A Multi-Party Negotiation Game for Improving Crisis Management Decision Making

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Abstract
This paper presents a training game intended to train crisis management teams to negotiate collaboratively in order to reach the group goal in the best way possible. The importance of the group goal in comparison to their individual goals is touched upon as well, as are various conflicts that can occur during such a negotiation. The game, which is implemented in the Blocks World 4 Teams environment, gives a team a specific scenario and allows them to negotiate a plan of action. This plan of action is then performed by agents, after which the team members will be debriefed on their performance. An experiment, containing multiple rounds to test the effect the game has on participants, is planned in the near future.

1. Introduction
A crisis can be defined as a threat to the basic infrastructures or the fundamental values and norms of a social system (Rosenthal 1984). Crises have the effects of threatening higher priority goals and restricting response times (Herman 1963). They also have a high level of uncertainty (Rosenthal 1984).

Crises are usually managed using a network-centric approach (van de Ven et al. 2008). This approach has evolved from Network Centric Warfare (NCW) which was used by the military (Alberts and Hayes 2007). The main goal of NCW was to share information between all parties, with the motivation being that having a superior information position gives you an advantage over your opponent. By adapting this to crisis management the Network Centric Operations (NCO) system was conceived. NCO allows information to be shared horizontally as well as vertically throughout the organization dealing with the crisis, and also allows information to be shared amongst multiple units. The network-centric approach contains a single commander in chief that controls all the actors in the network. For this approach to work correctly all actors should have the most up to date information, which means that all information should be shared amongst all actors. Also each of the actors should have common goals which they all are striving to achieve.

However, a crisis management organization often consists of multiple teams that contain multiple disciplines. An evaluation of crises has shown that the previously mentioned criteria for a working network-centric approach are usually not met (van Santen, Jonker and Wijngaards 2009). These teams usually consist of members who do not share the same goals, instead having their own goals that they want to achieve.

Therefore (van Santen, Jonker and Wijngaards 2009) claim that the crisis management decision making process should be seen as a multi-party multi-issue negotiation, as each of the parties in one of the decision-making teams has their own interests and preferences. So in order to make a decision each party has to make some compromises, the final decision is based on the attitude, negotiation strategy and negotiation skills of each party. Importantly, the authors pose that the team will perform better if each team member takes the preferences of other team members into account. However at the start of the process each team member will not have this knowledge, nor do they typically try to gain this knowledge in the process. Thus they negotiate competitively, meaning that they will prioritize their own preferences. The authors thus propose that crisis management workers should be trained so that they can negotiate using a collaborative mindset instead of a competitive mindset. In this paper we present the design of a game to train precisely this.

Our game is played by a team that has one group goal to achieve, with each team member also having his own goal...
to achieve. A negotiation phase is used to create the plan of action, after which software agents play the game based on the negotiation outcome. This allows the players to see the effect that their negotiation result has on the performance. At the end of such a round a debriefing is given to summarize the results to the team and let the team reflect on their performance.

The paper is structured as follows: Section 2 will give examples of other games that are similar to our game. Section 3 details the overall design of the various parts of our game, as well as the environment that we used to create the game. Section 4 presents the protocol for the experiment that we intend to perform in the near future using our game. Section 5 is the conclusion of this paper.

2. Related Work

2.1 Negotiation

In a crisis management team decisions need to be made about the proper course of action. However as a crisis management team does not usually have a team leader, instead consisting of various individuals with differing roles with corresponding responsibilities and preferences, this decision is not easily made. (van Santen, Jonker and Wijngaards 2009)

For example in the case of a huge fire the police would want to evacuate civilians from the area to keep them safe, while the fire brigade does not want this as this would create panic among the civilians located in the area.

Negotiation is one of the main procedures for dealing with opposing preferences like these (Carnevale and Pruitt 1992). Such a negotiation can take several forms, either a bilateral negotiation (between two parties only) or a multi-party negotiation (between more than 2 parties) (Crump 2006). The topic of negotiation can usually be divided into issues for which each issue has a set of possible values for that issue. Each actor in the negotiation has a preferred outcome, depending on their personal preferences, which will most often not be shared by the other actor(s) as they have differing interests.

The crisis management decision-making process can be seen as a multi-party negotiation containing multiple issues that are to be negotiated about (van Santen, Jonker and Wijngaards 2009). The outcome of this negotiation contains the plan of action for the crisis.

2.2 Related Games

Various other games (Agapiou 2006; Heuvelink 2009; Moura 2003; Briot et al. 2009) have been created that incorporate teamwork and/or negotiation to some extent. In this section we will highlight the two that come closest to our vision.

The SimParc project (Briot et al. 2009) focuses on participatory park management. The goal of the game is to make players understand conflicts and make them able to negotiate about them. The game takes place in a park council, which consists of various stakeholders like the community or the tourism operator. The topic of discussion is the zoning of the park which entails the desired level of conservation for each part of the park. Each stakeholder has a different preference concerning the zoning for each part of the park, which quickly leads to conflicts of interest. A special player type is the park manager who acts as an arbiter and makes the final decision based on the final input from the players. The game starts with an allocation of roles to players after which they can present their first proposal for each part of the park. After this the players can freely negotiate about their proposals. This negotiation is a multi-party negotiation as each player can send messages through the system to multiple other players. Bilateral negotiation is also possible when a player negotiates only with a single other player. When all negotiations are finished each player can adjust their proposal if necessary and the park manager will then make a final decision. Each player can then receive information about their performance and can also ask the park manager to explain his final decision.

The SimParc game is very similar to crisis management as it contains a group goal (zoning the park), and each stakeholder has his own goal to achieve. The players also get the opportunity to negotiate with others in order to come to a solution. However the game strongly differs from crisis management in one aspect which is the inclusion of a park manager who makes a final decision. In crisis management teams such an entity does not exist as teams do not have a hierarchical structure. In our game we also do not intend to have a team leader, instead a team where every team member has equal say.

A second example is Colored Trails. The game Colored Trails (Moura 2003) was developed for testing the decision-making procedures in task-oriented settings; it is used for examining agent and human behavior. It focuses on the interaction between the individual goal and the group goal which is modeled in the game. The game can be played by more than 2 players and consists of a rectangular board containing colored squares. The players get a starting position on this board, a goal position and an initial set of chips. The objective for the players is to reach the goal square. Players can only move to a square which is adjacent to the one they currently occupy. This can only be done however by having a chip with the same color as the square the player wants to move to. This can result in a negotiation between two players to exchange chips using a standardized messaging protocol. Some parameters can be changed to vary the game, for example the board visibility can be changed so that players aren't allowed to see the
entire board or the knowledge of the other players' chips can be toggled on or off. After the game is over, the results are calculated using a scoring function which uses the number of chips the player has left, the distance to the goal position, the number of moves made by the player and whether or not the player has reached the goal state. This is the base scoring function of the game; it can be made more complex by also taking into account the results of other players with a certain weight. This weight can be adjusted to make other players' success more important than this player's own success or vice versa. Group goals can thus be modeled by adding a scoring component that can only be maximized when all players reach their goal and are therefore composed of multiple individual goals.

The Colored Trails game can therefore be adapted to create a team having the group goal of maximizing other players' scores, while each team member also has an individual goal of maximizing his own score. The negotiation protocol in the game can then be used by the team members to decide which chips to exchange with what other team member. However this negotiation protocol is currently limited to negotiations between two players. A negotiation in the crisis management domain often contains more than two players. In our game we therefore also want the ability for multi-party negotiations to be present. The Colored Trails game would therefore not be suitable for our needs.

To conclude, SimParc uses a hierarchical structure for its teams and Colored Trails does not support multi-party negotiations. Therefore both games are not suitable for the crisis management domain.

3. Game Design

3.1 Blocks World For Teams (BW4T)

For our game we use the Blocks World For Teams (BW4T) environment as a basis (Johnson et al. 2009). This environment was originally created to study human-agent teamwork. We chose it because it is simple and it is not directly related to crisis management. The latter is important as we believe that crisis management environments may not be realistic enough for our target group of crisis management experts, which might hamper their immersion in the game and reduce the training effect. Therefore the environment was deliberately made more abstract.

The BW4T environment, shown in Figure 1, consists of 9 rooms in which colored blocks are hidden. One or more simulated robots, which can be controlled by humans or software agents, can traverse these rooms in order to find these blocks.

Figure 1. BW4T environment

The goal of the game is to collect certain colors in a certain order. This color sequence is displayed to the right of the green arrow. Players can pick up one block at a time and can bring it back to a special room called the drop zone where it should be dropped in accordance with the desired color sequence. Players also have the ability to send messages to other players, for example telling them what blocks they have found in a room. A constraint that holds for all players is that they can not see other players.

3.2 Extension of BW4T with Individual Goals

BW4T as proposed by Johnson et al. includes a group goal (the color order in which blocks need to be collected). We also need individual goals for the players, as we want to create conflict between the group goal and individual goals of players, and between the individual goals themselves. We consider a conflict between two goals to exist when the achievement of one goal hinders the achievement of the other. Creating these conflicts is necessary as in crisis management these conflicts also occur. Therefore we extend the original BW4T game to include individual goals. We will call this extension BW4T-I.

Various kinds of individual goals may be thought of, creating different kinds of conflicts. Whether a conflict with the group goal occurs, depends also on the choice of the group goal. The criteria we propose for selection of individual goals are as follows:

- High severity of conflict, as a higher amount of conflict should improve awareness of these conflicts in players.
- Possibility of an integrated plan, meaning the possibility of creating a plan that achieves all goals with a lower performance impact. This should show players of our game that by
negotiating collaboratively these solutions can be found.

- Relation to crisis management, there should be some way to translate a certain individual goal to the crisis management domain. This would allow us to use similar goals in the case of creating a more realistic crisis management training game in the future.

A combination of individual goals, group goal and block configuration, is what we define as a scenario for the game. Below we present two of the three scenarios that have been implemented in our game, and that satisfy our criteria.

One scenario that has been implemented in our game is the following:

- Group goal: Red, Blue, Green, Yellow, Red, Red, Blue, Green, Yellow
- Individual goal (All team members): Search all rooms

The block configuration for this scenario was chosen in such a way that each room has to be explored in order to achieve the group goal. The group goal therefore also contains nine colors as there are nine rooms. This is not a problem when only one player plays this scenario and searches all the rooms. However with more players searching all the rooms, this creates a conflict with the group goal as it takes a lot longer to achieve it. An integrated plan can be created to lessen the delay by letting each player explore the rooms in a different order; however the result will still be slower than dropping the individual goals entirely. The amount of conflict is high as achieving the group goal is delayed greatly by all players searching every room. A translation to crisis management could be a fireman needing to check all houses for survivors.

A second scenario that we have implemented is the following:

- Group goal: Red, Yellow, Purple, Blue, Blue, Red
- Individual goal (All team members): Collect the most blocks relevant for the mission

In this scenario the only conflict that occurs is between the team members’ individual goals. When one member achieves his goal, the others cannot do this anymore. This could result in a team that does not cooperate and splits into individual players. The conflict severity is therefore very high. The choice of six colors in the group goal was made deliberately to allow for an integrated plan of letting each member collect two blocks and by doing that equally distributing the loss amongst the team. However this all depends on if the team members are prepared to agree with this. The blocks configuration was chosen at random as it has no further impact on this scenario. A translation to crisis management could be a medic wanting to save most of the victims because he feels responsible for doing this.

Other scenarios can be thought of, for example by giving each team member different individual goals. A different individual goal could be not entering a certain subset of rooms (as these could be dangerous) or only being allowed to pick up blocks of a specific color.

3.3 Game Outline

As our game is intended for training crisis management experts, it will start with a negotiation phase. In this negotiation phase the team members will need to make a decision on how they are going to play the game, depending on the group and individual goals. They need to reach an outcome in ten minutes, which emulates the time pressure contained in the crisis management decision making process. This outcome will be given to the agents that will play the game based on this. This allows the team members to see the direct effect of their negotiation outcome, and also prevents team members from changing their plans during the game. After the agents finish the game, a debriefing will be given to the team members. The next round starts after this debriefing.

It was necessary to create a fixed negotiation domain for the game, as the agents need to be able to work with the negotiation outcome. In order to create this domain, we conducted two experiments with the purpose of determining the issues and values in this domain.

The first experiment was held with three participants who were instructed to negotiate freely for three different scenarios. The goal of this experiment was to obtain a list of issues and values for the negotiation. For each scenario each participant received the group goal and his individual goal. The negotiations were filmed, from which we gathered the following list of issues and values.

- What information is shared between the team members?
  Values:
  - Next location
  - What blocks you’ve found in a room
  - The blocks that are picked up
  - The blocks that are dropped
- What rooms in what order do the team members explore?
- Which team member collects what color from the global goal list?
• Do team members wait until all individual goals have been reached before dropping the last block?
• Are team members allowed to enter other rooms than the ones contained in their exploration list?
• Which team member drops their individual goal?
  Values: No-one, random or a specific team member

A second experiment was then held with the goal of finalizing this list. The set up of the experiment was similar except that the participants were not allowed to negotiate freely this time. Instead they were given the above list of issues and values and were asked to discuss these issues if they wanted, but they were also allowed to discuss issues that were not contained in this list. These negotiations were filmed and analyzed, after which it was determined that no new issues or values had been discussed. Therefore this list of issues and values is now used in the final game.

The debriefing phase summarizes the results of the negotiation, including how the team members behaved during the negotiation, as well as the resulting performance of the agents. The team members will be told whether they made any concessions when there were disagreements, which indicates whether they have been cooperative. They will also be told whether they made any concessions on their individual goals in order to improve the performance on the group goal. This performance is measured in the game by taking the amount of time it took to complete it. The performance itself will also be told to the team members, as well as the difference between it and an optimal solution for the group goal. This difference shows them what effect their outcome actually had on the group goal’s performance. This should lead them to reflect on this outcome, and ideally change their perception on the importance of the group and individual goals in a next round.

3.4 Agents for BW4T-I

As the agents should show the effect of a certain negotiation outcome all of their reasoning uses this outcome.

The agents follow a task structure containing three tasks. These tasks are the exploration, delivery and drop off tasks. These tasks will be explained briefly in this section.

Figure 2 shows the exploration task which is performed first by an agent. This task is used to find the next block that the agent should collect.

Figure 3 shows the delivery task which is used to pick up the next color that the agent should pick up. The agent will continue exploring if the next color that the agent should pick up is not the next color in the group goal list.

Figure 4 shows the final task which entails dropping a block in the drop zone. When this block is the last block, meaning that the game will end after it is dropped, the agent can decide to wait until all agents have reached their individual goal or to finish his own goal if necessary.
4. Experiment

Now that we have designed and implemented our game we intend to test the effect it has on people. The goal of our game is to shift the focus from individual goals to the group goal as well as to show players what conflicts can occur and to solve these conflicts more effectively. The experiment will use three participants per group. Each group will perform two rounds. There will be six groups in total. Since three scenarios have been devised, this allows us to test every scenario combination for their effects.

A subjective measurement will be done in the form of a questionnaire which will measure the importance players attach to the global and individual goals, as well as the amount of conflict they noticed during the experiment and how satisfied they are with the resolution of these. The questionnaire will also contain reflection questions which allow the participants to determine whether they were satisfied with the outcome and if they would change their behavior in retrospect.

Objective measurements will be done by analyzing the negotiation as well as checking the agent’s performance. A checklist of certain behaviors will be devised, which should show a change in behavior from the first to the second round in the experiment.

5. Conclusion

This paper presented a training game which can be used to train crisis management experts in order to negotiate more collaboratively. As the crisis management decision making process can be seen as a multi-party multi-issue negotiation where each party has their own goal in addition to a group goal, all these elements are present in our game.

The BW4T environment was used as a starting point for our game design. The environment already supported a notion of a group goal in its scenarios. Individual goals were added to new BW4T scenarios, in order to create various conflicts, of which in total three were created.

Team members are allowed to negotiate the plan of action for a scenario within 10 minutes, using a predetermined negotiation domain.

Agents were implemented, that have the ability to play the game based on the negotiation outcome. The performance of these agents is used in the debriefing phase in which the results of the previous scenario are relayed to the team members. This should lead to a change in behavior in the next round.

In the near future we intend to perform the experiment that was described in the previous section, in order to test whether our devised game actually changes the perception towards individual and group goals in participants. Moreover, we will investigate the use of automated negotiation agents, using the Genius environment (Hindriks et al. 2009), to replace part of the human participants in the first phase of the game. These agents should be endowed with the ability to exhibit different negotiation styles, corresponding with more or less collaborative behavior.

References


