

COMP6203: Lab Index

Intelligent Agents
2018 Fall: Semester 1
University of Southampton

1 Lab Sessions

Labs will be held at 16:00-18:00 in **Building 59/ECS Teaching Lab (Level 2)** on Wednesdays.

You can download all lab documents combined as a pdf document from [here](#).

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Wednesday 17 Oct 2018	Lab #1: Introduction <ul style="list-style-type: none"> This lab aims to give an introduction to Automated Negotiation and the simulation environment for negotiation, GENIUS
Wednesday 24 Oct 2018	Lab #2: Bids/Issues/Values/Profiles <ul style="list-style-type: none"> This lab introduces the concepts: bids, issues, preference profiles and utility spaces in detail.
Wednesday 31 Oct 2018	Lab #3: Protocols <ul style="list-style-type: none"> This lab introduces the protocols in automated negotiation. The protocols determine the overall order of actions during a negotiation. Parties are obliged to stick to this protocol as deviations from the protocol are caught and penalized.
Wednesday 7 Nov 2018	Lab #4: Implementing Caduceus <ul style="list-style-type: none"> This lab shows how to implement a previous winner (ANAC2016) of the international automated negotiation competition.
Wednesday 14 Nov 2018	Lab #5: Quality Measures <ul style="list-style-type: none"> This lab shows how to evaluate your agent against various benchmark metrics.
Wednesday 21 Nov 2018	Lab #6: Bidding Strategies/Opponent Modelling/Acceptance Strategies <ul style="list-style-type: none"> This lab shows some key components of a negotiation agent and how to start improving them.
Wednesday 28 Nov 2018	Lab #7: Q&A Session
Wednesday 5 Dec 2018	Lab #8: Q&A Session

COMP6203: Lab #1

Intelligent Agents
Wednesday, 17 October 2018
University of Southampton

This lab aims to give an introduction to *Automated Negotiation* and the simulation environment for negotiation, *GENIUS*. At the end of this lab, you will have a brief idea about the area and keywords such as: preference profile, domain, negotiation protocol and so on.

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1 Designing a Negotiation Party



Figure 1: Organizing a party involves choosing music, food, drinks, catering, etc.

1. Imagine you have just graduated and plan to throw a nice party for that occasion.
2. The problem is that you do not want to organize everything yourself.
3. Fortunately, a friend of yours has also graduated and wants to throw a party as well.
4. You decide to organize the party together, however you have different preferences. You will now have to make joint decisions about what the party will look like; that is, you will have to *negotiate*.

Being a computer science student, you want to use your skills to make a negotiating party so the party is as close to *your preferences* as possible.

To approach this *negotiation problem*, to be a good negotiator, you may consider:

- Orienting yourself towards a win-win approach.
- Planning and having a concrete strategy.
- Determining which offers you will never accept.
- Creating options for mutual gain.
- Taking the preferences of your opponent into account
- Generating a variety of possibilities before deciding what to do.
- Paying a lot of attention to the flow of negotiation.

1.1 Short Introduction

To approach this problem from a computer science perspective, in the field of *Automated Negotiation*, this problem is modelled in various ways. To give a brief introduction to these

models, assume that there are:

- **A set of agents:** the participants of negotiation.
 - e.g. *negotiating parties, humans or software agents*
- **A domain:** the context the agents are negotiating in.
 - e.g. *example above: organizing parties, negotiating a business deal, smart grids, negotiating the electric prices*
- **An issue:** a troubling point that requires negotiation.
 - e.g. if domain is organizing party: what food to buy
- **Preference profiles:** a set of profiles, that captures individuals preferences.
 - e.g. If the domain is *party*, assume that Agent A prefers *Pizza* over *Hamburger* for the **Food** issue. Agent B prefers *Hamburger* over *Pizza*.
- **A deadline:** when the negotiation halts.
 - e.g. 1 hour, 2000 rounds (will be explained later)
- **A protocol:** how the negotiation is going to take place.
 - e.g. [Round-robin](#) fashion, a mediator based

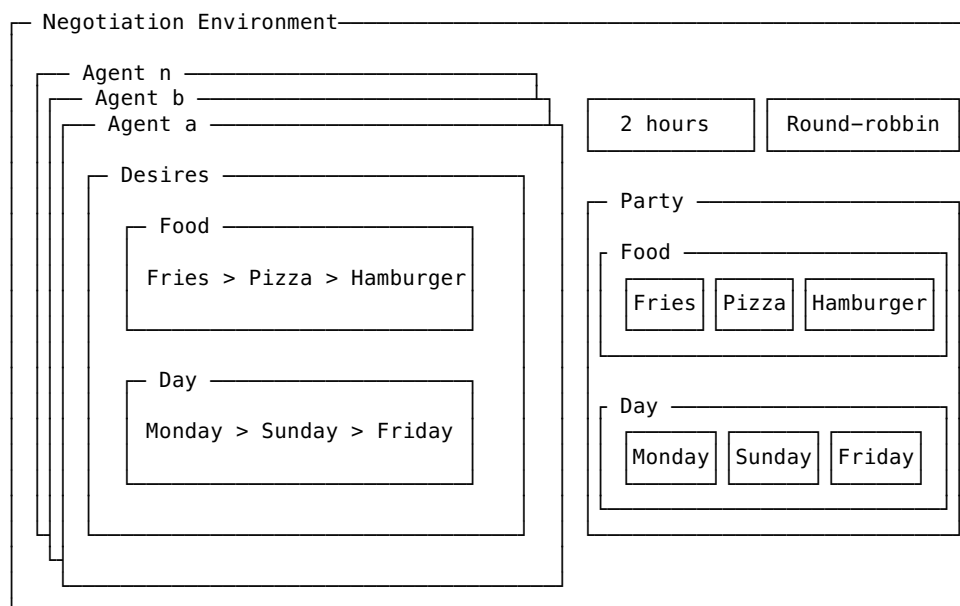


Figure 2: A simple negotiation environment

Practice: Try to match the terms in [Figure 2](#) with definitions.

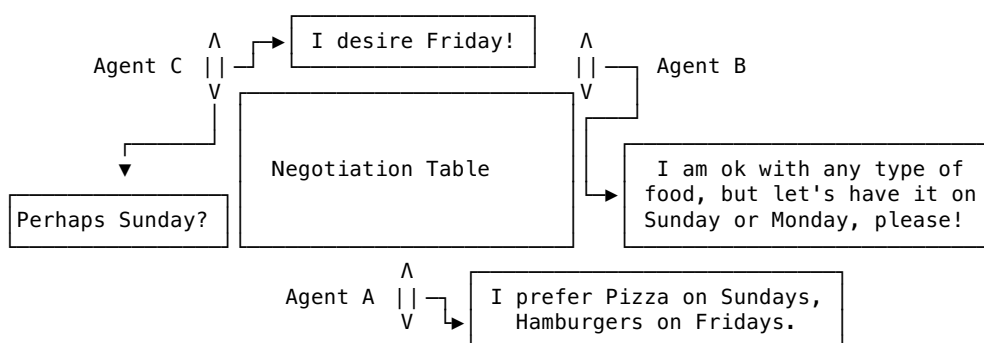


Figure 3: A negotiation session between three agents

Practice: What will be the best possible scenario that all agents might agree on in [Figure 3](#)?

2 Task 1: Set up GENIUS Environment

Throughout this module, you are expected to implement *a negotiating agent*. You are expected to use Java programming language in the automated negotiation simulation platform [GENIUS](#).

2.1 Prerequisites



Make sure that you have downloaded and installed the exact versions of prerequisites. Newer Java versions known to have some issues with GENIUS 9.1.2.

2.1.1 Software Prerequisites

- [Java Development Kit 8](#)
- [GENIUS 9.1.2](#)

2.1.2 Resources

- [Java Cheatsheet](#) *Remember/learn the basics of Java programming language.*
- [GENIUS Manual](#) *Official user guide, detailed explanations about the simulation platform*
- [Unofficial GENIUS 9.1.1 Javadoc](#) *Shows Java API of GENIUS, while you are implementing your agent, you can have a look at the method definitions when necessary [here](#).*

2.2 Installation

There are three different options to follow to set up the simulation environment. If you want to set the environment from scratch follow Option 1. We recommend IntelliJ Java IDE for implementation. If you are more experienced with Eclipse, you can follow Option 3.

2.2.1 Option 1

You can watch the video below which explains how to set it up from scratch with using IntelliJ.

Figure 4: *How to set up Genius from scratch*

Index of the video:

- 0:00 Introduction & Checking Java Installation
- 0:49 Java IDE Installation
- 1:05 Downloading Genius (Simulation Environment)
- 1:35 Creating a project and compiling ExampleAgent
- 3:30 Running Genius GUI
- 4:20 Adding ExampleAgent to Genius
- 4:35 Running a single negotiation session

- 5:19 Running a tournament (a set of negotiation sessions)
- 5:55 Checking logs of a tournament
- 6:32 Setting up automatic compilation for IntelliJ

2.2.2 Option 2

You can simply clone (or [download as a zip archive](#)) this repository (latest version of Genius included) with version control system git by:

```
git clone https://github.com/tdgunes/ExampleAgent.git
```

and import the ExampleAgent folder as a project to IntelliJ (other major Java IDEs also should work).

2.2.3 Option 3

You can follow the steps from the [official manual](#), in Section 12.

3 Task 2: Run GENIUS with ExampleAgent

Follow the steps on the video given above and run ExampleAgent in GENIUS with some opponent agents. You need to validate that your development environment is ready.

COMP6203: Lab #2

Intelligent Agents
Wednesday, 24 October 2018
University of Southampton

This lab introduces the concepts: bids, issues, preference profiles and utility spaces in detail.

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- 1 Theory Crash Course
 - 1.1 Domain: Bids, Issues, Values
 - 1.2 Preference Profiles, Utility Spaces
 - 1.2.1 Additive Utility Space
 - 1.2.2 Partially Ordered Space
- 2 Task 1: The laptop domain and preferences in GENIUS
 - 2.1 Add the preference profiles to the domain
 - 2.1.1 Creating an uncertain preference profiles
 - 2.2 Double check the created XML
- 3 Task 2: Accessing the preference profile via API
 - 3.1 Subtask 1: AdditiveUtilitySpace Exercise
 - 3.2 Subtask 2: Partially Ordered Space Exercise

1 Theory Crash Course

This section provides the essential theory to understand the negotiation process. In the next section, API definitions will be provided.

1.1 Domain: Bids, Issues, Values

A domain D specification determines what type of offers that can be made by the agents during negotiation. For instance, agents are to negotiate on what type of laptop to purchase, a domain that describes this negotiation can be:

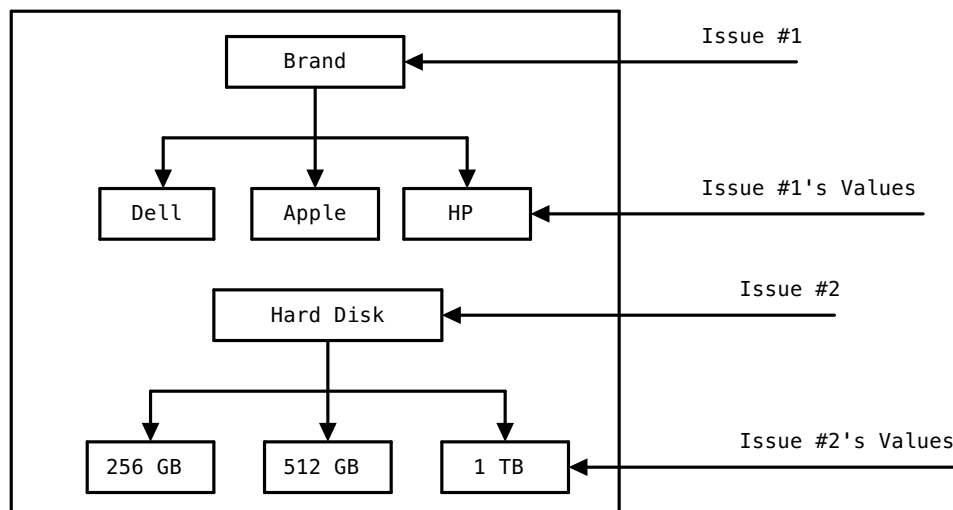


Figure 1: An example domain for laptop negotiation

A domain contains n issues:

$$D = (I_1, \dots, I_n)$$

Each issue i
consists of k
values:

$$I_i = (v_1^i, \dots, v_k^i)$$

An offer from an agent a
that can be formulated as choices c
:

$$b_a = (v_{c_1}^i, \dots, v_{c_n}^n)$$

Example: With this notation, to define Figure 1 formally with additional issue *Monitor*
:

$$D_{laptop} = (Brand, HardDisk, Monitor) I_{Brand} = (Dell, Apple, HP) I_{HardDisk} = (256GB, 512GB, 1TB) I_{Monitor} = (13", 15", 17")$$

The agent a
can generate a bid b
as:

$$b_a = (\text{Brand: Dell, HardDisk: 1TB, Monitor: 13"})$$

1.2 Preference Profiles, Utility Spaces

Following the example the bid, let's assume that there are only two agents: Agent a and Agent b negotiating about *which laptop to buy*.

1. Agent a
makes an offer: $b_a = (\text{Brand: Dell, HardDisk: 1TB, Monitor: 13"})$
2. When Agent b
observes the offer, the question is: how preferable is the bid b_a
for Agent b
?

Each agent has their own preferences for each issue. In this example, for instance:

- Agent a
prefers **a more portable laptop with high storage**.
- Agent b
's only requirement is **a larger screen** in a laptop.

We say each agent has a *preference profile* that represents these preferences. Each participant agent has their own profile. There are many types of different profiles¹, the two we are going to focus are:

- **Additive Utility Space:** The space is additive, when a bid is evaluated, this space can generate a total utility.
- **Partially Ordered Space²:** Instead of assigning utility value to bid, this space stores a partial order of values. By partial ordering, the available information about the preferences of an agent is that for some bid X is preferred over bid Y for a subset of the possible bids.

1.2.1 Additive Utility Space

Formally the utility of a bid is calculated as:

$$U(b_a) = \sum_{i=1}^n \omega_i \frac{eval(v_{c_i}^i)}{max(eval(I_i))}$$

Let's again assume, our agent is working in Laptop domain (as defined in Equation 4).

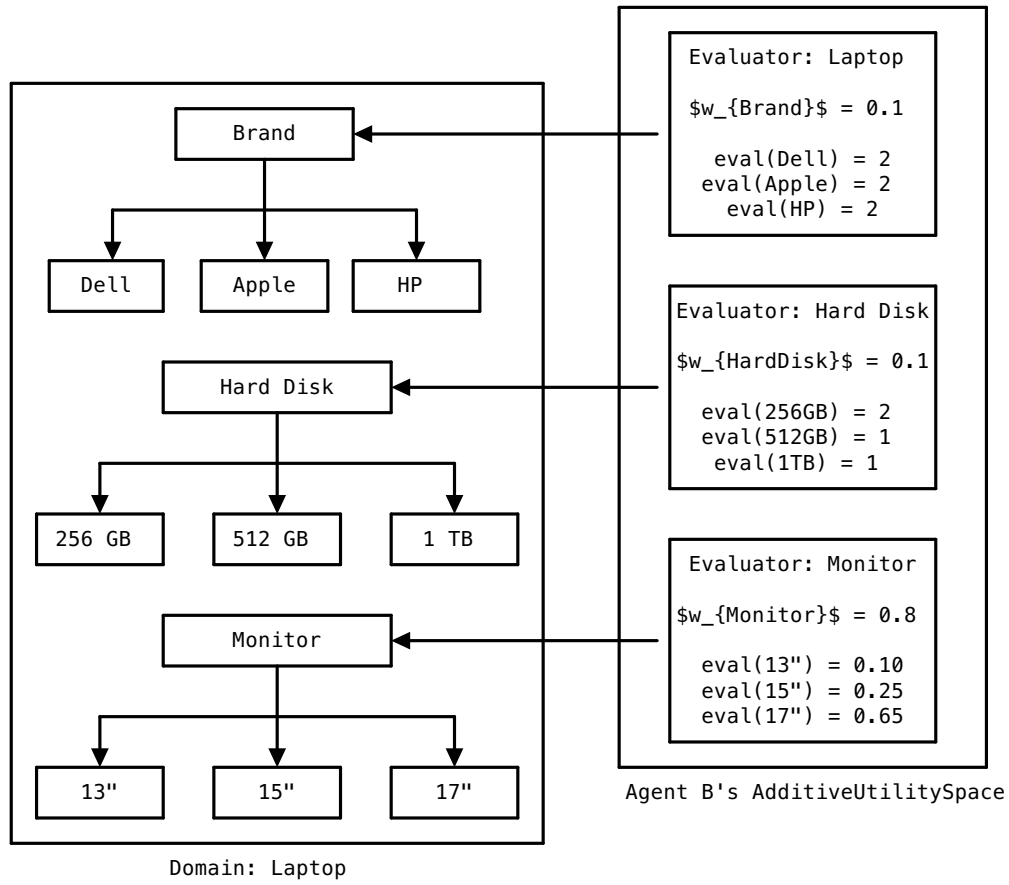


Figure 2: Preference Profile of Agent *b*
(instantiated with AdditiveUtilitySpace)

Practice³: Calculate the utility of $b_a = (\text{Brand: Dell, HardDisk: 1TB, Monitor: 13"})$ for Agent *b*.

1.2.2 Partially Ordered Space

We expect there will three parameters of such space that will control the generation of bids:

- **comparisons:** a subset of bids that are selected randomly from all possible bids that are assumed to be visible.
- **errors:** the number of errors in the orders



errors parameter is not used for now, assume that it is always zero.

With regards to our previous example, if the comparisons equal to the number of possible bids (in D_{laptop}

, the number of bids are: $\prod_i^k |I_i|$

, which is 27

), the negotiating agent can observe all the possible bids:

$$B_a^{\text{ordered}} = (b_a^1, b_a^2, b_a^3, \dots, b_a^{27})$$

B_a is sorted by the utility of the each bid starts, from lowest to highest, can be such as:

$$b_a^1 < b_a^2 < b_a^3 \leq \dots \leq b_a^{27}$$

The list may include bids with same utilities consecutively. Whenever parameter **comparisons** is set to some value, assume that it is 4

. Four bids will be randomly sampled from B_a

. Then, the agent can only observe, for instance:

$$\text{randomly_sample}(B_a^{\text{ordered}}, 4) = (b_a^{21}, b_a^{10}, b_a^4, b_a^5)$$

With negotiation sessions that has partially ordered space as uncertainty, the agent needs to reason and predict about the other unknown parts of the space. Also, since the utilities of each bid are unknown too, from by observing the order the negotiating agent may need to predict the utilities of the other bids too.

!!! note

Genius 9.1.2 includes `UncertaintyAgentExample.java`, which demonstrates the API to access this preference profile.

¹ Genius User Guide mentions: `ConstraintUtilitySpace` and `NonlinearUtilitySpace`.

² It is expected that [ANAC 2019](#) (Automated Negotiation Competition) is going to include partially ordered preference profiles.

2 Task 1: The laptop domain and preferences in GENIUS

You are expected to create the same domain as shown in [Figure 2](#) in GENIUS.



There is already a laptop domain included in GENIUS. Use **lab2_laptop** as the name for the new domain.

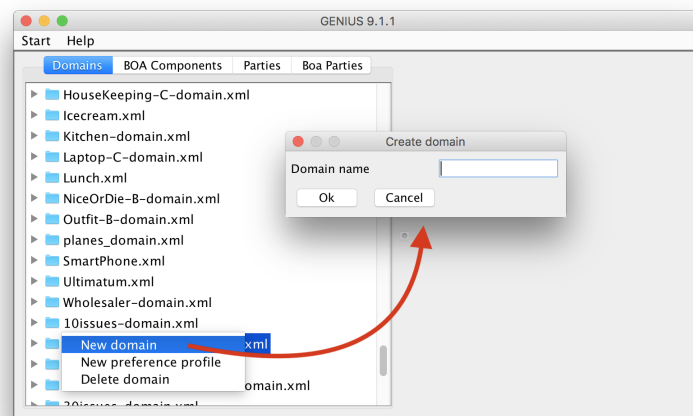


Figure 3: Right click to the left bar

2.1 Add the preference profiles to the domain

After saving the domain with issues create a preference profile for Agent B and an arbitrary profile for Agent A.

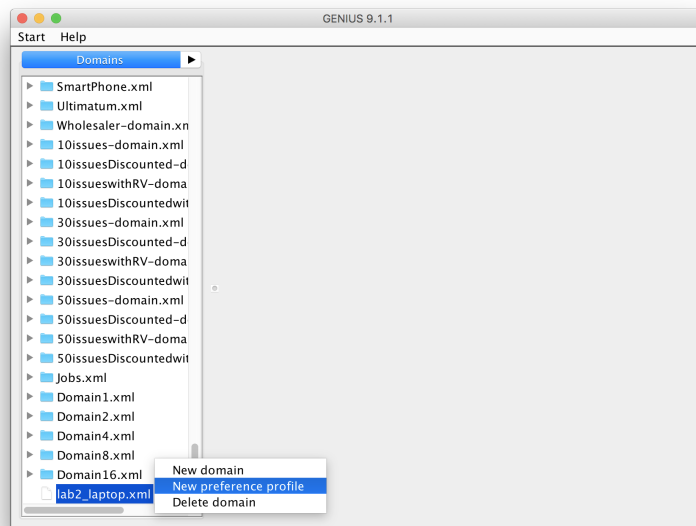


Figure 4: Right click to domain's name

2.1.1 Creating an uncertain preference profiles

You can set the preference profile as uncertain and set *comparisons* metrics:

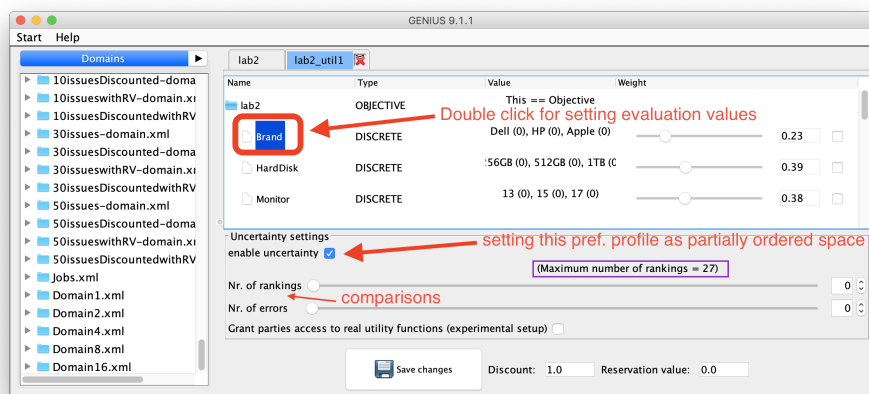


Figure 5: Setting uncertain preference profile

Practice: Why do you think that *maximum number of rankings* (as shown in purple box in Figure 5) is set to 27?

2.2 Double check the created XML

When you create the preference profiles and the domain, have a look at the created XML files. They are by default located at:

```
{PROJECT_WORKING_DIRECTORY}/genius/templates/lab2_laptop
```

Check whether lab2_laptop_util1.xml is similar as below:

```

<utility_space>
  <objective name="lab2_laptop" index="0" description="" etype="objective"
type="objective">
    <issue vtype="discrete" name="Brands" index="1" etype="discrete"
type="discrete">
        <item evaluation="2.0" index="1" value="Dell"></item>
        <item evaluation="2.0" index="2" value="Apple"></item>
        <item evaluation="2.0" index="3" value="HP"></item>
    </issue>
    <issue vtype="discrete" name="Monitor" index="2" etype="discrete"
type="discrete">
        <item evaluation="10.0" index="1" value="13"></item>
        <item evaluation="20.0" index="2" value="15"></item>
        <item evaluation="65.0" index="3" value="17"></item>
    </issue>
    <issue vtype="discrete" name="Hard Drive" index="3" etype="discrete"
type="discrete">
        <item evaluation="2.0" index="1" value="256GB"></item>
        <item evaluation="1.0" index="2" value="512GB"></item>
        <item evaluation="1.0" index="3" value="1TB"></item>
    </issue>
    <weight index="1" value="0.1"></weight>
    <weight index="2" value="0.1"></weight>
    <weight index="3" value="0.8"></weight>
  </objective>
  <discount_factor value="1.0"></discount_factor>
  <reservation value="0.0"></reservation>
</utility_space>

```

Figure 6: Contents of lab2_laptop_util1.xml

3 Task 2: Accessing the preference profile via API

3.1 Subtask 1: AdditiveUtilitySpace Exercise

Copy paste the code snippet below `init(NegotiationInfo info)` method of your agent:

```

AbstractUtilitySpace utilitySpace = info.getUtilitySpace();
AdditiveUtilitySpace additiveUtilitySpace = (AdditiveUtilitySpace) utilitySpace;

List<issue> issues = additiveUtilitySpace.getDomain().getIssues();

for (Issue issue : issues) {
    int issueNumber = issue.getNumber();
    System.out.println(">> " + issue.getName() + " weight: " +
additiveUtilitySpace.getWeight(issueNumber));

    // Assuming that issues are discrete only
    IssueDiscrete issueDiscrete = (IssueDiscrete) issue;
    EvaluatorDiscrete evaluatorDiscrete = (EvaluatorDiscrete)
additiveUtilitySpace.getEvaluator(issueNumber);

    for (ValueDiscrete valueDiscrete : issueDiscrete.getValues()) {
        System.out.println(valueDiscrete.getValue());
        System.out.println("Evaluation(getValue): " +
evaluatorDiscrete.getValue(valueDiscrete));
        try {
            System.out.println("Evaluation(getEvaluation): " +
evaluatorDiscrete.getEvaluation(valueDiscrete));
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
}

```

Run a single negotiation session and validate if your agent can access the preference profile or not.

3.2 Subtask 2: Partially Ordered Space Exercise

This time, in this space only the preference order of some bids are observed. To access the ranking list of these bids, we use `userModel` field of `AbstractNegotiationParty` class:

```
List<bid> bids = userModel.getBidRanking().getBidOrder();
```

Run a single negotiation session with partially ordered spaces for laptop domain and check if you can access them.

Also try to access the properties of a bid, using `Bid` class:

```
List<issue> issuesList = bid.getIssues();

for (Issue issue : issuesList) {
    System.out.println(issue.getName() + ": " + bid.getValue(issue.getNumber()));
}
```

³ *cs0 sj, remsu p elyl*

COMP6203: Lab #3

Intelligent Agents
Wednesday, 31 October 2018
University of Southampton

This lab introduces the protocols in automated negotiation. The protocols determine the overall order of actions during a negotiation. Parties are obliged to stick to this protocol as deviations from the protocol are caught and penalized.

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1 Theory Crash Course

This section provides the essential theory to understand how agents communicate with each other to handle negotiations. First some definitions:

- **Bilateral:** Only two agents are participating in the negotiation session.
- **Multilateral:** Usually refers to more than two agents participating in the negotiation session.

The examples we give on the protocols that defined below are going to be in multilateral settings. However, bilateral settings are also possible with these protocols.

1.1 Protocols without a Mediator

The protocols that are mentioned in this section, does not have a third-party agent that handles communication between negotiators.

1.1.1 SAOP: Stacked Alternating Offers Protocol

According to this protocol [Aydoğan2017], all of the participants around the table get a turn per round; turns are taken clock-wise around the table. The first party starts the negotiation with an offer that is observed by all others immediately. Whenever an offer is made the next party in line can take the following actions:

1. Make a counter offer (*thus rejecting and overriding the previous offer*)
2. Accept the offer
3. Walk away (e.g. *ending the negotiation without any agreement*)

This process is repeated in a turn taking clock-wise fashion until reaching an agreement or reaching the deadline. To reach an agreement, all parties should accept the offer. If at the deadline no agreement has been reached, the negotiation fails.

To illustrate:

Round 1:

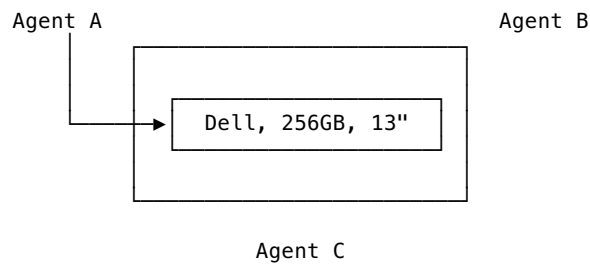


Figure 1: Agent A makes an offer

The second party can *accept this offer, make a counter offer* or *walk away*. Let's assume that Agent B makes a counter-offer.

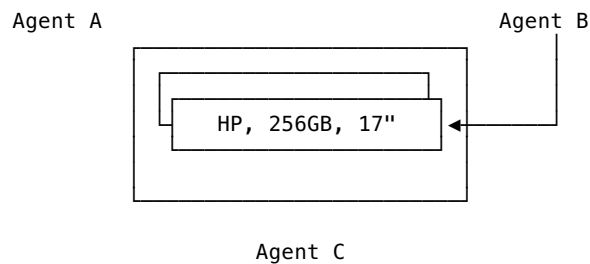


Figure 2: Agent B makes a counter offer

Assume that Agent A and Agent B accept the offer on the negotiation table. Since they all agree on this offer, the negotiation ends with this offer.

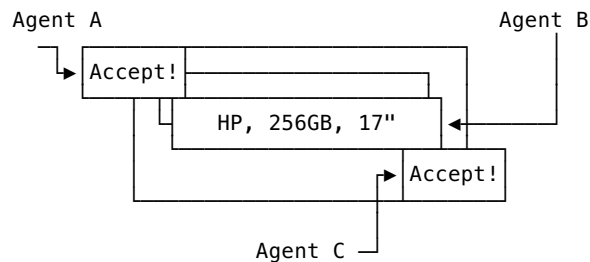


Figure 3: Agent A and Agent B accepts Agent B's offer.

This protocol is used in the international negotiation competition multiple times. For more about this, check [GENIUS's User Guide Section 2.1](#), [ExampleAgent Wiki](#) and [a question from previous year](#).

The next protocols are good to know, but our main focus will be on SAOP.

1.1.2 Alternating Multiple Offers Protocol

There are two phases that consecutively happen in negotiation sessions with this protocol:

- **Bidding Phase** (*every even round (round 0, round 2, ...)*): Each agent submits a bid to the table (i.e. negotiation system).
- **Voting Phase**: (*every odd round (round 1, round 3, ...)*) Each agent observes every bid from every agent. Each bid is voted by each agent. Their vote can be accept or reject.

Before bidding phase starts again, if a bid gets accept votes from all parties, the negotiation ends with this bid.

1.1.3 Alternating Majority Consensus Protocol

This protocol is essentially same as *Alternating Multiple Offers Protocol*, the main difference is that the protocol keeps track of **the acceptance of offers**. At the end of an negotiation, the most favorable but not accepted by everybody offer is accepted by all parties. If any offer is accepted before the deadline by everybody, the negotiation ends.

For example, assume that negotiation ends because of the deadline and (*Dell*, 256GB, 13 ") is offered and accepted by the majority then other offers, then everybody accepts this offer, because of the protocol.

1.2 Protocols with a Mediator:

The protocols that are mentioned in this section, have a third-party agent that handles communication between negotiations. This *mediator* agent hears all of the bids from all parties and the mediator determines which bid to be voted by others. Mediators determines an outcome by observing the votes.

1.2.1 Simple Mediator Based Protocol

In this protocol:

- The mediator creates a bid in each round.
- Other negotiating parties, either accept or reject as before. But they can not provide a counter-offer.
- The mediator informs all parties about the outcome of the round.

This continues until the deadline is reached or a bid from mediator agent is accepted by every negotiating agent.

There are several implemented mediators in GENIUS:

- *RandomFlippingMediator*: generates random bids by flipping one issue of the current offer.
- *FixedOrderFlippingMediator*: same as *RandomFlippingMediator* with a fixed-seed random generator.

1.2.2 Mediator Feedback Based Protocol

This protocol extends *Simple Mediator Based Protocol* by changing votes to feedbacks. Instead of negotiating agents provide a binary vote (i.e. [Reject, Accept]), with this protocol they can provide a feedback (i.e. ['better', 'worse', 'same']) to the mediator.

The mediator generates a different bid in each round as same as before, trying to generate towards to some optimum. The accepted bid is considered as the one that did not get a 'worse' vote from parties.

2 Other Factors

Negotiation sessions are parametrized with two additional parameters: *time pressure*, *discount factor* and *reservation value*. These influence the agents performance throughout the negotiation.

2.1 Reservation Value

Reservation Value is the utility of *walking away*. In other words, it is a real-valued threshold that a rational negotiating agent should not accept any offers below that threshold.

Each agent may have a different reservation value.

2.2 Time Pressure

Each negotiation session has a predefined deadline, it can be in real time as *seconds* or *rounds*. The simulation environment GENIUS normalizes the time t such that $t \in [0, 1]$

2.2.1 Discount Factor

Apart from a deadline, a negotiation session may also feature a **discount factor** d , which decreases the utility of the bids under negotiation as time passes. It is bounded in range $d \in [0, 1]$

. Utility of a bid at the normalized time t

from an agent $U_d^t(b_a)$

is calculated as:

$$U_d^t(b_a) = U(b_a) \cdot d^t$$

where $U(b_a)$

is the utility of the bid without the influence of the discount factor.

Practice: What will happen if $d = 1$

? If d

is very small or very high, what will be the affect on the negotiation?



Time pressure has little meaning if the profile is not defined in terms of utilities, e.g. partially ordered preference profiles.



Reservation values also gets discounted in the same way.

3 Task 1: Implement a simple agent for SOAP protocol

3.1 Subtask 1: Half Best & Half Random

Try to write an agent that gives best offer for itself for half of the time during the negotiation, the agent should give random offers.

Use the snippet from below as a starting point.

```

import java.util.List;

import genius.core.AgentID;
import genius.core.Bid;
import genius.core.actions.Accept;
import genius.core.actions.Action;
import genius.core.actions.Offer;
import genius.core.parties.AbstractNegotiationParty;
import genius.core.parties.NegotiationInfo;

public class YourAgentsName extends AbstractNegotiationParty {
    private final String description = "YourAgentsName";

    @Override
    public void init(NegotiationInfo info) {
        super.init(info);
    }

    @Override
    public Action chooseAction(List< Class< ? extends Action > > list) {
    }

    @Override
    public void receiveMessage(AgentID sender, Action act) {
        super.receiveMessage(sender, act);
    }

    @Override
    public String getDescription() {
        return description;
    }
}

```

Getting the best bid:

```

private Bid getMaxUtilityBid() {
    try {
        return this.utilitySpace.getMaxUtilityBid();
    } catch (Exception e) {
        e.printStackTrace();
    }
    return null;
}

```

Creating random bids:

```

Bid randomBid = this.generateRandomBid();

```

Accessing normalized time $t \in [0, 1]$
:

```

double time = this.getTimeLine().getTime();

```

3.2 Bonus Subtask: Count the counter-offers and accept messages

Try to count the acceptance and counter-offers from which agents. You may think about storing them in a Map.

4 Task 2: Print other factors

Try to print discount factor and discounted reservation values in each turn, when your agent is

making an action.

Accessing discount factor d
and reservation value r
:

```
System.out.println("Discount Factor is " + getUtilitySpace().getDiscountFactor());  
System.out.println("Reservation Value is " +  
getUtilitySpace().getReservationValueUndiscounted());
```

5 Bibliography

[Aydoğan2017] Aydoğan R., Festen D., Hindriks K.V., Jonker C.M. (2017) Alternating Offers Protocols for Multilateral Negotiation. In: Fujita K. et al. (eds) Modern Approaches to Agent-based Complex Automated Negotiation. Studies in Computational Intelligence, vol 674. Springer, Cham
https://link.springer.com/chapter/10.1007/978-3-319-51563-2_10#citeas

COMP6203: Lab #4

Intelligent Agents
Wednesday, 7 November 2018
University of Southampton

This lab shows how to implement a previous winner ([ANAC2016](#)) of the international automated negotiation competition.

Contents

- 1 Theory Crash Course
 - 1.1 Caduceus IPO - *Incremental Portfolio Approach*
- 2 Task 1: Implement Caduceus IPO - *Incremental Portfolio*
- 3 Task 2: Implement Caduceus CO - *Crossover*
- 4 Bonus Task: Further improvements
- 5 Bibliography

1 Theory Crash Course

To get you more familiar with how to implement a more sophisticated agent, we introduce Caduceus agent, which got the first in 2016 and a slightly different version got the second in 2017.

To learn theory, have a look at:

- [The conference paper](#) [[Gunes2017](#)]
- [The poster](#)
- [The presentation](#)

of the Caduceus.

In short, Caduceus incorporates the strategies of multiple agents. We call it experts. These experts can be agents that we know that they are good in negotiation. Metaphorically, it is as if you ask help from multiple friends and try to combine their opinions.

This type of combined approaches exist in:

- Machine Learning
 - [Ensemble Learning](#)
 - Algorithm portfolios
- Artificial Intelligence
 - Genetic Algorithms (*slightly similar*)
 - Mixture of Experts

1.1 Caduceus IPO - *Incremental Portfolio Approach*

Essentially, Caduceus has a set of experts
 A .

$$A = \{a_1, \dots, a_n\}$$

A set of *impact* weights each assigned to the experts.

$$\Omega = \{\omega_1, \dots, \omega_n\}$$

Therefore, Caduceus' algorithm IPO variation a slightly easier to implement version for generating bids is:

- $B \leftarrow \{\}$
- **for each** $i \in A$
 do

- $a_i' \leftarrow$
query agent i
with action a
in time t
- if $\text{type}(a_i') = \text{bid}$
then
 - $B \leftarrow B \cup \{a_i'\}$
 - $\ell_{bid} \leftarrow \ell_{bid} + 1$
- else
 - $\ell_{accept} \leftarrow \ell_{accept} + 1$
- if $\ell_{accept} > \ell_{bid}$
then return accept
- else return a bid b'
from **weighted random sample set** B
according to Ω

where:

- ℓ_{accept}
: the number of experts that generates *accept action*,
 - i.e. the number of experts that recommend accepting the offer that is on the table
- ℓ_{bid}
: the number of experts that generates *bid action*
 - i.e. the number of experts that recommend making a counter offer
- a_i'
: action that agent i recommends to Caduceus to take

2 Task 1: Implement Caduceus IPO - *Incremental Portfolio*



Make sure the expert agents set are receiving the messages from the opponent agents.



You can pick your experts from previous competitions. But be careful, if you are going to use agents from:

- From ANAC 2016: agents protocol was set to be SOAP.
- From ANAC 2017: agents can access data from their past negotiations from a tournament. Check the details [here](#).
- From ANAC 2019 (upcoming): agents which can work with partially ordered preference profiles will be used, protocol is expected to be bilateral version of SOAP.

3 Task 2: Implement Caduceus CO - *Crossover*

Implement *Crossover Strategy* of Caduceus: Algorithm 1.2 without *waiting phase* from the paper.

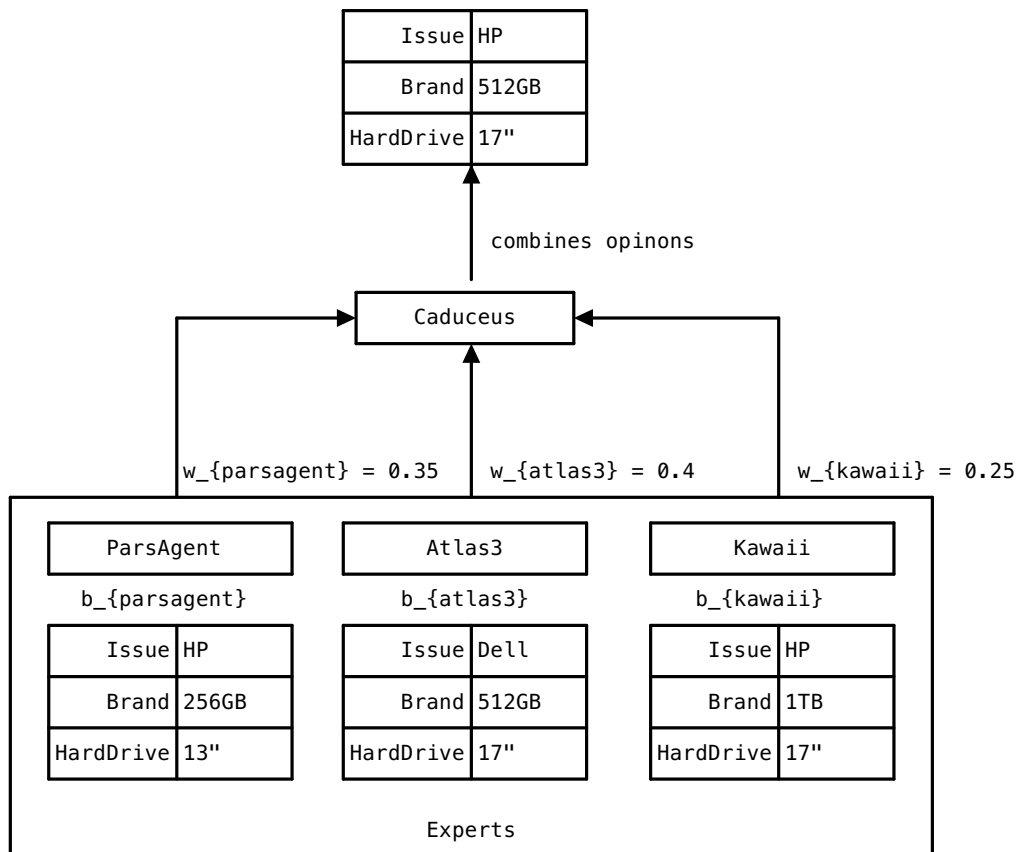


Figure 1: CO version of Caduceus combines experts opinions

The modification that you are going to do to IPO is changing how the bid is generated. In CO version pick the values of the issues that are offered the most by the experts.

4 Bonus Task: Further improvements

- Instead of each agent has same impact on the votes, how about using weights to vote?
- Try to come up with an heuristic to find weights of each expert.

5 Bibliography

[Gunes2017] Güneş T. D., Arditi E., and Aydoğan R., "Collective Voice of Experts in Multilateral Negotiation," in PRIMA 2017: Principles and Practice of Multi-Agent Systems: 20th International Conference, Nice, France, October 30 – November 3, 2017, Proceedings, B. An, A. Bazzan, J. Leite, S. Villata, and L. van der Torre, Eds. Cham: Springer International Publishing, 2017, pp. 450–458.
https://link.springer.com/chapter/10.1007/978-3-319-69131-2_27

COMP6203: Lab #5

Intelligent Agents
Wednesday, 14 November 2018
University of Southampton

This lab shows how to evaluate your agent against various benchmark metrics.

Contents

- 1 Theory Crash Course
 - 1.1 Definitions
 - 1.2 Quality Metrics
 - 1.2.1 Individual Utility
 - 1.2.2 Distance to Pareto Curve
 - 1.2.3 Distance to Nash Point
- 2 Task 1: Run a simple tournament and plot these metrics
- 3 Bonus Task 1: Compute & plot pareto efficient frontier
- 4 Bonus Task 2: Parse tournament-*.log.xml, calculate additional metrics
- 5 Bibliography

1 Theory Crash Course

There are multiple quality metrics that can help you to analyse your negotiating agent:

1.1 Definitions

- **A negotiation session:** A single run of a negotiation, beforehand the names of agents, which preference profiles that they are assigned to and some other parameters needs to be given to make a single run.
- **A tournament:** Consists of many negotiation sessions. A tournament takes a set of negotiation agents, a domain (with many preference profiles.) and some parameters to determine negotiation sessions such as:
 - Deadline
 - Repetitions (*repetition of a negotiation session*)
 - Data Persistency (*access to data of the previous negotiation sessions*)
 - Protocol

1.2 Quality Metrics

1.2.1 Individual Utility

The utility that is gained from the perspective of an agent. For Agent A, for instance it is:

$$U_a(b_{accepted}) = \sum_{i=1}^n \omega_i \frac{eval(v_{c_i}^i)}{\max(eval(I_i))}$$

$b_{accepted}$

is the accepted bid that is accepted by everybody.

If in the negotiation environment:

- the protocol is SOAP
- an agent walks-away
- or deadline is reached

Everyone gets their reservation value (if discounted, they get discounted reservation

value) as their own individual utility.

- **Distance to Social Welfare** (Defined in [MultilateralAnalysis.java:299](#)): The sum of all the individual utilities of all agents.

$$S(b_a) = \sum_{i=1}^n U_a(b_a)$$

1.2.2 Distance to Pareto Curve

(Defined in [MultilateralAnalysis.java:322](#)): The accepted bid's distance to pareto curve.

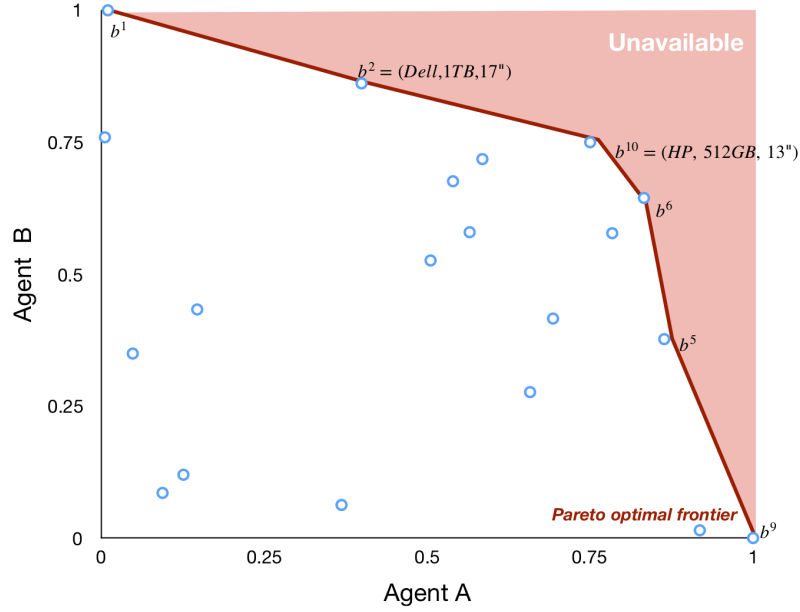


Figure 1: Available bids in the pareto frontier

“A negotiation outcome is said to be Pareto efficient if there is no other outcome that will make at least one agent better off without making at least one other agent worse off. Intuitively, if a negotiation outcome is not Pareto efficient, then there is another outcome that will make at least one agent happier while keeping everyone else at least as happy.” [Jennings2001]

The distance is calculated by getting all the bids which are on the curve. Iterating each bid and getting minimum distance, formally (following example [Figure 1](#)):

$$P(b_a) = \min(\{ ||U(b_a) - U(b_1)||, \dots, ||U(b_a) - U(b_9)|| \})$$

where $||U(b_i) - U(b_j)||$

is the euclidean distance between two bids and $U(b_i)$

is a tuple that holds each utility that each agent would gain from bid b_i

, such that:

$$U(b_i) = (U_1(b_i), \dots, U_k(b_i))$$

1.2.3 Distance to Nash Point

Defined in [MultilateralAnalysis.java:313](#): Nash point is a certain point in (number of agents) dimensional space, such that all parties are in (nash) equilibrium. Assume that b_{nash} is the nash point, let's say Agent A and Agent B are negotiating end. This bid is accepted. This means that Agent A can not improve his utility without hurting Agent B

utility and this must apply for the other way around. [Jennings2001]

To see how this point is found, have a look at its implementation ([MultilateralAnalysis.java:333](#)) in GENIUS. Once the distance is found, the euclidean distance is again calculated between the accepted bid b_a and b_{nash} .

2 Task 1: Run a simple tournament and plot these metrics

1. Open the GENIUS user interface
2. Create a new tournament with these settings:

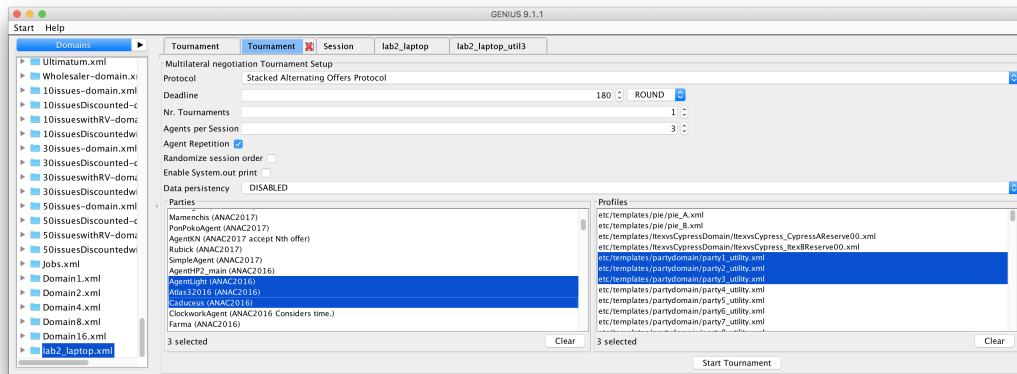


Figure 2: Tournament settings

3. Locate the logs: e.g. ExampleAgent/genius-{version}/log/tournament-*. (xml | log)
4. Open tournament-*.logStats.xml, you can find the mean results of the metrics that we mentioned.
 - While you are developing your agent, you can check these for your agents performance
5. Try to get familiar on how to plot these results (MS Excel, Numbers, matplotlib, Matlab)

3 Bonus Task 1: Compute & plot pareto efficient frontier

Computer and draw pareto efficient frontier in a graph such as [Figure 1](#).

4 Bonus Task 2: Parse tournament-*.log.xml, calculate additional metrics

1. You can calculate **the standard deviation** of each these metrics to see how much the mean performance deviates.
 - You can use a scripting language to parse the log files.
 - You can use MS Excel with tournament-*.log.csv directly with pivot tables.
 - More on this is in Genius User Guide.
2. Try to come up with additional metrics. Some tips:
 - How is your agent performing under:
 - big/small domains many issues and values)
 - discrete, continuous issues
 - and so on.

Running tournaments from command line.

You can define multiple tournaments in an xml file and GENIUS can run them.

5 Bibliography

[Jennings2001] Jennings, N. R., Faratin, P., Lomuscio, A. R., Parsons, S., Wooldridge, M. J., & Sierra, C. (2001). Automated negotiation: prospects, methods and challenges. *Group Decision and Negotiation*, 10(2), 199-215.

<http://www.cs.ox.ac.uk/people/michael.wooldridge/pubs/gdn2001.pdf>

COMP6203: Lab #6

Intelligent Agents
Wednesday, 21 November 2018
University of Southampton

This lab shows some key components of a negotiation agent and how to start improving them.

Contents

- 1 Theory Crash Course
 - 1.1 A simple BOA Party:
 - 1.1.1 Offering Strategy: ChoosingAllBids
 - 1.1.2 Opponent Modelling: UniformModel
 - 1.1.3 Acceptance Strategy: AC_Const
 - 1.1.4 Opponent Model Strategy: BestBid
 - 2 Task 1: Create this BOA Agent from GENIUS User Interface
 - 3 Task 2: Define this BOA Agent programmatically
 - 4 Task 3: Change *Opponent Modelling* approach with frequency based approach

1 Theory Crash Course

We separate our negotiating agent's grand strategy into smaller strategies:

- **Offering Strategy** (i.e. *Bidding Strategy*): the strategy of what bids to generate
- **Opponent Modelling**: how to best capture / predict the preferences of our opponents
- **Acceptance Strategy**: our strategy of deciding when to accept, when to counter-offer, when to walk away.
- **Opponent Model Strategy**: how to use opponent modelling to select a bid for opponent

There are many papers in the literature focuses on a specific part of the design of an negotiating agent. We recommend you to check the bibliography to existing negotiation strategies.

GENIUS has a framework called BOA to allow mixing different components without implementing your agent from scratch. You can have a look to experiment with strategies.



Early version GENIUS initially allowed bilateral negotiations. Therefore, some components of BOA is focused on only bilateral negotiations. Double check their source code to make sure.

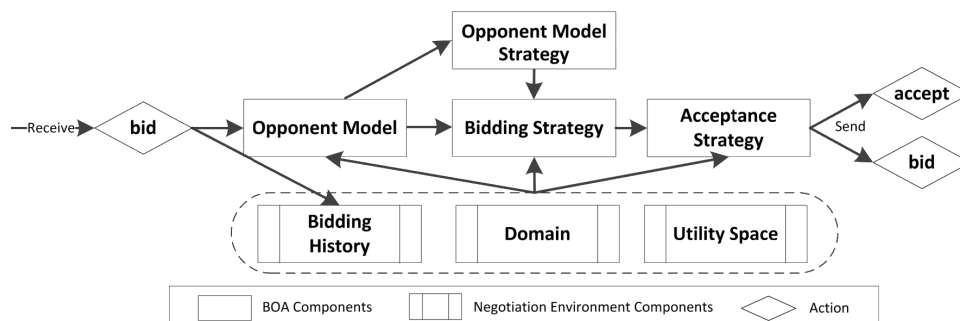


Figure 1: BOA Framework

```
opponentModel.init(negotiationSession, omParams);
omStrategy.init(negotiationSession, opponentModel, omsParams);
offeringStrategy.init(negotiationSession, opponentModel, omStrategy,
    osParams);
acceptConditions.init(negotiationSession, offeringStrategy,
    opponentModel, acParams);
```

Figure 2: *BoaParty*, the relationships between strategies *negotiationSession* holds values such as: *BidHistory*, *Domain*, *OutcomeSpace*

1.1 A simple BOA Party:

We can make our simple agent by combining already available strategies from GENIUS. Assume that these are picked:

1.1.1 Offering Strategy: *ChoosingAllBids*

"An offering strategy which creates a list of possible bids and then offers them in descending order. If all bids are offered, then the last bid is repeated."

1.1.2 Opponent Modelling: *UniformModel*

"Simple baseline opponent model which always returns the same preference."

1.1.3 Acceptance Strategy: *AC_Const*

"This Acceptance Condition accepts an opponent bid if the utility is above a constant."

1.1.4 Opponent Model Strategy: *BestBid*

"This class uses an opponent model to determine the next bid for the opponent, while taking the opponent's preferences into account. The opponent model is used to select the best bid."

Exercise: try to define the behaviour of our BOA agent that uses all these component above.

2 Task 1: Create this BOA Agent from GENIUS User Interface

1. Go to the BOA Parties tab in GENIUS.
2. Right click and click add new item.
3. Observe all available components.
4. Pick the ones we mentioned above.
5. After creating the agent, have a couple of runs to make sure it works.

3 Task 2: Define this BOA Agent programmatically

You need to use *B0AParty* class to extend your new agent.

```

import genius.core.boaframework.BoaParty;
import genius.core.boaframework.SessionData;
import genius.core.parties.NegotiationInfo;
import genius.core.persistent.PersistentDataType;
import negotiator.boaframework.omstrategy.NullStrategy;

import java.util.HashMap;

public class SimpleBoaParty extends BoaParty {
    public SimpleBoaParty () {
        super (null , new HashMap < String , Double > () , null ,
            new HashMap < String , Double > () , null ,
            new HashMap < String , Double > () , null ,
            new HashMap < String , Double > ());
    }
    @Override
    public void init ( NegotiationInfo info ) {
        SessionData sessionData = null ;
        if ( info . getPersistentData ()
            . getPersistentDataType () == PersistentDataType. SERIALIZABLE ) {
            sessionData = ( SessionData ) info . getPersistentData (). get ();
        }
        if ( sessionData == null ) {
            sessionData = new SessionData ();
        }
        negotiationSession = new NegotiationSession( sessionData ,
            info . getUtilitySpace (), info . getTimeline ());
        opponentModel = new MyrequeryModel ();
        opponentModel . init ( negotiationSession , new HashMap < String , Double >
        ());
        omStrategy = new NullStrategy( negotiationSession );
        offeringStrategy = new MyBiddingStrategy ( negotiationSession ,
            opponentModel , omStrategy );
        acceptConditions = new AC_Next ( negotiationSession , offeringStrategy , 1,
            0);
        // we have init 'd all params here , don 't call super init
    }
    @Override
    public String getDescription () {
        return " Simple BOA Party ";
    }
}

```

4 Task 3: Change *Opponent Modelling* approach with frequency based approach

As you noticed from the implementation of the `UniformModel`, it returns equally evaluations of each bid. Instead of this dummy component, write a frequency based approach that looks at the bid history and makes better predictions about opponents preference profile.