Applications of Reinforcement Learning to Combinatorial Optimization

May 29, 2024

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Can RL be a useful tool for OR?

Two use cases:

- Logistics: middle mile
- Set covering

Hard constraints: the problems have structure

Can RL deal with it?

Middle-mile logistics

The problem in a nutshell:

- Hubs, trucks with fixed schedule
- Shipments to move from one hub to another
- Constraints: truck capacity, shipment deadline

Model it as an MDP?

- State: a time-expanded graph
  - Nodes are hubs with time
  - Edges are trucks with their schedule
  - Parcels are located at nodes
- Transition: one shipment moves from one hub to another
- Reward: whenever a shipment reaches its destination
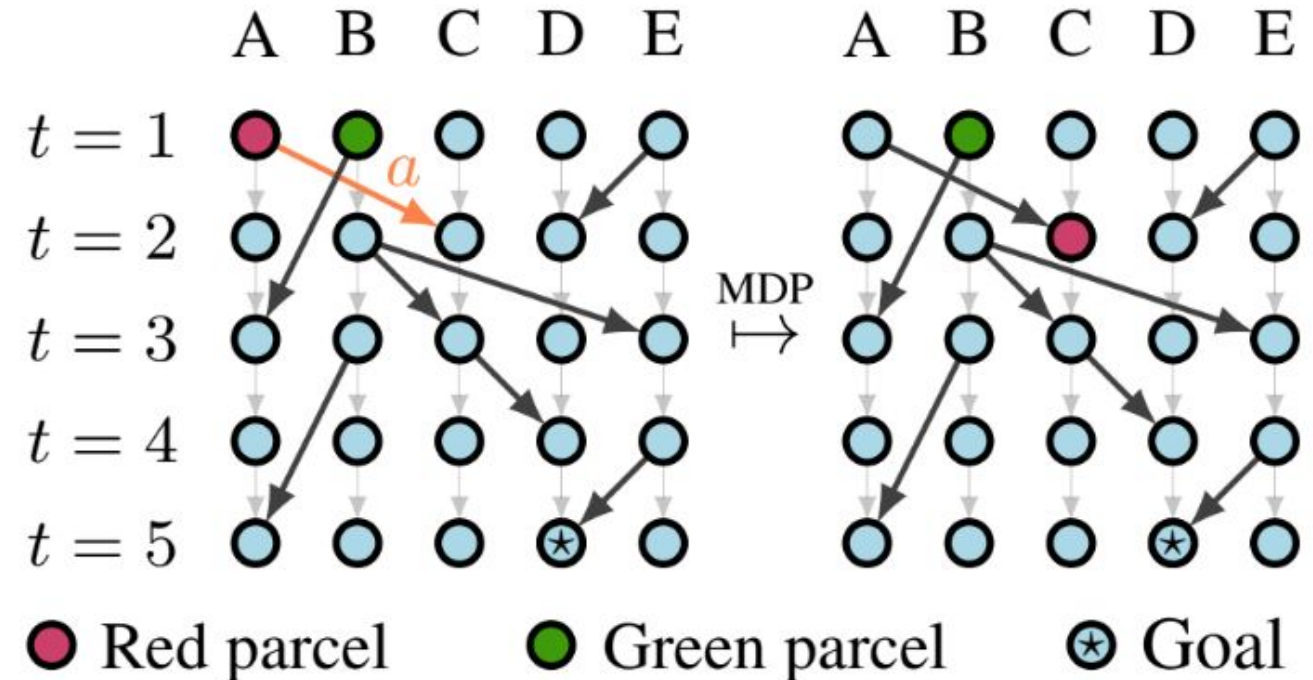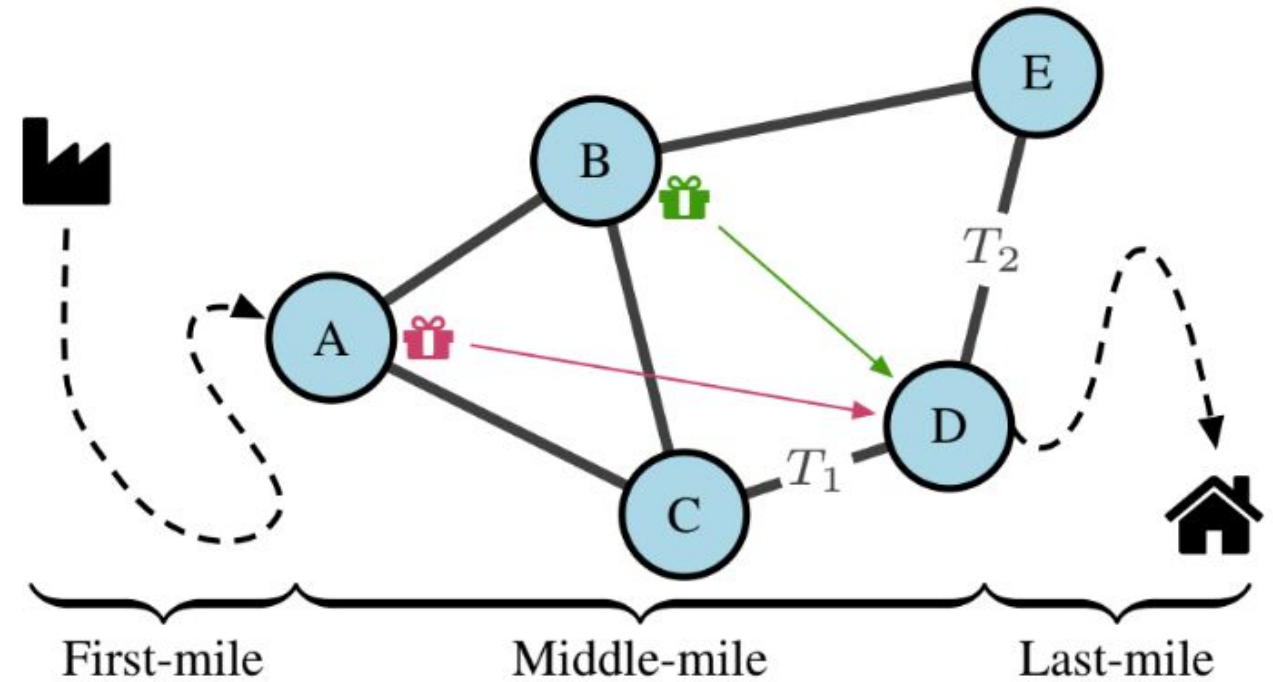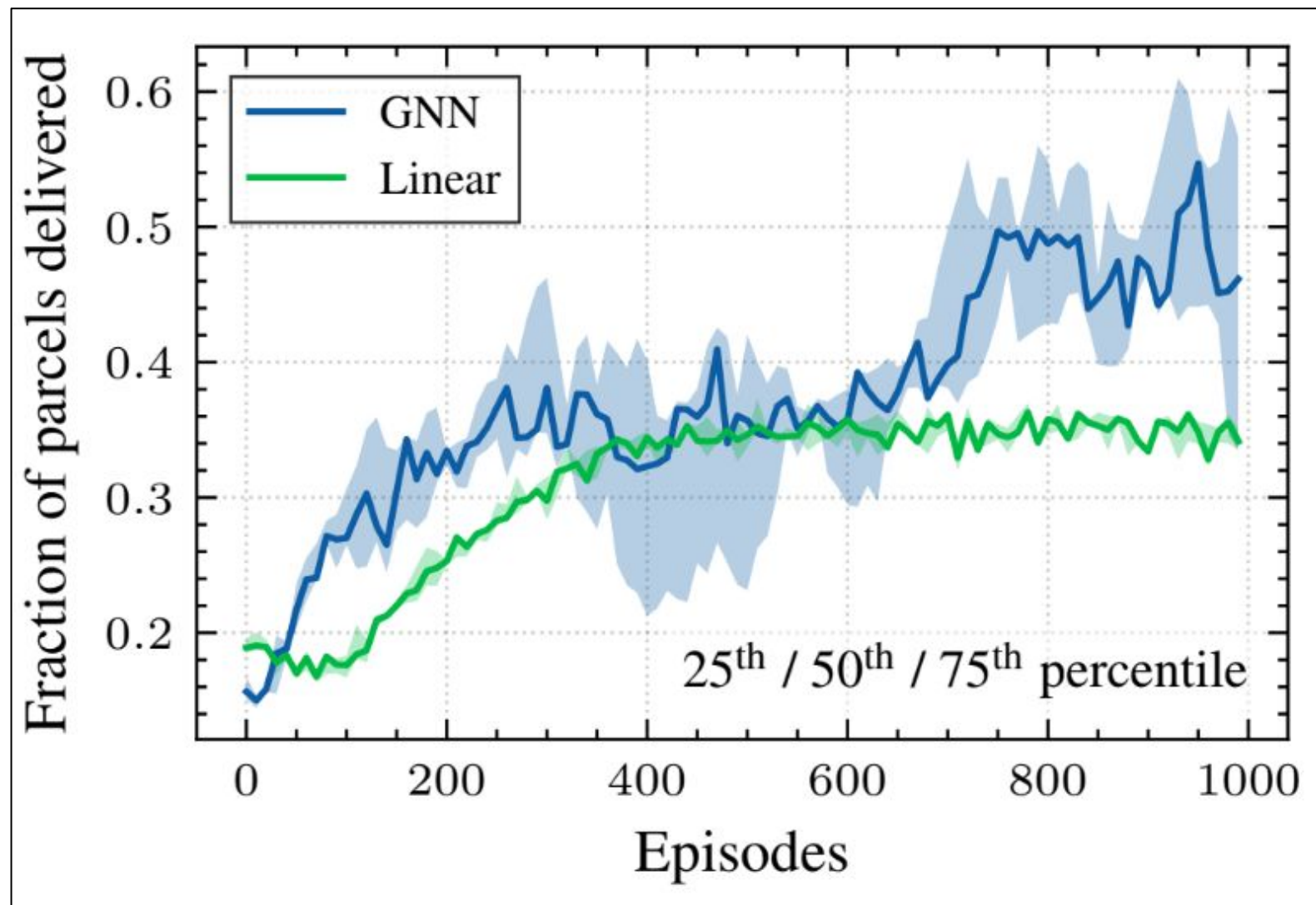
Middle-mile logistics

Use RL to solve the problem

- PPO for RL
- GNN for the Q and policy functions

Results?

- GNNs provide a good fit
- Significantly more parcels delivered than with a linear model!

Feasibility achieved through:

- Modelling for deadlines
- Learning and state for capacities

Middle-Mile Logistics Through the Lens of Goal-Conditioned Reinforcement Learning
Onno Eberhard, Thibaut Cuvelier, Michal Valko, Bruno de Backer
Conference on Neural Information Processing Systems (NeurIPS) Goal-Conditioned Reinforcement Learning Workshop, New Orleans (USA), December 2023.

Set covering

The problem in a nutshell:

- Items to cover (e.g., chessboard square): rows
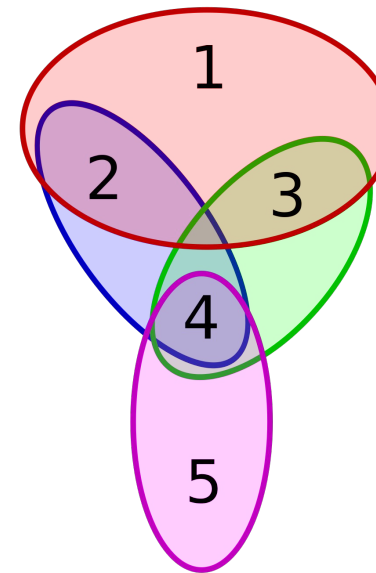- Subsets that cover items (e.g., knights): columns

Direct applications in vehicle routing: cover shipments with possible routes

Model it as an MDP?

- State: items covered, subsets with number of items they will cover
- Transition: one subset at a time
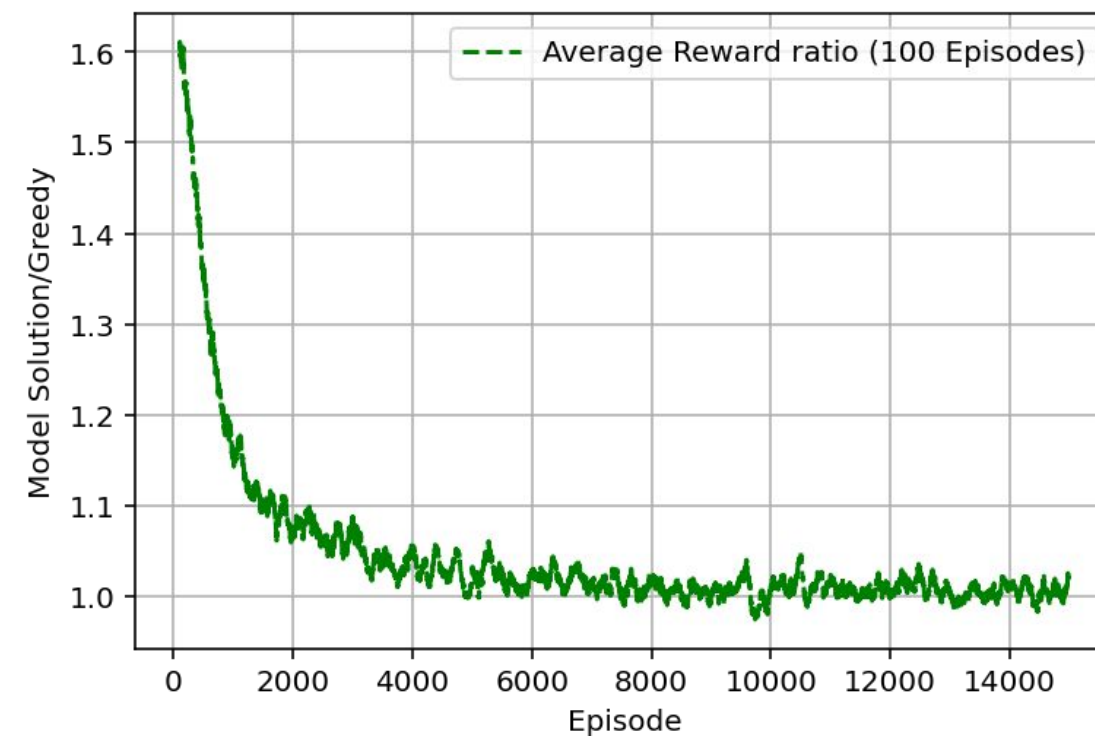- Reward: total cost of solution (number of subsets)

Results?

- DQN: works slightly better than a greedy heuristic (Chvátal)
- Not (yet) scaling to any number of items/subsets

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Instance of knights covering

Results not yet published

Thank You