Designing a Negotiating Party

Group 29

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1 ANALYZE PARTY DOMAIN

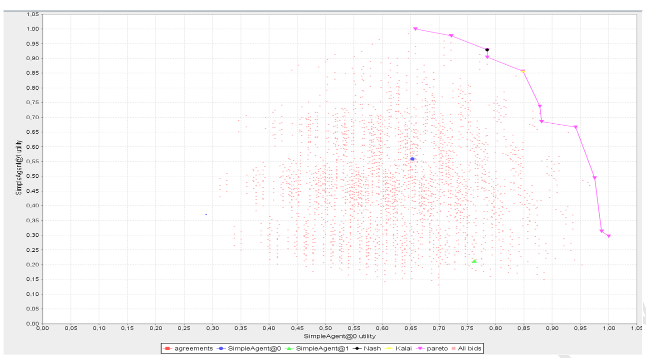

Figure 1: The Pareto efficient frontier for two utility profiles of the party domain.

1.A

We show the Pareto efficient frontier in Figure 1. This frontier is the set composed of all Pareto efficient allocations. A bid is Pareto efficient if, given the current utilities, every deviation within the bid will yield a lower utility for at least one of the agents. Therefore, in Figure 1, the Pareto frontier can be seen as the lines between the bids with utilities that dominate other bids.

1.B

Two instances of the simple agent with random **bidding** performance:
A bid is generated at random by the starting bidder. This will be accepted by the opposing agent above a certain threshold utility. A Pareto optimal point can be reached but depends on the bidder randomly generating it and has a utility the other bidder accepts.

BoulwareNegotiationParty vs ConcederNegotiationParty
The BoulwareNegotatiationParty ACTS as if he never makes any concessions: it opens the negotiation with a bid that evaluates to his maximum attainable utility. The opposing (conceding) party will continuously make concessions in form of its bid. Since the Boulware party ACTS like it does not make any concessions, it will never accept a different offer than his own. However, the Boulware party will make slight concessions if enough time has passed, which slightly devalues its utility. Therefore, the conceding party is the decider on when to accept the Boulwares (Note: initial!) offer. Related to the Pareto optimal outcome: since the Boulware party does make concessions when a sufficient amount of time has passed, the accepted bid is not guaranteed to be a Pareto optimal point.

2 NEGOTIATION STRATEGY

2.A

Agent type	Performance Measure	Environment	Actuators	Sensors
Negotiator	Utility, Time, Deal	Time, Opponent(s)	Bid, Acceptance	Evaluation values

Description: *Performance measure*

- Utility: **based on individuals' evaluation**
- Time: **explain relation to deadline**
- Deal: **deal/no deal**

Environment

- Time: **the agent has to consider the time that he has**
- Opponent(s): **this is the adversary of the agent**

Actuators

- Bid: **offer a new bid**
- Acceptance: **accept or reject the bid**

Sensors

- Evaluation values: **The agents uses their own evaluation values to determine if the bid is to be accepted or rejected.**

2.B

2.0.1 Offering Strategy. An offering strategy is a mapping which maps a negotiation trace to a bid. The offering strategy can interact with the opponent model by consulting with it. [1]

2.0.2 Opponent Model. An opponent model is in the BOA framework a learning technique that constructs a model of the opponent's preference profile. [1]

2.0.3 Opponent Model Strategy. An opponent model strategy specifies how the opponent model is used to select a bid for the opponent and if the opponent model may be updated in a specific turn. [1]

2.0.4 Acceptance Strategy. The acceptance strategy determines whether the opponent's bid is acceptable and may even decide to prematurely end the negotiation. [1]

2.C: The Acceptance Strategy

For the acceptance strategy we consider a combination of the following conditions.

AC_{next} : We start with accepting any bid of the opponent if it yields a higher utility than the bidding strategy. We take into account the opponents action combined with our own bid. This approach will yield a local optimum in the short term, by avoiding the possibility that the opposing agent will accept the direct counteroffer, yielding a smaller utility.

$AC_{combination}(T, \alpha)$: In this acceptance condition, two basic accepting conditions will be combined: AC_{time} and $AC_{const}(\alpha)$. The latter strategy accepts any bid yielding a utility larger or equal than α, whereas the first of these acceptance strategy traditionally splits the negotiation time into two phases: $[0, T)$ and $[T, 1]$, where, in the latter phase, the party is more prone to accept a bid yielding a relatively low utility. This strategy will result in a larger percentage of agreements.

We propose an adaptation on this strategy using a polynomial given variable T instead of a fixed value α, ie $AC_{time}[f(T)]$. We define function $f(T)$ as follows:

$$f(T) = (1 - D)\alpha(1 - T^{\beta}) + D \tag{1}$$

Here, α, β denote coefficients determining the shape of the function. Let D denote a dummy parameter which is equal to one if the agent which equals to one if our agent starts the first round, and zero otherwise. This allows for a more conceding acceptance strategy if our agent is not in a more dominant position. We will explain this concepts of turn-based tactics in detail in Section 2.0.4.

Therefore, given $D = 0, \forall \alpha, \beta,\ f(T)$ will yield α if $T = 0$, $f(T) = 0$ if $T = 1$ and $f(T)$ is decreasing over T. Hence, the agent that does not have turn 1, will accept any offer with a utility larger or equal to α, similar to $AC_{const}(\alpha)$ and yields every bid in the final round. Therefore, every negotiation will end in an agreement, in confirmation with AC_{time}. Furthermore, if $D = 1$, $f(T) = 1, T \in [0, 1]$. This implies that the agent who starts the negotiation has an acceptance strategy equivalent to AC_{next}.

Currently, we use parameters $\alpha = 1, \beta = 25$.

In addition to the turn of the agent and the opponent's most recent offer, this strategy also considers the (time until) the deadline.

2.D: The Bidding Strategy

We will adapt our bidding strategy, from the general random bidding strategies. Given a certain threshold, we want to send a random bid with a utility larger or equal than this threshold. Instead of generating completely random bids and only sending them if they meet the threshold, we will first establish all possible bids and then choose one at random. If no possible bids above our given threshold exists, we will iteratively lower the threshold by a fixed values, until one or more bids exist. This adaptation guarantees that every bid will satisfy the threshold. Hence, it is not possible to send an undesirable bid if no sufficient bid is found over time.

Similar to the acceptance strategy, the values of the thresholds are directly dependent on whether or not the agent has the starting turn every roudn (see Section 2.0.4) . In the bidding strategy, however, they remain constant over time (ie 0.7 and 0.9 for agent having turn 1, turn 2, respectively).

Turn based negotiations

In this section we will we make some observations regarding the turn-based protocols of this assignment. We will then use these observations to support our previously derived strategies.

The negotiation is played in rounds, given this fact we could let the strategy depend on the order of turns per party. The stated protocol dictates that the party that starts off the negotiation (in the first round), will start each next round. For this negotiation we could lend insights from the field of game theory for this sequential, dynamic game. In accordance with the previous sections, let $D = 1$ denote the agent that has the first turn in every round, 0 otherwise.

Hence, we have a dynamic game with a known deadline and a pay-off of zero for both agents if no agreement is reached at the deadline. Game theory suggests that therefore, if the turn of the second agent in the last round is reached, the last agent effectively gets to choose between the utility attained at the last received bid and a utility of zero. In this case, the utility of zero would imply no agreement is reached. Since an agent aims to optimize its personal pay-off, this situation will pressure any party to accept the last offer. Retroactively the agent, having $D = 1$, can utilize a bid with an higher utility in the last round than previous bids would suggest, given that the opposing agent is more willing to accept.

According to the concept of the subgame perfect nash equilibria (SPNE) (see eg [3]), we can apply dynamic backtracking for each subgame in a dynamic game to find the 'optimal' choice. This will result in the observation that the agent for which $D = 1$ can generate bids with a larger utility and accept less bids from the opposing parties, and still end up in an agreement.

This is visualized in Figure 2. Consider two parties who both comply to our described strategies. If Agent 2 gets a turn in the last round of the negotiation, it will always accept, since his own pay-off of 'accepting' (v_2), is strictly larger than the pay-off of 'terminating (0).

Given this information, if Agent 1 gets a turn in the last round of the negotiation, he can use this information when choosing the action that yields the highest pay-off. This is either 'accepting' yielding v_1, or 'bidding', which gives $\hat{v}_1$. Since agent 1 can observe its own utilities for both bids, the two can be compared and therefore the action yielding the maximum can be chosen with certainty. This is embedded in the acceptance strategy AC_{next}. The turn prior (turn 2 in second-to-last round), Agent 2 can either accept, yielding utility equal to v_2, or generate a new bid. This second option is the first option we encounter when backtracking yielding any uncertainty. The obtained utility for Agent 2, in case he does not accept, is dependent on the remaining action of Agent 1. We can generalize this notion of uncertainty back to the beginning of the negotiation. Therefore, we can now conclude that the agent who has the first turn of the negotiation, will be in a more dominant position throughout the entire negotiation. We use this notion in both our acceptance and bidding strategy using dummy parameter

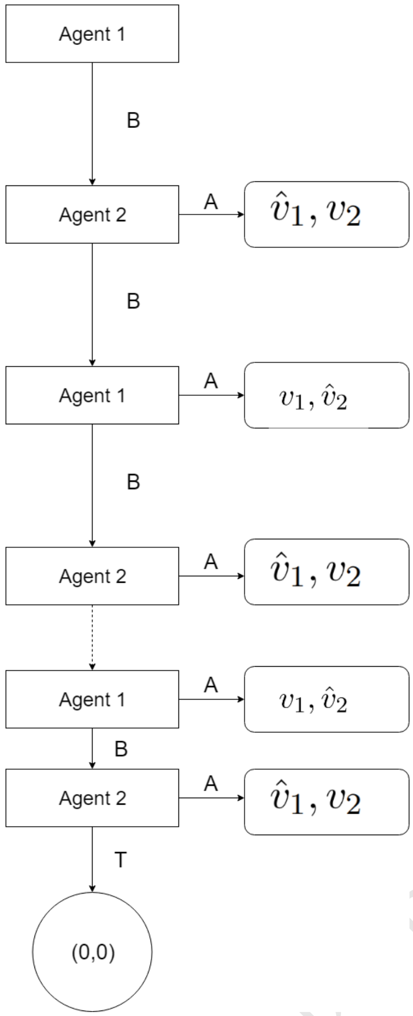

Figure 2: Flowchart of the obtained utilities based on the actions of both agents. B denotes the action of a sent offer; A represents the accepting action of an agent; T denotes a terminating action (no agreement). The obtained utilities for both agents are given in the terminating nodes, where v_i denotes an observed utility for agent i, and $\hat{v}_i$ denotes an unobserved utility.

D.

For an extensive survey on dynamic game theory, we refer to [2].

REFERENCES

[1] T. Baarslag, W. Pasman, K. Hindriks, and D. Tykhonov. 2019. Using the Genius Framework for Running Autonomous Negotiating Parties.

[2] Basar, Tamer, Olsder, and Geert Jan. 1999. *Dynamic noncooperative game theory.* Vol. 23. Siam.

[3] Morrow and James D. 1994. *Game theory for political scientists.* Vol. 23. Princeton University Press.