# Traffic Signal Plans Explorer: A General Framework for Visualising Traffic Evolution

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## Abstract

We present the Traffic Signal Plans Explorer, a framework for visualising and exploring traffic signal plans generated via PDDL+ planning. Designed to support both traffic experts and non-specialists, the tool offers a web-based interface for high-level network analysis and a SUMO-based adapter for detailed simulation. Users can inspect junction settings and link dynamics, and simulate plan execution step by step. The system bridges planning technology with practical traffic control, enhancing the transparency and usability of automatically generated solutions.

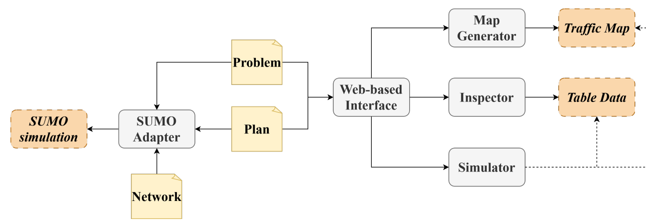


Figure 1: Overview of the proposed architecture. Inputs, Components, and Outputs are in yellow, grey, and amber.

## Introduction

In the broader context of urban traffic control, traffic signal optimisation is the primary means by which traffic controllers can influence traffic in a target urban area.

In a nutshell, the problem of traffic signal optimisation aims to minimise congestion and delays in a network by adjusting the durations of green times on the controlled junctions. Green times affect active traffic movements, which allow vehicles to cross the junction and move throughout the network.

The traffic signal optimisation problem has been effectively tackled using PDDL+ planning (Vallati et al. 2016; McCluskey and Vallati 2017; Percassi et al. 2023), with recent developments focusing on the approach deployability (Kouaiti et al. 2024). This line of research provides approaches that can efficiently generate high-quality signal plans with significant benefits in terms of congestion and emissions reduction, as demonstrated in both simulations and real-world deployments in the UK. Further, the use of the PDDL+ planning formalism also supports traffic simulation and what-if analysis to evaluate alternative scenarios (Bhatnagar et al. 2022; Percassi and Vallati 2024).

Besides efficient generation of effective traffic signal control strategies, there is a need to communicate these strategies to traffic control experts and to enable non-planning experts to explore the plans and evaluate the expected outcomes. An initial effort in this direction was made by Bhatnagar et al. (2023), who proposed a framework featuring a visualiser that graphically displays the expected traffic evolution for a specific UK urban network. To foster the use of the approach, there is a need for more general tools that can visualise any network and provide the user with detailed information interactively.

To address this gap, this work presents the *Traffic Signal Plans Explorer* framework, which enables the visualisation and exploration of traffic signal plans generated by PDDL+ planning. In particular, it supports two types of interactive plan exploration: a holistic one, implemented through a web-based interface that provides high-level information about the network and its performance, and a more detailed one that leverages the SUMO (Simulation of Urban MObility) simulator (Krajzewicz et al. 2012).

## Traffic Signal Plans Explorer

The proposed framework is shown in Figure 1. Both the web-based interface and the SUMO Adapter require two inputs: a problem specification, describing the urban traffic planning scenario, and a plan simulation, containing the planned actions along with a time-stamped execution trace generated by running the plan through a PDDL+ simulator (Scala, Percassi, and Vallati 2026). For simplicity, here we assume that the problem specification includes the domain model. The SUMO Adapter requires an additional input: an XML file containing the traffic network description.

Three main network components are extracted from the problem specification: traffic signal configurations, junctions, and links. A configuration is a collection of stages that a junction cycles through, each with a defined green time.

A stage represents a specific set of permitted traffic movements that can occur while the stage is active. Each movement represents the transition of vehicles from an incoming link to an outgoing link through a junction, with an as-

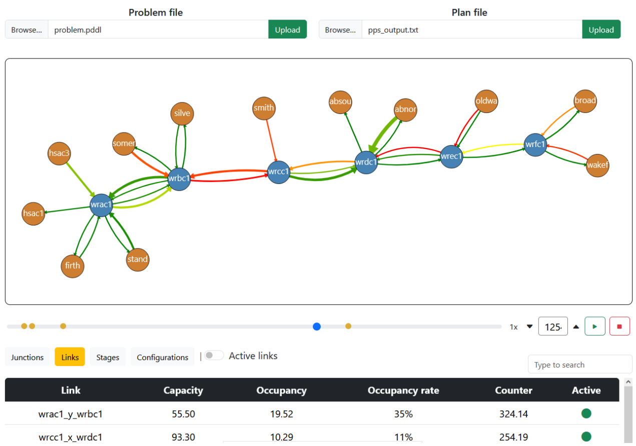


Figure 2: Web-based interface visualisation with example scenario. The top half shows traffic conditions for each link in the network using the map generator model, while the bottom half displays detailed information from the inspector module.

sociated turn rate, indicating the expected number of vehicles performing that movement during stage activation. Each junction cycles through different stages over time. A junction can be in an active stage, allowing the movements defined by that stage, or in an intergreen period, which is a transitional phase between two stages. Road segments connecting junctions are modelled as links, each with a fixed capacity, an occupancy, and a counter tracking the number of vehicles that have passed through.

The web-based interface consists of three modules: Map Generator for creating traffic maps, Inspector for displaying network information, and Simulator for step-by-step plan simulation. This web-based approach transfers easily to different traffic scenarios and problem instances.

The SUMO Adapter produces a SUMO simulation consistent with the original planning solution.

## Web-based Interface

The web-based interface implements a traffic visualisation and exploration system (Figure 2), based on the provided problem specification and plan simulation.

The *Map Generator* module creates a topological representation of the road network as a directed graph, where vertices denote junctions and edges correspond to road links. Vertices are colour-coded (blue for controllable, orange for non-controllable), while edges are coloured by occupancy, with a gradient from green (empty) to red (full).

The *Inspector* module provides a tabular representation of the network, organised into separate tabs (Junctions, Links, Stages, and Configurations), each displaying the corresponding network components.

The *Simulator* module enables real-time simulation through multiple playback options: automatic playback at predefined speeds, manual playback to step forward and backwards, and a step-entry feature for visualising specific steps. As the simulation runs, the module takes each step

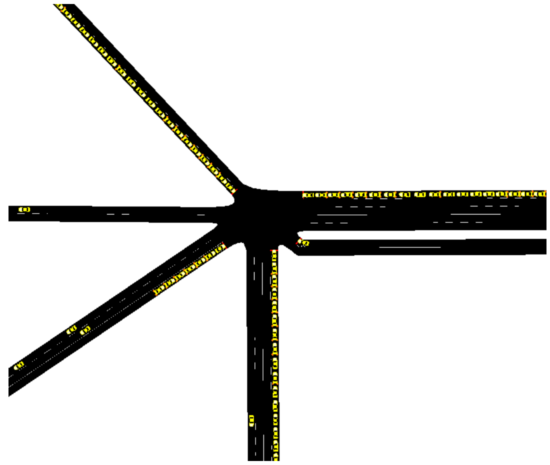

Figure 3: Example of a plan execution visualisation through the SUMO simulator.

from the plan simulation data and applies the corresponding network changes, updating both the traffic map and tables.

## SUMO-based Visualisation and Exploration

The SUMO Adapter enables the visualisation of plans and traffic evolution directly in SUMO, as shown in Figure 3.

The adapter leverages TraCI (Traffic Control Interface) (Krajzewicz et al. 2012), a Python library that enables interaction with the simulator and manages its execution. To begin with, the SUMO adapter integrates the three inputs required by the simulator.

The simulator automatically manages the cycling through stages for each junction. At each simulation step, the system performs several actions through TraCI to maintain a coherent representation of the traffic flow: the actions specified in the plan are applied to update the active configurations at the junctions, new vehicles are introduced on incoming links, and existing vehicles are moved between links according to the defined turn rates.

# Conclusion

The Traffic Signal Plans Explorer framework bridges the gap between automated planning and practical traffic control by enabling intuitive visualisation and simulation of PDDL+ signal plans. It empowers both planning and traffic experts to analyse, interpret, and validate signal strategies across diverse urban scenarios, fostering broader adoption and informed decision-making. Future work will focus on integrating OpenStreetMap data to enhance visualisation and on supporting plan modification through human interaction.

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