# Negotiation Assignment

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## Aim:

To develop a strategy and create an agent that attempts to maximize its utility in a negotiation against other rational agents in the domain RentalHouse.

## Implementation:

### Basic Outline:

Our strategy consists of three distinct intervals (inspired by FSEGA 2010).

1) The first interval consists of the first 85% of the rounds.

- During this interval, the agent sets a minimum threshold for any offer made by the agent. Initially, 1000 random offers are generated.
- When asked to make an offer, the agent picks a random offer with utility greater than the above mentioned minimum threshold, which is initially set to 1.
- Every round the minimum threshold is lowered by a very small amount, so that it reaches a fixed value by the time it reaches the second interval.
- Also, the agent at each offer keeps track of all the previous offers made to it by its opponent to construct an opponent model for each of its opponents. Also, It maintains a list of the 10 best bids, according to its own utility per opponent.
- **Offer acceptance**: The agent accepts an offer based on the following criteria taking inspiration from its usage in IAMHaggler. It accepts a bid:
    - When the utility of the offered bid is at least 98% of the utility of its own previous offer.
    - When the utility of the offered bid is at least 98% of current maximum utility (minimum threshold).
    - When the utility of the offered bid is at least 98% of the utility of its own upcoming offer.

2) The second interval consists of the next 10% of the rounds.

- In this interval, the minimum threshold is lowered slightly. The offering mechanism, and the accepting mechanism remain the same. It continues to learn the opposition's model.

3)The final interval consists of the final 5% of the rounds.

- This interval takes the time constraint into consideration and attempts to offer the best bid according to the bids that have previously been offered by the other agents in the negotiation. This is done to maximize chances of an agreement while trying to maximize the utility it can obtain by the end of the negotiation.
- **Opponent Model Construction:** The opponent model is constructed by keeping track of the history of bids offered by the opponent agent. From this history, we keep a track of the following:

- The top ten bids offered by the opponent agent corresponding to our agent's utility are maintained. This helps us make irresistible offers to the opponents during the final interval (last 5% of the negotiation session) to maximize our utility.
- The frequency of a particular issue value is maintained to determine the weight of an issue's value. The intuition is that the more the frequency of an issue's value, the more important that value must be within that issue for the opponent.
- The variance across an issue is also maintained to judge the weight of an issue. This keeps in check the change with respect to the frequency of values proposed for that issue.
- The number of changes of an issue's values is maintained to also be used in the calculation of the weight of an issue. If the values proposed in an issue change frequently from the previous bid, the issue must be of lesser importance to the proposer.
- A utility calculator function is also a part of the model which given a bid, calculates the estimated utility for the opponent agent.

The opponent agent's utility is calculated using the following formula:

Utility = Sum ( Weight of an issue * Weight of the value )

Where the weight of an issue = Variance of the issue / Change in the values of the issue

weight of a value = Frequency of that value / Maximum frequency of a value

- Based on the opponent model constructed, the agent tries to find common bids in the top 10 offered by all its opponents. If there are common bids, the one with the highest utility is chosen. If there are no common bids, all of the top 10 bids from all of the agents are looked through for the bid that maximises the utility of the agent + ( the mean utility of the other agents/ variance of the utilities of the other agents. ). The bid with the maximum value of that is offered.

## Intuition:

The intuition behind this design is basically, once you know the opponent model, you can more easily predict what they will accept and won't accept. This model borrows various aspects from many agents and tries to put them together in different ways. In this model, we keep track of bids by various opponents, by being very hardheaded throughout till the last 5%. We observe how they function so we can better tune our model of their profile. Then, in the end we propose an offer to them that they have already proposed to us. Since it previously proposed it, it is likely for a rational opponent to accept this proposal, especially due to the time constraint. In the case of a bilateral negotiation, this will signify the end of the negotiation. In case of a multilateral negotiation, if there are no common offers, we try to find one offer out of the collection of top 10 offers that suits everyone. To make it suit everyone we take the bid that maximises the utility of the agent + ( the mean utility of the other agents/ variance of the utilities of the other agents. ). We want it to be fair to everyone else, hence the mean of the utilities of the other agents is considered, but we also want to make sure that one agent is not dominating this, thus we consider the variance as well. If the variance is low, it means more agents are getting high utility, and if it's low it means that the distribution is not equal.