mobil.TUM 2024
International Scientific Conference on Mobility
Extended Abstract Submission

mobil.TUM 2024 – The Future of Mobility and Urban Space, April 10-12, 2024

Improving the Field Deployment Process of Innovative Junction Control Algorithms with a Cloud-Based Approach

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Keywords: *cloud computing, deployment, field experiment, junction control, mobility, traffic management*

This work addresses the following topic(s) from the Call for Contributions:
(Please check at least one box)

☐ Placemaking to integrate urban spaces and mobility
☐ Promoting sustainable mobility choices in metropolitan regions
☒ Governing responsible mobility innovations
☐ Shaping the transition towards mobility justice
☐ System analysis, design, and evaluation
☐ other: ________________________

Extended Abstract

Problem statement

Traffic lights play a major role in managing traffic. Today, their primary purpose is ensuring traffic safety at junctions and improving traffic flow for motorized individual transport in particular. There are plenty of new approaches with different goals around. Some try to improve the traffic at intersections by developing new control algorithms, replacing the mostly rule based approaches that are currently being used (e.g. Erdmann, 2013 or Oertel, 2015). Others try to incorporate vulnerable road users with new data sources like camera systems (e.g. Eggers et al., 2022). A lot of these developments are tested in simulations like SUMO (Alvarez Lopez et al., 2018). However, promising approaches need to be transferred into the real world to further refine them and prepare broad distribution in the traffic system.

In this contribution, we want to present some of our experiences developing and deploying new junction control algorithms on junctions in Germany from the VITAL and VITAL.NET projects (Oertel et al., 2017), analyze the challenges we encountered and how a cloud-based approach can speed up the development, testing and even large-scale deployment of new control algorithms.

Research objectives

We want to develop an architecture that allows for significantly accelerated development cycles for innovative junction control algorithms with the current generation of controllers that will be used for the foreseeable future. The focus lies on test and deployment in the field as well as the ability to quickly adjust to unforeseen challenges and changing requirements. Thus, sources for delays in preparation of field tests and deployment need to be identified and improved upon. Additionally, innovative data sources need to be able to be incorporated into the architecture without disruption and independent from each other.

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Methodological approach

This contribution first describes our current development and deployment process of new junction control algorithms from the basic idea over prototyping and evaluating the new approach in simulations, to redesigning the approach to work with current controllers up to finally deploying and evaluating the approach in the field. Special focus is given to steps past the simulation phase as they are more critical to the deployment process and development cycles in the field.

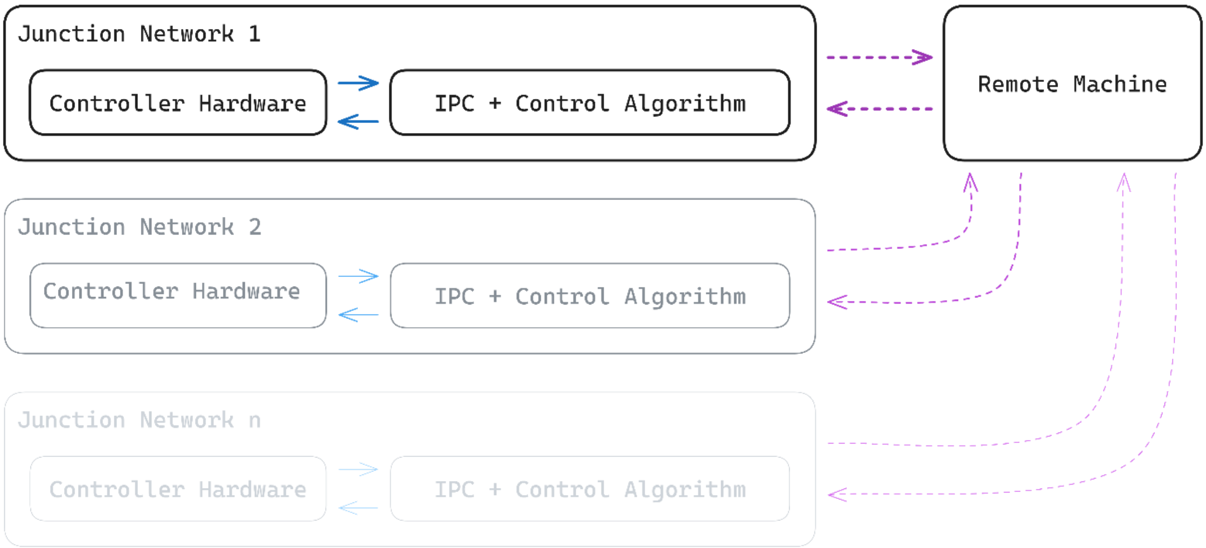

Figure 1: Original system architecture for field tests.

When deploying control algorithm into the field, we initially used the system architecture depicted in figure 1. It focused on every junction separately at the time. The junction controller was adjusted to take inputs specifically designed for the control algorithm we deployed from an industrial computer (IPC). The IPC runs the control algorithm because it either is too computationally expensive to run on the controller itself or needs additional detectors that are not compatible with the controller's interfaces. Rudimentary maintenance was possible with via Virtual Private Network (VPN) from remote machines. We describe the challenges we encountered with this design as well as dependencies to other stakeholders like administrations, public transport and contractors in this contribution.

Afterwards, we present the cloud-based architecture shown in figure 2. Each junction keeps its own VPN. An industrial computer (IPC) collects the data from the controller hardware and potential other detectors and publishes it on the local Message Queuing Telemetry Transport (MQTT) server. A gate transfers the data to a global MQTT, where it is read by the encoding/decoding unit (endec) of the cloud. Only there the data is decoded into a human-readable format and pushed as such onto the cloud MQTT. From there, a control algorithm processes the data and sends back switch commands to the corresponding junction controller.

The client logic on the controller should be as flexible as possible to be adaptable to as many control algorithms as possible. In contrast to the old design, as little processing as possible is done at the junction. That way, the need to adjust components at junction level is minimized. Everything else is managed easily maintainable in the cloud. A SUMO simulation of the junction even allows a pseudo live view of the current junction state. We also propose solutions to maintain accountability for administrations and potential other stakeholders while significantly reducing the complexity and thus time of their involvement.

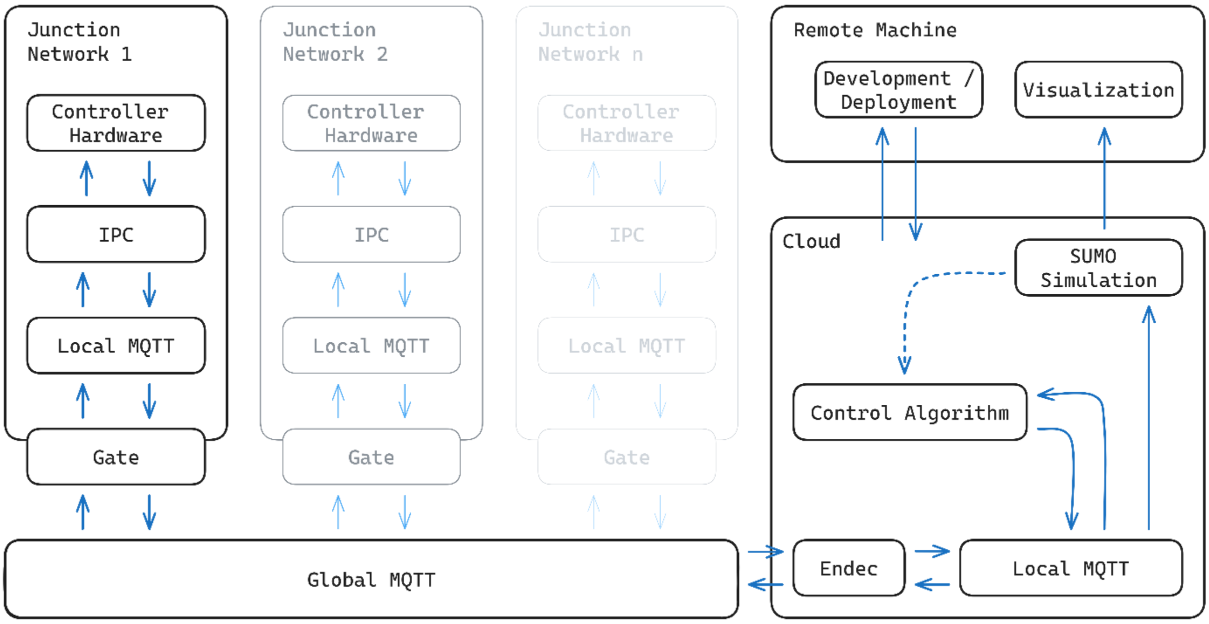

Figure 2: Cloud-based architecture for controlling multiple junctions.

Expected results

The suggested cloud architecture is expected to significantly reduce deployment time for new junction control algorithms, allowing for rapidly accelerated innovation cycles. Additionally, moving the computational burden from the controller into the cloud enables the use of more computation heavy approaches, which would not be possible on the controller or even an IPC. Additional data sources can freely be integrated and do not need to implement the standard interfaces enforced by the controller. Furthermore, after the initial setup, no further changes need to be made to the controller, reducing administration approval times and dependencies on service contractors. Potential delays due to communication are expected to be uncritical as the controller only operates in second intervals. Finally, safety at the controlled junctions is unaffected by the architecture as all safety-critical operations as well as fallback control algorithms are still located at the controller itself.

We are currently in the process of implementing the architecture at Tostmannplatz (figure 3), a junction that is part of the Application Platform Intelligent Mobility (Bauer et al., 2009) in Brunswick. Here we expect to gather results in terms of system latency and availability, but also workflow and deployment process improvements.

Figure 3: The signalized junction Tostmannplatz in Brunswick.

Sources

Alvarez Lopez, Pablo / Michael Behrisch / Laura Bieker-Walz / Jakob Erdmann / Yun-Pang Flötteröd / Robert Hilbrich / Leonhard Lücken / Johannes Rummel / Peter Wagner / Evamarie Wießner (2018): *Microscopic Traffic Simulation using SUMO*. In: 2019 IEEE Intelligent Transportation Systems Conference (ITSC), pp. 2575-2582. IEEE. The 21st IEEE International Conference on Intelligent Transportation Systems, 4.-7. Nov. 2018, Maui, USA. doi: 10.1109/ITSC.2018.8569938

Bauer, Sascha / Eike Bretschneider / Jürgen Rataj / Tilo Schumann (2009): *AIM – Application Platform Intelligent Mobility*. 16th World Congress for ITS Systems and Services, 21.- 25. Sept. 2009, Stockholm, Sweden.

Eggers, Kim Jannik / Robert Oertel / Martin Hesse (2022): *Local Traffic Safety Analyzer (LTSA) - Improved road safety and optimized signal control for future urban intersections.* 4th Symposium on Management of Future Motorway and Urban Traffic Systems 2022 (MFTS2022), 30. Nov. - 02. Dec. 2022, Dresden, Germany.

Erdmann, Jakob (2013): *Combining Adaptive Junction Control with Simultaneous Green-Light-Optimal-Speed-Advisory*. WiVeC 2013, 2.-3. June 2013, Dresden, Germany. doi: 10.1109/wivec.2013.6698230.

Oertel, Robert (2015): *Verlustzeitbasierte Steuerung von Lichtsignalanlagen*. Dissertation, DLR Institute of Transportation Systems.

Oertel, Robert / Jakob Erdmann / Tobias Hesse / Anja Mann / Robert Markowski / Jan Trumpold / Peter Wagner (2017) *Steuerung von Lichtsignalanlagen auf der Basis von Fahrzeuginformationen – Umsetzung und Feldtests.* HEUREKA 2017 - Optimierung in Verkehr und Transport, 22.-23. Mar. 2017, Stuttgart, Germany.