NeurIPS 2020 L2RPN Robustness and Adaptability Tracks Competition Winning Approach

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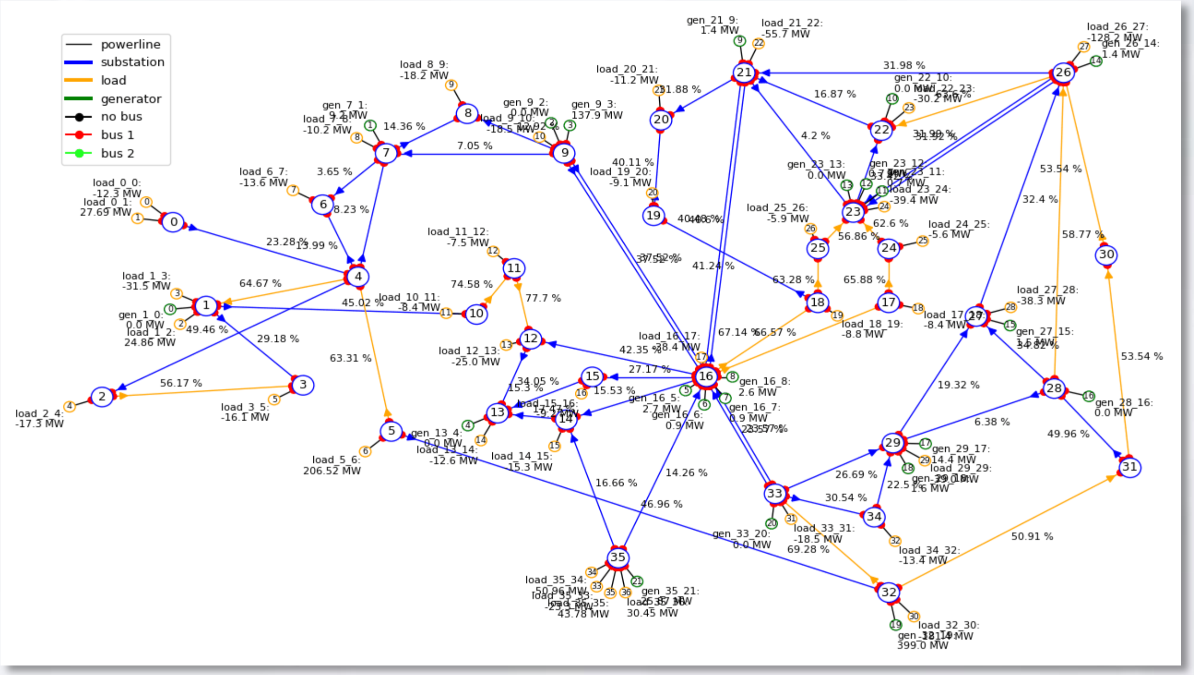
Track1 : Robustness Track

Problem description

Methodology

Tricks

Results

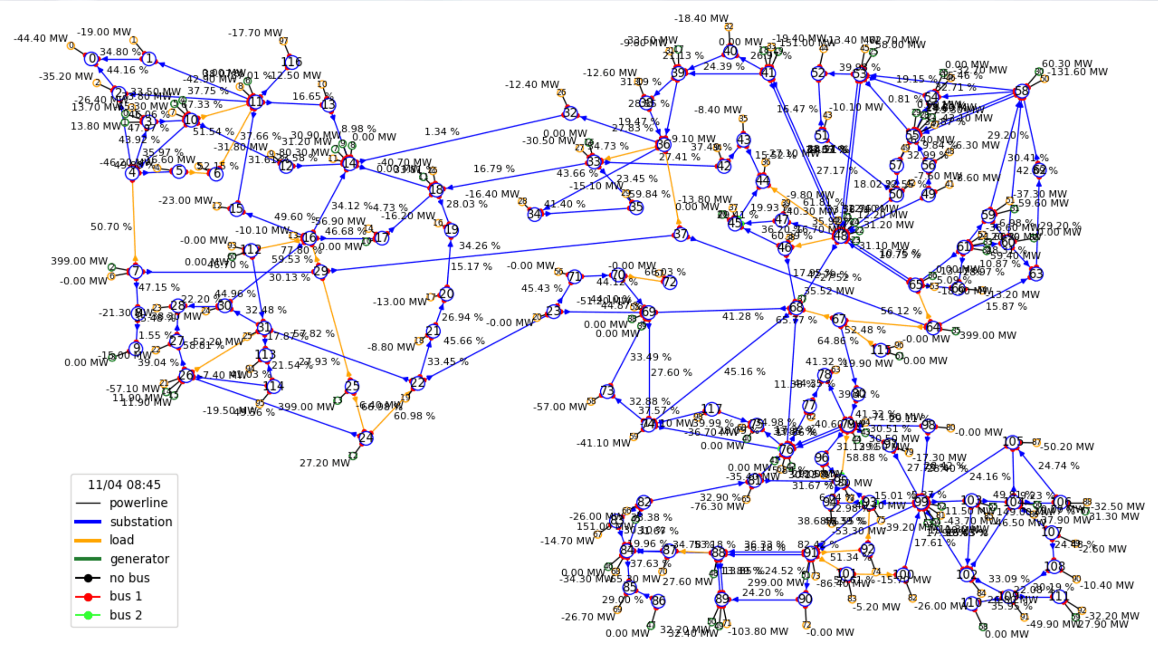


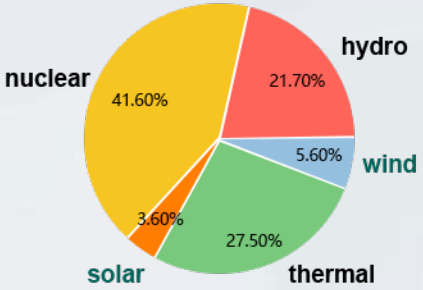
An adversarial opponent will attack some lines of the grid everyday randomly.

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

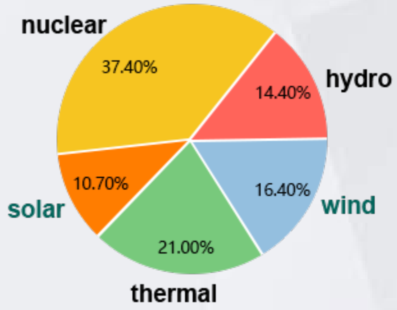
- **Operation Cost:** Operate the grid as long as possible, minimize the operation cost including powerlines losses, redispatch cost and blackout cost (penalty).

Track2: Adaptability Track





Renewable energies varying from 1x to 3x



- **Goal:** Develop agent to adapt to new energy productions in the grid with an increasing share of renewable energies which might be less controllable.
- **Operation Cost:** Operate the grid for as long as possible, minimize the operation cost including powerlines losses, redispatch cost and blackout cost (penalty).

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Rules and Score

Rules and Constraints

- Demand-supply balance should be met at any time without load shedding.
- Tripping power plant is not allowed.
- Electrical islands are not allowed.
- Any action has a certain cool down time.

…

Score

The agent with less blackouts and less operation costs will be given higher score.

$$\mathrm{C}_{operations}(t) = \mathrm{C}_{loss}(t) + \mathrm{C}_{redispatching}(t)$$

$$\mathrm{C}_{blackout}(t) = Load(t) * \beta * p(t), \beta \geq 1$$

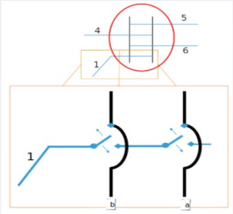
$$C(e) = \sum_{t=1}^{t_{end}} \mathrm{C}_{operations}(t) + \sum_{t=t_{end}}^{T_e} \mathrm{C}_{blackout}(t)$$

$$Score = \sum_{i=1}^{N} C(e_i)$$

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

State

State chosen:

- Some states (such as **prod_p, load_p, topology_vect, time_next_maintenance, line_status, rho etc.**) are necessary in our action selecting process.
- Inherent properties in power grid (e.g **thermal_limit** of lines) and some properties of generators (e.g **max_ramp_up**)

State unchosen:

- Another part of states (such as **date, time, prod_q, load_q etc.**) which have no contribution to our action selecting process.

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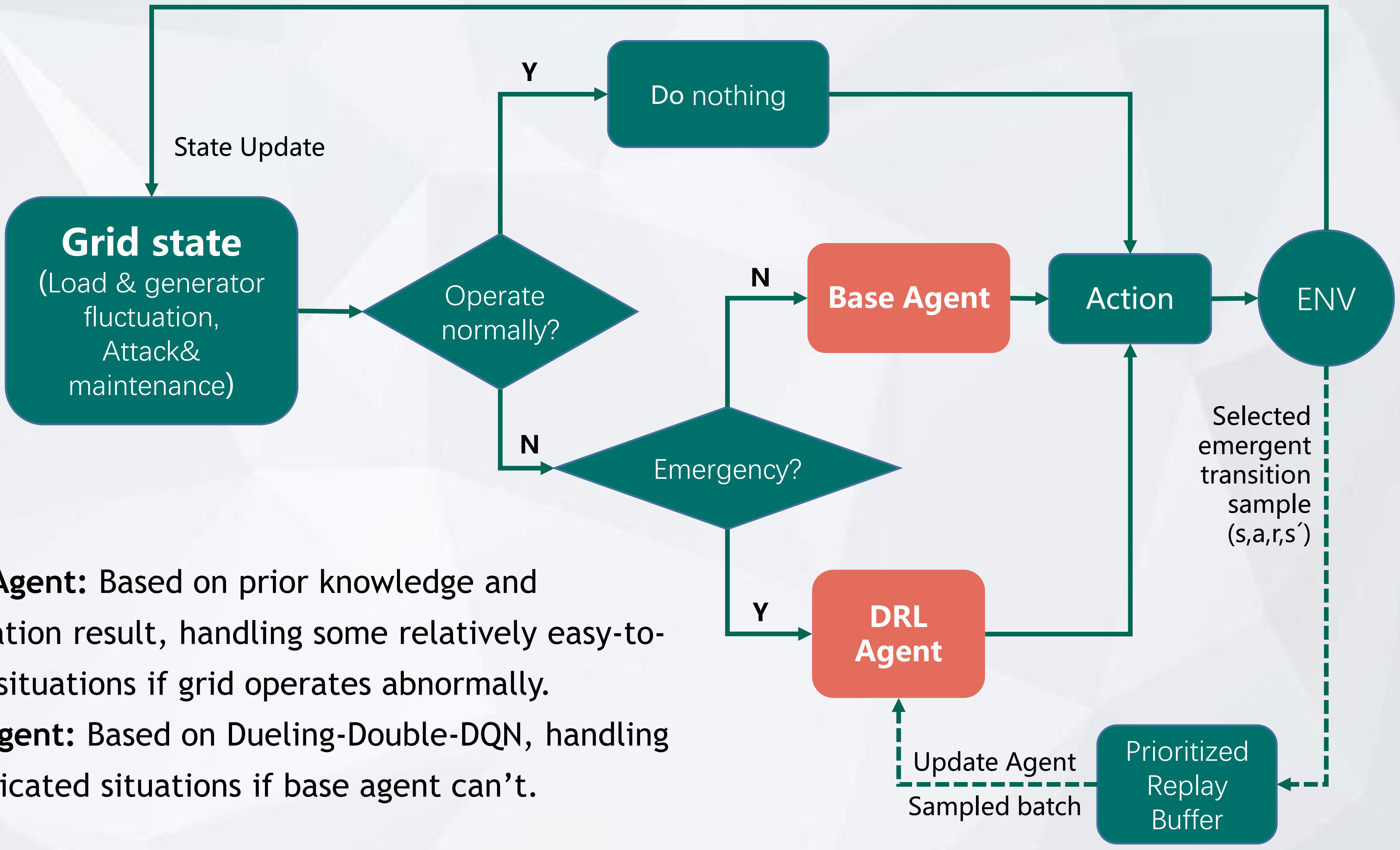
Dual-agent strategy



Base Agent: Based on prior knowledge and simulation result, handling some relatively easy-to-solve situations if grid operates abnormally.

DRL Agent: Based on Dueling-Double-DQN, handling complicated situations if base agent can't.

**Inspired by the works of Ziming Yan, Yan Xu, Nanyang Technological University (https://github.com/ZM-Learn/L2RPN_WCCI_a_Solution)*

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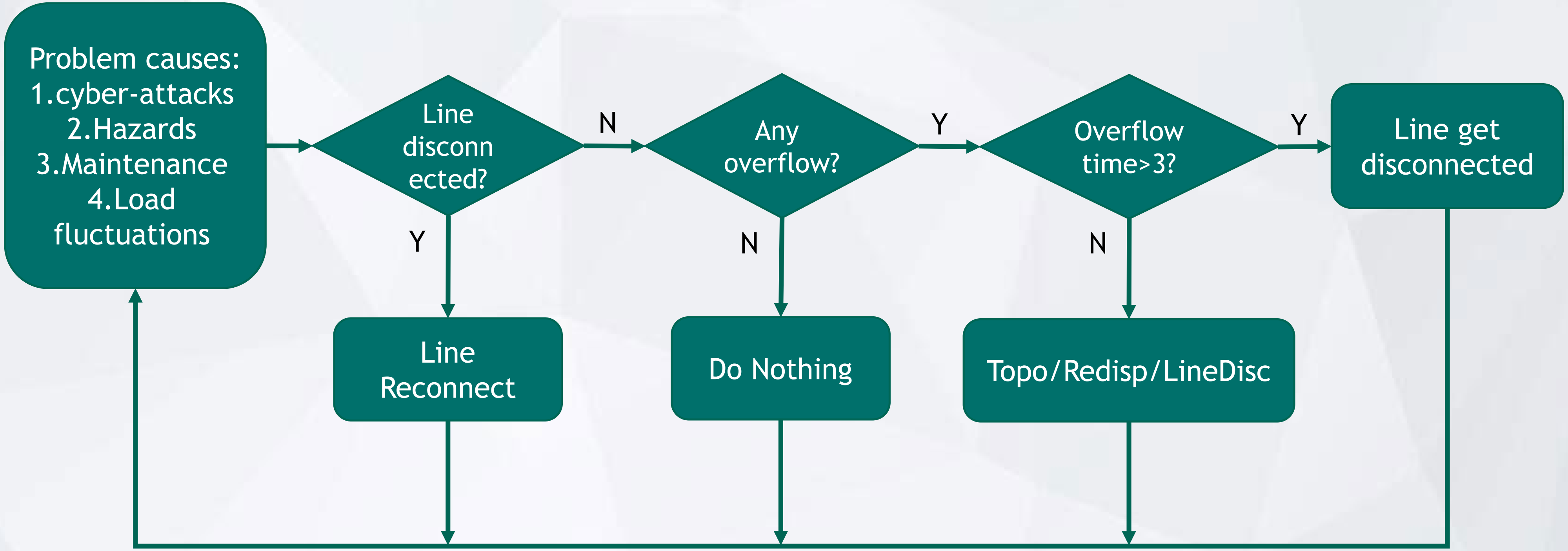
Base-agent strategy



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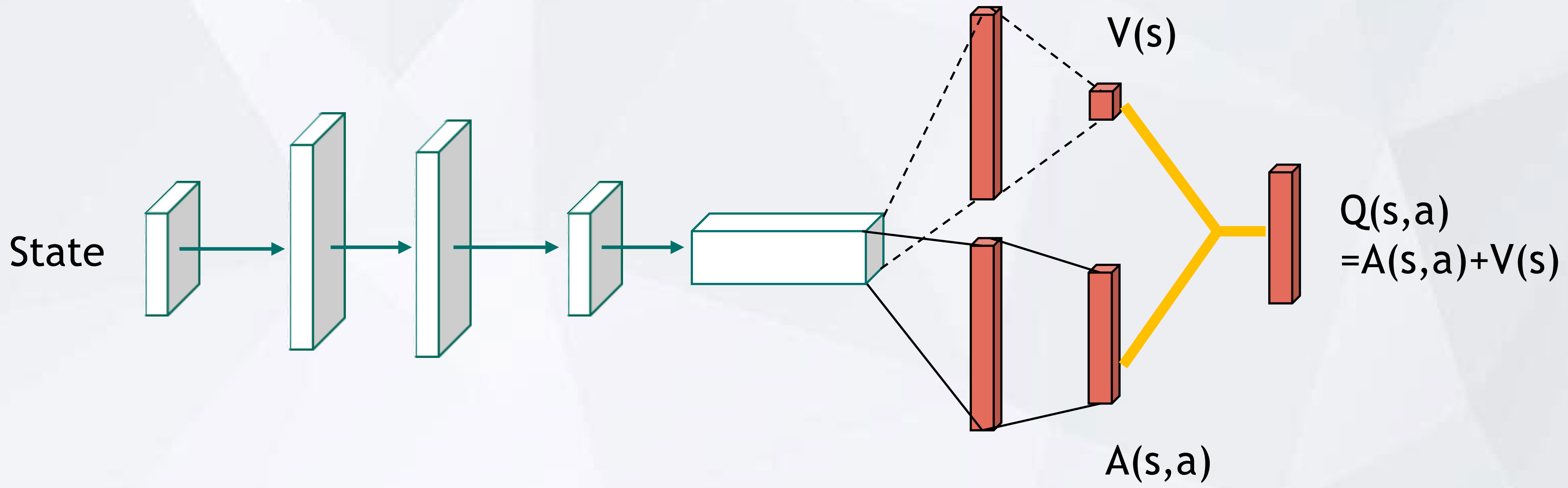
DRL agent

We adopt the Dueling-Double-DQN(D3QN) algorithm for our DRL agent, a kind of value based algorithm which can handle discrete action-space problems.



D3QN Neural network structure diagram

Robustness Track: State size=744， Action size=885

Adaptability Track: State size =2300， Action size =1164

Rewards

Rewards: (factors considering)

1. **Sandbox** - economic
2. **Close-To-OverFlow** - overflow
3. **Distance** - difference with initial topology
4. **Line-capacity** – available transfer capacity

Robustness Track (Track1)

- Sandbox-Reward
- Close-To-OverFlow-Reward
- Distance-Reward

Adaptability Track (Track2)

- Sandbox-Reward
- Close-To-OverFlow-Reward
- Distance-Reward
- Lines-Capacity-Reward

Reward=∑Weight(i)*Reward(i),i∈(Sandbox, CloseToOverflow, Distance, LineCapacity)

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Reduced Action-space

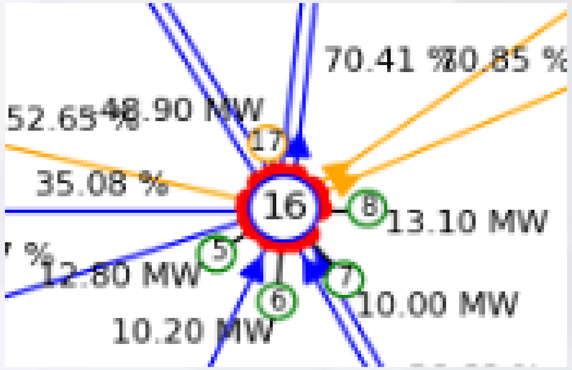
- **Robustness Track （Track1)**
- Before reduce: 130k (2^17 = 131,072)
- After reduce: 885

  58 line, 786 topo, 40 redisp, 1 donothing

- **Adaptability Track （Track2)**
- Before reduce: even more!
- After reduce: 1164

  185 line, 978 topo, 1 donothing

Why action-space need to be reduced?



- The topology action number is huge due to complex action combination.
- Difficult for system simulation and agent training.
- We reduce them according to domain knowledge and experiments.

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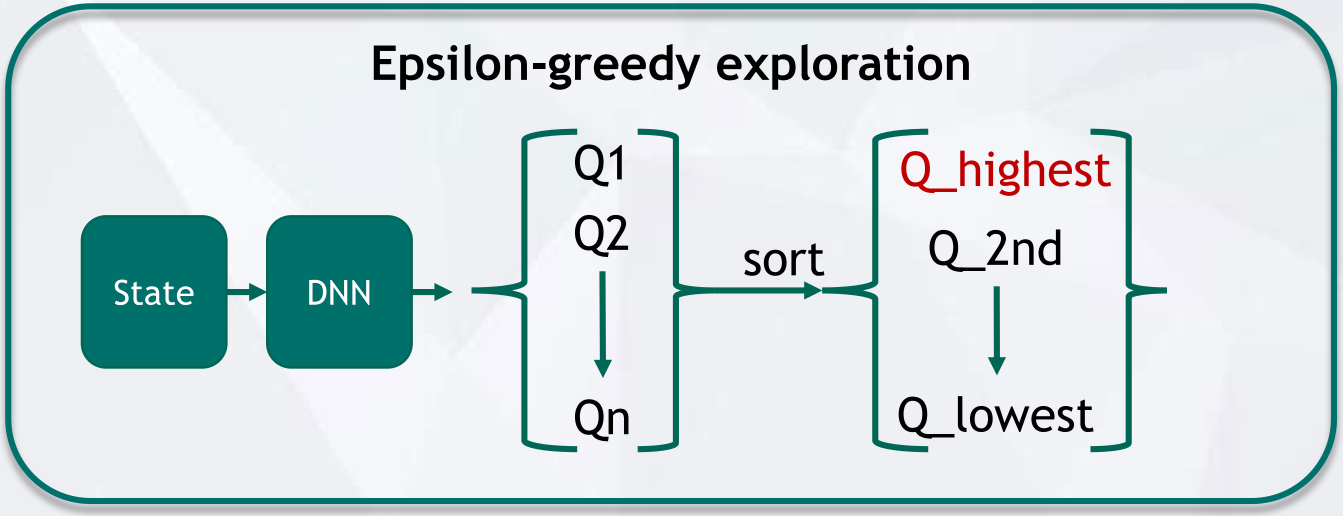
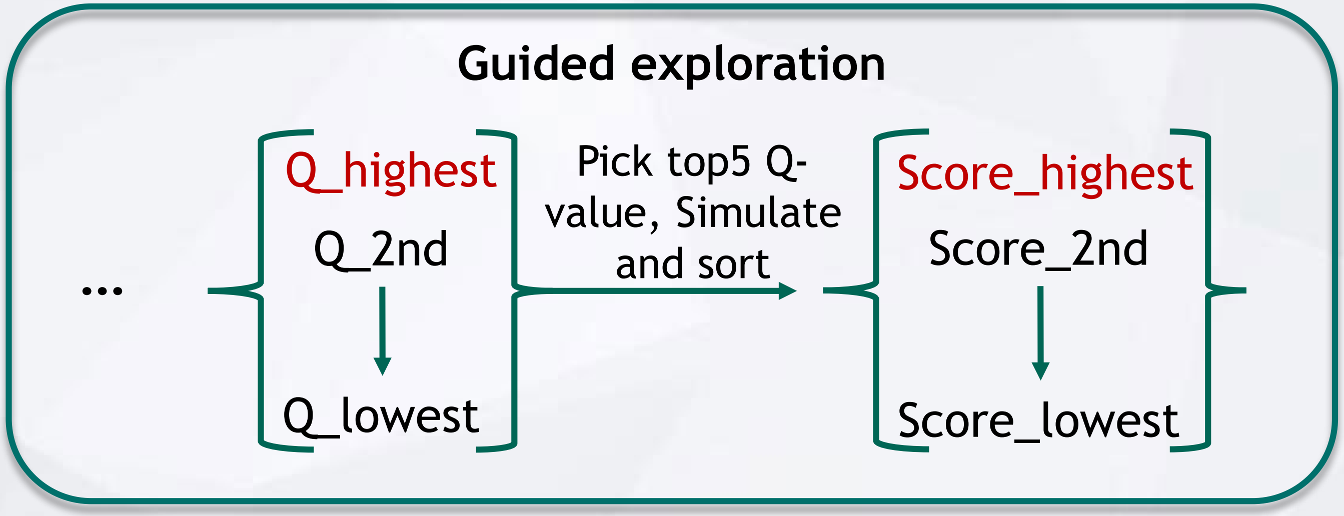
Guided exploration

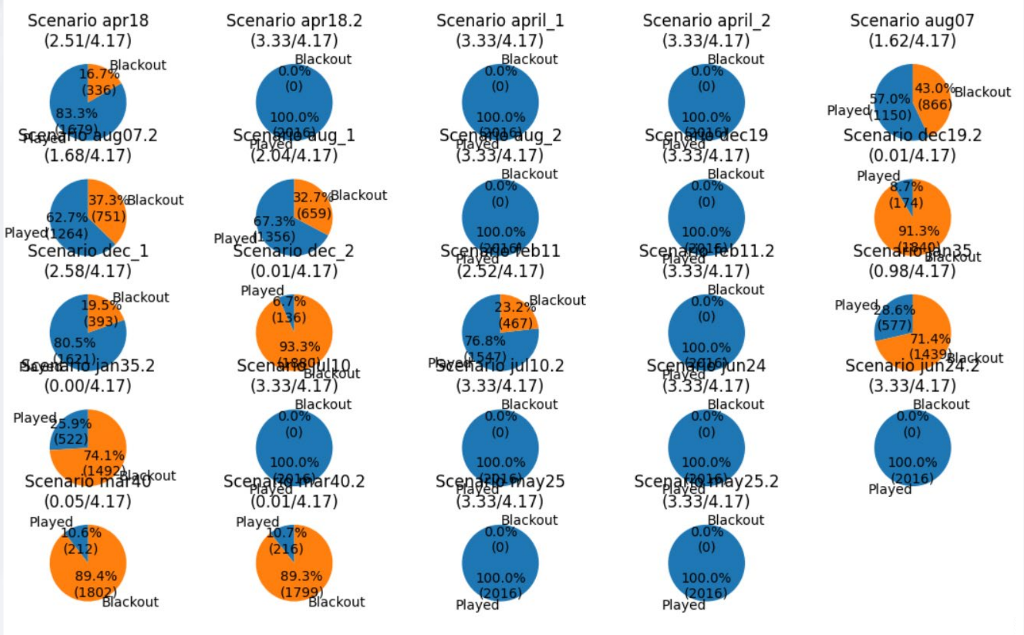


- Large Action-space
- Long MDP chain
- Local optimum

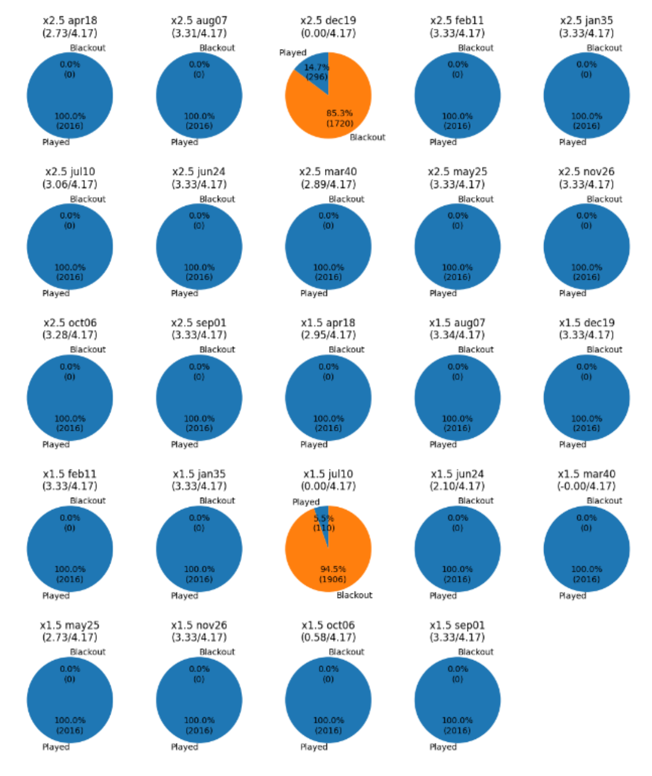


- Stable
- Better experience
- Efficient

Results



Robustness Track Test Result



Adaptability Track Test Result

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

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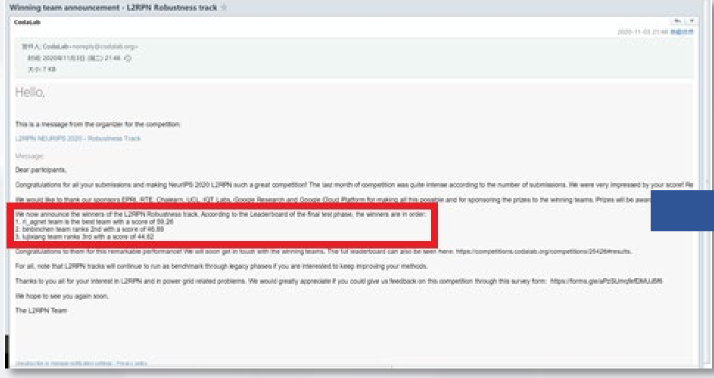
Robustness Track:



Winning team announcement - L2RPN Robustness track

CodaLab

Hello,

This is a message from the organizer for the competition:

L2RPN NEURIPS 2020 - Robustness Track

Message:

Dear participants,

Congratulations for all your submissions and making NeurIPS 2020 L2RPN such a great competition! The last month of competition was quite intense according to the number of submissions. We were very impressed by your score! Re

We would like to thank our sponsors EPRI, RTE, Chalearn, UCL, IQT Labs, Google Research and Google Cloud Platform for making all this possible and for sponsoring the prizes to the winning teams. Prizes will be awar

We now announce the winners of the L2RPN Robustness track. According to the Leaderboard of the final test phase, the winners are in order:
1. rl_agnet team is the best team with a score of 59.26
2. binbinchen team ranks 2nd with a score of 46.89
3. lujixiang team ranks 3rd with a score of 44.62

Congratulations to them for this remarkable performance! We will soon get in touch with the winning teams. The full leaderboard can also be seen here: https://competitions.codalab.org/competitions/25426#results.

For all, note that L2RPN tracks will continue to run as benchmark through legacy phases if you are interested to keep improving your methods.

Thanks to you all for your interest in L2RPN and in power grid related problems. We would greatly appreciate if you could give us feedback on this competition through this survey form:

We hope to see you again soon,

The L2RPN Team

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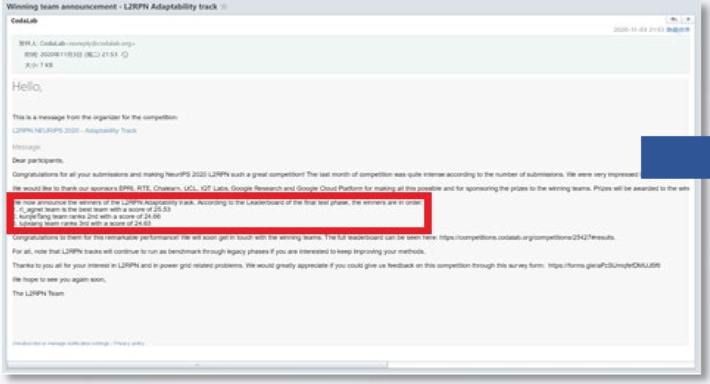
Adaptability Track:



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We now announce the winners of the L2RPN Adaptability track. According to the Leaderboard of the final test phase, the winners are in order:
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2. kunjieTang team ranks 2nd with a score of 24.66
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We are one of top performers in both NeurIPS Robustness Track and Adaptability Track competitions.

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Thanks!