# Chapter 1
# Introduction

According to statistics from the automotive industry, as of 2022, there were about 1.446 billion cars in the world. It means that approximately 17.7 percent of people own a car. By the end of 2035, it is anticipated that the total number of vehicles on earth will reach 2 billion[9]. Although the widespread use of automobiles has made transportation more convenient, it has also led to an increase in traffic fatalities. The "World Health Organizatio" says that 1.3 million people die in traffic accidents every year. There are an additional 20 to 50 million people who sustain non-fatal injuries, many of whom end up developing disabilities. Road traffic accidents result in significant economic damages for individuals, one's family, and nations. Most nations lose 3% of their gross domestic product to road accidents.[53].

However, this fatality, economic and environmental damages can be avoided by using the intelligent transportation system (ITS)[19], [35]. Enhancing the safety and efficiency of transportation services is the primary objective of ITS. Through the use of wireless communication and diverse sensors, ITS enhances traffic safety. In addition to enhancing traffic safety, processing real time information offers a number of additional advantages for vehicle networks. Detecting and avoiding traffic jams, cooperative driving, and route guidance are a few of the examples. It can save a considerable amount of time and fuel, thus providing economic benefits. Particularly, vehicular ad hoc networks (VANETs) are regarded as the most prominent technology for ensuring and maintaining a vast array of applications, ranging from road safety and traffic control to infotainment[13]. The motivations for developing efficient data dissemination options in the automotive context are discussed in Section 1.1. In section 1.2, the major contributions of this thesis are listed. The thesis structure is outlined in Section 1.3.

## 1.1 Motivation

VANET is a type of ad hoc network with some specific characteristics that make it different from MANET. Vehicles can only move on restricted road structures. There are no power restrictions on the processing capacity of vehicles. However, diverse traffic conditions, rapidly varying road topologies result into dynamic networks. In addition, the high speed of vehicles and frequent disconnection under low-traffic conditions will exacerbate the difficulties of vehicular networking [65].

Wireless access in vehicular networks (WAVE) is a protocol stack designed specifically for vehiclular communication. The IEEE 802.11p standard defines physical and Mac layer activities in WAVE, while network, application, and security layers are governed by the IEEE 1609 standards. The IEEE 1609 standards are divided into the following four components: Application resource management is covered by IEEE 1609.1, whereas security concerns are covered by IEEE 1609.2. In addition, services at the network and transport layers are provided by IEEE 1609.3. Finally, IEEE 1609.4 supports multichannel functionality. The IEEE 802.11p standard is an enhanced version of the IEEE 802.11 standard designed to improve wireless connectivity in high-speed vehicles [24]. It provides vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. However, in the absence of centralized control, this will result in unreliable communication. [43].

A total of 75 MHz of bandwidth is reserved for implementing ITS applications. The band is divided into seven different channels of 10 MHz each. There is one control channel (CCH) and six service channels available. Safety-related applications are the most crucial in ITS, so all the safety-related messages need to be communicated through this single control channel. The other six channels, referred to as service channels (SCH), are used in both safety-related and non-safety-related applications. All vehicles listen to the Control Channel (CCH) for 50 ms and switch to the Service Channel (SCH) for another 50 ms. During control channel intervals, safety messages are exchanged [12].

The primary motivation for this thesis is the diverse issues that arise when sending safety-related messages over a network of vehicles. Our research is primarily centered on data dissemination systems designed using vehicle-to-vehicle (V2V) communications.

Based on the aforementioned scope, this thesis focuses primarily on the following research question:

*How can we achieve effective data dissemination through inter-vehicle communications while meeting the specific criteria of safety applications?*

## 1.2 contribution

- There are many different multi-hop data dissemination protocols in the literature. This thesis provides a concise classification of the most important schemes widely used for safety-related data dissemination.

- We provided an in-depth performance analysis of existing multi-hop broadcast approaches, including native flooding and representative delay-based broadcast techniques. A realistic simulation setup with real road networks is used to evaluate the performance. The evaluation is provided for a wide range of vehicle densities.

- To overcome the few drawbacks of basic delay-based techniques, we propose an adaptive delay-based methodology based on sender coverage and signal quality. The aim of the proposed design is to achieve high reachability with acceptable delay performance. The proposed design is intended to reduce frequent message contention and increase the reliability of the protocol.

## 1.3 Thesis outline

This thesis is structured as follows: in the second chapter, we present an overview of VANETs from the perspectives of architecture, characteristics, types of communication, technology, and applications. In the context of VANET, the third chapter discusses data dissemination difficulties, models, and types. We examine existing data dissemination optimization methodologies by considering the broadcast storm problem, not only for safety-oriented applications but also for convenience-oriented applications. Then, we examine the various data dissemination strategies. We categorize various data dissemination systems based on the broadcast scheme. Our two different data dissemination strategies are described in the fourth chapter. Later in the fifth chapter, simulation results are used to evaluate the performance of our proposed methods. The final chapter offers concluding remarks and suggestions for future research.