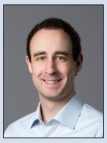

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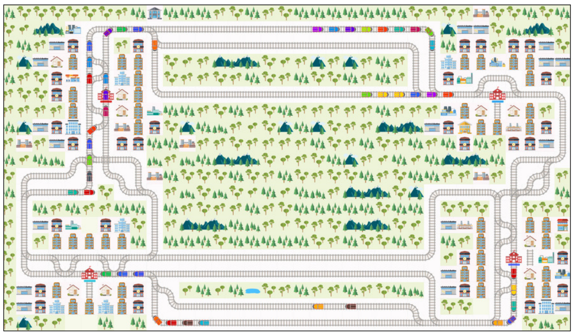
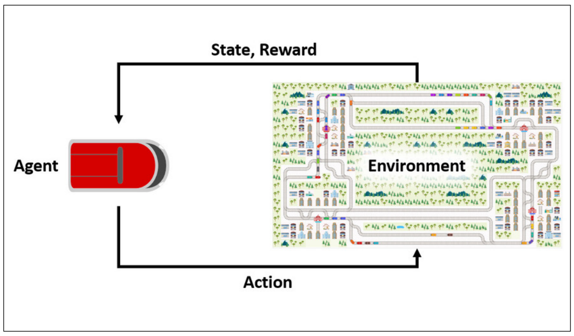
Existing and novel Approaches to the Vehicle Rescheduling Problem

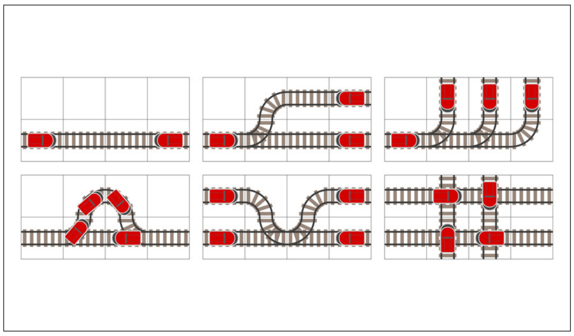
In the course of the Flatland Challenge by Swiss Federal Railways (SBB)



Flatland Environment: railway network with operating trains
Own presentment



Reinforcement Learning: scheme of the learning cycle
Own presentment



Examples of deadlocks on railway networks
Own presentment

Problem:

Every day, vast quantities of passengers and freight are transported around the globe. Since the demand for mobility is growing, the transport capacity will have to be massively increased in the future. The Swiss Federal Railways (SBB) would like to investigate novel approaches to optimize traffic management. For this reason, the public competition Flatland Challenge was launched.
The Flatland Challenge aims to address two fundamental problems in the world of traffic: The first problem concerns Multi-Agent Path Finding (MAPF), where any number of trains should be routed from their current location to the desired destination as fast as possible but without any conflicts. However, a train can unexpectedly be disturbed, for example by a malfunction. In such a situation, the Vehicle Rescheduling Problem (VRSP) occurs, where the malfunction causes a replanning of the routes.

Approach:

For both problems, there are several existing approaches, as well as novel methods. In the course of this thesis, the following approaches to MAPF were investigated:

- Linear Programming
- Constraint-based Search
- Operator Decomposition & Independence Detection
- Optimal Anytime Algorithm
- Prioritized Planning

Some of these approaches provide an optimal solution but at the expense of a non-polynomial runtime. Thus, suboptimal algorithms were also considered to find a solution in a reasonable time. Furthermore, different approaches for the VRSP were examined:

- Rescheduling by MAPF algorithm
- Robust Scheduling (Complete Path Reservation)
- Reinforcement Learning

An additional risk in a railway network is the occurrence of deadlocks, where several trains block each other. Therefore, various approaches to detect deadlocks were considered as well.

Result:

Concerning MAPF, it was shown that the theoretically optimal solutions were not suitable for use in a real-time traffic management system. Instead, suboptimal algorithms that provide fast solutions are more appropriate. For VRSP, reinforcement learning was almost able to keep up with robust scheduling and thus demonstrated the potential of this novel approach. In conclusion, reinforcement learning is a novel but promising method which could be used in railway traffic in an optimizing way.