International Journal of Business Data Communications and Networking
Volume 20 • Issue 1 • January-December 2025

Strength Optimized Weight Balancing for Traffic Management in Vehicular Ad-hoc Networks

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ABSTRACT

Due to rapid population growth and industrialization, residents of large cities often face severe traffic congestion during their commutes. This leads to unexpected delays, increased accident risks, fuel wastage, and a decline in public health, particularly in urban areas where pollution exacerbates unsanitary conditions. In response, many smart cities are implementing traffic control systems based on traffic automation principles to mitigate these issues. A key challenge lies in using real-time analytics and online traffic data to efficiently manage traffic flow. To address this, the current research proposes an advanced monitoring system leveraging highly flexible mobile agent technology for intelligent data analytics. In the context of a Vehicular Ad-hoc Network (VANET), the mobile agent incorporates additional features such as crime reduction, accident prevention, enhanced driver flexibility, and improved security. These features are combined with a congestion control algorithm to optimize traffic flow and prevent congestion at the entry points of smart traffic zones. Simulation results using the Ns2 simulator demonstrate significant improvements in reducing delays and preventing accidents caused by heavy traffic.

KEYWORDS

VANET, Smart City, Traffic Management, Video Monitoring, Signal System

1. INTRODUCTION

The design of an advanced traffic control system involves integrating traffic signals and control centers with GIS-enabled digital road maps of the city, leveraging the intelligent computational capabilities of data analytics (Singh et al., 2016). A key challenge in this context is the real-time processing of online traffic data and its accurate application to optimize traffic flow. Data analytics tools gather data from the Traffic Management System and, using GIS mapping with real-time support, provide actionable insights to drivers, aiding in traffic congestion reduction. Furthermore, real-time information such as tourist attractions, parking availability, and distance to key locations are also displayed on large digital platforms, enhancing both traffic management and the overall visitor experience.

DOI: 10.4018/IJBDCN.368561

The key components of an advanced traffic management system involve utilizing data analytics as a core module to intelligently process traffic data and integrate traffic signals and control centers with the city's digital road map, enabled by GIS. The primary challenge in this setup is the real-time application of online traffic data to optimize traffic flow. Through GIS mapping and real-time analytics, data analytics tools collect information from the Traffic Management System to provide drivers with valuable insights, helping to reduce traffic congestion (V. Chamolo, 2024). Additionally, real-time information on essential tourist details, such as parking availability, distances, and key attractions, is projected on large digital screens at city entrances, guiding drivers to their destinations. This not only helps reduce fuel consumption but also saves time by minimizing the effort spent searching for tourist spots. Moreover, this system contributes to a smart urban lifestyle, making the environment cleaner, less polluted, and more hygienic (M. Driss, 2024).

Vehicular Ad-hoc Networks (VANETs) are gaining significant attention in modern road traffic management and control systems, driven by advancements in wireless communication technologies. VANETs leverage the network connectivity between vehicles and infrastructure, allowing for dynamic real-time communication to address the growing challenges of traffic congestion in smart cities. By providing smart vehicles with predictive information about road conditions and optimal routes, VANETs enable timely decision-making to avoid congestion and improve overall traffic flow. Additionally, VANETs contribute to reducing traffic incidents, crime, accidents, parking issues, and overcrowding in urban environments. The widespread adoption of wireless technologies has empowered vehicles with a range of smart capabilities, transforming traditional drivers into "smart drivers" capable of receiving, interpreting, and responding to intelligent signals from traffic control systems. VANETs offer flexible communication mechanisms, supporting both infrastructure-based and vehicle-to-vehicle (V2V) communication, eliminating the dependency on fixed infrastructure. The proposed solution for mitigating smart city traffic congestion integrates dynamic data analytics via mobile agents with a refined technical approach, optimizing the VANET framework to tackle the issue of traffic flow and congestion management effectively (H. Zhang et al., 2023).

Mobile agents are highly adaptable software entities that enable platform independence and seamless interoperability among peripheral devices, controllers, workstations, and between client-server architectures. Their self-contained, reconfigurable nature during runtime makes them ideal for supporting various application software environments. Mobile agents are widely used in applications such as digital signatures, on-demand network services, and database management systems. The complexity of the tasks managed by the mobile agent significantly affects the throughput and performance of mobile agent-based systems (J. Gao et al., 2022). One of the challenges in platform communication is selecting an appropriate scripting language that ensures ease of application and system integration. The proposed solution utilizes mobile agents to implement an automated traffic control system's congestion management algorithm within a smart city context. Section 2 provides an extensive literature review and analysis of related applications, while Section 1 introduces the problem domain and scope. Section 3 outlines the proposed paradigm within a VANET (Vehicular Ad-hoc Network) framework, detailing the technical architecture and components involved. This section also addresses the safety and security measures integral to the system's design. Section 4 demonstrates the simulation results using the Ns2 simulator, including technical setup, methodology, and performance outcomes. Finally, Section 5 discusses future enhancements to the model, concluding the article with a roadmap for further research and development.

2. LITERATURE SURVEY

2.1. Introduction to Vehicular Ad-hoc Networks (VANETs)

Vehicular Ad-hoc Networks (VANETs) are a subclass of Mobile Ad-hoc Networks (MANETs) designed for improving road traffic management, safety, and providing real-time communication between vehicles and infrastructure. VANETs enable vehicles to communicate with each other