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Leveraging Edge Computing for Real-Time Traffic Management and Simulation with SUMO in Smart Cities

A Goal Document for a Master's Thesis Work

By

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1. Introduction

Urbanization and technological advancements have led to a growing interest in smart cities, and Intelligent Transportation Systems (ITS) play a crucial role in improving urban mobility. The emergence of edge computing provides the opportunity to process large amounts of data closer to where it is generated, thereby reducing latency and improving the efficiency of traffic management systems. The aim of this thesis is to explore the integration of edge computing with ITS with a focus on real-time traffic management and simulation using Simulation of Urban Mobility (SUMO).

2. Background and Motivation

With the increasing complexity of urban traffic networks and the proliferation of connected and autonomous vehicles, traditional cloud-based traffic management systems face challenges in scalability, data latency, and network reliability. Edge computing emerges as a promising solution by offering localized data processing, which is crucial for real-time applications such as traffic management and simulation. This research is motivated by the need for scalable and efficient traffic management solutions that can accommodate the dynamic nature of urban traffic while ensuring safety and optimizing traffic flow.

3. Project Aims and Main Challenges

The primary aim of this project is to design and implement a real-time traffic management system that leverages edge computing and SUMO for adaptive signal control in smart cities.

The main challenges include:

Developing algorithms that can dynamically adjust traffic signals based on real-time data and predictive analysis.

Ensuring the scalability of the solution to accommodate different urban layouts and traffic densities.

Integrating the proposed system with existing urban traffic management infrastructure.

4. Approach and Methodology

The research will employ a mixed-methods approach, including a literature review, system design, simulation experiments, and performance evaluation. The proposed framework will be designed to leverage edge computing capabilities for processing traffic data and making real-time traffic management decisions. SUMO will be used to simulate urban traffic scenarios, evaluate the performance of the proposed framework, and compare it with traditional traffic management systems. Performance metrics such as latency, scalability, traffic flow efficiency, and safety will be analyzed.

5. Previous work

This project builds upon a foundation of research in the domains of edge computing, intelligent transportation systems (ITS), and traffic simulation tools, particularly the Simulation of Urban Mobility (SUMO). Key studies and developments that inform this thesis include:

1. Edge Computing in ITS: We are able to know edge computing in reducing latency for ITS applications and the potential to process real-time data closer to the source[1].

2. Traffic Simulation with SUMO: An overview of demonstrating SUMO's applicability in modeling complex urban traffic scenarios, serving as a basis for this project's simulation component[2].

3. Adaptive Signal Control: Wei explored adaptive signal control systems, presenting algorithms that adjust traffic lights based on real-time traffic conditions[3].

4. Integration of Edge Computing with Traffic Management: Khan[4] focused on the integration of edge computing with traffic management systems, showcasing how localized data processing can enhance responsiveness and efficiency in ITS.

And also, based on Zahra's[5] article, this research presents a novel approach to intersection management using Vehicle-to-Infrastructure (V2I) communication, offering valuable perspectives on the potential for real-time traffic optimization and the work in exploring a hierarchical control strategy for autonomous intersection management.

6. Advancements and Outcome

This thesis is expected to contribute to the field of Intelligent Transportation Systems by:

Proposing a novel framework for integrating edge computing with ITS for real-time traffic management and simulation.

Demonstrating the benefits of edge computing in enhancing the scalability, reliability, and efficiency of traffic management systems in Smart Cities.

Providing insights into the application of SUMO in conjunction with edge computing for improved traffic simulation and management.

7. Resources

Resources required for this project include access to edge computing platforms, SUMO software, traffic data from urban areas, and OTM(Open Street Map). And also, I will base on Zahra's simulation platform[5].

8. Reference

[1] T. Gong, L. Zhu, F. R. Yu and T. Tang, "Edge Intelligence in Intelligent Transportation Systems: A Survey," in IEEE Transactions on Intelligent Transportation Systems, vol. 24, no. 9, pp. 8919-8944, Sept. 2023

[2] M. A. Dian Khumara, L. Fauziyyah and P. Kristalina, "Estimation of Urban Traffic State Using Simulation of Urban Mobility(SUMO) to Optimize Intelligent Transport System in Smart City," 2018 International Electronics Symposium on Engineering Technology and Applications, Bali, Indonesia, 2018, pp. 163-169

[3] L. Wei, L. Gao, J. Yang and J. Li, "A Reinforcement Learning Traffic Signal Control Method Based on Traffic Intensity Analysis," 2023 42nd Chinese Control Conference (CCC), Tianjin, China, 2023, pp. 6719-6724,

[4] L. U. Khan, I. Yaqoob, N. H. Tran, S. M. A. Kazmi, T. N. Dang and C. S. Hong, "Edge-Computing-Enabled Smart Cities: A Comprehensive Survey," in IEEE Internet of Things Journal, vol. 7, no. 10, pp. 10200-10232, Oct. 2020

[5] S. Chamideh, W. Tärneberg and M. Kihl, "A Safe and Robust Autonomous Intersection Management System Using a Hierarchical Control Strategy and V2I Communication," in IEEE Systems Journal, vol. 17, no. 1, pp. 50-61, March 2023

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