

# Emerging Technologies in Transportation Systems: Challenges and Opportunities

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## ABSTRACT

*Emerging technologies have been used as a complementary tool to solve different problems that modern society faces every day. One area where the emerging technologies have a big opportunity is transportation. As cities become larger, the number of vehicles and the need for transportation is growing quickly. In this sense, the modern society is facing more traffic congestion, higher fuel bills and the increase of CO<sub>2</sub> emissions. It is imperative to improve and develop a sustainable transportation system that uses in a better way the existing infrastructure and that infrastructure have to be complemented with the application of emerging technologies. This work gives readers a global vision of traffic and transportation issues and how merging technologies contribute to solve transportation problems. In addition, it analyzes some of the emerging technologies and how each technology might be used to improve transportation systems. Finally, a classification of applications for transportation systems is explained and some real applications that are being developed in both academic and industrial environment are described.*

*Keywords: IEEE 802.11p, Intelligent Transportation Systems (ITS), Long Term Evolution (LTE), Vehicle-to-Infrastructure (V2I), Vehicle-to-Vehicle (V2V), Vehicular Network (VANET), Worldwide Interoperability for Microwave Access (WiMAX)*

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## 1. INTRODUCTION

Modern society depends on mobility, which provides personal freedom and access to services for business and pleasure. The amount of time to travel from one location to another can vary significantly based on the current

traffic conditions. The growing volume of traffic has adverse effects on the environment, public health and especially in accidents that cause fatalities, injuries and material damages. Vehicular traffic congestion is one of the most critical concerns for a modern society where cities are ever-growing. Traffic congestion is a

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condition on road networks that occurs as use increases. It is of paramount importance to improve the safety and efficiency of transportation. In order to solve these serious transportation problems, the proposed solutions must be based on intelligent mechanisms and the application of information and communication technologies to make traffic control and management more efficient and safety. Several research groups focus their attention on the emerging technologies as a feasible alternative that contributes to solve the transportation problems (Chatzigiannakis, Grammatikou & Papavassiliou, 2007; Qing, Mak, Jeff & Sengupta, 2007).

Due to the development of Information Technologies, technological advances and wireless communications, the Transportation Systems are rapidly gaining an importance, creating the vision towards more intelligent transportation systems. These systems, which are known as Intelligent Transportation Systems (*ITS*), attempt to apply information and communications technologies to vehicles and transportation infrastructure to manage and control items that are typically independent of each other, such as vehicles, loads, and routes. The final goal is to improve safety and reduce vehicle wear, transportation times, and fuel consumption, among others. *ITS* can contribute to the transportation solution applying the latest information and communication technologies, such as wireless, sensing, cellular, mesh, and computing technologies to transportation systems. However, the intelligent level depends on technological integration level and the technologies used or applied (Figure 1). When these technologies are integrated into the transportation system's infrastructure, and in vehicles themselves, they can help to relieve congestion, improve safety and enhance productivity. The main challenge will be to integrate all technologies within a complementary and cooperative environment that solves the transportation problems. The proposal of a new cooperative environment composed by different network technologies and integrated applications will focus on creating safer roads, more efficient mobility and minimizing the environmental

impact. Additionally, the development of predictive techniques and algorithms will allow transportation systems to increase their grade of intelligence by means of advanced modeling and comparison of historical baseline.

It will be necessary to accelerate and coordinate the deployment and use of *ITS* applications and services for road transport and their connections with other modes of transport, to ensure seamless access and continuity of services. In this sense, EU has proposed an action plan that includes specific measures in these areas (Mobility and Transport, 2009; European commission & Directorate-General for Mobility and Transport, 2011):

- Optimal use of road and traffic data.
- Traffic and freight management.
- Road safety and security.
- Integrating *ITS* applications in the vehicle.
- Data protection and liability.

The direct benefit will be a faster, better-coordinated and more harmonized use of intelligent transport systems and services, which in turn will contribute to more efficient, cleaner and safer transportation systems.

This paper gives the readers a global vision of the traffic and transportation issues, the efforts of development about standards for transportation management, and how the application of emerging technologies might contribute or are contributing to the solution of transportation challenges. The paper is organized as follows: section 2 provides an overall view of the background in transportation systems. Section 3 describes fundamental concepts, definitions, defined *ITS* architectures and the standards development. Some of the emerging technologies typically implemented in *ITS* are described in section 4. Section 5 presents several applications and developing projects of different countries and regions where emerging technologies are (or will be) applied. Finally, the last part of the paper presents the conclusions of the work.

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