Evaluating Possibilities of Flexible Train Schedules to Allow High-priority Sporadic Traffic
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Sporadic High-priority Train Schedules

Exploring the Feasibility of Flexible Schedules for Passenger and High-priority Cargo Trains

Our work evaluates the possibilities of flexible schedules for passenger trains to meet deadlines of sporadic high-priority cargo traffic. This cargo traffic needs to be dispatched at unpredictable times, has little tolerance for delays, and passenger traffic needs to let it pass. We will use SUMO simulations to investigate schedules with time windows instead of points in time for departures and arrivals. The results will provide insights into the feasibility and benefits of flexible schedules for dispatching interwoven cargo and passenger traffic.

Methodology for Running Simulations

Simulation Modules Are Configurable by the User and Results Are Logged for Analysis

To get the simulation model, we use OpenStreetMap (OSM), as seen in Figure 1. From there we are exporting the data concerning the railways using *yaramo*, a custom railway data model, as a tool. From this we generate the SUMO simulation model as well as a *PlanPro* model, a file format for digital railway planning, of the region. In a future version, we will use PlanPro instead of OSM as input to have more precise data for the simulation model.

The resulting simulation is configurable through user input in many ways. For example, train routes with different frequencies (fixed schedules) or probabilities (sporadic schedules) of driving can be defined. At the simulation start, those configurations are used to initialize the components surrounding the simulation in SUMO, like the interlocking, the logging and the schedule component as seen in Figure 1.

To evaluate simulations with different configurations, results and decisions made during the runtime of the simulation, are logged. Then they are converted to metrics, such as total delays, the precision of the schedule, and more.

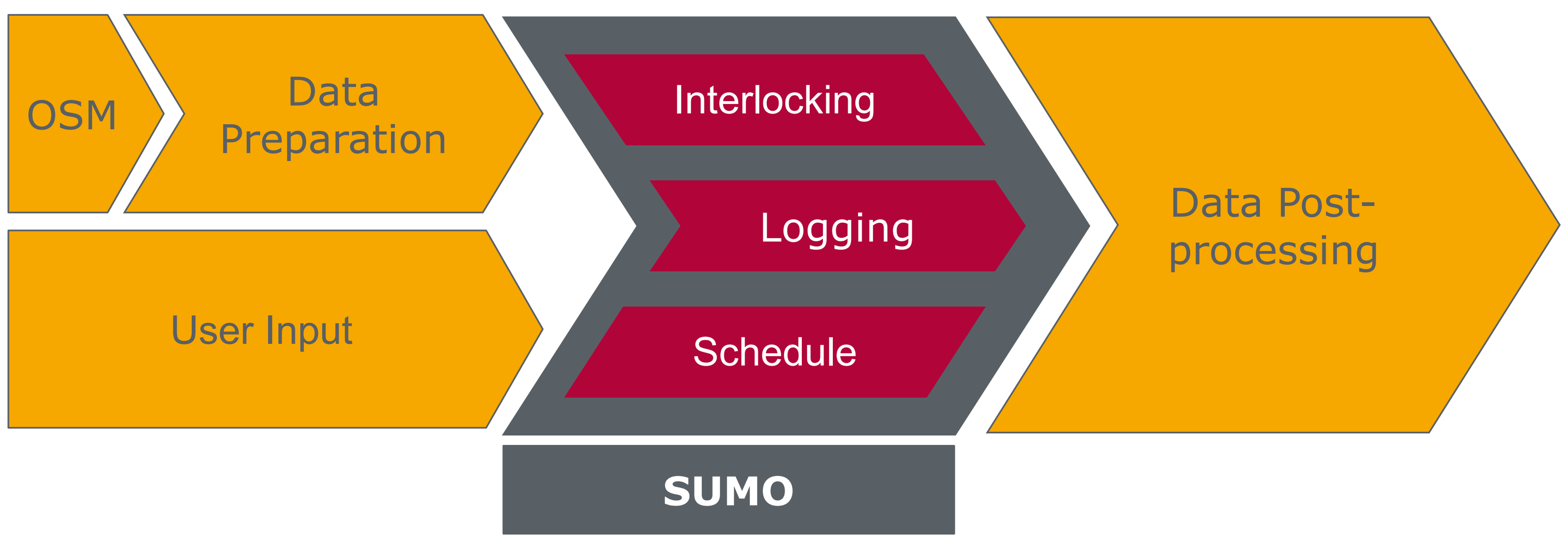

Fig. 1: Workflow of a single simulation run.

- Simulation Component
- User-configurable Simulation Component
- External Component

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Components Running the Simulation

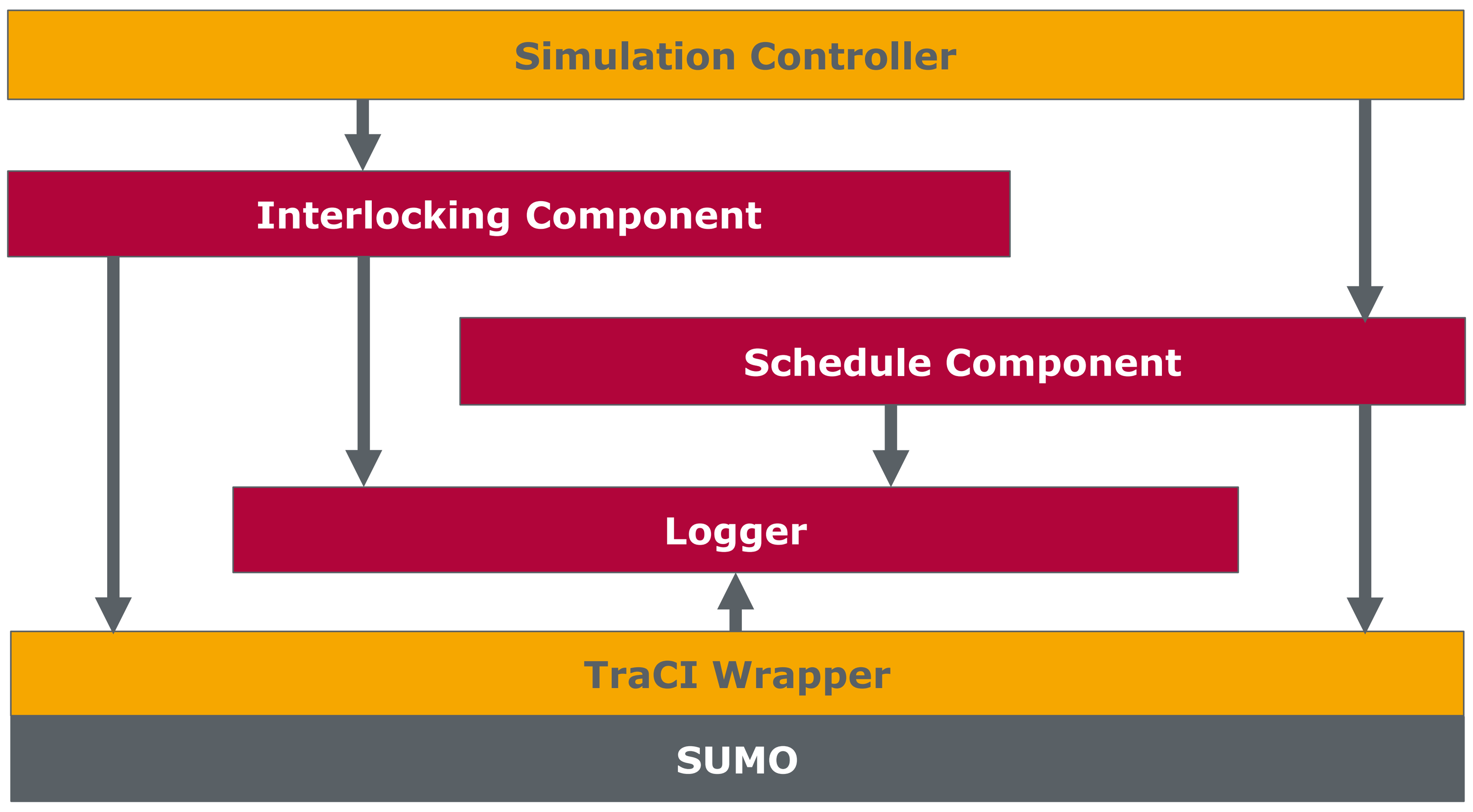

Fig. 2: Conceptual architecture of the simulation application.

Simulations Are Composed of Different Modular Components

We are using SUMO as the simulation backend to run our railway simulation. To provide a simple way of adding different aspects to the simulation, we are developing multiple components that interact with SUMO through a custom TraCI Wrapper. The simulation controller orchestrates these components. An architectural overview is shown in Figure 2.

One of the mentioned components is a train spawner which creates periodic passenger trains and sporadic cargo trains. Since we want more flexible control over the train route and spawn times of the trains, we are creating each train separately.

Furthermore, we add an interlocking component that ensures that the predefined routes for the trains are set and not conflicting with other trains. Additionally, the interlocking component will dynamically determine and change the route different trains take to avoid delays. This helps to build a more realistic train simulation.

Another component is the logger, which monitors the simulation to allow evaluation later.

Methodology for Evaluating Results

The Results of Simulations Can Be Used to Evaluate Punctuality of Traffic and the Need for Time Windows

After multiple simulation runs with varying parameters, results will be collected and agglomerated. With this data, we evaluate to which extend sporadic high-priority cargo trains and periodic passenger trains reached their destination in time. The delay data of periodic passenger trains over multiple simulation runs can be used to calculate the deviation of arrivals and departures at passenger stations. These deviations can be used to evaluate whether a periodic schedule would work in this scenario or whether a flexible schedule needs to be incorporated. These flexible schedules would then be defined by using schedule windows.

Next Steps

Currently, the project is still work in progress. The next step is therefore the full implementation of the above. Additionally, the possibility to generate actual timetables from the simulation could be investigated as well as the dynamic rerouting of trains depending on different events.

It is also planned to utilize fault injection to test the resilience to faults of the railway transport systems in the simulation. This could be, for example, trains stopping on open tracks or blocked tracks due to faulty switches or signals.

Ultimately, the collected data should enable the optimization of the respective timetables based on predefined criteria.

In the future, it may also be possible to access our system through an easy-to-understand graphical user interface. This would open the field of applicants to also include people without technical expertise.

Summary

- Periodic passenger trains and sporadic high-priority cargo train traffic share the same railway network.
- Simulations are composed of different configurable and modular components.
- Co-simulation allows for the usage of a realistic interlocking.
- Results of the simulation are used to evaluate the yet unusual concept of time windows in schedules as well as the punctuality.