Optimizing the PDDL domain of TUSP to improve planner performance

Modifying the domain to improve planner execution time, plan quality, and problem solvability

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1. Background

- TUSP: Train Unit Shunting Problem [1]
  - Parking trains in shunting yards.
  - Such that they can leave when needed (Figure 1).
- PDDL: Planning Domain Definition Language [2]
  - Problems as code.
  - Initial state and goal state.
- Planners
  - Find sequence of actions.
  - Such that initial => goal.
  - This research:
    - 4 planners from IPC 2018

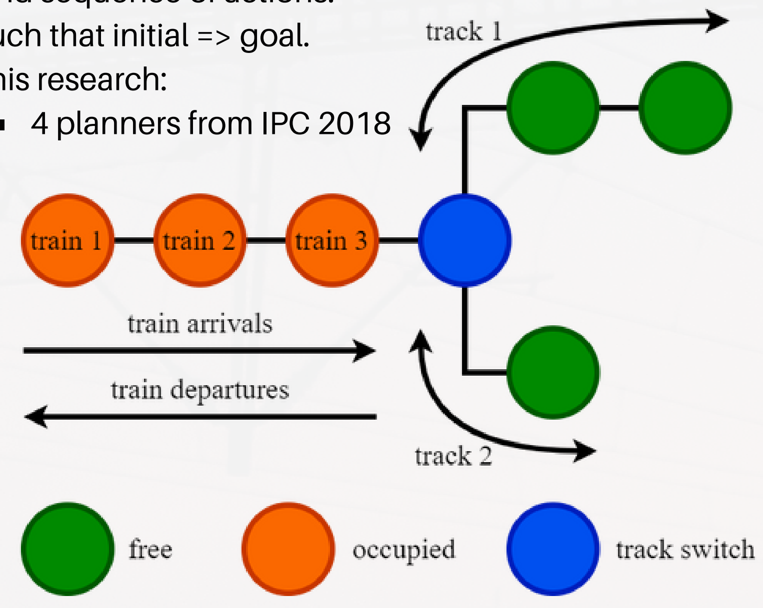

Figure 1: *Shunting yard example diagram. Trains 1, 2, and 3 are arriving at the shunting yard and need to be parked on either track 1 or track 2. This should be done in such a way that each train can depart with as little delay as possible when they need to.*

2. Research Question

To what extent can we improve planner performance by optimizing the PDDL domain of TUSP?

Three sub-questions:

1. *Is it possible to decrease the **total execution time** of planners?*
2. *Is it possible to increase the **quality** of the **plan** generated by planners?*
3. *Is it possible to increase **problem solvability**?*

3. Domain Modifications

- Initial domain (Figure 2)
  - Domain provided by supervisor.
- PT domain (path-to-track)
  - **Combined actions.**
  - Move from path to track in 1 step.
- MSR domain (minimize-switching-reallocation)
  - **Action costs.**
  - Minimize switching + reallocation.
- PT+MSR domain (Figure 3)
  - Combined actions + action costs.

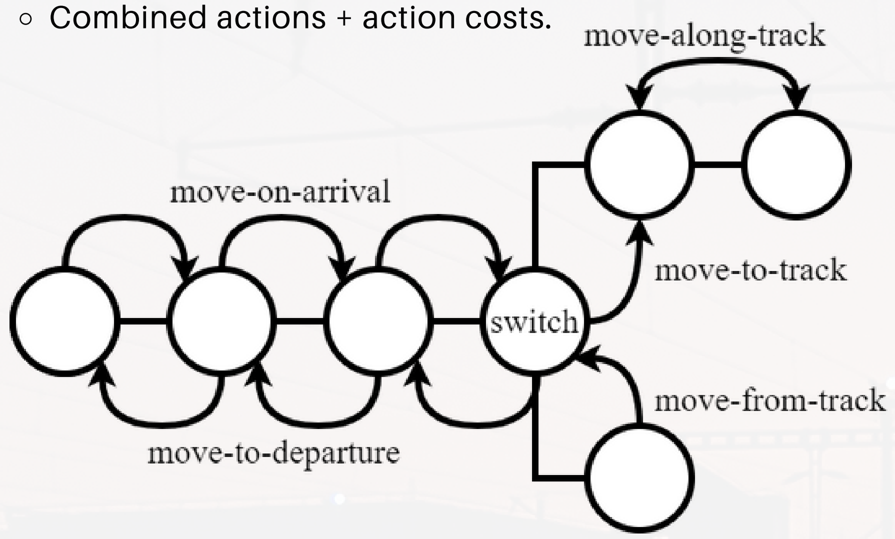

Figure 2: *Initial domain actions. A train can move in five ways.*

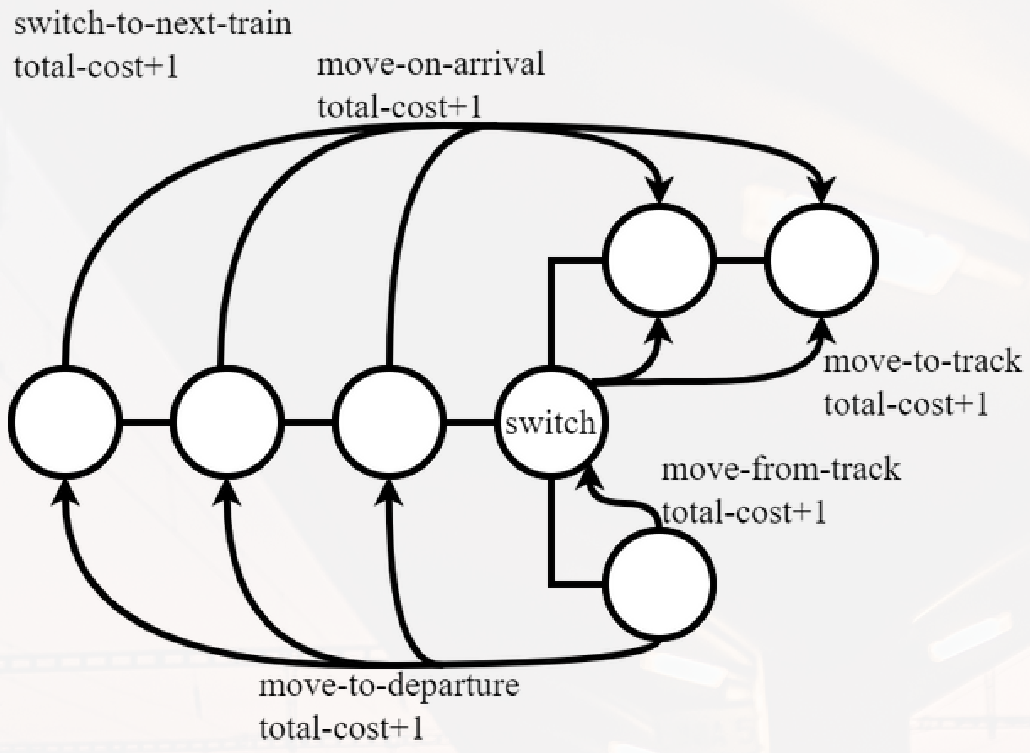

Figure 3: *PT+MSR domain actions. A train can move in four ways.*

4. Results

	initial	PT	MSR	PT+MSR
LAMA 2011	150.50s	0.20s	423.80s	0.75s
DecStar	206.29s	0.34s	591.46s	1.27s
Freelunch-Madagascar	0.01s	0.06s	0.02s	0.11s
Saarplan	7.73s	0.03s	40.84s	0.12s

Table 1: *Planner total execution time of each planner per domain*

	initial	PT	MSR	PT+MSR
LAMA 2011	70	14	82	26
DecStar	70	14	82	26
Freelunch-Madagascar	74	14	127	27
Saarplan	70	14	127	28

Table 2: *Shortest plan length of each planner per domain*

	initial	PT	MSR	PT+MSR
LAMA 2011	38	12	12	12
DecStar	48	12	12	12
Freelunch-Madagascar	56	12	57	13
Saarplan	51	12	51	14

Table 3: *Train switches in each plan per domain*

	initial	PT	MSR	PT+MSR
LAMA 2011	1	1	10	5
DecStar	2	1	8	6
Freelunch-Madagascar	1	1	1	1
Saarplan	2	1	3	1

Table 4: *Number of plans found by each planner per domain*

5. Discussion

- Execution time (Table 1)
  - Decreases in PT.
  - Increases in MSR.
- Plan quality (Table 2 & 3)
  - PT decreases plan length + train switching for all planners.
  - MSR decreases train switching for LAMA 2011 & DecStar.
  - No differences in train reallocation.
- Problem solvability (Table 4)
  - Number of plans make no difference.
  - Correlation between execution time & number of plans.

6. Conclusion

- PT domain shows the best improvements of all domains.
  - Faster execution time + less steps.
- LAMA 2011 shows the best improvement of all planners.
  - Effectively minimizes plan cost [3].

7. Limitations & Future Work

- Only one problem instance used.
- Limited scope of complete TUSP.
  - No varying train unit sizes.
  - No time stamps.
  - No different shunting yard types.
- Techniques can be used in similar domains.
  - TUSP.
  - And other logistics domains.

[1] Richard Freling, Ramon M. Lentink, Leo G. Kroon, and Dennis Huisman. Shunting of passenger train units in a railway station. Transportation Science, 39(2):261–272, 2005.
[2] Maxence Grand, Humbert Fiorino, and Damien Pellier. Retro-engineering state machines into PDDL domains. In IEEE International Conference on Tools with Artificial Intelligence, pages 1186–1193, Baltimore (virtual conference), United States, 2020.
[3] Silvia Richter, Matthias Westphal, and Malte Helmert. Lama 2008 and 2011. 2011.

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Paper:

Code: