Argumentation-based negotiation protocol

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Problem description

With the aim of helping a car manufacturer launch a new car on the market. An engine must satisfy some technical requirements, while also be attractive to the majority of customers.To create the best choice among a large set of options, we decided to simulate a negotiation process where agents have different opinions and preferences. 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

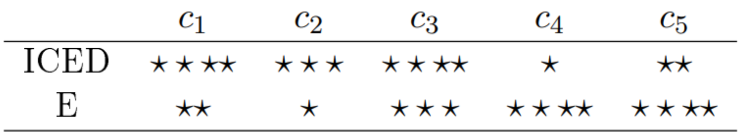
Implementation

Agents

Agents representing human engineering will need to negotiate with each other to make a joint decision regarding choosing the best engine. They each have different opinions about the set of items, which can be represented by a performance table. As well as an order of preference among the criteria.

Performance Table

A performance table is used to summarize an agent's preferences. It tells the agent's opinion for each object about each criterion.



	c_1	c_2	c_3	c_4	c_5
ICED	★★★★	★★★	★★★★	★	★★
E	★★	★	★★★	★★★★	★★★★

Table 3: Performance Table of A_1

Arguments

The type of supporting arguments an agent can give are:

- $argue\ (item,\ c1\ =\ GOOD)$

The types of counter-arguments taken into account for a PRO argument about $c1$ are:

- $argue\,(not\,item,\ c2\ =\ BAD,\ c2\ >\ c1)$
- $argue\,(not\,item,\ c1\ =\ BAD)$
- $argue\,(alternative,\ c1\ =\ GOOD)$

The types of counter-arguments taken into account for a CON argument about $c1$ are:

- $argue\,(item,\ c2\ =\ GOOD,\ c2\ >\ c1)$
- $argue\,(item,\ c1\ =\ GOOD)$

NOTE: In the previous GOOD is the same as VERY_GOOD, and BAD is the same as VERY_BAD.

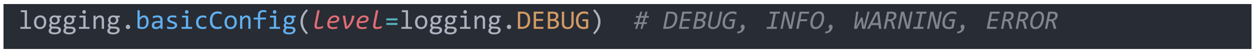
Negotiation protocol

- A1 starts by proposing an item.
- If the item is in 10% most preferred items it’s accepted, if not A2 asks why.
- A1 lists the best supporting argument for the item
- If A2 doesn’t have a counter argument, A2 accepts the proposal, else A2 gives a counter argument
- Agents keep arguing until one of them doesn’t have a counter argument, in which case this agent either accepts or rejects the proposed item.
- If the item is accepted the negotiation is done, if not we propose a new item and start again.

NOTE: To avoid a loop of counter arguments, an agent cannot give the same argument twice.
NOTE 2: We could imagine a more creative way of handling conflicting preferences, by adding a level of “resolve” or “convincing”, where a more resolved agent has more probability to convince another one of their preference.

Logging

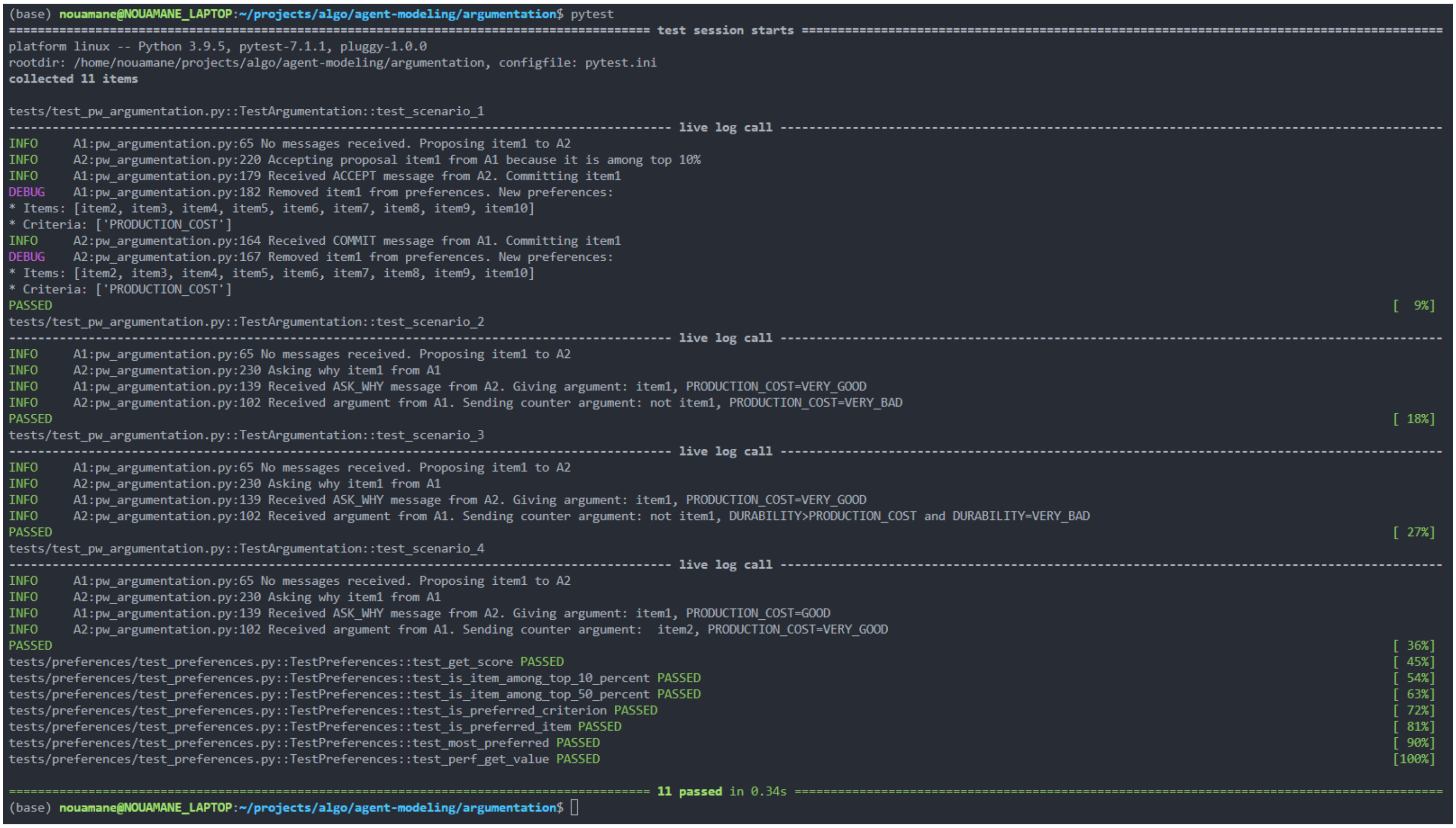
We used the `logging` library to customize and colorize the logs of each agent. We could also easily configure how much details we want to show in logs by configuring the line:



```
logging.basicConfig(level=logging.DEBUG)  # DEBUG, INFO, WARNING, ERROR
```

Testing

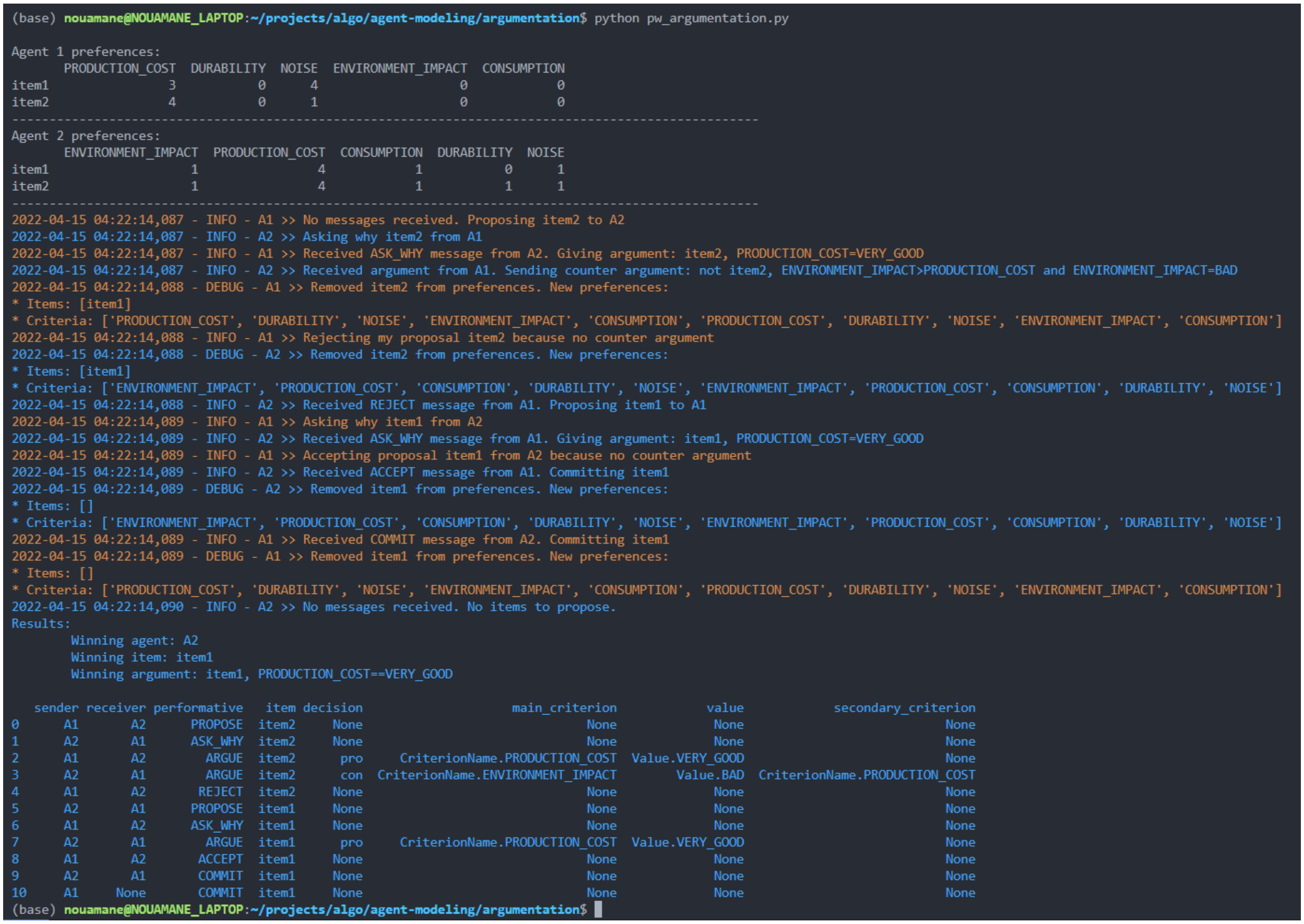
We also implement some tests for the `Preferences` class, and 4 basic negotiation scenarios. The tests can be found in the `tests` folder.
To run the test we can use pytest as such:



```
(base) nouamane@NOUAMANE_LAPTOP:~/projects/algo/agent-modeling/argumentation$ pytest
========================================================================================== test session starts ==========================================================================================
platform linux -- Python 3.9.5, pytest-7.1.1, pluggy-1.0.0
rootdir: /home/nouamane/projects/algo/agent-modeling/argumentation, configfile: pytest.ini
collected 11 items

tests/test_pw_argumentation.py::TestArgumentation::test_scenario_1
-------------------------------------------------------------------------------------------- live log call ---------------------------------------------------------------------------------------------
INFO     A1:pw_argumentation.py:65 No messages received. Proposing item1 to A2
INFO     A2:pw_argumentation.py:220 Accepting proposal item1 from A1 because it is among top 10%
INFO     A1:pw_argumentation.py:179 Received ACCEPT message from A2. Committing item1
DEBUG    A1:pw_argumentation.py:182 Removed item1 from preferences. New preferences:
* Items: [item2, item3, item4, item5, item6, item7, item8, item9, item10]
* Criteria: ['PRODUCTION_COST']
INFO     A2:pw_argumentation.py:164 Received COMMIT message from A1. Committing item1
DEBUG    A2:pw_argumentation.py:167 Removed item1 from preferences. New preferences:
* Items: [item2, item3, item4, item5, item6, item7, item8, item9, item10]
* Criteria: ['PRODUCTION_COST']
PASSED                                                                                                                                                                                            [  9%]
tests/test_pw_argumentation.py::TestArgumentation::test_scenario_2
-------------------------------------------------------------------------------------------- live log call ---------------------------------------------------------------------------------------------
INFO     A1:pw_argumentation.py:65 No messages received. Proposing item1 to A2
INFO     A2:pw_argumentation.py:230 Asking why item1 from A1
INFO     A1:pw_argumentation.py:139 Received ASK_WHY message from A2. Giving argument: item1, PRODUCTION_COST=VERY_GOOD
INFO     A2:pw_argumentation.py:102 Received argument from A1. Sending counter argument: not item1, PRODUCTION_COST=VERY_BAD
PASSED                                                                                                                                                                                            [ 18%]
tests/test_pw_argumentation.py::TestArgumentation::test_scenario_3
-------------------------------------------------------------------------------------------- live log call ---------------------------------------------------------------------------------------------
INFO     A1:pw_argumentation.py:65 No messages received. Proposing item1 to A2
INFO     A2:pw_argumentation.py:230 Asking why item1 from A1
INFO     A1:pw_argumentation.py:139 Received ASK_WHY message from A2. Giving argument: item1, PRODUCTION_COST=VERY_GOOD
INFO     A2:pw_argumentation.py:102 Received argument from A1. Sending counter argument: not item1, DURABILITY>PRODUCTION_COST and DURABILITY=VERY_BAD
PASSED                                                                                                                                                                                            [ 27%]
tests/test_pw_argumentation.py::TestArgumentation::test_scenario_4
-------------------------------------------------------------------------------------------- live log call ---------------------------------------------------------------------------------------------
INFO     A1:pw_argumentation.py:65 No messages received. Proposing item1 to A2
INFO     A2:pw_argumentation.py:230 Asking why item1 from A1
INFO     A1:pw_argumentation.py:139 Received ASK_WHY message from A2. Giving argument: item1, PRODUCTION_COST=GOOD
INFO     A2:pw_argumentation.py:102 Received argument from A1. Sending counter argument:  item2, PRODUCTION_COST=VERY_GOOD
PASSED                                                                                                                                                                                            [ 36%]
tests/preferences/test_preferences.py::TestPreferences::test_get_score PASSED                                                                                                                     [ 45%]
tests/preferences/test_preferences.py::TestPreferences::test_is_item_among_top_10_percent PASSED                                                                                                  [ 54%]
tests/preferences/test_preferences.py::TestPreferences::test_is_item_among_top_50_percent PASSED                                                                                                  [ 63%]
tests/preferences/test_preferences.py::TestPreferences::test_is_preferred_criterion PASSED                                                                                                        [ 72%]
tests/preferences/test_preferences.py::TestPreferences::test_is_preferred_item PASSED                                                                                                             [ 81%]
tests/preferences/test_preferences.py::TestPreferences::test_most_preferred PASSED                                                                                                                [ 90%]
tests/preferences/test_preferences.py::TestPreferences::test_perf_get_value PASSED                                                                                                                [100%]

========================================================================================== 11 passed in 0.34s ===========================================================================================
(base) nouamane@NOUAMANE_LAPTOP:~/projects/algo/agent-modeling/argumentation$ 
```

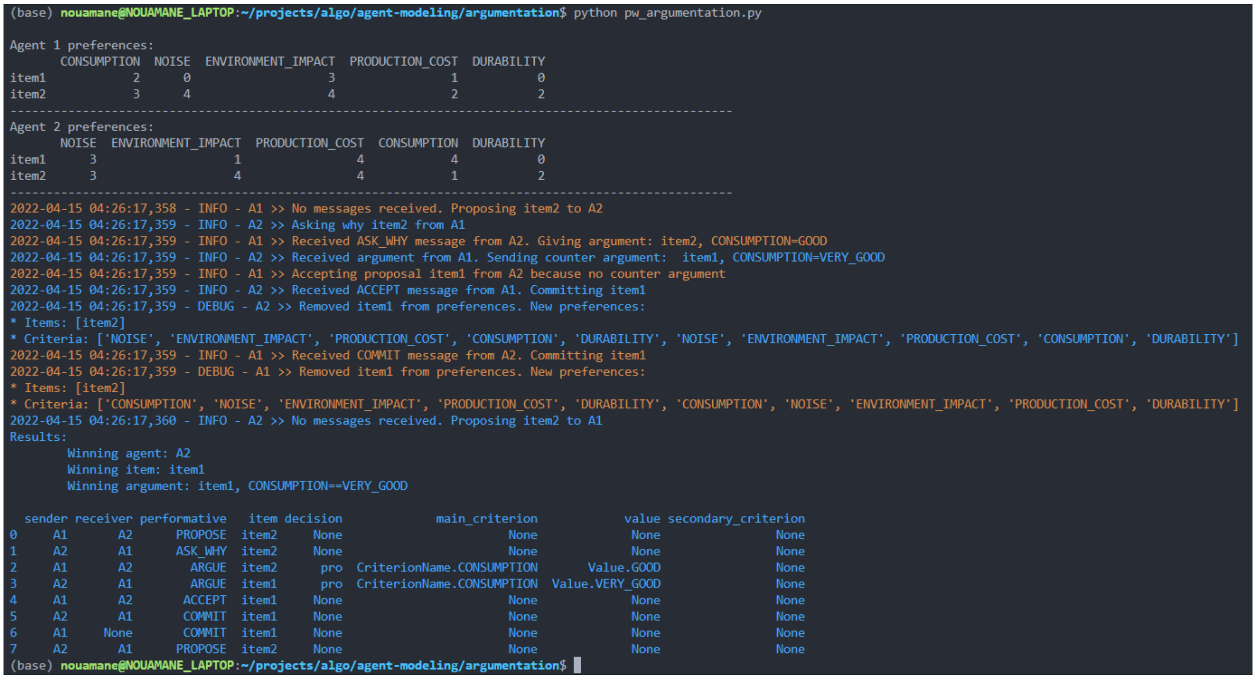
Simulation

Example with REJECT:



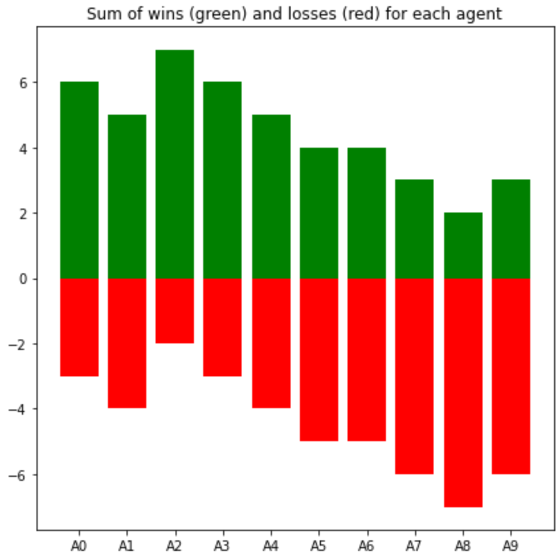
```
(base) nouamane@NOUAMANE_LAPTOP:~/projects/algo/agent-modeling/argumentation$ python pw_argumentation.py

Agent 1 preferences:
       PRODUCTION_COST  DURABILITY  NOISE  ENVIRONMENT_IMPACT  CONSUMPTION
item1                3           0      4                   0            0
item2                4           0      1                   0            0
----------------------------------------------------------------------------------------------------
Agent 2 preferences:
       ENVIRONMENT_IMPACT  PRODUCTION_COST  CONSUMPTION  DURABILITY  NOISE
item1                   1                4            1           0      1
item2                   1                4            1           1      1
----------------------------------------------------------------------------------------------------
2022-04-15 04:22:14,087 - INFO - A1 >> No messages received. Proposing item2 to A2
2022-04-15 04:22:14,087 - INFO - A2 >> Asking why item2 from A1
2022-04-15 04:22:14,087 - INFO - A1 >> Received ASK_WHY message from A2. Giving argument: item2, PRODUCTION_COST=VERY_GOOD
2022-04-15 04:22:14,087 - INFO - A2 >> Received argument from A1. Sending counter argument: not item2, ENVIRONMENT_IMPACT>PRODUCTION_COST and ENVIRONMENT_IMPACT=BAD
2022-04-15 04:22:14,088 - DEBUG - A1 >> Removed item2 from preferences. New preferences:
* Items: [item1]
* Criteria: ['PRODUCTION_COST', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'CONSUMPTION', 'PRODUCTION_COST', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'CONSUMPTION']
2022-04-15 04:22:14,088 - INFO - A1 >> Rejecting my proposal item2 because no counter argument
2022-04-15 04:22:14,088 - DEBUG - A2 >> Removed item2 from preferences. New preferences:
* Items: [item1]
* Criteria: ['ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'CONSUMPTION', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'CONSUMPTION', 'DURABILITY', 'NOISE']
2022-04-15 04:22:14,088 - INFO - A2 >> Received REJECT message from A1. Proposing item1 to A1
2022-04-15 04:22:14,089 - INFO - A1 >> Asking why item1 from A2
2022-04-15 04:22:14,089 - INFO - A2 >> Received ASK_WHY message from A1. Giving argument: item1, PRODUCTION_COST=VERY_GOOD
2022-04-15 04:22:14,089 - INFO - A1 >> Accepting proposal item1 from A2 because no counter argument
2022-04-15 04:22:14,089 - INFO - A2 >> Received ACCEPT message from A1. Committing item1
2022-04-15 04:22:14,089 - DEBUG - A2 >> Removed item1 from preferences. New preferences:
* Items: []
* Criteria: ['ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'CONSUMPTION', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'CONSUMPTION', 'DURABILITY', 'NOISE']
2022-04-15 04:22:14,089 - INFO - A1 >> Received COMMIT message from A2. Committing item1
2022-04-15 04:22:14,089 - DEBUG - A1 >> Removed item1 from preferences. New preferences:
* Items: []
* Criteria: ['PRODUCTION_COST', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'CONSUMPTION', 'PRODUCTION_COST', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'CONSUMPTION']
2022-04-15 04:22:14,090 - INFO - A2 >> No messages received. No items to propose.
Results:
        Winning agent: A2
        Winning item: item1
        Winning argument: item1, PRODUCTION_COST==VERY_GOOD

   sender receiver performative   item decision                    main_criterion            value            secondary_criterion
0      A1       A2      PROPOSE  item2     None                              None             None                           None
1      A2       A1      ASK_WHY  item2     None                              None             None                           None
2      A1       A2        ARGUE  item2      pro     CriterionName.PRODUCTION_COST  Value.VERY_GOOD                           None
3      A2       A1        ARGUE  item2      con  CriterionName.ENVIRONMENT_IMPACT        Value.BAD  CriterionName.PRODUCTION_COST
4      A1       A2       REJECT  item2     None                              None             None                           None
5      A2       A1      PROPOSE  item1     None                              None             None                           None
6      A1       A2      ASK_WHY  item1     None                              None             None                           None
7      A2       A1        ARGUE  item1      pro     CriterionName.PRODUCTION_COST  Value.VERY_GOOD                           None
8      A1       A2       ACCEPT  item1     None                              None             None                           None
9      A2       A1       COMMIT  item1     None                              None             None                           None
10     A1     None       COMMIT  item1     None                              None             None                           None
(base) nouamane@NOUAMANE_LAPTOP:~/projects/algo/agent-modeling/argumentation$ 
```

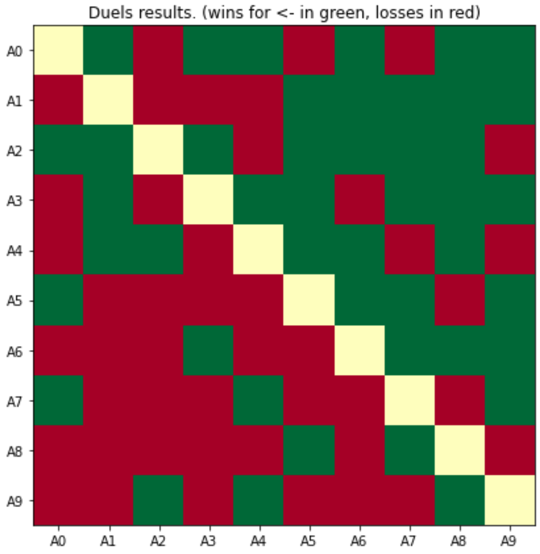
Example with alternative item proposal:



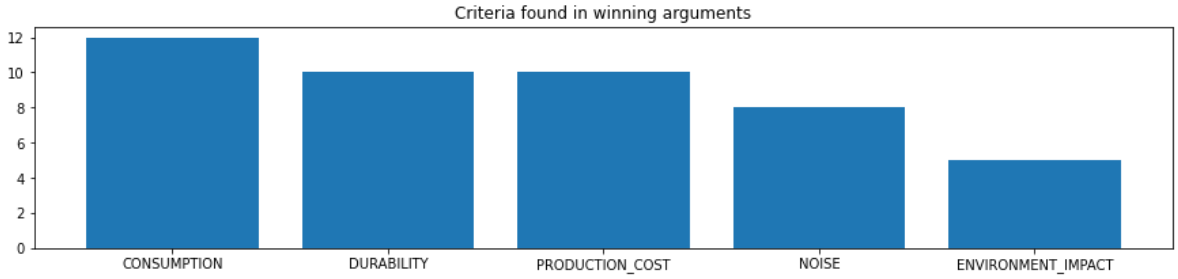
```
(base) nouamane@NOUAMANE_LAPTOP:~/projects/algo/agent-modeling/argumentation$ python pw_argumentation.py

Agent 1 preferences:
       CONSUMPTION  NOISE  ENVIRONMENT_IMPACT  PRODUCTION_COST  DURABILITY
item1            2      0                   3                1           0
item2            3      4                   4                2           2
----------------------------------------------------------------------------------------------------
Agent 2 preferences:
       NOISE  ENVIRONMENT_IMPACT  PRODUCTION_COST  CONSUMPTION  DURABILITY
item1      3                   1                4            4           0
item2      3                   4                4            1           2
----------------------------------------------------------------------------------------------------
2022-04-15 04:26:17,358 - INFO - A1 >> No messages received. Proposing item2 to A2
2022-04-15 04:26:17,359 - INFO - A2 >> Asking why item2 from A1
2022-04-15 04:26:17,359 - INFO - A1 >> Received ASK_WHY message from A2. Giving argument: item2, CONSUMPTION=GOOD
2022-04-15 04:26:17,359 - INFO - A2 >> Received argument from A1. Sending counter argument:  item1, CONSUMPTION=VERY_GOOD
2022-04-15 04:26:17,359 - INFO - A1 >> Accepting proposal item1 from A2 because no counter argument
2022-04-15 04:26:17,359 - INFO - A2 >> Received ACCEPT message from A1. Committing item1
2022-04-15 04:26:17,359 - DEBUG - A2 >> Removed item1 from preferences. New preferences:
* Items: [item2]
* Criteria: ['NOISE', 'ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'CONSUMPTION', 'DURABILITY', 'NOISE', 'ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'CONSUMPTION', 'DURABILITY']
2022-04-15 04:26:17,359 - INFO - A1 >> Received COMMIT message from A2. Committing item1
2022-04-15 04:26:17,359 - DEBUG - A1 >> Removed item1 from preferences. New preferences:
* Items: [item2]
* Criteria: ['CONSUMPTION', 'NOISE', 'ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'DURABILITY', 'CONSUMPTION', 'NOISE', 'ENVIRONMENT_IMPACT', 'PRODUCTION_COST', 'DURABILITY']
2022-04-15 04:26:17,360 - INFO - A2 >> No messages received. Proposing item2 to A1
Results:
        Winning agent: A2
        Winning item: item1
        Winning argument: item1, CONSUMPTION==VERY_GOOD

  sender receiver performative   item decision            main_criterion            value secondary_criterion
0     A1       A2      PROPOSE  item2     None                       None             None                None
1     A2       A1      ASK_WHY  item2     None                       None             None                None
2     A1       A2        ARGUE  item2      pro  CriterionName.CONSUMPTION       Value.GOOD                None
3     A2       A1        ARGUE  item1      pro  CriterionName.CONSUMPTION  Value.VERY_GOOD                None
4     A1       A2       ACCEPT  item1     None                       None             None                None
5     A2       A1       COMMIT  item1     None                       None             None                None
6     A1     None       COMMIT  item1     None                       None             None                None
7     A2       A1      PROPOSE  item2     None                       None             None                None
(base) nouamane@NOUAMANE_LAPTOP:~/projects/algo/agent-modeling/argumentation$ 
```

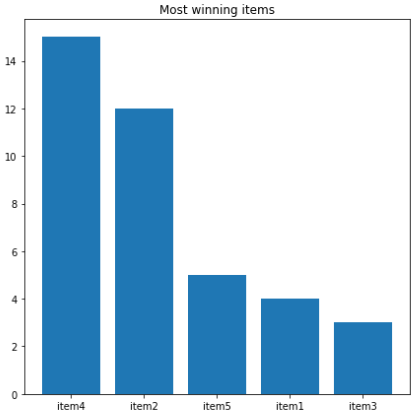
Experiments:
We set up 10 agents with random opinions about 5 items, and we simulate negotiations between each pair of agents. The simulation can be found in the file `experiments.ipynb.` We find that for our experiment Item4 was the most winning item, and the winning argument was CONSUMPTION. While the winning agent is A2. We notice that CONSUMPTION is the most important criterion for A2.

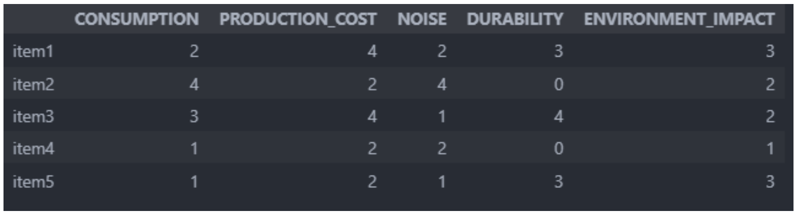




	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9
A0	🟨	🟩	🟥	🟩	🟩	🟥	🟩	🟥	🟩	🟩
A1	🟥	🟨	🟥	🟥	🟥	🟩	🟩	🟩	🟩	🟩
A2	🟩	🟩	🟨	🟩	🟥	🟩	🟩	🟩	🟩	🟥
A3	🟥	🟩	🟥	🟨	🟩	🟩	🟥	🟩	🟩	🟩
A4	🟥	🟩	🟩	🟥	🟨	🟩	🟩	🟥	🟩	🟥
A5	🟩	🟥	🟥	🟥	🟥	🟨	🟩	🟩	🟥	🟩
A6	🟥	🟥	🟥	🟩	🟥	🟥	🟨	🟩	🟩	🟩
A7	🟩	🟥	🟥	🟥	🟩	🟥	🟥	🟨	🟥	🟩
A8	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟩	🟨	🟥
A9	🟥	🟥	🟩	🟥	🟩	🟥	🟥	🟥	🟩	🟨







	CONSUMPTION	PRODUCTION_COST	NOISE	DURABILITY	ENVIRONMENT_IMPACT
item1	2	4	2	3	3
item2	4	2	4	0	2
item3	3	4	1	4	2
item4	1	2	2	0	1
item5	1	2	1	3	3