Multiagent systems

CentraleSupélec

# Argumentation-based Negotiation for choosing a car engine !

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## 1 The story ...

Imagine that a car manufacturer wants to launch a new car on the market. For this, a crucial choice is the one of the engines that should meet some technical requirements but at the same time be attractive for the customers (economic, robust, ecological, etc.). Several types of engines exist and thus provide a large offer of cars models: essence or diesel Internal Combustion Engine (ICE), Compressed Natural GAS (CNG), Electric Battery (EB), Fuel Cell (FC), etc. The company decides to take into account different criteria to evaluate them: Consumption, environmental impact (CO2, clean fuel, $NO_X$[1]...), cost, durability, weight, targeted maximum speed, etc. To establish the best offer/choice among a large set of options, they decide to simulate a negotiation process where agents, with different opinions and preferences (even different knowledge and expertise), discuss the issue to end up with the best offer. The simulation will allow the company to simulate several typologies of agent behaviours (expertise, role, preferences, ...) at a lower cost within a reasonable time.

The practical sessions in this Multi-Agent System Course will be devoted to the programming of a negotiation & argumentation simulation. Agents representing human engineering will need to negotiate with each other to make a joint decision regarding choosing the best engine. The negotiation comes when the agents have different preferences on the criteria, and the argumentation will help them decide which item to select. Moreover, the arguments supporting the best choice will help build the justification supporting it, an essential element for the company to develop its marketing campaign.

**Warning**. As we are limited in the time and the idea is not to built at the end a software, but to understand the different concepts described in the course, we will take the following assumptions to ease the programming:

- the example illustrates only two agents for the moment !
- The agents share the same set of options (items) and the same set of criteria.
- The negotiation protocol is run only between each pair of agents.
- We will not update or modify the knowledge base of an agent.

## 2 An illustrative Example

Let consider two agents: $A_1$ and $A_2$. They have to select only one item between the ICE Diesel (ICED) engine and the Electric (E) one: there is only room left for one of them. The agents consider five different criteria:

[1] Nitrogen oxyde

- $c_1$: cost of production (€, lower is better),
- $c_2$: consumption (L/100 km, lower is better),
- $c_3$: durability (measured on a qualitative scale ranging from 1 (lowest performance) to 4 (best performance), higher is better),
- $c_4$: environmental impact (measured on a qualitative scale ranging from 1 (low environmental impact) to 4 (high environmental impact), lower is better),
- $c_5$: degree of Noise (measured in dB, lower is better)

For illustration, the performances of the two engines, on each criterion, are described in Table 1

| | $c_1$ | $c_2$ | $c_3$ | $c_4$ | $c_5$ |
|---|---|---|---|---|---|
| ICED | 12 330 | 6.3 | 3.8 | 4.8 | 65 |
| E | 17 500 | 0 | 3 | 2.2 | 48 |

Table 1: Engines Data

Moreover, each agent has it own evaluation table for the items. This table is constructed by defininining threasholds, called *profiles*, that separate scale of values of each criterion between very bad($\star$/■), bad ($\star\star$/■) good ($\star\star\star$/■) and very good ($\star\star\star\star$/■). These *profiles* represent the preferences of the agent. For instance, Table 2 below gives the profiles of $A_1$ for $c_1$ and $c_3$, and the resulting labeling of the two engine according to $c_1$ and $c_3$ is depicted in Figure 1.

| Profile | $c_1$ | $c_3$ |
|---|---|---|
| $p^{1\star}$ | 17 250 | 1.5 |
| $p^{2\star}$ | 15 500 | 2.5 |
| $p^{3\star}$ | 12 500 | 3.5 |

Table 2: Limiting Profiles for $A_1$

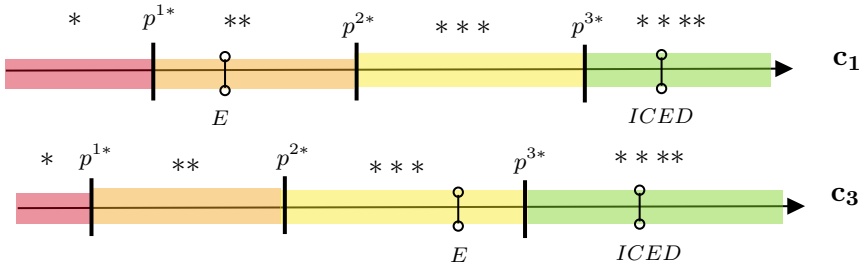



Figure 1: Representation of performances w.r.t. category limits for $c_1$ and $c_3$.

**Notes**. The values given here are abitrary values. We shall not discuss the choice of the criteria, the possible scales, or the rating for each engine. You may think about preference learning and elicitation task in decision theory to obtain these values, but this is out of the scope of this course.

The resulting labeling for both candidate engines on all 5 criteria for agent $A_1$ is given into Table 3. What matters is this table:

| | $c_1$ | $c_2$ | $c_3$ | $c_4$ | $c_5$ |
|---|---|---|---|---|---|
| ICED | ⋆⋆⋆⋆ | ⋆⋆⋆ | ⋆⋆⋆⋆ | ⋆ | ⋆⋆ |
| E | ⋆⋆ | ⋆ | ⋆⋆⋆ | ⋆⋆⋆⋆ | ⋆⋆⋆⋆ |

Table 3: Performance Table of $A_1$

Concerning the agent $A_2$. Table 4 and Table 5 give respectively the limiting profiles and the performance table for agent $A_2$.

| Profile | $c_1$ | $c_3$ |
|---|---|---|
| $p^{1\star}$ | 20 500 | 1.8 |
| $p^{2\star}$ | 18 000 | 2.0 |
| $p^{3\star}$ | 12 300 | 3.5 |

Table 4: Limiting Profiles for $A_2$

The resulting labeling for both candidate engines on all 5 criteria for agent $A_2$ is given into Table 5. What matters is this table:

| | $c_1$ | $c_2$ | $c_3$ | $c_4$ | $c_5$ |
|---|---|---|---|---|---|
| ICED | ⋆⋆⋆ | ⋆⋆ | ⋆⋆⋆ | ⋆ | ⋆ |
| E | ⋆⋆⋆ | ⋆⋆ | ⋆⋆ | ⋆⋆⋆⋆ | ⋆⋆⋆⋆ |

Table 5: Performance Table of $A_2$

Moreover, agents have different order of preferences among the criteria themselves (total order in our example):

- $A_1 : c_1 \succ c_4 \succ c_2 \succ c_3 \succ c_5$
- $A_2 : c_4 \succ c_5 \succ c_1 \succ c_2 \succ c_3$

**Warning**.
In the rest of the work, we have two ways to generate the performance tables of $A_1$ and $A_2$ :

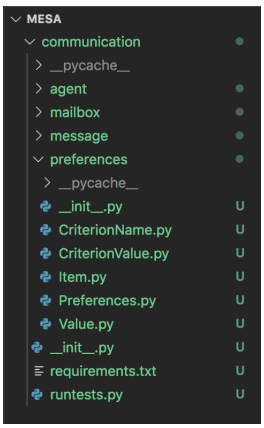
1. Randomly generate the two tables 3 and 5,
2. Randomly generate the profiles for each agent. Then, we construct the performance table by relying on the profiles and the Engines Data.

A basic version of the work is to adopt the first way and then move to the second one to improve the proposed code.

## 3 The Python project

In the third session of the course, part "Interaction with mesa library", we have used a communication layer in Mesa to handle the direct interactions on the Alice/Bob example. In this practical work we will use this layer and add argumentation and negotiation features. To do so, you can download from EDUNAO the mesa package. Thus you should have the following, such that

- communication: the root folder of the communication layer;
- agent: the folder which will contain the implementation of the communicating agent class;
- mailbox: the folder which will contain the implementation of the mailbox class;
- message: the folder which will contain the implementation of the message and performative class.




**Warning**.
The provided packages and all the code only help you start. You are free to use the code as it is or to change the structure and the content of the code. Mainly, you are free to modify the functions, names, arguments, and everything you judge necessary to change.

# 4 What is your goal?

To give an idea of what is the target of this practical work, in what follows is the algorithm 1 of the argumentation-based negotiation that we will try to implement. You can examine the algorithm to get a first idea of the structure and content. A complete understanding of the algorithm is not necessary at the moment, as the different steps in the next sessions will allow you to build it.

Moreover, to have a quick understanding of the algorithm, the following "fictitious" example dialogue could be produced by our agents. Each line is composed of the number of the dialogue turn, the name of the sender agent (the recipient agent is the other one), and the message itself.

```
01: Agent1 - PROPOSE(ICED)
02: Agent2 - ASK_WHY(ICED)
03: Agent1 - ARGUE(ICED <= Cost=Very Good)
04: Agent2 - PROPOSE(E)
05: Agent1 - ASK_WHY(E)
06: Agent2 - ARGUE(E <= Environment Impact=Very Good)
07: Agent1 - ARGUE(not E <= Cost=Very Bad, Cost>Environment)
08: Agent2 - ARGUE(E <= Noise=Very Good, Noise > Cost)
09: Agent1 - ARGUE(not E <= Consumption=Very Bad)
10: Agent2 - ARGUE(notICED <= Noise=Very Bad, Noise> Cost)
11: Agent1 - ARGUE(ICED <= Durability=Very Good)
12: Agent2 - ARGUE(not ICED <= Environment =Very Bad, Environment >
Durability)
13: Agent2 - ARGUE(E <= Durability=Good)
13: Agent1 - ACCEPT(E)
14: Agent1 - COMMIT(E)
15: Agent2 - COMMIT(E)
```

**Algorithm 1:** Example of a communication protocol

initialization;

- create a set of $n$ agents ;
- set-up a list of $m$ items $\{o_1, \ldots, o_m\}$
- set-up a list of $k$ criteria $\{c_1, \ldots, c_k\}$

**foreach** *agent $i$ in agents* **do**
  define preference of $i$ (criteria order, a performance taable)
**end**
**foreach** $(X, Y) \in$ *agents* **do**
  $X$: propose $(o_i)$;
  $Y$: receivers-message(propose$(o_i)$);
  **if** *($o_i \in$ 10% favorite items of $Y$)* **then**
    **if** *($o_i = o_j \mid o_j$ top item of $Y$)* **then**
      $Y$: accept$(o_i)$;
      $X$: commit$(o_i)$;
      $Y$: commit$(o_i)$;
      ‘
    **end**
    **else**
      $Y$: propose$(o_j)$
    **end**
  **end**
  **else**
    $Y$: ask_why$(o_i)$
  **end**
  $X$: receive-message(ask_why$(o_i)$) **if** *($X$ has at least one argument pro $o_i$)* **then**
    $X$: argue($o_i$, reasons);
  **end**
  **else**
    $X$: propose$(o_j)$, $j \neq i$
  **end**
  $Y$: receive-message(argue($o_i$, reasons))
  **if** *($Y$ has a counter-argument($o_i$)* **then**
    **switch** *(if reasons correspond to ($c_i = x$) )* **do**
      **case** *($Y$ has a better alternative $o_j$, $j \neq i$, on $c_i$)* **do**
        $Y$: argue($o_j$, $c_i = y$, $y$ is better than $x$)
      **end**
      **case** *($o_i$ has a bad evaluation on $c_i$)* **do**
        $Y$: argue(not $o_i$, $c_i = y$, $y$ is worst than $x$)
      **end**
      **case** *($o_i$ has a bad evaluation on $c_j (j \neq i)$ and $c_j$ is an important criterion for $Y$ )* **do**
        $Y$: argue(not $o_i$, $c_j = y$ with $y$ is worst than $x$, $c_j \succ c_i$)
      **end**
    **end**
    **switch** *(if reasons correspond to ($c_i = x$ and $c_i \succ c_j$) )* **do**
      **case** *($Y$ has a better alternative $o_j$, $j \neq i$, on $c_i$)* **do**
        $Y$: argue($o_j$, $c_i = y$, $y$ is better than $x$)
      **end**
      **case** *($Y$ prefer $c_j$ to $c_i$)* **do**
        $Y$: argue(not $o_i$, $c_j = y$, $c_j \succ c_i$)
      **end**
    **end**
  **end**
  **else**
    $Y$: accept$(o_i)$;
    $X$: commit$(o_i)$;
    $Y$: commit$(o_i)$;
  **end**
**end**

# 5 Agents' Preferences

**Warning**.
From now de not forgot to make unit tests for each function implemented to check the behaviour of your code.

## 5.1 The preference package

The preference package includes different classes described in what follows:

- `Item` class: encodes the items (engines). Each item is described by a name represented by a String value and a description represented by a String value;
- `CriterionName` class: implements the possible criterion name (e.g. environment impact, Cost, etc.)
- `CriterionValue` class : associates an Item with a CriterionName and a Value.
- `Value` class: implements the Value class Enumeration containing the possible values (e.g. Bad, Good, etc.)
- `Preferences` class: whose instances represent the preferences of agents. One agent will be associated with a single instance of this class. The preferences consists of: a list of criteria ordered (from most important to least important) and a list of value about each item on each criterion.

**Warning**. For testing your agents during this session, please consider the preferences of Tables 3 and 5 and the criteria ordering corresponding to $A_1$ and $A_2$

## 5.2 Testing you `Preference` class

1. Using the methods present in the `Preferences` class and the get_score(self, preferences) function that computes the value of each item (see `Item` class), add to your class a method that allows an agent to select its most preferred item in a list. In case of equality, select one randomly. If you think that it is helpful to add another function of your choice, please feel free to do it.

```
def most_preferred(self, item_list):
     """Returns the most preferred item from a list.
     """
    # To be completed
     return best_item
```

2. Add to your class a method that checks whether an item belongs to the 10% most preferred one of the agent.

```
def is_item_among_top_10_percent(self, item):
    """
    Return whether a given item is among the top 10 percent of the preferred
    items.

    :return: a boolean, True means that the item is among the favourite ones
    """
    # To be completed
```

3. Run the unit tests at the end of the `Preferences` class (Preferences.py) to check wether you code is correct or not. You should get the output of the Figure3.

You can add other units tests not included in the file.

```
Diesel Engine (A super cool diesel engine)
Electric Engine (A very quiet engine)
Value.VERY_GOOD
True
Electric Engine > Diesel Engine : False
Diesel Engine > Electric Engine : True
Electric Engine (for agent 1) = 362.5
Diesel Engine (for agent 1) = 525.0
Most preferred item is : Diesel Engine
```

Figure 2: Outputs Preferences Class

# 6 Agents and Messages

## 6.1 Performatives and Messages content

During the dialogue (negotiation), we will need some locutions/performatives. we will mainly consider the following:

- PROPOSE: it is used to propose to select an item. Its content is the name of the item.
- ACCEPT: it is used to accept to select an item. Its content is the item's name. It should always appear after a PROPOSE of the same item, but several other message can exist between the proposal and the acceptance.
- COMMIT: it is used to confirm that an object has to be selected. Its content is an item's name. Both agents must send (and receive) this message at the end of the interaction.
- ASK_WHY: it is used to ask another agent to propose arguments for a given item. Its content is an item's name. It should be used after a propose. This message expects an ARGUE message as answer.
- ARGUE: it is used to explain to the other party in the dialogue the reasons in favor or against a given item.

You should check that these performatives are implemented in MessagePerformative.py, if not make sure to add the missing ones. Again, you can add other perfomatives (for instance, REJECT. You need then to update the protocol to integrate this new locution).

## 6.2 Agent and Communication

1. Create a new Python file named pw_argumentation.py (as it is illustrated in the following picture) at the root of the mesa folder

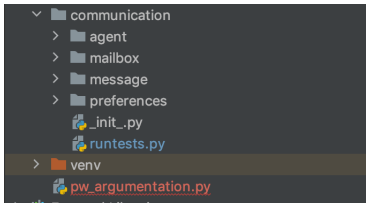



Figure 3: Outputs Preferences Class

This file will contain our class of agents and our model for the argumentation simulation (will be completed as we go through our sessions).

```python
from mesa import Model
from mesa.time import RandomActivation

from communication.agent.CommunicatingAgent import CommunicatingAgent
from communication.message.MessageService import MessageService
```

```
6
7
8  class ArgumentAgent(CommunicatingAgent):
9   """ ArgumentAgent which inherit from CommunicatingAgent.
10  """
11  def __init__(self, unique_id, model, name):
12      super().__init__(unique_id, model, name)
13      self.preference = None
14
15  def step(self):
16      super().step()
17
18  def get_preference(self):
19      return self.preference
20
21  def generate_preferences(self, preferences):
22      # see question 3
23      # To be completed
24
25 class ArgumentModel(Model):
26  """ ArgumentModel which inherit from Model.
27  """
28  def __init__(self):
29      self.schedule = RandomActivation(self)
30      self.__messages_service = MessageService(self.schedule)
31
32      # To be completed
33      #
34      # a = ArgumentAgent(id, "agent_name")
35      # a.generate_preferences(preferences)
36      # self.schedule.add(a)
37      # ...
38
39      self.running = True
40
41  def step(self):
42      self.__messages_service.dispatch_messages()
43      self.schedule.step()
44
45
46 if __name__ == "__main__":
47  argument_model = ArgumentModel()
48
49  # To be completed
```

2. As it was done at the end of the course 3 (Alice/Bob example), create two communicating agents named $A_1$ and $A_2$ (you may give them names if you want). These agents have an instance of `Preferences` classe. The list of items is the same for the different agents (the list of criteria may be not, you choose).

3. Write a method that allows to generate the preferences of the agent (see the example for $A_1$ and its corresponding ranking on criteria). You can also try to have a function that read the data from a csv file (not mandatory).

```
1 def generate_preferences(self, preferences):
2     """
3      Set the preferences of the agent
4
5      """
6      # To be completed
```

4. Implement the following situation between the two agents:

- $A_1$ to $A_2$ : PROPOSE(item) (no matter which one for the moment)
- $A_2$ to $A_1$ : ACCEPT (item).

5. Update the propose/accept interaction between Agent1 and Agent2, with the following:

   - $A_1$ to $A_2$ : PROPOSE (item)
   - $A_2$ to $A_1$: ACCEPT (item) if the item belongs to its 10% most preferred item, otherwise ASK_WHY(item).

6. In case of acceptance, update the protocol to take into account the double-COMMIT interaction (see below). Both agents ($A_1$ and $A_2$ ) simply send a COMMITmessage to each other as soon as they have the three following information:

   - One agent made a proposal on the item;
   - The other agent accept the proposal on the item;
   - The item is available in the agent's list.

   $A_1$ to $A_2$: PROPOSE(item)

   $A_2$ to $A_1$: ACCEPT (item)

   $A_1$ to $A_2$: COMMIT (item)

   $A_2$ to $A_1$: COMMIT(item)

   After receiving the COMMIT each agent remove the item from its list of items.

   Otherwise $A_1$ to $A_2$: ARGUE()

**Warning**.
For the moment the content of this message is empty, more in the next session.