Modeling of a power system for RL

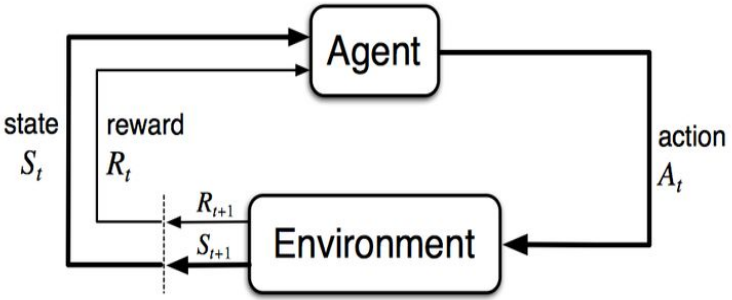


Fig. 1 - *Reinforcement Learning interaction loop*

Observation: flows, productions, consumptions, power grid topology, month, day, hour, etc

Action: connect/disconnect **one** transmission line **or** change the electrical configuration within a substation

Reward: penalize overflowed lines, distance to reference grid topology, number of disconnected loads/prods, etc.

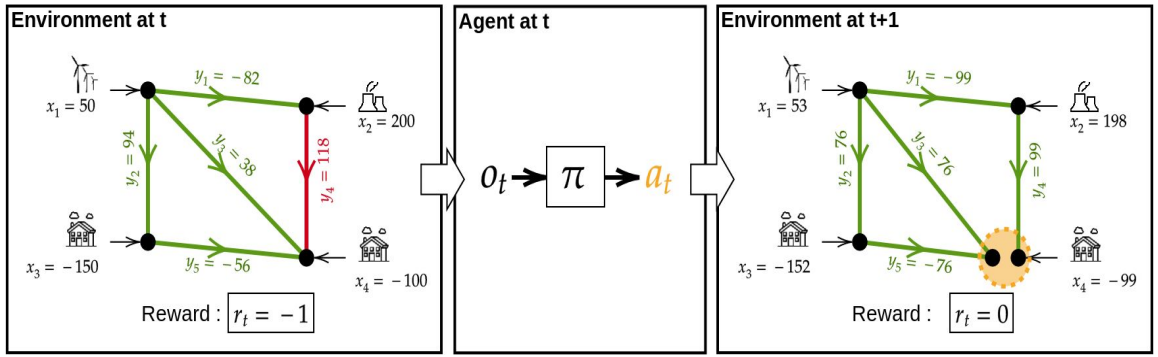


Fig. 2 - *Step-by-step evolution of the RL environment*

Ref:https://docs.google.com/presentation/d/1h8wsIakp-sBPy_TBdry58DaBLpk_RdWFDrFMizUWbOA/edit#slide=id.g55afcc5738_3_84

Interesting RL problem

- A **state space** described by both **continuous** variables (flows in lines) and **discrete** variables (line interconnection patterns).

- A **discrete combinatorial action space** (change in line interconnection patterns).

- **Stochastic components** in the environment as obstacles:
  - Scheduled operations on the grid (maintenance)
  - Random variations in injections due e.g. to weather conditions (changing loads and productions)
  - Unpredictable incidents (lines broken by a thunderstorm).

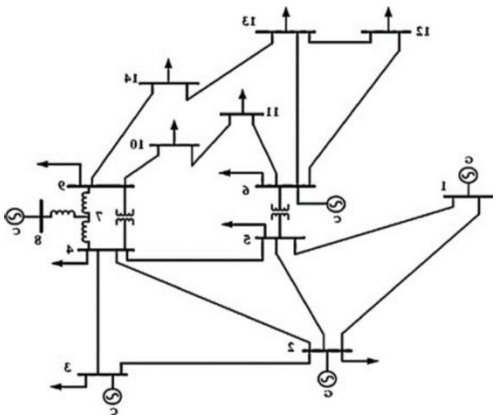
- **Various reward models** created to adjust the game difficulty level & curriculum.

- A real-world problem with high safety and **robustness** requirements

Ref: https://docs.google.com/presentation/d/1h8wsIakp-sBPy_TBdry58DaBLpk_RdWFDrFMizUWbOA/edit#slide=id.g55afcc5738_3_84

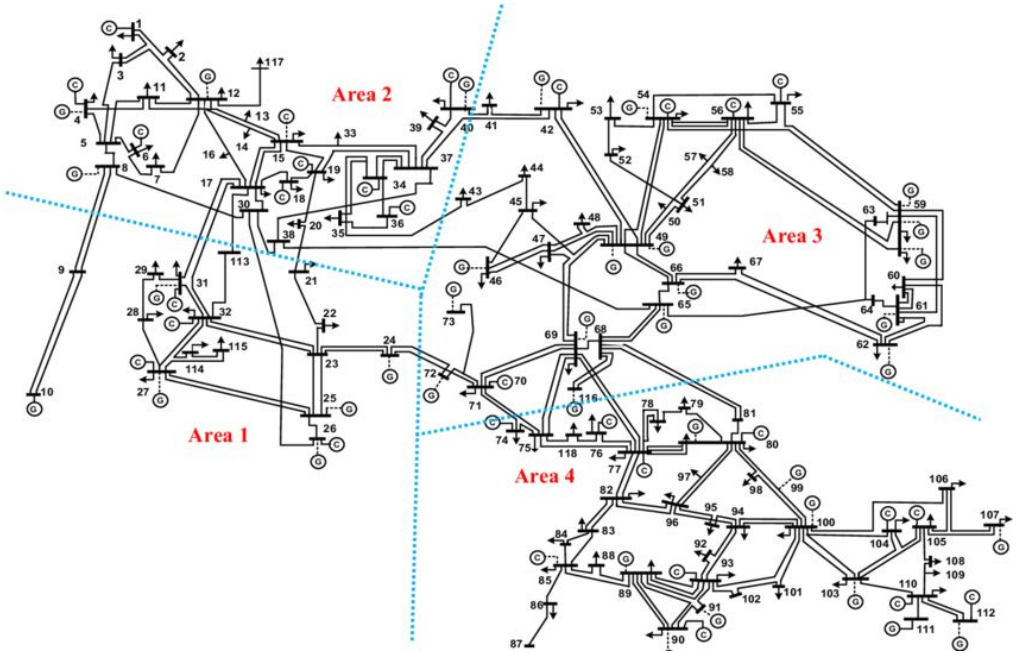
Setting the environment: Grids for L2RPN

Open-source cases
from Matpower library



IEEE 14

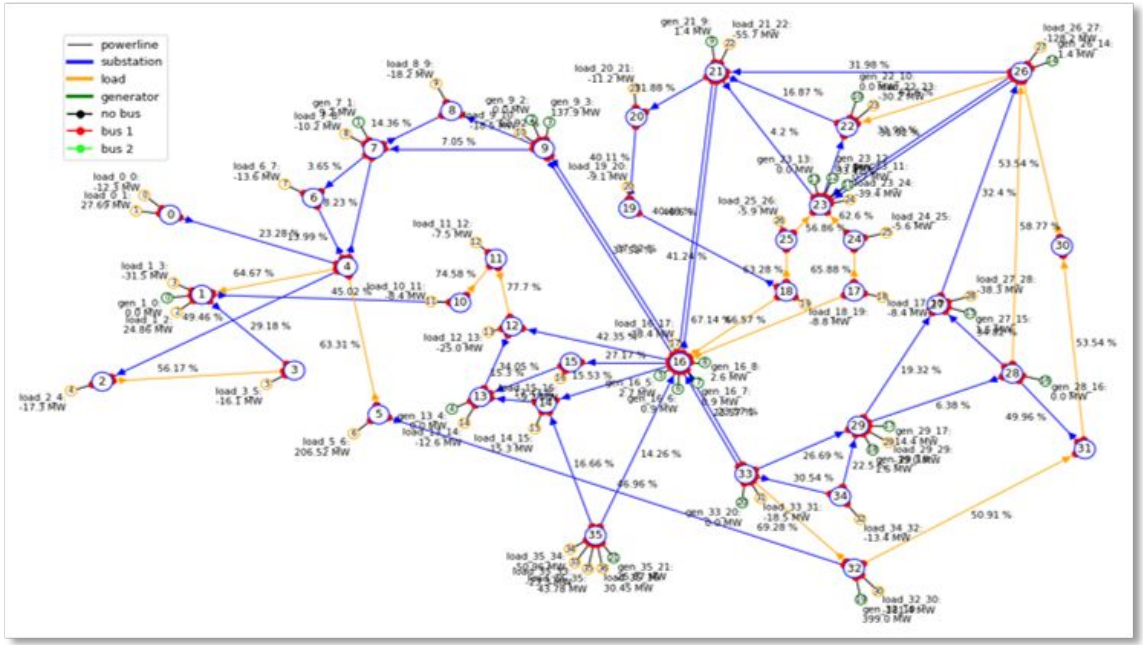
With associated line capacities



IEEE 118
(California power grid)

Ref: https://docs.google.com/presentation/d/1h8wsIakp-sBPy_TBdry58DaBLpk_RdWFDrFMizUWbOA/edit#slide=id.g55afcc5738_3_84

Track1 : Robustness Track



An adversarial opponent will attack some lines of the grid everyday randomly.

- **Goal:** Develop agent to be robust to unexpected events and keep delivering reliable electricity everywhere even in difficult circumstances.

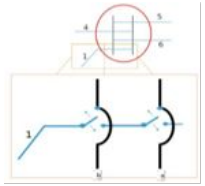
- **Operation Cost:** Operate the grid as long as possible, minimize the operation cost including power lines losses, redispatch cost and blackout cost (penalty).

Ref: https://github.com/lujasone/NeurIPS_2020_L2RPN_Comp_An_Approach/blob/main/NeurIPS-competition_winnning_apprach.pdf

Action

Do-Nothing action

Powerline Status action: reconnecting / disconnecting a power line



Substation Topological action: switching busbar connection between double busbars for each substation object.

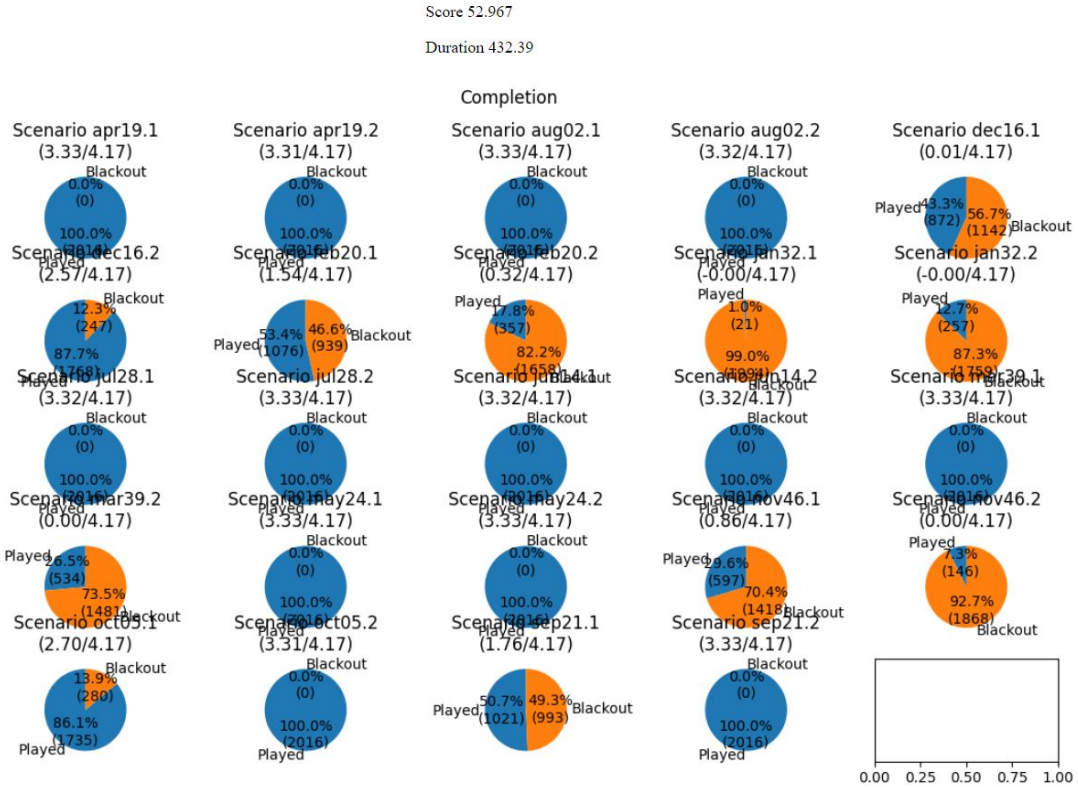
Generation redispatch action: modifying the production set point with redispatching

Ref: https://github.com/lujasone/NeurIPS_2020_L2RPN_Comp_An_Approach/blob/main/NeurIPS-competition_winnning_apprach.pdf

Reward:

- Done & game over : -210
- Done & not game overt : + 500
- Not done : $\sum$ (2 - max_rho (1 if max_rho < 0.95 else 2)

Results



- 50-year simulated training data and 24-week test data.
- Blue indicates scenarios passed,orange indicates scenarios black-out.
- We will optimize our agent for the failed cases in future work.