ExpertOp4Grid

Release 0.1.BETA

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STARTING KIT

CHAPTER

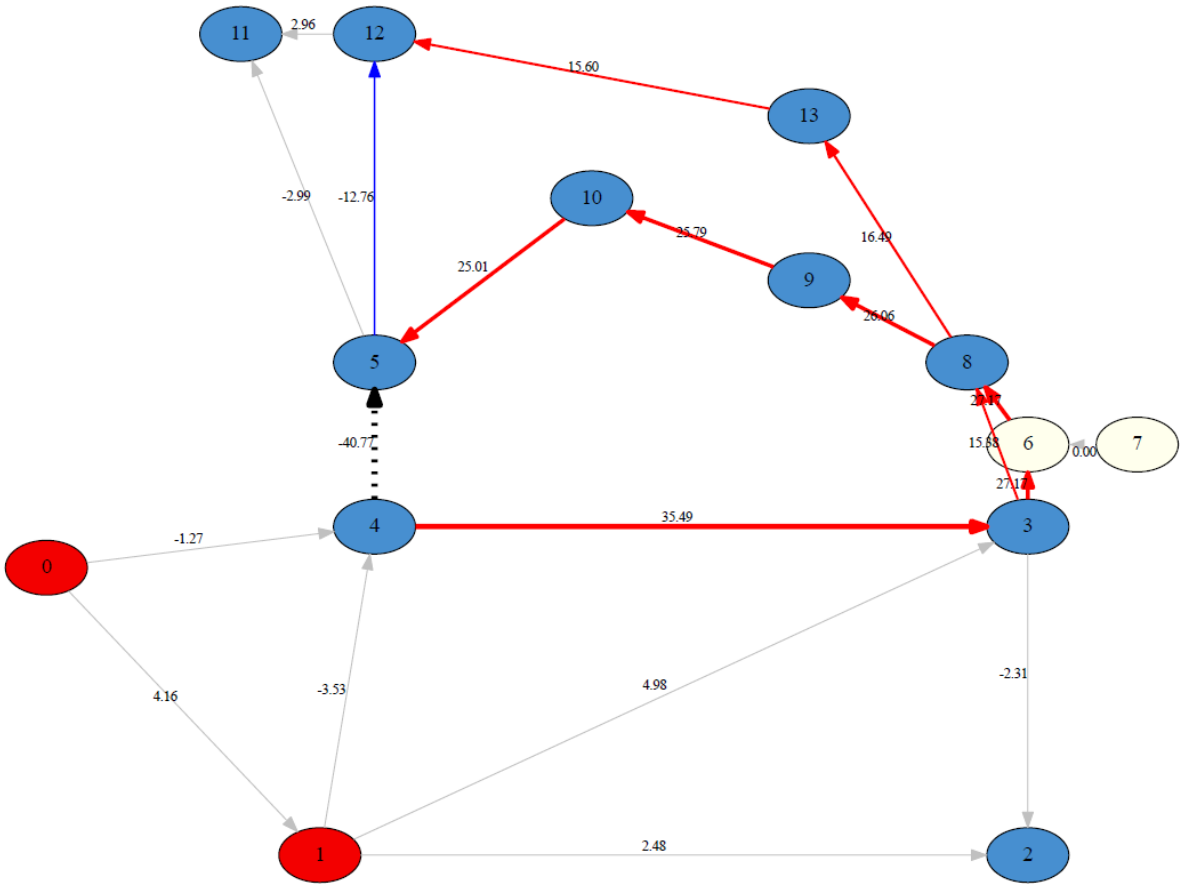
ONE

MENTIONS

1.1 Quick Overview

This is an Expert System which tries to solve a security issue on a power grid, that is on overload over a power line, when it happens. It uses cheap but non-linear topological actions to do so, and does not require any training. For any new overloaded situations, it computes an influence graph around the overload of interest, and rank the substations and topologies to explore, to find a solution. It simulates the top ranked topologies to eventually give a score of success:

4 - it solves all overloads, 3 - it solves only the overload of interest 2 - it partially solves the overload of interest 1 - it solves the overload of interest but worsen other overloads 0 - it fails. The expert agent is based It is an implementation of the paper: “Expert system for topological action discovery in smart grids” - https://hal.archives-ouvertes.fr/hal-01897931/file/_LARGE__bf_Expert_System_for_topological_remedial_action_discovery_in_smart_grids.pdf



Influence Graph example for overloaded line 4->5. The electrical paths highlighted there will help us identify interesting topologies to reroute the flows.

1.2 Features

- Analyse a power network when a line is in overflow
- Run simulations to understand the network constraints
- Return a ranking of topological actions that would solve the overflow, or reduce it
- If ran manually (through command line), can also output a series of graph to help visualise the state of the network

1.3 Contribute

- Issue Tracker: https://github.com/marota/ExpertOp4Grid/issues
- Source Code: https://github.com/marota/ExpertOp4Grid

1.4 Support

If you are having issues, please let us know. We have a discord located at: $discordlink

1.5 License

CHAPTER

TWO

INSTALLATION

To install ExpertOp4Grid and AlphaDeesp execute the following lines:

2.1 1. (Optional)(Recommended) if you want to run in manual mode, install graphviz

This is for neato package, it allows to transform a dot file into a pdf file.

Warning: It is important to install graphviz executables before python packages

First install executable

- On Linux

```
apt-get install graphviz
```

- On Windows, use package finder (equivalent of apt-get on Windows)

```
winget install graphviz
```

Then ensure that graphviz and neato are in the path. You often have to set it manually. For example on windows you can use the following command line:

```
setx /M path "%path%;'C:\Users\username\graphviz-2.38\release\bin"
```

Then you can move to python packages installation

2.2 2. Install the package from Pypi

```
pip install ExpertOp4Grid
```

2.3 3. (Optional) If you want to run simulation with pypownet instead of Grid2op:

- Clone pypownet somewhere else :

```
cd .. git clone https://github.com/MarvinLer/pypownet.git
```

- Install from within that folder:

```
python setup.py install --user
```

or

```
cd ExpertOp4Grid pipenv shell cd ../pypownet python setup.py install
```

2.4 4. (Optional) Compile and output the sphinx doc (this documentation)

Run `./docs/make.bat html`

CHAPTER

THREE

GETTING STARTED

3.1 Manual Mode

To execute in **manual mode**, type: `expertop4grid -l 9 -s 0 -c 0 -t 0`

–ltc | -l int
Integer representing the line to cut. For the moment, only one line to cut is handled

–snapshot | -s int
If 1, will generate plots of the different grid topologies managed by alphadeesp and store it in alphadeesp/ressources/output

–chronicscenario | -c string
Name of the folder containing the chronic scenario to consider By default, the first available folder will be chosen

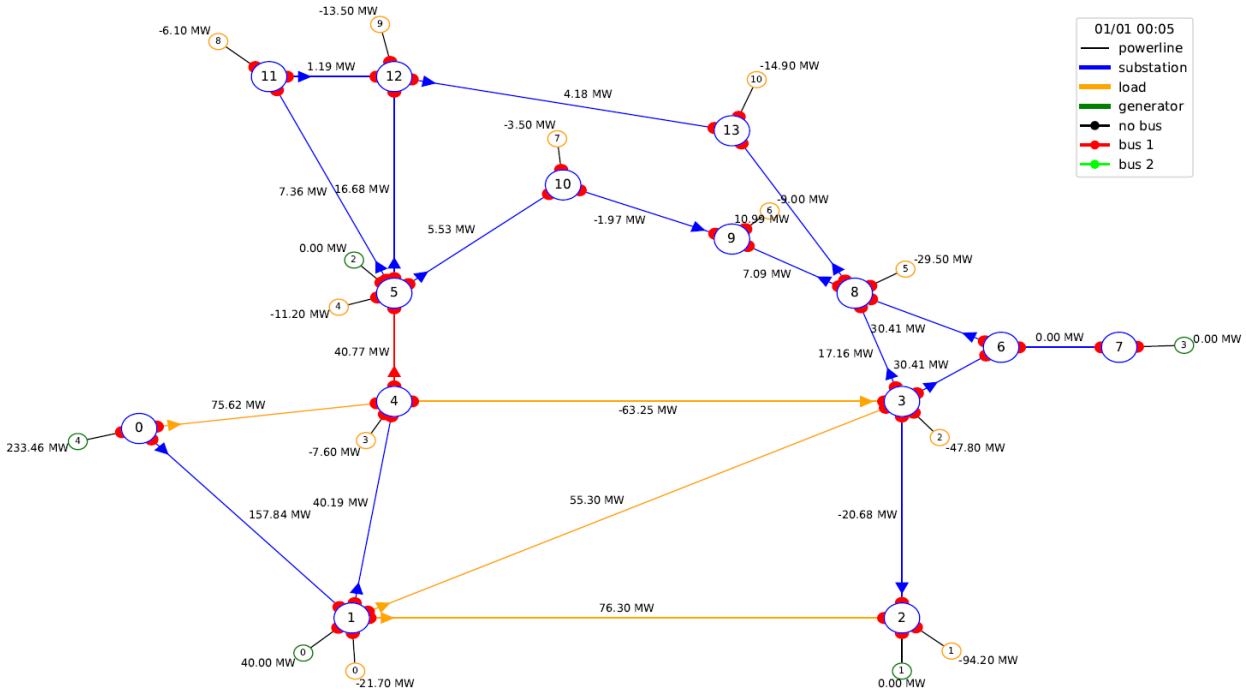
–timestep | -t int
Integer representing the timestep number at which we want to run alphadeesp simulation

–fileconfig | -f string
Path to .ini file that provides detailed configuration of the module. If none is provided, a default config.ini is provided in package

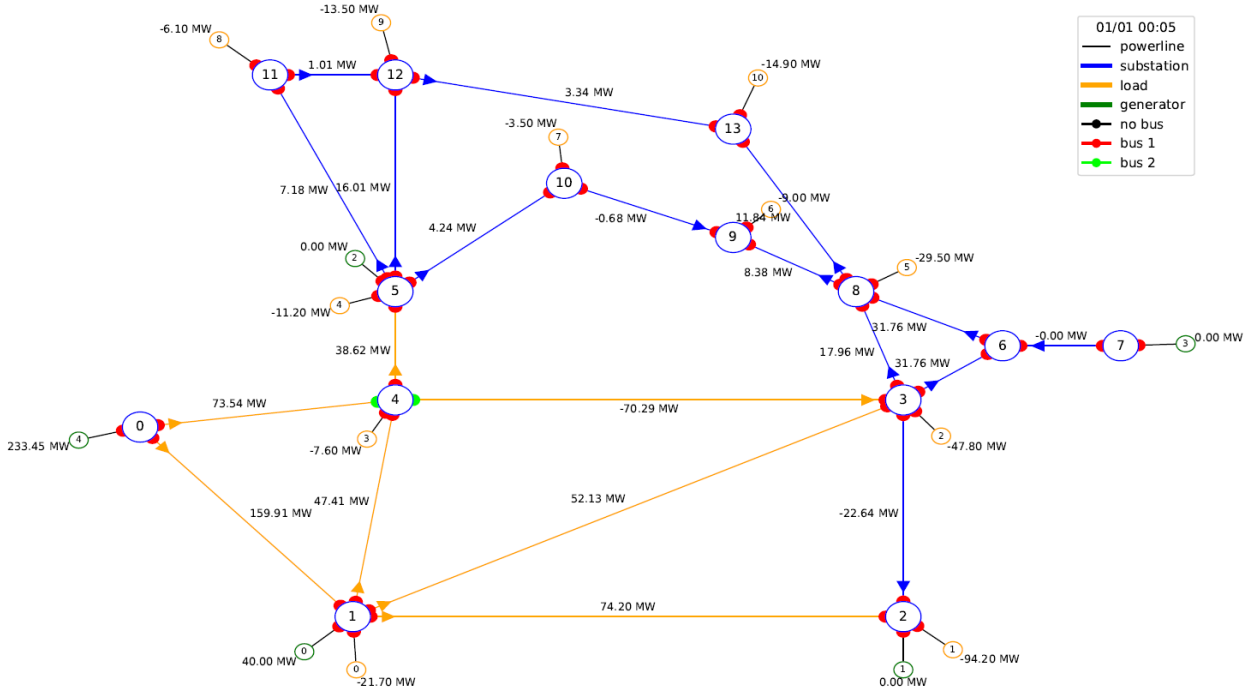
In any case, an end result dataframe is written in root folder.

If you run the same command with '-s 1' to print the plots, you will indeed see that:

- On the intial state, you had an overflow to solve



- The expert system indeed finds a solution topology for it at substation 4



See **Algorithm Description section** to learn more about the workflow and results.

In manual mode, further configuration is made through alphadeesp/config.ini

- *simulatorType* - you can chose Grid2op or Pypownet
- *gridPath* - path to folder containing files representing the grid. If no value is provided, a default grid will be loaded (l2rpn_2019) containing one chronic as a simple usecase example

- *outputPath* - path to write outputs in case snapshot mode is activated. If no path is provided, ExpertOp4Grid will write image results in the current working directory (folder named output/grid/linetocut/scenario/timestep)
- *CustomLayout* - list of couples reprenting coordinates of grid nodes. If not provided, grid2op will load grid_layout.json in grid folder
- *grid2opDifficulty* - "0", "1", "2" or "competition". Be careful: grid datasets should have a difficulty_levels.json
- *7 other constants for alphadeesp computation* can be set in config.ini, with comments within the file

3.2 Agent Mode

To execute in **agent mode**, please refer to ExpertAgent available in l2rpn-baseline repository

https://github.com/mjothy/l2rpn-baselines/tree/mj-devs/l2rpn_baselines/ExpertAgent

Instead of configuring through config.ini, you can pass a similar python dictionary to the API

3.3 Tests

To launch the test suite in git repo: `pipenv run python -m pytest --verbose --continue-on-collection-errors -p no:warnings`

3.4 Debug Help

- To force specific hubs

in AlphaDeesp.compute_best_topo() function, one can force override the hubs result. Check in code, there are commented examples.

- To force specific combinations for hubs

If one wants a specific hub, a user can "force" a specific node combination. Check in the code, there are commented examples

CHAPTER

FOUR

DESCRIPTION

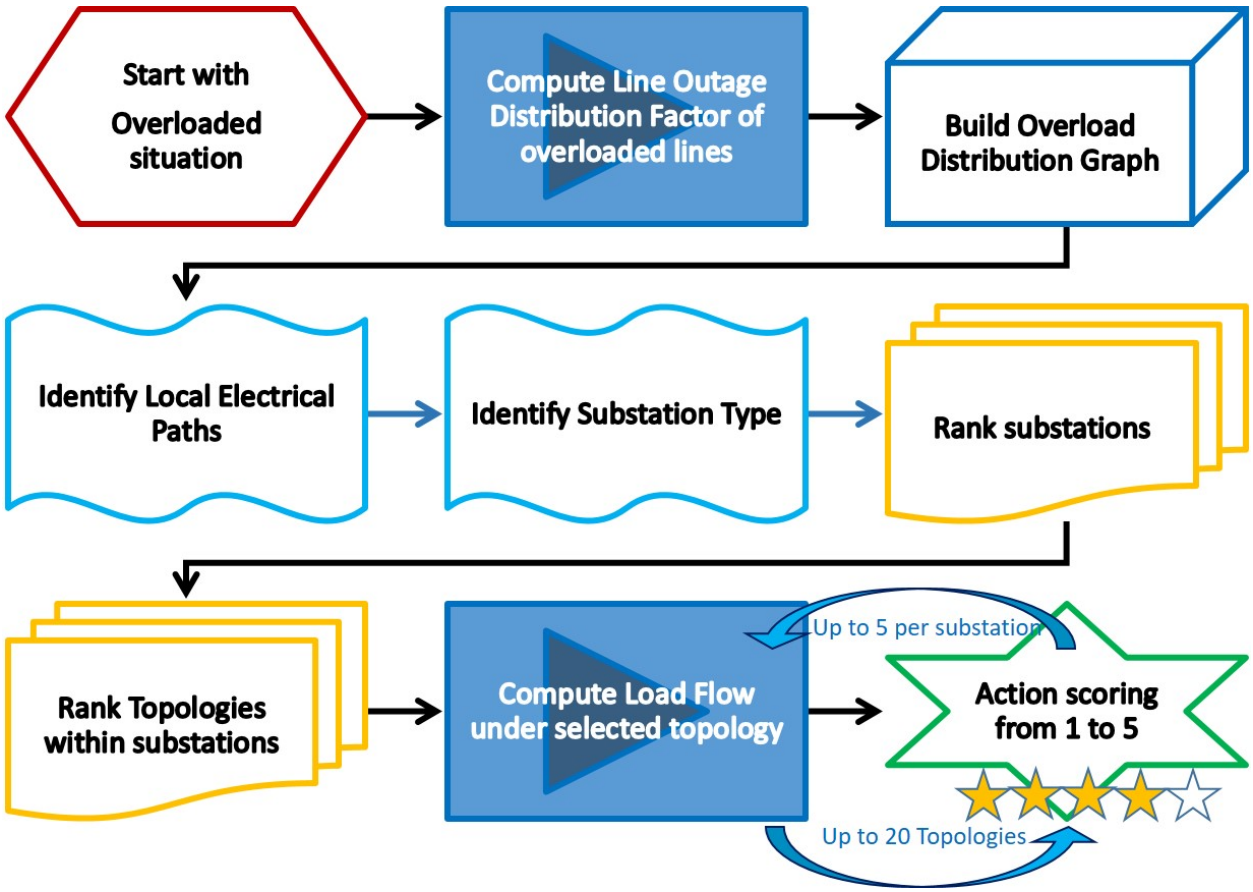
4.1 Introduction

This module represents an expert agent that finds solutions to optimize a power network. The expert agent is based on a research paper (https://hal.archives-ouvertes.fr/hal-01897931/file/_LARGE__bf_Expert_System_for_topological_remedial_action_discovery_in_smart_grids.pdf)

Given a power grid and a line in overflow (referred as *Line to cut*) the expert agent will run simulations on the network and try to find and rank the best topological actions (changing elements of the graph from one bus to the other) to hopefuly solve the overflow.

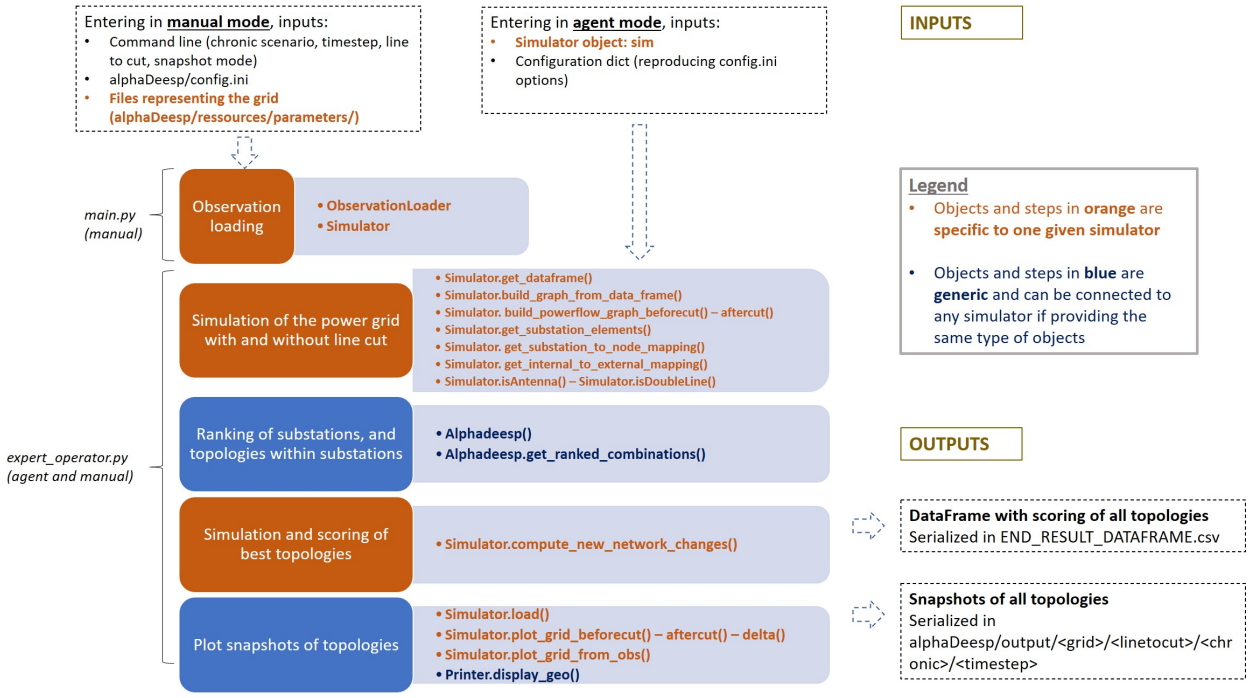
4.2 Workflow overview

We can decompose the Expert System algorithm along those successive steps. Based on the overload distribution graphs it builds, it tries to identify relevant patterns in it described by expert knowledge, to eventually find good spots to reroute the flows. It ranks those substations apriori by relevance and then test them by simulation to get a final score of sucess. Notice that 2 of those steps involves running simulations: it indeed relies on a simulator backend to work.



4.3 Workflow implementation

The following picture shows an overview of the different inputs and outputs, and of the major modelisation steps.



Whether entering in manual mode or agent mode, different sets of inputs are provided.

Objects and steps in orange are specific to one given simulator. Two objects are manipulated as such

- ObservationLoader object
- Simulator object

See examples of implementation with Grid2op simulations and Pypownet simulations, in following scripts

- alphaDeesp/core/grid2op/Grid2opObservationLoader.py
- alphaDeesp/core/grid2op/Grid2opSimulation.py
- alphaDeesp/core/pypownet/PypownetObservationLoader.py
- alphaDeesp/core/pypownet/PypownetSimulation.py

It can be substituted by your favorite simulator if it provides the same interface methods and returns the same type of objects to be able to work with AlphaDeesp

4.4 Outputs of the process

When called, the main.py/expert_operator.py will return three objects : `ranked_combinations, expert_system_results, action`

4.4.1 ranked_combinations

This dict contains all topological configurations per node, sorted from best to worst by the simulation.

4.4.2 expert_system_results

The main dataframe presenting quantitative information for all simulated topologies

	overflow ID	Flows before	Flows after	Delta flows	Worsened line	Prod redispat	Load redispat	Internal Topo	Topology app	Substation ID	Rank Substati	Topology sco	Topology simu	Efficacity
0	9.0	40.76827239	-7.599999904	48.36827087	[6]	4.172348022	0.0	[0 0 1 1 1]	[2, 2, 2, 1, 1]	4.0	1.0	40.29	1.0	249.5369873046875
1	9.0	40.76827239	48.56959533	-7.801322937	[9]	0.832244873	0.0	[0 0 0 1 1]	[1, 2, 2, 1, 1]	4.0	1.0	39.02	0.0	-6.461189746856689
2	9.0	40.76827239	38.61765289	2.150619506	[]	0.011703491	0.0	[0 0 1 0 1]	[2, 1, 2, 1, 1]	4.0	1.0	36.76	4.0	2.2398364543914795
3	9.0	40.76827239	51.02397155	-10.25569915	[9]	1.266403198	0.0	[0 1 1 0 0]	[2, 1, 1, 2, 1]	4.0	1.0	31.42	0.0	-8.08720874786377
4	9.0	40.76827239	40.54862213	0.219650268	[]	0.128341674	0.0	[0 1 0 1 0]	[1, 2, 1, 2, 1]	4.0	1.0	29.16	2.0	0.2179497927427292
5	9.0	40.76827239	58.26204299	-17.49377059	[2, 3, 9]	3.677261352	0.0	[0 1 1 1 0]	[2, 2, 1, 2, 1]	4.0	1.0	27.89	0.0	-12.063469886779785
6	9.0	40.76827239	35.20425033	5.564022064	[2, 3]	12.35440063	3.051757812	[0 0 1 1 0]	[2, 2, 1, 1, 1]	4.0	1.0	4.8	1.0	6.346175193786621
7	9.0	40.76827239	35.53104782	5.237224578	[2, 3]	10.69894409	3.051757812	[0 1 0 0 1]	[1, 1, 2, 2, 1]	4.0	1.0	-2.8	1.0	5.9294657707214355
8	9.0	40.76827239	39.73901367	1.029258728	[]	0.482406616	0.0	[0 1 1 0 1]	[2, 1, 2, 2, 1]	4.0	1.0	-4.07	4.0	1.032004952430725
9	9.0	40.76827239	39.09959411	1.668678283	[2]	6.288818359	0.0	[0 1 0 1 1]	[1, 2, 2, 2, 1]	4.0	1.0	-6.33	1.0	1.7099021673202515
10	9.0	40.76827239	-2.886579864	40.76827239	[6]	4.380401611	3.051757812	[0 1 1 1 1 0]	[1, 2, 2, 2, 1, 2	5.0	1.0	51.96	1.0	227.79396057128906
11	9.0	40.76827239	26.34083175	14.42744064	[]	2.823684692	0.0	[0 1 1 0 1 0]	[1, 2, 1, 2, 1, 2	5.0	1.0	48.97	4.0	21.288515090942383
12	9.0	40.76827239	26.31589317	14.45237922	[]	2.134414672	0.0	[0 0 0 1 0 1]	[2, 1, 2, 1, 1, 1	5.0	1.0	48.97	4.0	22.668455123901367
13	9.0	40.76827239	11.19999980	29.56827163	[6]	1.916412353	3.051757812	[0 0 1 1 1 0]	[1, 2, 2, 2, 1, 1	5.0	1.0	40.76	1.0	85.57772064208984
14	9.0	40.76827239	11.19999980	29.56827163	[6]	1.508529663	0.0	[0 1 0 0 0 1]	[2, 1, 1, 1, 1, 2	5.0	1.0	40.76	1.0	88.72957611083984
15	9.0	40.76827239	33.15359497	7.614677429	[]	1.147979736	0.0	[0 0 1 0 0 1]	[2, 2, 1, 1, 1, 1	5.0	1.0	39.2	4.0	9.455564498901367
16	9.0	40.76827239	33.20746231	7.560810089	[]	1.556594848	0.0	[0 1 0 1 1 0]	[1, 1, 2, 2, 1, 2	5.0	1.0	39.2	4.0	8.970056533813477
17	9.0	40.76827239	30.30297851	10.46529388	[]	1.000579833	3.051757812	[0 1 0 1 0 1]	[2, 1, 2, 1, 1, 2	5.0	1.0	37.77	4.0	13.942999839782715
18	9.0	40.76827239	30.53277587	10.23549652	[]	1.159561157	0.0	[0 0 1 0 1 0]	[1, 2, 1, 2, 1, 1	5.0	1.0	37.77	4.0	13.114059448242188
19	9.0	40.76827239	30.41880989	10.34946250	[]	0.856185913	0.0	[0 0 1 1 0 1]	[2, 2, 2, 1, 1, 1	5.0	1.0	36.21	4.0	13.747495651245117
20	9.0	40.76827239	32.24527359	8.522998809	[]	2.054061889	0.0	[0 0 1 1]	[2, 2, 1, 1]	12.0	1.0	29.1	4.0	10.400897026062012
21	9.0	40.76827239	42.20376968	-1.435497283	[]	0.972579956	0.0	[0 1 1 0]	[2, 1, 2, 1]	12.0	1.0	16.46	0.0	-1.3525135517120361
22	9.0	40.76827239	40.05780029	0.710472106	[]	0.038024902	0.0	[0 1 0 1]	[1, 2, 2, 1]	12.0	1.0	15.6	2.0	0.7036463022232056

- Simulated flows on the target line (line to cut) before and after topological actions is operated. The delta flow is the difference between both of them
- Worsened lines: new lines that got overloaded or initially overloaded lines which overload increased
- Redispatched Prod: sum of all the production increase or decrease at each generator
- Redispatched Load: difference between the total demand and the actual power supply in all loads (production - losses)
- Internal Topology applied: topology list as used in AlphaDeesp. Represents the bus of each element at the substation (column Substation ID)
- Topology applied: topology list as used in the simulator. Represents the bus of each element at the substation (column Substation ID)
- Substation ID: ID of the substation on which the toology is applied
- Topology score: quantitative score returned by Alphadeesp for this topology
- Topology simulated score: integer score (from 0 to 4) given by the simulator when computing powerflow on the grid after applying the topology
- Efficacity: flexible quantitative score to be returned by the simulator. It can for instance take into account the reward after applying the topological action

In manual mode, if option –snapshot is set to 1, plots of all simulated topos graphs are generated to dig into their consequences on the grid powerflow distribution. Plot names are meant to facilitate links between the snapshot and its correspondign line in the dataframe. See plots in the following didactic example.

4.4.3 action

This list contains all actions (generated by and for the chosen backend) that represent the topological states chosen by Alphadeesp. Sorted from best to worst, they are a syntactic sugar to give users a direct action to apply to their network. It is still recommended to parse the main dataframe to understand better what solutions are available.

4.5 Didactic example

We launch the expert operator in manual mode on the grid l2rpn_2019, with the Grid2opSimulator, on scenario a, at first timestep. There is an overflow on line 9 (between substation 4 and 5), so we provide ltc = 9. We want to see snapshots of the grid.

- Command line

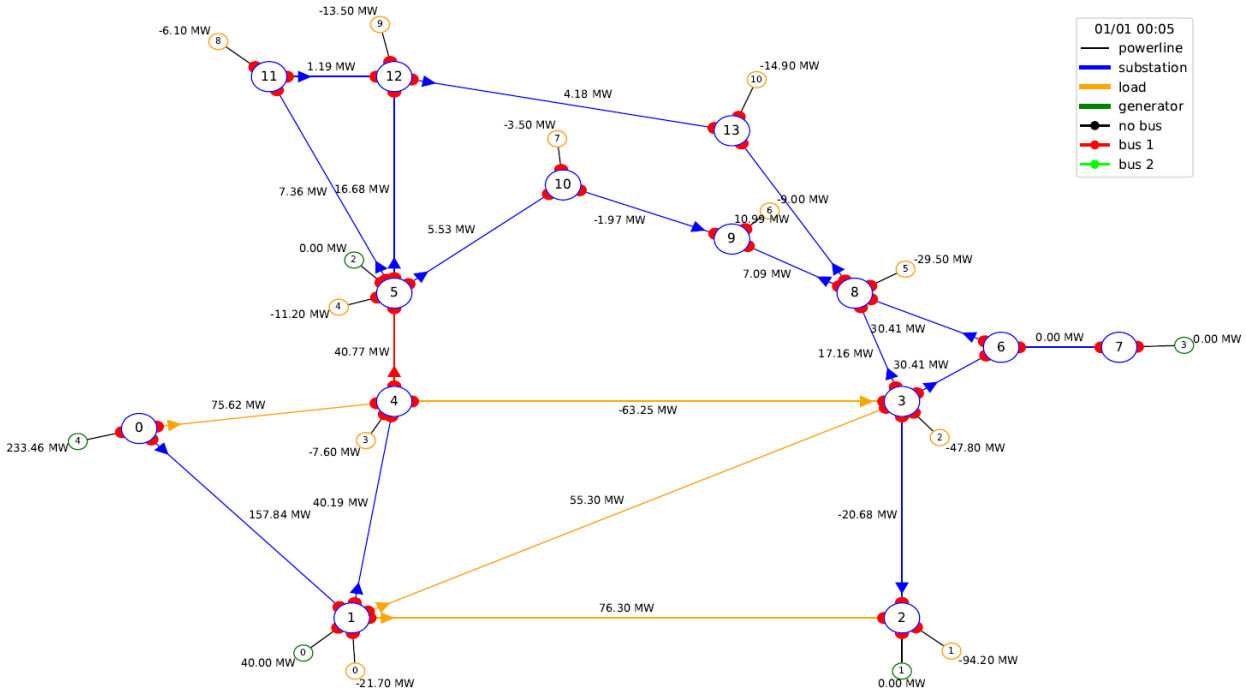
```
pipenv run python -m alphaDeesp.main -l 9 -s 0 -c 0 -t 0
```

- Beginning of config.ini

```
[DEFAULT]
# Simulator choice, either: "Pypownet" or "RTE"
simulatorType = Grid2OP
#simulatorType = Pypownet
#simulatorType = RTE

# Path to grid representation files
gridPath = ./alphaDeesp/ressources/parameters/l2rpn_2019
#gridPath = ./alphaDeesp/ressources/parameters/rte_case14_realistic
#gridPath = ./alphaDeesp/ressources/parameters/default14_static
```

- Layout of the grid in its current state (also called g_pow)



The simulator will then compute several objects to provide to AlphaDeesp, which will run a greedy algorithm to determine the best topological action to solve the overload. For more details, see the section *Algorithm Details*

- AlphaDeesp will then output a dataframe will all computed details about the best topologies found.

	overflow ID	Flows before	Flows after	Delta flows	Worsened line	Prod redispat	Load redispat	Internal Topo	Topology app	Substation ID	Rank Substati	Topology sco	Topology simi	Efficacity
0	9.0	40.76827239	-7.599999904	48.36827087	[6]	4.172348022	0.0	[0 0 1 1 1]	[2, 2, 2, 1, 1]	4.0	1.0	40.29	1.0	249.5369873046875
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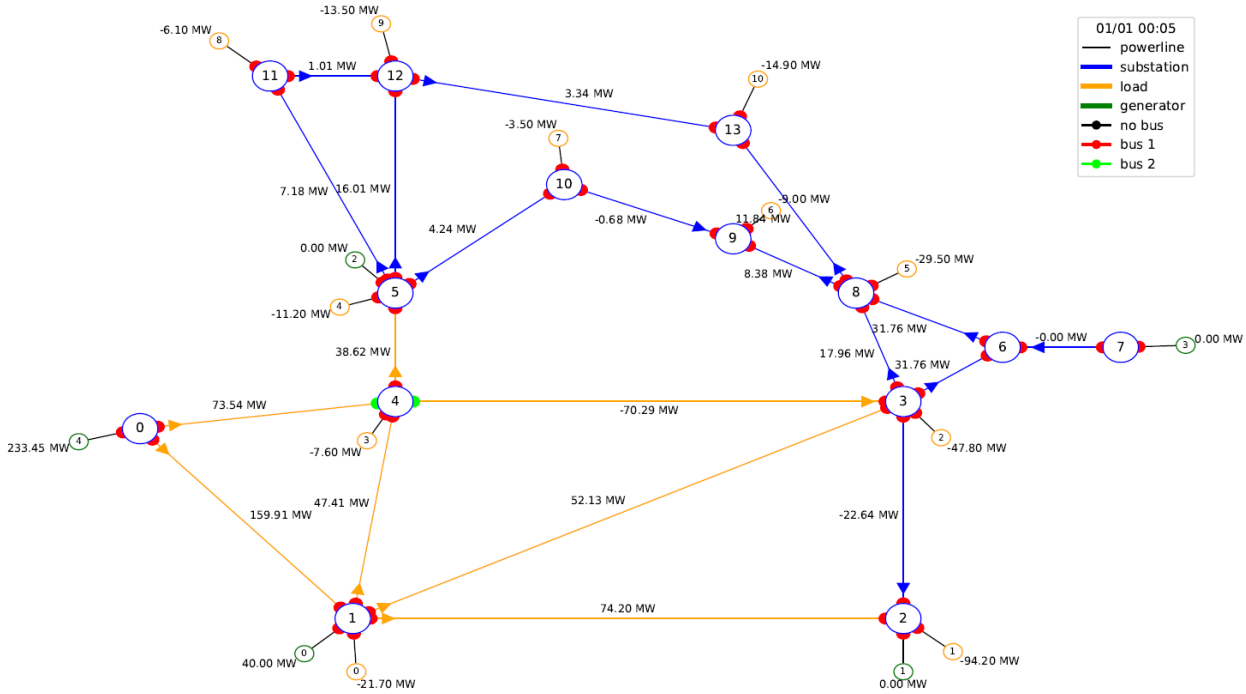
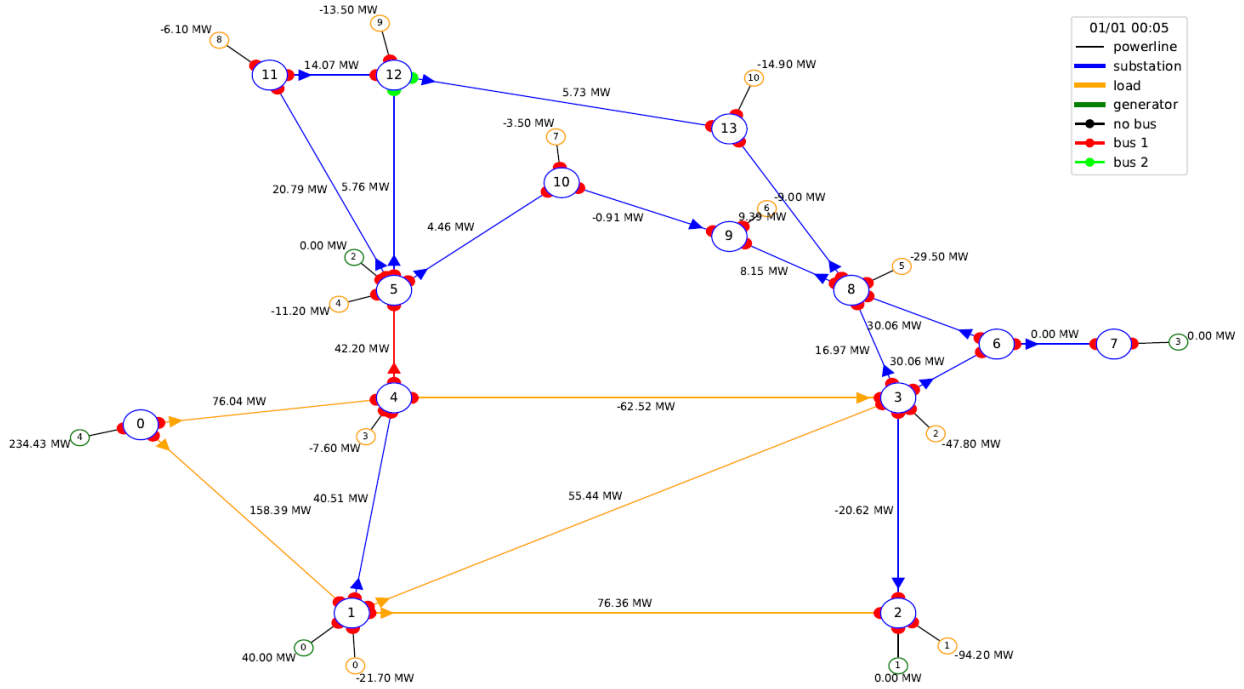
22	9.0	40.76827239	40.05780029	0.710472106	[]	0.038024902	0.0	[0 1 0 1]	[1, 2, 2, 1]	12.0	1.0	15.6	2.0	0.7036463022232056

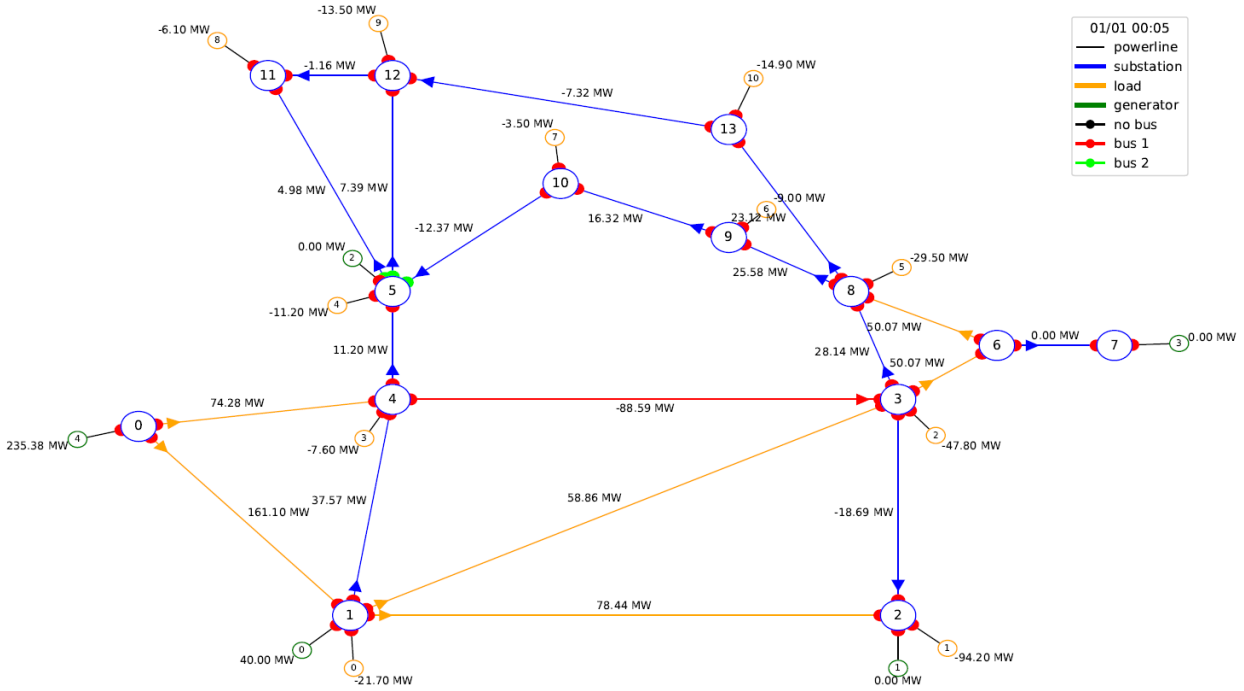
- The topology surrounded in green has got a 4 simulated score. We can see on the corresponding snapshot that it has resolved the overflow on line 9 by connected two lines to bus 1 at substation 4, which has divided the power flow in amount of line 9



- The topology surrounded in red has got a 0 simulated score. It does not resolve the power flow



- The topology surrounded in orange has got a 1 simulated score. It does resolved the power flow on line 9 but created an other one on an other line



4.6 Important limitations

- **For the moment, we allow cutting only one line when launching the expert system:**
  - ex python3 -m alphaDeesp.main -l 9
- The algorithm will only take the given timestep into account, meaning it will not try to learn from past or future behavior
- **Pypownet only** Only works with initial state of all nodes with busbar == 0
- **Pypownet only** At the moment, in the internal computation, a substation can have only one source of Power and one source of Consumption

CHAPTER

FIVE

ALPHADEESP ALGORITHM DETAILS

5.1 Call

Calling the alphaDeesp engine is done like so :

```
alphadeesp = AlphaDeesp(g_over, df_of_g, custom_layout, printer, simulator_data,
sim.substation_in_cooldown, debug = debug)              ranked_combinations = alphadeesp.
get_ranked_combinations()
```

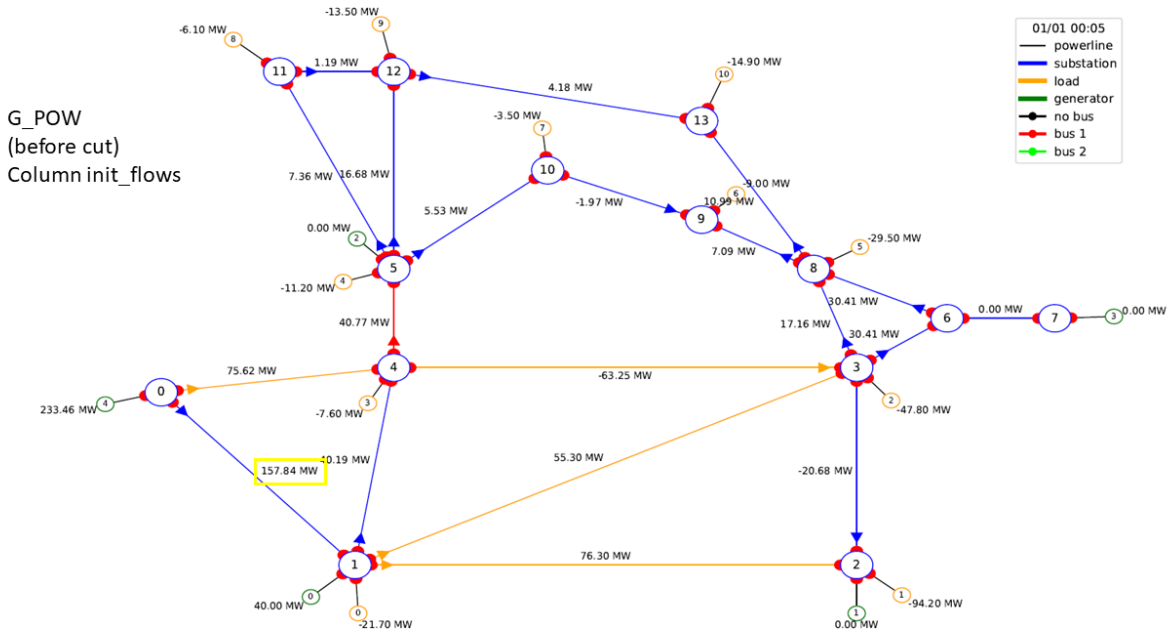
Alphadeesp hence gives you an oredered list of substations and topologies that should be relevant to solve your overload

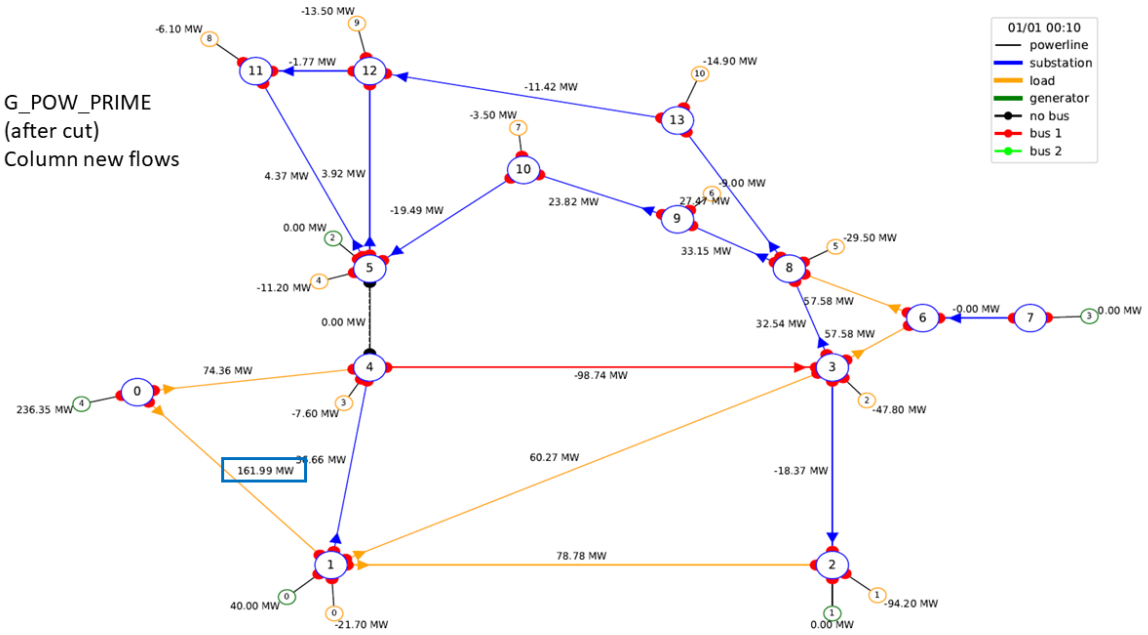
5.2 Inputs

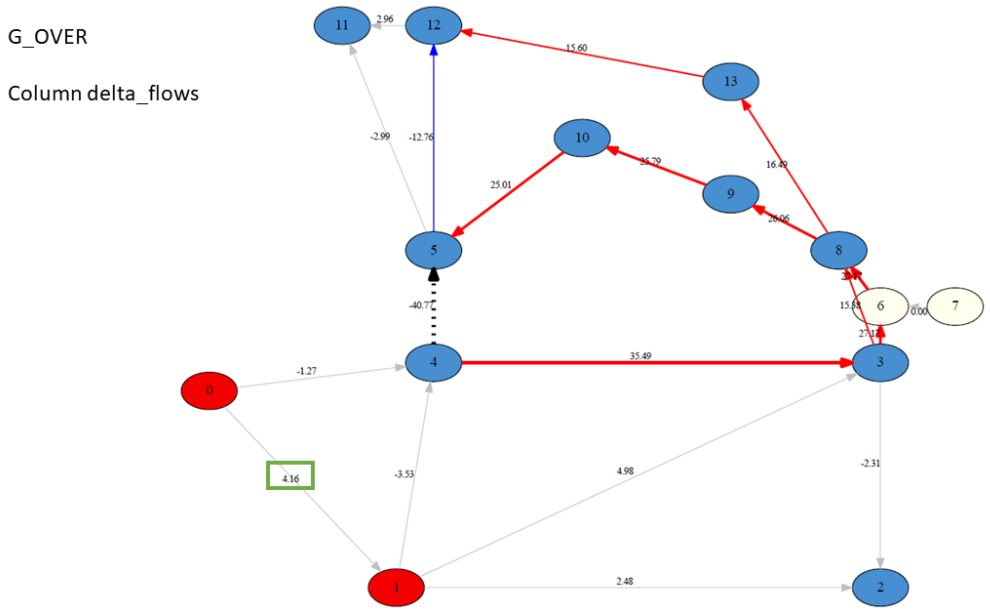
The following inputs will be required to be computed by the Simulation override.

- **g_over**
  A newtorkx graph representation of the grid with flow values
- **df_of_g**
  A dataframe representing a detailed view of the graph

idx_or	idx_ex	init_flows	swapped	new_flows	new_flows_swapped	delta_flows	gray_edges
0	1	157,836838	FAUX	161,994385	FAUX	4,157547	VRAI
0	4	75,6219482	FAUX	74,3562241	FAUX	-1,26572418	VRAI
1	2	76,3034973	FAUX	78,7802505	FAUX	2,47675323	VRAI
1	3	55,2951241	FAUX	60,2714195	FAUX	4,97629547	VRAI
1	4	40,1874847	FAUX	36,6566048	FAUX	-3,53087997	VRAI
3	2	20,6767883	VRAI	18,3699017	FAUX	-2,30688667	VRAI
4	3	63,2531548	VRAI	98,7436676	FAUX	35,4905128	FAUX
3	6	30,4084244	FAUX	57,5757179	FAUX	27,1672935	FAUX
3	8	17,162178	FAUX	32,5445709	FAUX	15,3823929	FAUX
4	5	40,7682724	FAUX	0	FAUX	-40,7682724	FAUX
5	12	16,6833191	FAUX	3,91919923	FAUX	-12,7641199	FAUX
5	11	7,35607958	FAUX	4,36635447	FAUX	-2,98972511	VRAI
10	5	5,52887249	FAUX	-19,4855537	VRAI	25,0144262	FAUX
7	6	0	FAUX	-1,7764E-14	VRAI	1,7764E-14	VRAI
6	8	30,4084244	FAUX	57,5757179	FAUX	27,1672935	FAUX
8	13	10,9850082	FAUX	27,4706421	FAUX	16,4856339	FAUX
8	9	7,08559322	FAUX	33,1496468	FAUX	26,0640535	FAUX
9	10	1,96642911	VRAI	-23,8234444	VRAI	25,7898735	FAUX
12	11	1,18748784	FAUX	-1,77053511	VRAI	2,95802295	VRAI
13	12	4,17812109	FAUX	-11,42062	VRAI	15,5987411	FAUX







- **custom_layout**
  The layout of the graph (list of (X,Y) coordinate for edges. Used for plotting.
- **printer**
  A printer service for logs and graphs
- **simulator_data**
  A dict composed of :
  - **substations_elements**

A local representation of the network from G_OVER (G_POW - G_POW_PRIME) using AlphaDeesp model objects from `network.py`

Each PRODUCTION or CONSUMPTION has the value of G_POW (the initial values)

Each ORIGINLINE or EXTREMITYLINE has the values of flow(G_POW) - flow(G_POW_PRIME)

{

0: [
PRODUCTION Object ID: 1, busbar_id: 0, value: 233.4587860107422 ,

ORIGINLINE Object ID: 1, busbar_id: 0, connected to substation: 1, flow_value: [4.16] ,

ORIGINLINE Object ID: 2, busbar_id: 0, connected to substation: 4, flow_value: [-1.27]],

1: [
PRODUCTION Object ID: 2, busbar_id: 0, value: 40.0 ,

CONSUMPTION Object ID: 1, busbar_id: 0, value: 21.700000762939453 ,

ORIGINLINE Object ID: 3, busbar_id: 0, connected to substation: 2, flow_value: [2.48] ,

ORIGINLINE Object ID: 4, busbar_id: 0, connected to substation: 3, flow_value: [4.98] ,

ORIGINLINE Object ID: 5, busbar_id: 0, connected to substation: 4, flow_value: [-3.53] ,

EXTREMITYLINE Object ID: 1, busbar_id: 0, connected to substation: 0, flow_value: [4.16]],

2: [
PRODUCTION Object ID: 3, busbar_id: 0, value: 0.0 ,

CONSUMPTION Object ID: 2, busbar_id: 0, value: 94.19999694824219 ,

EXTREMITYLINE Object ID: 2, busbar_id: 0, connected to substation: 3, flow_value: [-2.31] ,

EXTREMITYLINE Object ID: 3, busbar_id: 0, connected to substation: 1, flow_value: [2.48]],

3: [
CONSUMPTION Object ID: 3, busbar_id: 0, value: 47.79999923706055 ,

EXTREMITYLINE Object ID: 4, busbar_id: 0, connected to substation: 4, flow_value: [35.49] ,

ORIGINLINE Object ID: 6, busbar_id: 0, connected to substation: 6, flow_value: [27.17] ,

ORIGINLINE Object ID: 7, busbar_id: 0, connected to substation: 8, flow_value: [15.38] ,

EXTREMITYLINE Object ID: 5, busbar_id: 0, connected to substation: 1, flow_value: [4.98] ,

ORIGINLINE Object ID: 8, busbar_id: 0, connected to substation: 2, flow_value: [-2.31]],

4: [
CONSUMPTION Object ID: 4, busbar_id: 0, value: 7.599999904632568 ,

ORIGINLINE Object ID: 9, busbar_id: 0, connected to substation: 5, flow_value: [-40.77] ,

EXTREMITYLINE Object ID: 6, busbar_id: 0, connected to substation: 0, flow_value: [-1.27] ,

EXTREMITYLINE Object ID: 7, busbar_id: 0, connected to substation: 1, flow_value: [-3.53] ,

ORIGINLINE Object ID: 10, busbar_id: 0, connected to substation: 3, flow_value: [35.49]],

5: [
PRODUCTION Object ID: 4, busbar_id: 0, value: 0.0 ,

CONSUMPTION Object ID: 5, busbar_id: 0, value: 11.199999809265137 ,

ORIGINLINE Object ID: 11, busbar_id: 0, connected to substation: 12, flow_value: [-12.76] ,

ORIGINLINE Object ID: 12, busbar_id: 0, connected to substation: 11, flow_value: [-2.99] ,

EXTREMITYLINE Object ID: 8, busbar_id: 0, connected to substation: 10, flow_value: [25.01] ,

EXTREMITYLINE Object ID: 9, busbar_id: 0, connected to substation: 4, flow_value: [-40.77]],

6: [
EXTREMITYLINE Object ID: 10, busbar_id: 0, connected to substation: 7, flow_value: [0.0] ,

ORIGINLINE Object ID: 13, busbar_id: 0, connected to substation: 8, flow_value: [27.17] ,

EXTREMITYLINE Object ID: 11, busbar_id: 0, connected to substation: 3, flow_value: [27.17]],

7: [
PRODUCTION Object ID: 5, busbar_id: 0, value: 0.0 ,

ORIGINLINE Object ID: 14, busbar_id: 0, connected to substation: 6, flow_value: [0.0]],

8: [
CONSUMPTION Object ID: 6, busbar_id: 0, value: 29.5 ,

ORIGINLINE Object ID: 15, busbar_id: 0, connected to substation: 13, flow_value: [16.49] ,

ORIGINLINE Object ID: 16, busbar_id: 0, connected to substation: 9, flow_value: [26.06] ,

EXTREMITYLINE Object ID: 12, busbar_id: 0, connected to substation: 3, flow_value: [15.38] ,

EXTREMITYLINE Object ID: 13, busbar_id: 0, connected to substation: 6, flow_value: [27.17]],

9: [
CONSUMPTION Object ID: 7, busbar_id: 0, value: 9.0 ,

ORIGINLINE Object ID: 17, busbar_id: 0, connected to substation: 10, flow_value: [25.79] ,

EXTREMITYLINE Object ID: 14, busbar_id: 0, connected to substation: 8, flow_value: [26.06]],

10: [
CONSUMPTION Object ID: 8, busbar_id: 0, value: 3.5 ,

ORIGINLINE Object ID: 18, busbar_id: 0, connected to substation: 5, flow_value: [25.01] ,

EXTREMITYLINE Object ID: 15, busbar_id: 0, connected to substation: 9, flow_value: [25.79]],

11: [
CONSUMPTION Object ID: 9, busbar_id: 0, value: 6.099999904632568 ,

EXTREMITYLINE Object ID: 16, busbar_id: 0, connected to substation: 12, flow_value: [2.96] ,

EXTREMITYLINE Object ID: 17, busbar_id: 0, connected to substation: 5, flow_value: [-2.99]],

12: [
CONSUMPTION Object ID: 10, busbar_id: 0, value: 13.5 ,

EXTREMITYLINE Object ID: 18, busbar_id: 0, connected to substation: 13, flow_value: [15.6] ,

EXTREMITYLINE Object ID: 19, busbar_id: 0, connected to substation: 5, flow_value: [-12.76] ,

ORIGINLINE Object ID: 19, busbar_id: 0, connected to substation: 11, flow_value: [2.96]],

13: [
CONSUMPTION Object ID: 11, busbar_id: 0, value: 14.899999618530273 ,

EXTREMITYLINE Object ID: 20, busbar_id: 0, connected to substation: 8, flow_value: [16.49] ,

ORIGINLINE Object ID: 20, busbar_id: 0, connected to substation: 12, flow_value: [15.6]]

}

- `substation_to_node_mapping`
- **`internal_to_external_mapping`**
  A dict linking the substation ids from substations_elements (internal) to the observation substations (external)

```
substation_list =  [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]
internal to external mapping
{0: 1,
 1: 2,
 2: 3,
 3: 4,
 4: 5,
 5: 6,
 6: 7,
 7: 8,
 8: 9,
 9: 10,
 10: 11,
 11: 12,
 12: 13,
 13: 14}
external to internal mapping
{1: 0,
 2: 1,
 3: 2,
 4: 3,
 5: 4,
 6: 5,
 7: 6,
 8: 7,
 9: 8,
 10: 9,
 11: 10,
 12: 11,
 13: 12,
 14: 13}
```

- **substation_in_cooldown**
  List of substation that are in cooldown
- **debug**
  Boolean flag for debugging purposes

5.3 Outputs

The alphaDeesp object then provides a list : `ranked_combinations`

This is a list of dataframes with the following columns :

- **score**
  the score of the topology from 0(worst) to 4(best)
- **topology**
  An array of integers (bus_ids) showing the topology of a node
- **node**
  The node on which the topology was applied

5.4 Simulating AlphaDeesp suggestions

This ranked_combinations list is then used to simulate all topologies with the Simulation override : `expert_system_results, actions = sim.compute_new_network_changes(ranked_combinations)`

You eventually know which selected topologies are indeed successful.

5.5 Last Note

AlphaDeesp substation and topology rankings could be improved to make the selection of actions always more relevant and efficient.