Practical assignment 4

Group 9

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Make your party perform well under preference uncertainty. When there is preference uncertainty, a fully specified utility function is unavailable; instead, the user's preferences are specified in alternative ways, such as by a ranking of a (limited) set of outcomes. The standard implementation provided by the environment estimates the utility function from a ranking by using a simple counting heuristic. Implement your own way of estimating the utility function from a given set of bid rankings. (A hint for an alternative implementation is that you could apply ideas similar to the ones used in your opponent model.) Explain your design choices and test how your agent performs under different degrees of preference uncertainty.

We use similar strategies to that in Opponent Strategy to estimate the utility space under preference uncertainty. The general idea is to traverse from the highest ranking bid down to the lowest ranking bid and add more weights to the issue of which the value remains unchanged while the overall ranking decreases. The implementation is similar. We start traversal from the higher ranking bids, and for each bid, we look back at a number of bids, which is the maximum number of values among all issues in the domain, increase the weight of the issue if any issue value appears more than one. After normalising all weights, we form the estimated utility space. Then combination strategies of estimated utility space and ranking rules are applied to Acceptance Strategy and Bidding Strategy.

For Acceptance Strategy dealing with uncertain profiles, our normal strategy will do just fine. However, to make sure that our agent is able to accept bids with as high utility as possible, we apply an additional rule that checks if the bid ranks at least as high as the acceptance threshold which is a function of a constant and time mentioned above. For example, at some time, our calculated acceptance threshold is 0.8, then a bid with an estimated utility higher than 0.8 and ranks at least 80% in the bid order shall be accepted immediately.

As for Bidding Strategy under uncertainty, we stick to the previous method that bidding towards a utility goal with or without using the OM. However, there is no absolute guaranteed that our estimated utility space is accurate enough to find a bid that matches the utility goal. So we check if the bid found by the utility space does rank at least as high as the percentage value of the utility goal in the bid order. If it does, we offer the bid to the opponent. If not, an arbitrarily small number, i.e. 0.01, is added to the utility goal. Then keep bidding till it's rank is satisfied. For instance, the utility goal at some time is 0.8, if the bid found by the utility space doesn't rank higher than 80% in the bid order, we increase the utility goal to 0.81 and keep bidding.

The combination of estimated utility space and ranking rules performs better than any method alone. Our estimated utility space tends to overestimate utilities with high uncertainty degree, i.e. more than 1500 bid rankings. So it happens that our AS accepts a high-utility bid but actually with a low ranking. This is why we add the ranking rules as a double insurance. After playing in several tournaments against many agents, we observed that the combination strategy does help beat other agents with higher agreement utilities. However, we sometimes stuck in the strategies and result in no agreements.

3. QUANTIFY THE PERFORMANCE OF YOUR PARTY

Have your party negotiate against itself, and against the three ANAC2011 parties HardHeaded,Gahboninho, and TheNegotiator on the party domain. Run several negotiation sessions using various utility profiles. Report on the outcomes reached. Try to explain why the outcome is as it is. Are any of the outcomes a Nash solution? Is it possible to reach an efficient outcome, i.e. an outcome that lies on the Pareto Frontier?

All the following tests are run in the Party domain.

As we have said, our acceptance strategy focuses more on getting some agreement that is generally good than aiming for the highest possible outcome. We believe that with that we can get a better overall outcome than agents that always try to get as high as possible and then end up with no agreement.

<u>*Group 9 vs Group 9*</u>

Table 1:

Utility profile Group 9 (1)	Utility Value	Utility profile Group 9 (2)	Utility Value	Number of rounds	Distance to Pareto frontier	Distance to Nash product
1	0.848	2	0.856	10	0	0.096
1	0.859	3	0.817	16	0	0
1	0.967	4	0.821	2	0.048	0.112
2	0.824	3	0.814	1	0.04	0.047
2	0.84	4	0.774	149	0	0
3	0.828	4	0.857	8	0.131	0.142

3	0.866	5	0.866	14	0	0
3	0.939	6	0.811	2	0.065	0.134
4	0.94	5	0.806	2	0.024	0.095
4	0.893	6	0.819	2	0.106	0.183
5	0.924	6	0.803	2	0.055	0.081
5	0.864	7	0.812	14	0.09	0.115
5	0.806	8	0.826	3	0.036	0.161
6	0.827	7	0.821	2	0.061	0.075
6	0.824	2	0.664	164	0.099	0.12
7	0.826	8	0.831	9	0	0.056
7	0.863	3	0.813	108	0	0
7	0.846	4	0.94	10	0.941	0.055
8	0.824	1	0.808	1	0.127	0.15
8	0.837	2	0.825	6	0	0.098

Table 2:

Number of pareto optimal outcome	7
Average distance from pareto	0.0910955
Number of Nash outcomes	4
Average distance to nash	0.085931
Group9(1) average utility	0.86225
Group9(2) average utility	0.8192
Average number of rounds	26.25

If we have the same utility profile we always get the outcome ~0.8 - ~0.8, in 2 bids, with the agreement on the pareto optimal and the nash product, obviously. So we did not test those cases.

Since our acceptance strategy wants to get utilities above 0.8 we are getting an average just slightly over that point when we run against yourself. We often get an outcome on or at least very close to the pareto optimal frontier and the Nash product is also most often close by. The average number of bids is not very high here, since we are really just waiting to get a bid that is over 0.8 for both parties.

<u>Group 9 vs Hardheaded</u>

There is no party that is named hardheaded in genius , we were not sure If we were supposed to use the KLH that seemed to be a hard headed agent. So se we created a new one with a

HardHeaded bidding strategy, HardHeaded acceptance strategy, HardHeaded Frequency opponent model, and the BestBid opponent model strategy.

Table 3:

Utility profile Group 9	Utility Value	Utility profile Hardheaded	Utility Value	Number of rounds	Distance to Pareto frontier	Distance to Nash product
1	0.722	2	0.976	157	0	0.079
1	0.614	3	0.958	169	0	0.283
1	0.747	4	0.988	153	0	0.196
2	0.604	3	0.953	170	0	0.268
2	0.429	4	0.94	180	0.05	0.443
3	0.8	4	1	2	0	0.142
3	0.688	5	0.953	167	0.027	0.199
3	0.85	6	1	2	0	0.148
4	0.714	5	0.953	159	0	0.2
4	0.869	6	1	2	0	0
5	0.834	6	0.982	5	0	0.158
5	0.852	7	0.968	155	0	0.078
5	0.663	8	0.956	165	0	0.35
6	0.716	7	0.968	159	0	0.202
6	0.563	2	0.929	174	0	0.426
7	0.75	8	0.912	169	0	0.055
7	0.65	3	0.958	165	0	0.258
7	0.846	4	1	2	0	0.029
8	0.826	1	0.988	3	0	0.105
8	0.754	2	0.936	166	0	0.045

Table 4:

Number of pareto optimal outcomes	18
Average distance from pareto	0.0038355
Number of Nash outcomes	1
Average distance to nash	0.1831575
Number of wins	0
Number of loss	20

Our average utility	0.7244735
Their average utility	0.9658645
Average number of rounds	116.2

Here we are almost always on the pareto optimal frontier.But since Hardheaded is very stubborn agent and always continues to bid their highest bids we tend to concede and end with a lower utility. Here the average number of bids is very high. Since HardHeaded does not accept anything really, so we are just waiting until our time dependent acceptance strategy starts to accept lower values as the timeline gets close to the end.

<u>*Group 9 vs Gahboninho*</u>

Table 5:

Utility profile Group 9	Utility Value	Utility profile Gahboninho	Utility Value	Number of rounds	Distance to Pareto frontier	Distance to Nash product
1	0.658	2	1	164	0	0.145
1	0.5	3	0.998	117	0	0.398
1	0.709	4	1	158	0	0.235
2	0.432	3	1	180	0	0.445
2	0.448	4	1	180	0	0.452
3	0.8	4	1	1	0	0.142
3	0.583	5	1	172	0	0.314
3	0.85	6	1	2	0	0.148
4	0.81	5	0.925	172	0	0.1
4	0.869	6	1	2	0	0
5	0.834	6	0.959	4	0.023	0.145
5	0.853	7	0.968	10	0	0.078
5	0.834	8	0.848	no agreement	1.003	1.22
6	0.845	7	0.902	no agreement	1.058	1.239
6	0.842	2	0.78	no agreement	1.066	1.175
7	0.826	8	0.831	no agreement	1.032	1.178
7	0.449	3	0.983	180	0	0.448
7	0.846	4	1	2	0	0.029
8	0.869	1	0.963	15	0	0.054
8	0.49	2	1	178	0	0.315

Table 6:

Number of pareto optimal outcomes	15
Average distance from pareto	0.209108
Number of Nash outcomes	1
Average distance to nash	0.4130415
Number of wins	1
Number of loss	19
Our average utility	0.71735
Their average utility	0.95785
Average number of rounds	76.85

Here we are almost always on the pareto optimal frontier.But since Gahboninho mostly just bids his highest utility again and again. Which most often does not result in a very good utility value for us. So we keep on waiting for an acceptable bid according to our acceptance strategy, but that doesn't happen until we start conceding a lot near to the end of the negotiation session in most cases. Sometimes Gahboninho is too stubborn for us, so that leads to no agreement at all and other times we are "lucky" and get high enough utility in one of the first bids. The last case only happens when the highest possible utility for the opponent is coincidentally high enough for us to.

Group 9 vs TheNegotiator

Table 7:

Utility profile Group 9	Utility Value	Utility profile TheNegotiator	Utility Value	Number of rounds	Distance to Pareto frontier	Distance to Nash product
1	0.848	2	0.856	148	0	0.096
1	0.708	3	0.886	158	0.018	0.167
1	0.933	4	0.929	118	0	0
2	0.816	3	0.868	158	0	0.04
2	0.66	4	0.81	167	0.048	0.183
3	0.8	4	1	2	0	0.142
3	0.855	5	0.865	148	0.012	0.012
3	0.85	6	1	2	0	0.148
4	0.845	5	0.908	127	0.012	0.061
4	0.869	6	1	2	0	0

5	0.834	6	0.982	24	0	0.158
5	0.852	7	0.968	47	0	0.078
5	0.834	8	0.848	151	0	0.148
6	0.83	7	0.902	138	0.015	0.071
6	0.736	2	0.804	156	0	0.215
7	0.826	8	0.831	154	0	0.056
7	0.699	3	0.868	161	0.055	0.174
7	0.846	4	1	2	0	0.029
8	0.826	1	0.988	22	0	0.105
8	0.837	2	0.825	153	0	0.098

Table 8:

Number of pareto optimal outcomes	13
Average distance from pareto	0.0079705
Number of Nash outcomes	2
Average distance to nash	0.098936
Number of wins	2
Number of loss	18
Our average utility	0.8151295
Their average utility	0.9068695
Average number of rounds	101.9

We get better outcomes here than against the Gahboninho and Hardheaded. Our average utility is above 0.8 and we are very often on the pareto optimal frontier or at least very close to it.

In the end we tried running a tournament with these four agents. There our agent came out best. As we can see in the table below our mean utility is the highest and we are closest to the nash product in general. We also come in as a close second in the pareto distance and the welfare. So even though we don't do very well in individual negotiation sessions, it seems to be working well to use our strategy in tournaments.

Table 9:

	Group 9	TheNegotiator	Hardheaded	Gahboninho
Total Undiscounted Utility	79.435	76.137	28.327	31.594
Total Nash Dist	261.302	264.334	371.008	369.858
Total Pareto Distance	188.317	183.196	308.795	305.361

Mean Nash Distance	1.021	1.033	1.449	1.445
Mean Pareto Distance	0.736	0.716	1.206	1.193
Mean undiscounted	0.31	0.297	0.111	0.123
Mean Welfare	1.334	1.355	0.33	0.349

3.(b) Test your party in a small tournament while varying the acceptance strategy. Is there an acceptance strategy which is better than your acceptance strategy?

We created 4 new parties using our bidding strategy, opponent model and opponent model strategy but different acceptance strategies. The strategies we used were AC_Next, HardHeaded, NiceTitForTat and a randomly selected AgentK from 2010.

We first ran a tournament comparing each of these parties against each other. It was difficult to see the results for the tournament because Genius outputs a single file with tournament statistics and doesn't see the difference between the parties because they are all created by us with the BOA framework. Instead we had to parse the results from the tournament csv file in the log. Doing this shows that our party with our acceptance strategy does not do well compared to the other strategies. AC_Next and HardHeaded do the best with a total of ~15 utility, AgentK had ~14,5 utility, NiceTitForTat ~12,5 and our agent had only ~11,7 utility.

This is an interesting result and shows that if playing against agents similar to ours that we should maybe have an alternate acceptance strategy. Whether our acceptance strategy is suboptimal compared the others competing against other agents is yet to be seen. For future development this should be tested extensively. Also in our final report we mention different strategies that could improve our acceptance strategy in the future that would be worthy to test.

We then ran 5 tournaments with our party competing against the RandomParty, Conceder, Boulware and SimpleAgent. For each tournament we changed the acceptance strategy according to AC_Next, HardHeaded, NiceTitForTat and AgentK (like above). These are the results:

Table 10:

Party Domain	Utilties				
Acceptance Strategy	Group9	RandomParty	Boulware	Conceder	SimpleAgent
Original	20.76	15.91	18.19	16.46	15.24
AC_Next	13.92	7.99	12.02	9.5	9.48
NiceTitForTat	13.38	8.37	11.25	7.98	9.77
AgentK	16.53	11.78	12.81	11.13	11.72
HardHeaded	8.54	6.03	7.24	5.63	5.6

As we can see, our agent always wins and it is unclear whether any acceptance strategy therefore performs better. However with our original strategy the overall utilities are the highest for all agents which is good for everyone.

(c) Test your party in a small tournament and compare your opponent model with the original HardHeaded Frequency Model. Does your model lead to a significantly higher utility?

We tested our party in a tournament against itself but changing the opponent model with the HardHeaded Frequency Model, thus the acceptance strategy, the bidding strategy, and the opponent model strategy remain the same in both agents. Our acceptance strategy makes us accept a bid as soon as is above a specific threshold. That makes the negotiation session to be short in time (low number of rounds) and the opponent model to not being properly evolved since the ideal is to reach a long enough number of rounds so the opponent preference model is built from a larger range of bids.

In all the test we made, the parties played on both sides of the negotiation session, being, in that way, the preferences profiles interchangeable. In all the sessions inside a tournament, the utilities reached by the agents using a specific pair of preferences profiles did not change, being the higher utility linked to the same preference profile of the pair, as shown in the table.

In resume, our opponent model does not lead to a significantly higher utility when playing against the HardHeaded Frequency Model.

Table 11:

Agent1 (opponent model)	Agent2 (opponent model)	Profile1	Profile2	Utility1	Utility2
Group9	HardHeaded	party6	party7	0.82671	0.82078
HardHeaded	Group9	party6	party7	0.82671	0.82078
Group9	HardHeaded	party4	party6	0.89285	0.81869
HardHeaded	Group9	party4	party6	0.89285	0.81869
Group9	HardHeaded	party4	party7	0.83333	0.95956
HardHeaded	Group9	party4	party7	0.83333	0.95956

(d) One important question remains. How generic is your party? That is, does it work as well on the party domain as on other domains? To verify this, have your party negotiate against itself, and against at least three parties provided to you on at least three scenarios (for example, Laptop, Grocery and ADG). Make sure your party is able to deal

with discounted domains. Report on the outcomes reached. Try to explain why the outcome is as it is. Is any of the outcomes a Nash solution? Is it possible to reach an efficient outcome, i.e. an outcome that lies on the Pareto Optimal Frontier?

To verify that our party works on other domains as well as on the party domain we ran several negotiation sessions with our party against itself and several more parties (such as the BoulwareNegotiationParty, ConcederNegotiationParty, and SimpleAgent (ANAC2017)) on the domains specified in the heading.
When running against ourselves, no matter the domain in which we are playing, the number of necessary rounds to reach an agreement is really low, since, as mentioned in the previous question, our acceptance strategy accepts a bid that provides us a utility above a threshold. As it can be seen in the figures 3-7, the outcomes reached either lie on the Pareto Optimal Frontier or are extremely close to it, but none of them are a Nash solution. As soon as a bid offers a acceptable utility for both parties (above 0.8 for both), the parties reach an agreement.

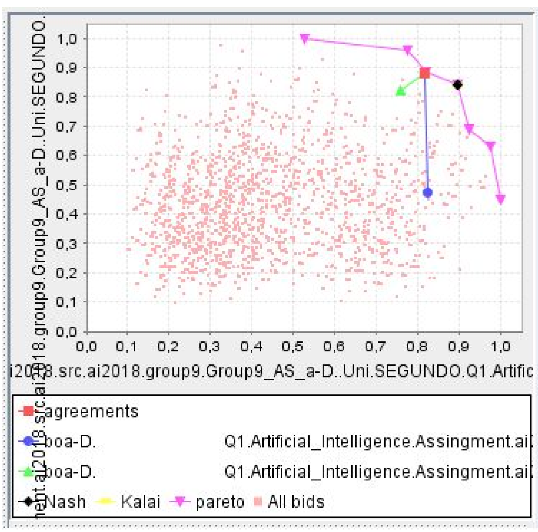

Figure 1:

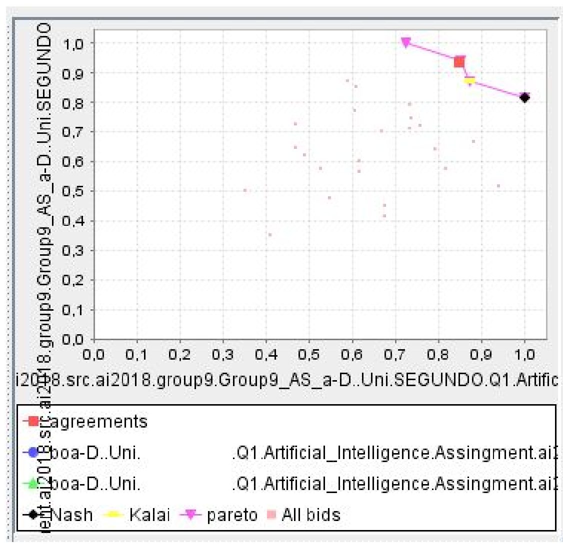

Figure 2:

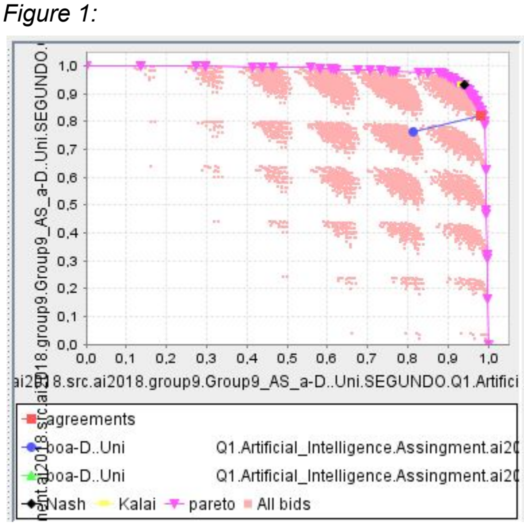

Figure 3:

When playing against the BoulwareNegotiationParty it is impossible for us to reach a higher utility than his. This is explained by our negotiation strategy, with which we accept any good from the opponent and, at the same time, we make bids to increase our utility, trying to also increase the opponent's utility by learning his preference profile, but beginning to grant in our bids moments before the negotiation enters in its second half. Since the Boulware party almost does not concede, it is highly likely us to have a lower final utility playing against him. However, when the negotiation extends in time, this party begins to concede, although in short steps, in order to be able to reach an agreement between the two parties. As a consequence of this, the final outcomes distance from the Pareto Optimal Frontier in almost all negotiations. This is shown in the figures 4-7.

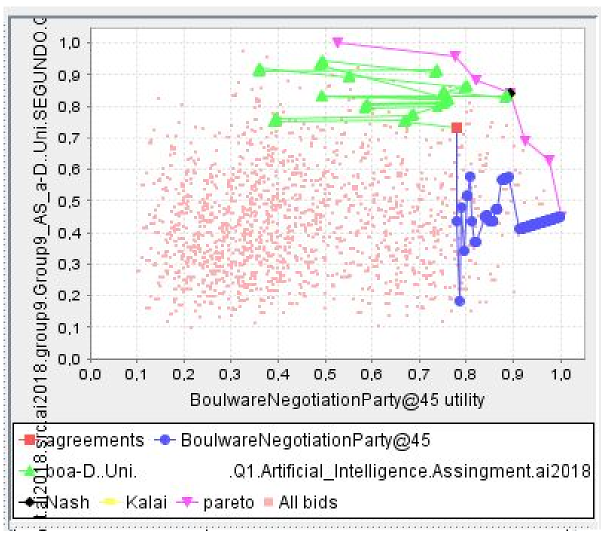

Figure 4:

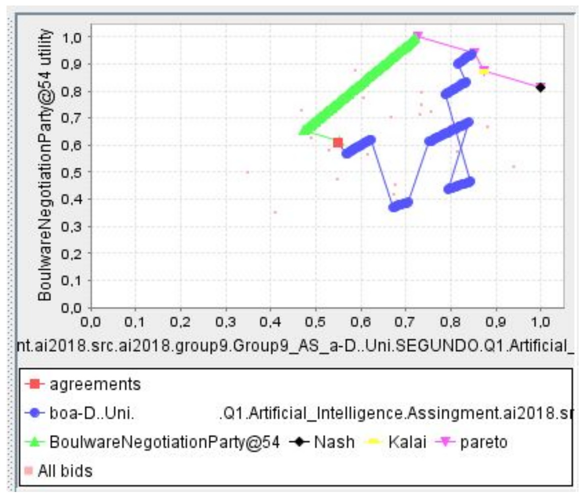

Figure 5:

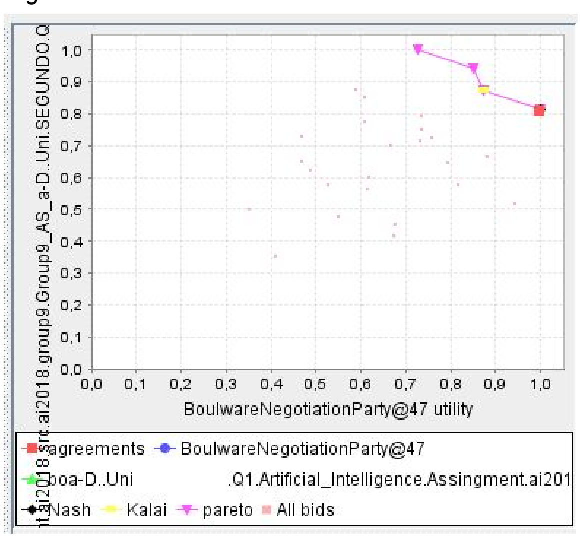

Figure 6:

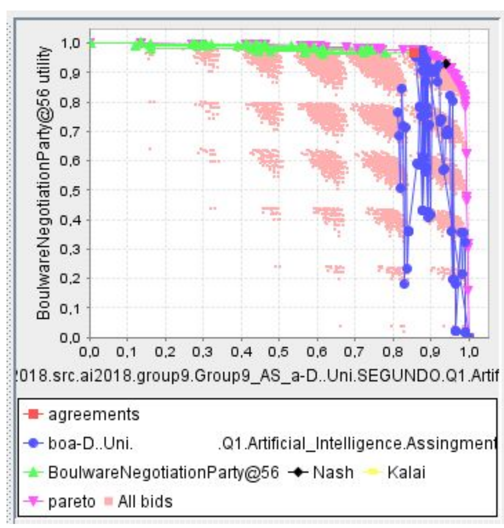

Figure 7:

Although our bidding strategy is good to deceptive our opponent regarding which are our preferences, starting at a lower utility than 1 prevent us to get better utilities if the negotiation ends too quickly and we could not reach our maximal utility in our bids. This is shown when playing against the Conceder party. Moreover, the acceptance strategy usually ends the negotiation with a low number of rounds when both parties are willing to concede, which is the case when playing against the mentioned party. However, the final outcomes lie either on the Pareto Optimal Frontier, being able to be also a Nash solution, or close to it.

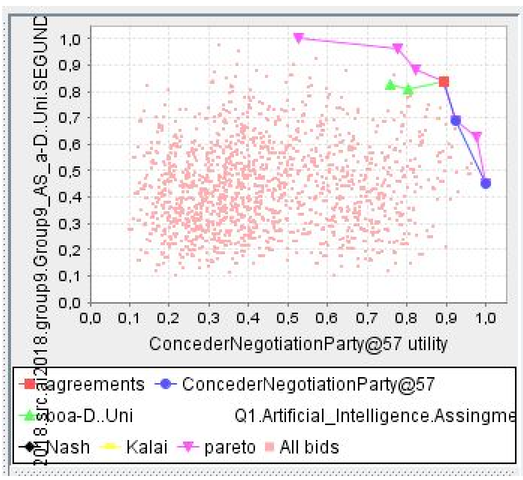

Figure 8:

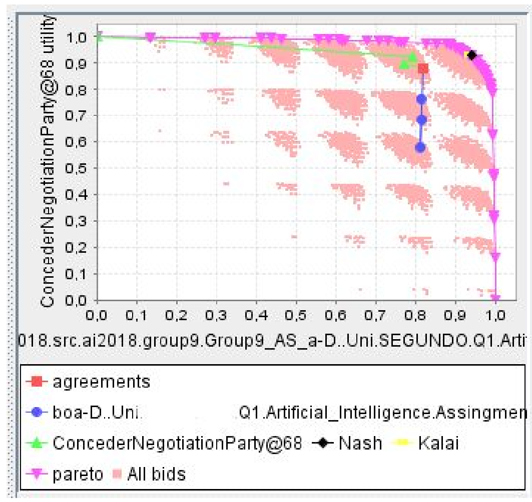

Figure 9:

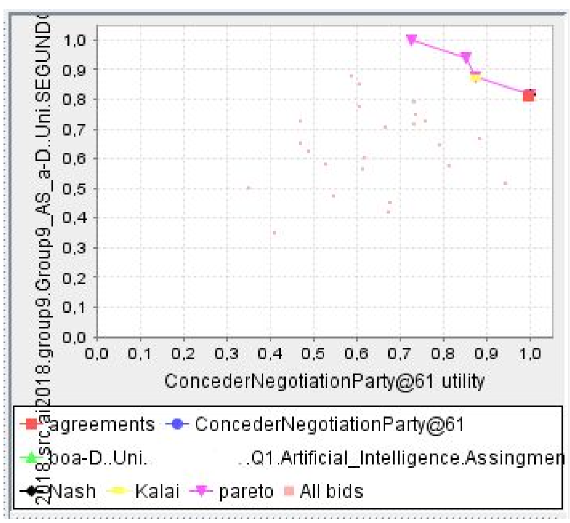

Figure 10:

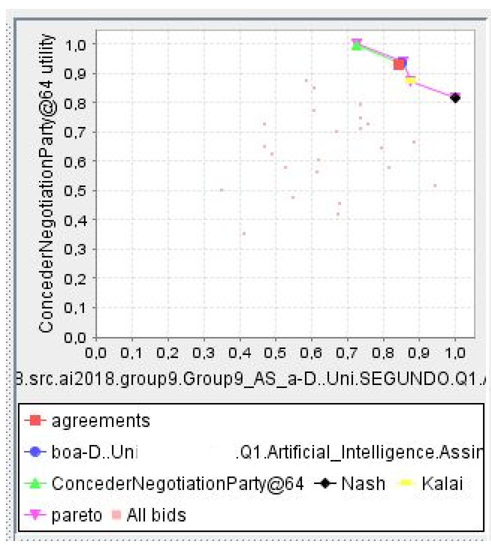

Figure 11:

Finally, when playing against the SimpleAgent, all said before also happens here. Our party tries to reach better result for itself, above 0.8 most of the time, but, when encountering to non-conceder opponent, it starts conceding to reach a not too bad agreement or even end the negotiation with a no-agreement.

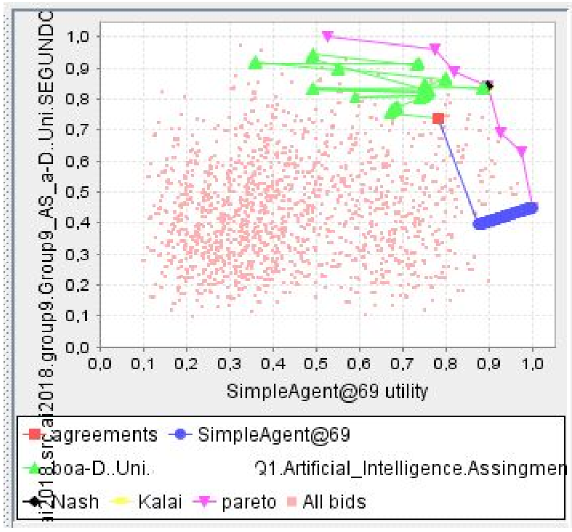

Figure 12:

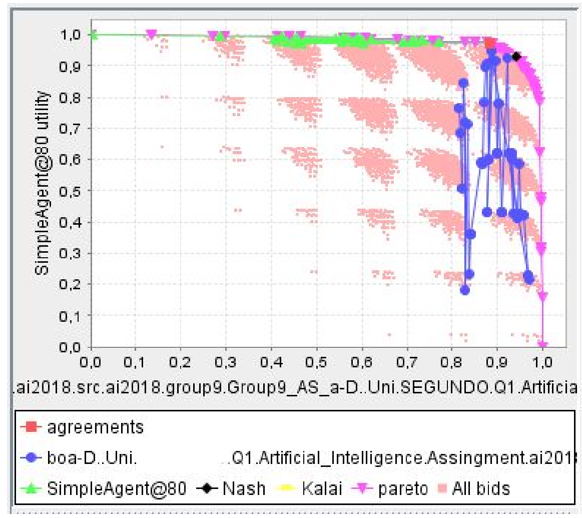

Figure 13:

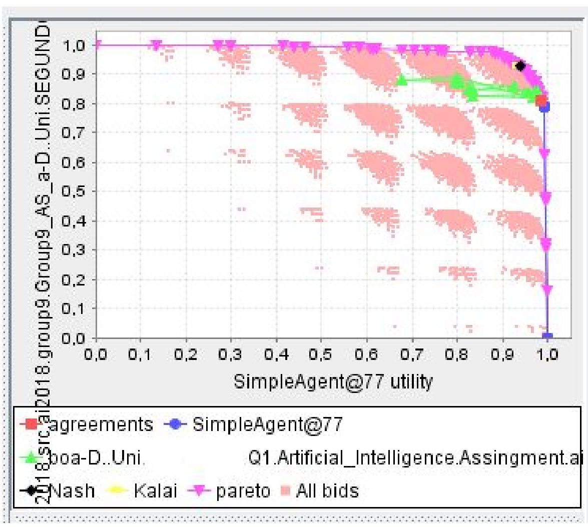

Figure 14:

Two of the tested domains are discounted, therefore it is demonstrated that our party is able to deal with this type of domains.

1.1.3 Future Perspectives

4. Given that you don't know the utility profile of the opponent, finding Pareto optimal deals is hard. An alternative for one-to-one negotiation as used in this practical assignment is to use a trusted mediator to which each party declares its private preferences. Using these true profiles, the mediator can compute an Pareto optimal and fair outcome. Do you think that introducing a mediator is a better option for finding an optimal outcome for both parties? If so, argue why you think so and describe the circumstances in which it is particularly suitable to use a mediator. If not, argue why you think it is not useful to do this.

In general, we think that using a mediator should result in more optimal outcomes for both parties. For the actual negotiation, having the mediator should not have disadvantages if it is perfectly unbiased. It should only help both parties in realizing what bids could be better for both parties. However this does rely strongly on the mediator being unbiased. Also there are some cases where using a mediator is not necessarily better. For simple negotiations of low importance, using a mediator would be nice but could also result in longer negotiations. Generally when it is more important to finish negotiations quickly then using a mediator could be worse since it may take longer.

There are also cases where negotiations occur between two agents where one is in a much better position than the other. This could be financially or the agent in the better position has a good reservation value. Also there could just be the case that one agent is in a better position because it has a much better negotiation strategy than the other agent. In these cases, the agent in the better position may not want to have a mediator. It knows that it can very likely get a good result when negotiating, and having a mediator may have a result closer to the Pareto optimal frontier but a total result that is worse for the agent. On the other hand, in these cases the agent in the worse position would very likely want to have the mediator so it can get a deal that is closest to the optimal frontier.

5. The parties in the negotiation environment have limited capabilities in order to achieve a negotiated deal. Think about capabilities (e.g. other actions or forms of communication) that a party might be extended with. Can you think of additional capabilities that would help an agent to achieve a better deal? If so, explain why these capabilities would help an agent to achieve a better deal. If not, argue why there will not be any capabilities that could help an party achieve a better deal.

There are a few additional capabilities that could be added to help agents. Although they also have disadvantages so they may not necessarily help in all cases. The following are ideas that would be interesting to have:

1. Having the added capability of accepting individual issues for a bid. An acceptance strategy might change then that instead of accepting bids you would accept issues which would then be "locked" in following bids. Bids after an issue is accepted would then have one fewer issue to be decided. This could result in shorter negotiations, since every time an issue is accepted then there are fewer bids possible. Also if an issue has much higher preference than others then an agent could gain a lot by being able to accept one issue and then caring less about other issues.

   However this has its disadvantages. An agent might need to be more careful when bidding in case it chooses bad bids for an issue and running the risk of that issue being accepted. Also opponent modeling could become much "easier" in the sense that agents will be more likely to bid better bids for themselves so they don't run the risk of losing on important issues. However this could also be viewed as an advantage.

2. Being able to communicate with the opponent would be an interesting capability. One way it could be implemented is that before negotiation, each agent would release its preferences for a set of issues. This could potentially help both agents realize bids that are better for both of them. Together with the possibility of accepting individual issues this could result in shorter and nicer negotiations for both agents.

   Of course, this could also result in bad negotiations. It is possible that the agents have complete opposite preferences for the issues communicated and will then be hard headed on those issues. Also communicating these issues will result in easier opponent modeling.