as,

$$\text{Score of Strategy} = \sum_{i=1}^{n} (w''_i U_i) \tag{3}$$

Evaluation of a series of strategies

There can be always more than one strategy to be negotiated. As a working assumption, the strategies are not interdependent and reviewed by agents one after another. An extreme situation should be avoided that agents depress the scores of several strategies deliberately so that the total score of the strategy they prefer to will be raised dramatically and as a result selected as the best solution after negotiations. However, from the other perspective, the information about ranking specified attributes may be necessary and helpful for scores. For example, two agents consider the size of the evacuation area but according to their preferences, the numbers given from all the strategies are unexpectedly big and close to each other. As a result, the direct distance function between the suggested areas from strategies and the expected area from agents fails to distinguish these strategies very well. In this situation, we need to add one parameter in the utility function of agent to reflect the rank of area.

Protocol

A negotiation protocol is a set of rules that specify how the agents can interact during the process of a negotiation, while a negotiation strategy determines, according to the negotiation history, which offers should be made or whether or not they accept their opponents' offers at a certain time of the negotiation process (Jennings et al. 2001). A majority of the protocols are of multistep interactions, but there are still a few one-step or one-shot protocols (Rosenschein et al. 1994). Multistep protocols are usually supposed to allow more efficient outcomes but take more time to complete than the one-shot ones. In the current work, we assume that all the agents are offered with several strategies before negotiation. They review the strategies independently and give scores to these strategies one by one. Then they sit together (e.g. in a meeting room) and negotiate the acceptances of these strategies on the basis of their scores. During the course of negotiation, they exchange their views on the strategies and consider carefully the reasons from those who have different opinions. They may see if some leeway is to be left from the opponents. They may see if they can give special offers so as to solve the opponents' problems. They may also compromise in some way to try to be unanimous for a certain attribute in negotiation with the majority.

Tactics

Negotiation strategies are often conceptualized as either integrative or distributive, such that they seek to maximize either joint or individual benefits, respectively (Raiffa, 1982). A negotiation attribute–based tactic in particular refers to a certain way of handling one or more negotiation attributes in pursuit of a joint or individual goal. The libraries of negotiation strategies have been studied in past decades and many effective tactics have been determined in various negotiation situations. In general, the tactics can be broadly split into two categories, cooperative and non-cooperative types. In the following, we list the simplest mathematical realizations of these two types:

Assume that n agents negotiate for one score of one strategy in the management of risk or bid for the production at auction. The scores/bids given from agents are denoted to be $\{s_i\}, i = 1, \dots, n$.

After negotiation, we obtain the final results:

Cooperative type (e.g. trade-off): $final\ score = \frac{\mathrm{Max}\{s_i\}+\mathrm{Min}\{s_i\}}{2}$

Non-cooperative type (e.g. auction): $final\ bid = \mathrm{Max}\{s_i\}\ or\ \mathrm{Min}\{s_i\}$

It will be very interesting and challenging to find out suitable negotiation strategies with respect to the specified negotiation topics.

Prepare negotiation

One negotiation process generally has three phases, pre-negotiation, on-going negotiation, and post-negotiation. The pre-negotiation phase deals with activities before formal negotiation. The actual negotiation process involves mainly the adaption of the rankings and the exchange of information including scores of strategies, offers, etc. between agents. It may also feature argumentation, learning, dynamic strategy selection, and impasse resolution. The last phase, post-negotiation, includes the analysis and improvement of a final agreement.

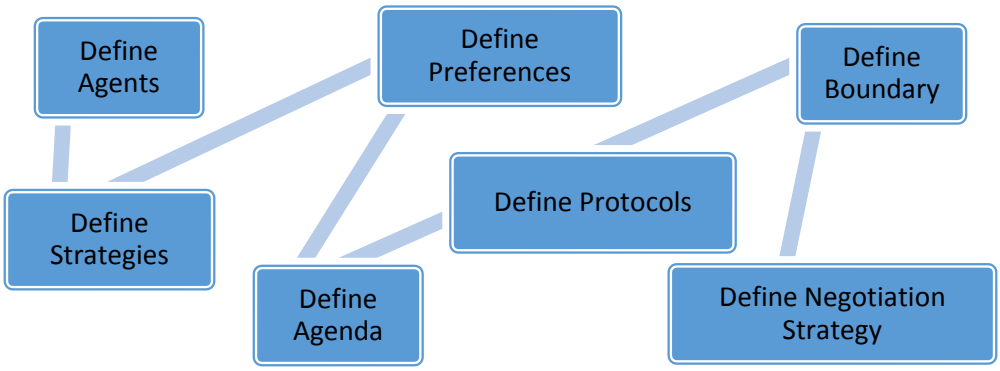

Figure 2: the sketch map of pre-negotiation.

When will agents start the negotiation?

Generally, the agents will consider several recommended strategies. Their task is to find out which one is the best. Before starting negotiation, the agents will review and score these recommended strategies. If all of them find that one strategy is better than all others, then this strategy will be selected out as the best solution and there is no need to negotiate. This situation is shown in the left part in Figure 3. However, usually the agents have different opinions and as shown in the right in Figure 3, Agent 1, 2, 6, 8 think Strategy Blue as the best strategy, while Agent 3, 4, 5, 7 think Strategy Orange is the best one. Furthermore, the scores of the two strategies from Agent 2 are not so different. The same situation appears to Agent 7. It means, Agent 2 and 7 are still in swaying between these two strategies and may change their minds easily during negotiations.

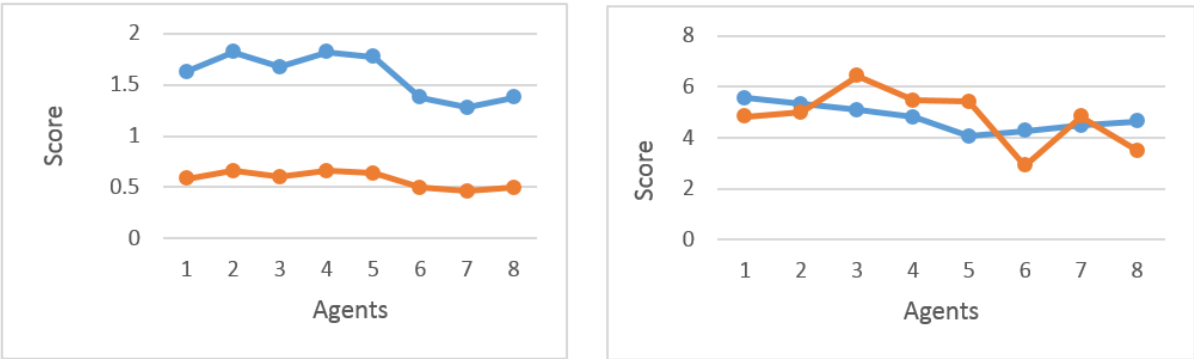

Figure 3: Scores of two strategies (Blue and Orange). Eight agents review these strategies. In the left figure the case is shown that no negotiation is needed because every agent ranks Strategy Blue already as the best one. In the right figure, the eight agents do not have the same rankings for the two strategies. Therefore, the negotiation is necessary so that the agents can get an agreement on one particular strategy as the best one.

When will agents stop the negotiation?

In the optimal situation, the agents stop the negotiation when they receive an agreement. But sometimes the preferences of agents differ very much from each other. They cannot convince the others of their opinion and therefore the negotiation fails.

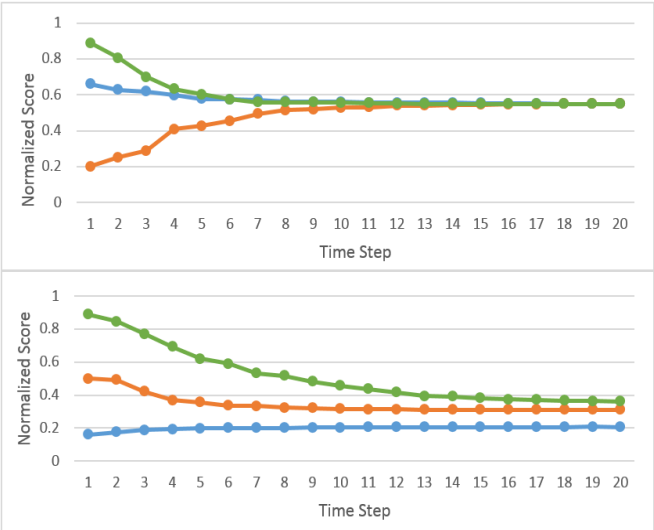

Figure 4: The comparison between successful negotiation (shown in the upper subfigure) and unsuccessful negotiation (shown in the lower subfigure).

In Figure 4, the cases of successful and unsuccessful negotiations are shown, respectively. We set the limit of the iterations to be 20, which means that the negotiation process stops after 20 single negotiations. In the upper part of Figure 4, before the negotiation, three agents give scores to the strategy, 0.2, 0.66 and 0.89 respectively. During the negotiation, the agents change their opinion and consequently the scores of the strategy go closer. After around 15 turns of negotiation, the scores of the strategy look almost the same. In the lower subfigure, no agreement is reached. At the beginning, the differences between the scores become smaller but then after time step 15, the score of the Blue Agent 3 reaches a constant value instead of approaching to the other two. The score of Agent 1 is going slowly to the score of Agent 2 but it may be possible that the tendency will be stopped and the value may never reach the score of Agent 2.

Example

In this section, we will show numerical results from the simulation experiments. The scenario describes the negotiation process of two agents negotiating on three strategies and successfully agree on the rank of one preferred strategy. The agents are of equal weight w''_i in (3). The negotiation tactics "random Tit-for-Tat" is used (Faratin et a al. 1998).

Example 1:

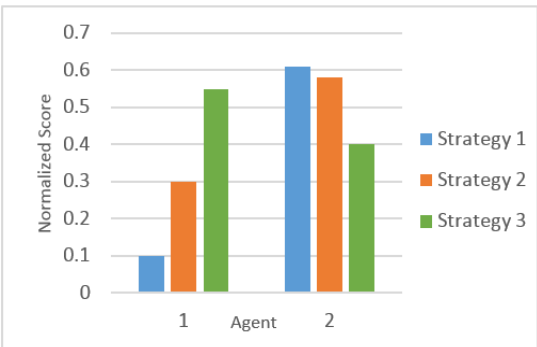

Figure 5: The initial setting of agents in example 1.

Before negotiation, Agent 1 considers Strategy 3 is the best one and Strategy 1 is the worst one. Agent 2 opts mainly for Strategy 1 and Strategy 2 and slight inclines to Strategy 1. Strategy 3 is not good for Agent 2.

The process of the negotiation is stopped after 20 iterations. From Subfigure 6.a-c, it can be observed that the two agents reach agreements for all the three strategies. For Strategy 1 and 2, Agent 1 gives always lower scores than Agent 2. But for Strategy 3, Agent 1 gives higher score. Compared to Agent 2, Agent 1 prefers Strategy 3. As seen from Subfigure 6.d, Agent 1 doesn't change the ranking of the three strategies during negotiation although the scores are changing. But Agent 2 changes his opinion according to Subfigure 6.e. At beginning, he scores the Strategy 1 and 2 almost the same but after 6 negotiations, he starts to realize the difference between them. On the other hand, he starts to consider Strategy 3 better than the others after 5 negotiations. From Subfigure 6.d-e, it can be found out that after around 16 negotiations, the scores are stable, which means, the process can be stopped without doubt. Subfigure 6.f gives the final result of negotiation.

Figure 6: The negotiation process and result of example 1. There are 6 subfigures, a, b, c, d, e and f. Subfigure 6.a shows the scores of Strategy 1 for 2 agents, Subfigure 6.b shows the scores of Strategy 2 and Subfigure 6.c is for Strategy 3. Subfigure 6.d shows the score of 3 strategies for Agent 1 and Subfigure 6.e indicates the score of 3 strategies of Agent 2. Subfigure 6.f is the final result of negotiations. Compared to the initial setting, the two agents get the same rank of these three strategies, which means, after negotiaiton, the two agents agree that Strategy 3 is the best one while Strategy 1 is the worst one.

Example 2:

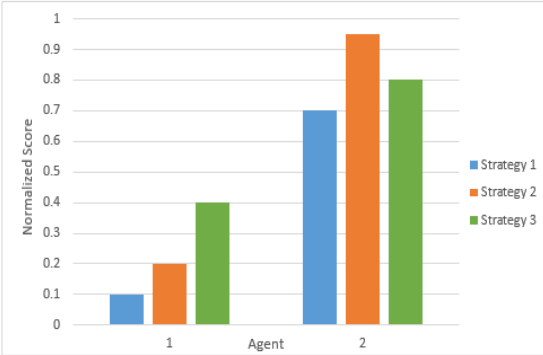

Figure 7: The initial setting of agents in Example 2.

Before negotiation, Agent 1 and Agent 2 have different ranking of the three strategies. Agent 1 prefers Strategy 3, then Strategy 2. Strategy 1 is his last choice. Agent 3 regards Strategy 2 as the best one among these strategies. He also considers Strategy 1 as the worst one.

The analysis of these subfigures shows similarities with Example 1. Particularly in Example 2, Agent 1 changes his opinion on Strategy 2 and Strategy 3 sharply but Agent 2 relatively maintains his opinion. By the way, the final result keeps the rank of Agent 2.

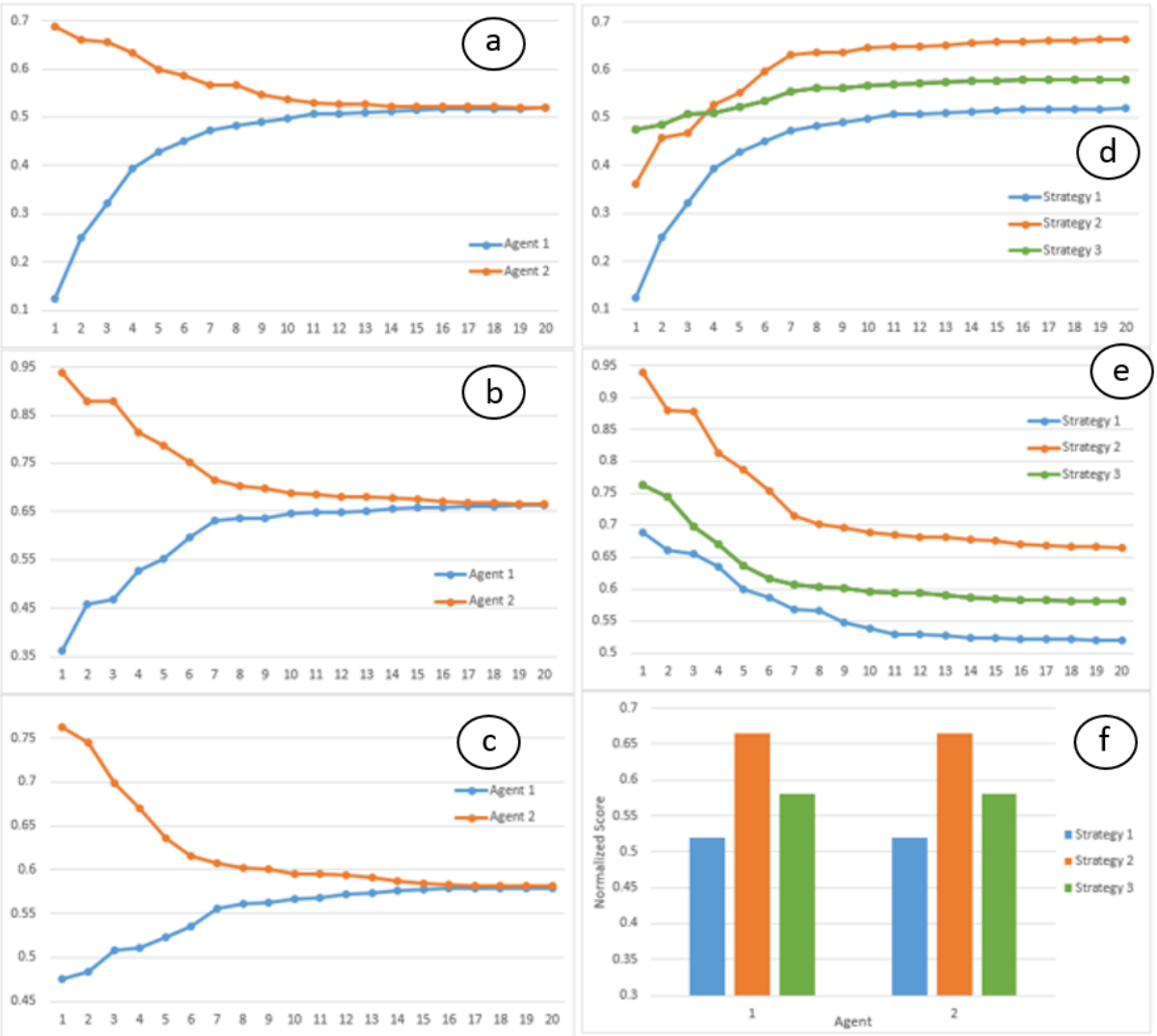

Figure 8: The negotiation process and result of example 2. There are 6 subfigures, a, b, c, d, e and f. Subfigure 8.a shows the scores of Strategy 1 for 2 agents, Subfigure 8.b shows the scores of Strategy 2 and Subfigure 8.c is for Strategy 3. Subfigure 8.d shows the score of 3 strategies for Agent 1 and Subfigure 8.e indicates the score of 3 strategies of Agent 2. Subfigure 8.f is the final result of negotiations. Compared to the initial setting, the two agents get the same rank of these three strategies, which means, after negotiaiton, the two agents agree that Strategy 2 is the best one and Strategy 1 is the worst one.

Example 3:

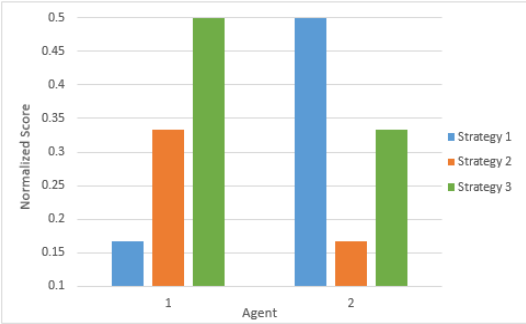

Figure 9: The initial setting of agents in Example 3

Before negotiation, Agent 1 sorts strategies by scores: Strategy 3 > Strategy 2 > Strategy 1, while Agent 2 sorts: Strategy 1 > Strategy3 > Strategy 2.

The two agents negotiate 20 times. Subfigures 10.a-c show how the scores of strategies go to the limit. Subfigures 10.e-f illustrate how the agents change their opinions to the strategies during the negotiations and the scores become stable after several negotiations so that the negotiations do not need to continue.

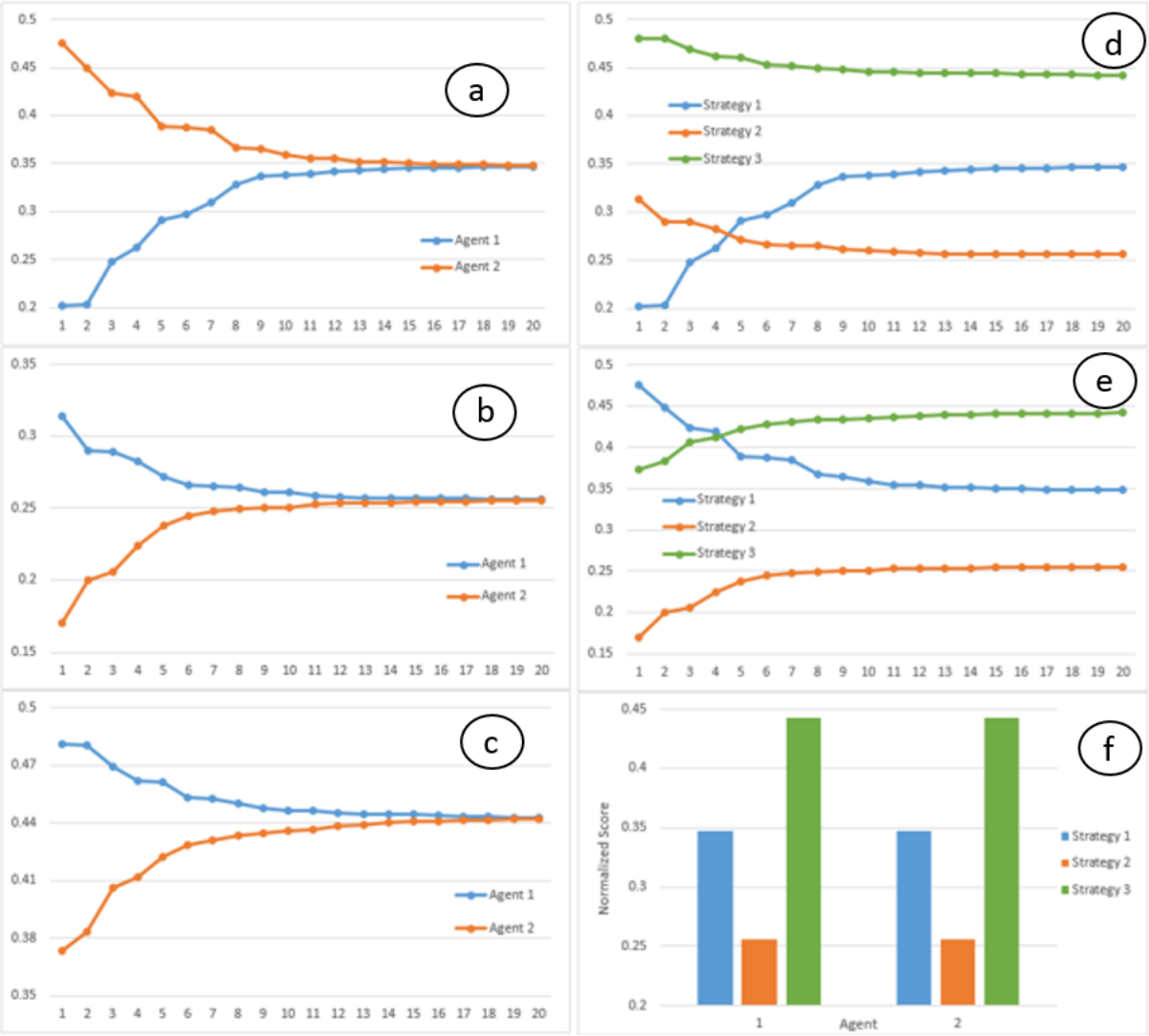

Figure 10: The negotiation process and result of example 3. There are 6 subfigures, a, b, c, d, e and f. Subfigure 10.a shows the scores of Strategy 1 for 2 agents, Subfigure 10.b shows the scores of Strategy 2 and Subfigure 10.c is for Strategy 3. Subfigure 10.d shows the score of 3 strategies for Agent 1 and Subfigure 10.e indicates the score of 3 strategies of Agent 2. Subfigure 10.f is the final result of negotiations. Compared to the initial setting, the two agents get the same rank of these three strategies that Strategy 3 is the best one and Strategy 2 is the worst.

Conclusion of the examples:

The three examples are designed to describe the successful negotiation process. In the three examples, the two agents have always different ranks of the recommended three strategies before negotiation. Therefore, negotiations between them are necessary. After negotiations, they reach an agreement on the same rank for these strategies. From the comparison of the three examples above, the final rank of strategies in Example 3 is different from those given by both agents in the initial setting. This means that both agents change their opinion considerably. In Example 1, Agent 1, and in Example 2, Agent 2, did not not change the rank of strategies although the scores of strategies were changed. So far, the current mathematical model and parameter settings can describe different phenomena of negotiation in an appropriate way. On the other hand, Example 2 indicates that if one agent gives always extremely higher scores than another agent no matter which strategy is used, the final rank of strategies will be of high probability the same as given by that agent before negotiation. To avoid this situation, we can normalize the scores of strategies with respect to each agent and each agent uses the percentages of scores of strategies in the negotiation. We can also set the weight of this special agent lower than the others.

Current work

In our current work (Bai, Müller, Raskob), an intelligent strategy evaluation system has been introduced in order to simulate the decision making process of stakeholders on computationally tractable assumptions. In the framework of the system, agents can score the recommended strategies before negotiation and negotiate them by using different negotiation skills. For a real situation, which is different to the examples shown above for understanding the methodology, we assume 25 stakeholders, who can be subdivided into 5 experts, 5 lawyers, 5 politicians, 5 from NGO, 5 from industry, to participate in the negotiation. The agents are together in one meeting room at the same time and review several recommended strategies. They have values of preferences according to four given criteria, effectiveness, cost, acceptance and resources needed and score the strategies on the basis of the preferences. This setting can be adapted to national conditions as will be done in the frame of the stakeholder panels planned for 2019. A Java application linked with a relational database has been implemented. 144 strategies were prepared and stored in this database which would be recommended to negotiation according to the accident phases and protect targets in query. Also these strategies can be adapted if necessary in a national context. The negotiation process is illustrated by animations. Results can be provided as time series which are the scores for all the agents in respect to each strategy and the scores for the strategies in respect to each agent. The descending list of scores for the strategies can be provided in XML format for further processing and evaluation.

Conclusion and future work

This deliverable has the description of multilateral automated negotiation from the view of psychologists and social scientists. General topics related to negotiation skills, for instance, the design of strategy, agent group, norm of conversation, agenda, consensus basis, preference, protocol etc. have been considered. Furthermore, we described how to model those topics in a mathematical and a statistical ways. The details can be found in the formula (1), (2) and (3) and the surrounding texts. Three numerical tests are given to demonstrate different phenomena during negotiation process. The methodology is implemented in a Java based program and was demonstrated in several workshops of WP6 of the CONFIDENCE project. Proposals for improvements were considered and implemented. The next step is now to refine the negotiation process and adapt the tool to national conditions that will be used in exercises and panels

To do so, a questionnaire for understanding decision making in several European countries has been prepared and sent to the partners of WP6 in particular and CONFIDENCE in general. Following the feedback that is expected early 2019; we can design new criteria, agent groups and negotiation strategies to adapt it to national needs.

References

- Allison, S. T., Beggan, J. K., Midgley, E. H. (1996). "The quest for "similar instances" and "simultaneous possibilities": Metaphors in social dilemma research". Journal of Personality and Social Psychology. 71, 479–497.
- Carnevale, P. J., and Probst, T. M. (1998). Social values and social conflict in creative problem solving and categorization. Journal of Personality and Social Psychology, 74, 1300–1309.
- Bousquet, F., Bakam, I., Proton, H., Le Page, C., (1998). Cormas: common-pool resources and multi-agent systems. Tasks Methods Appl. Artif. Intell. 1416, 826-837.
- Kahneman, D., Snell, J. (1990). Predicting utility. In R. M. Hogarth (ed.), Insights in Decision Making: A Tribute to HillelJ. Einhorn, 295–310; (1992). Predicting a changing taste: Do people know what they will like? Journal of Behavioral Decision Making, 5, 187–200.
- Kahneman, D. (1994). New challenges to the rationality assumption. Journal of Institutional & Theoretical Economics, 150, 18–36.
- Jennings, N. R., Faratin, P., Lomuscio, A., S. Parsons, S., Wooldridge, M., and Sierria, C. (2001). Automated negotiation: Prospects, methods and challenges. Group Decision and Negotiation, 10 (2), 199–215.
- Pruitt, D.G., Carnevale, P.J., (1993). Negotiation in Social Conflict. Open University Press, Buckingham, England.
- Pan, L., Luo, X., Meng, X., Miao, C., He, M. and Guo, X. (2013). A two-stage win–win multi-attribute negotiation model: optimization and then concession Computational Intelligence, 29 (4), 577-626.
- Gardner, R., Ostrom, E., and Walker, J. (1994). Rules, Games, and Common-pool Resources. University of Michigan Press, Michigan, US.
- Raiffa, H. (1982). The art and science of negotiation. Cambridge: Harvard University Press.
- Reed, M.S. (2008). Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417-2431.
- Rosenschein, J. S., and Zlotkin, G. (1994). Rules of Encounter: Designing Conventions for Automated Negotiation among Computers. MIT Press: Cambridge, MA.
- Müller, T. and Raskob, W. (2018). Addressing uncertainties by MCDA, Confidence deliverable in WP6.
- Faratin, P., Sierra, C., and Jennings, N.R. (1998). Negotiation decision functions for autonomous agents. Robotics and Autonomous Systems, 24, 159–182.
- Shaffer, V. A. and Arkes, H. R. (2009). Preference reversals in evaluations of cash versus non-cash incentives. Journal of Economic Psychology, 30 (6), 859-872.
- Traum, D., Gratch, J., Marsella, S., Lee, J., and Hartholt, A. (2008). Multi-party, multi-issue, multi-strategy negotiation for multi-modal virtual agents. In Proceedings of 8th international conference on intelligent virtual agents, Tokyo, Japan, September 2008.
- Bai, S., Müller, T., Raskob W. (2018), Intelligent strategy evaluation system for stakeholders based on multiagent negotiation simulation, manuscript submitted.