Chapter 4
STDMA-based Scheduling Algorithm for Infrastructured Vehicular Networks

Luis Silva, Paulo Pedreiras, Muhammad Alam and Joaquim Ferreira

Abstract A huge research effort has been devoted to the transportation sector in order to make it safer and more efficient, leading to the development of the so-called Intelligent Transportation Systems (ITS). In ITS there is a closed loop interaction between vehicles, drivers and the transportation infrastructure, supported by dedicated networks, usually referred to as vehicular networks. While some of the enabling technologies are entering their mature phase, the communication protocols proposed so far aren't able to fulfill the timeliness contraints of many ITS services, specially in road congestion scenarios. In order to tackle this issue, several medium access protocols (MAC), either relying on infrastructure or based on direct ad-hoc communication, have been designed. A great number of these protocols employ Time Division Multiple Access (TDMA) techniques to manage communications and attain some degree of determinism. Although the use of spatial reuse algorithms for TDMA protocols (STDMA) has been extensively studied as to increase the efficiency of standard ad-hoc and mesh networks, ITS networks exhibit a combination of features and requirements that are unique and aren't addressed by these algorithms. This chapter (This chapter is an extended work of [21]) discusses some of the most relevant challenges in providing deterministic real-time communications in ITS vehicular networks as well as the efforts that are being taken to tackle them. Focus on TDMA infrastructure-based protocols and on the challenges of employing spatial reuse methods in vehicular environments is placed. A novel wireless vehicular communication architecture called V-FTT, which aims at providing deterministic communications in vehicular networks, is also presented. The chapter concludes with the design of

---

L. Silva (✉) · P. Pedreiras · M. Alam
Instituto de Telecomunicações, Campus Universitário de Santiago, Aveiro, Portugal
e-mail: luis.silva.ua@gmail.com

P. Pedreiras
e-mail: pbrp@ua.pt

M. Alam
e-mail: alam@av.it.pt

J. Ferreira
Instituto de Telecomunicações, ESTGA-Universidade de Aveiro, Aveiro, Portugal
e-mail: jjcf@ua.pt

M. Alam et al. (eds.), *Intelligent Transportation Systems*,
Studies in Systems, Decision and Control 52,
DOI 10.1007/978-3-319-28183-4_4

a traffic scheduling analysis, a STDMA slot assignment algorithm and a Matlab simulator for V-FTT.

Keywords ITS · MAC · TDMA · STDMA

4.1 Vehicular Networks

Wireless vehicular networks for cooperative Intelligent Transport Systems (ITS) have raised widespread interest in the last few years due to their potential applications and services. Cooperative applications with data sensing, acquisition, processing and communication provide an unprecedented potential to improve road safety, passengers' comfort and traffic management. In order to support such visionary scenarios, communication between applications deployed in vehicles and applications deployed in the back offices of emergency services, road operators or public services is required. These applications run unattended, reporting information and taking commands from counterpart applications in the vehicle or network.

The European Telecommunications Standards Institute (ETSI) EN 302 665 standard has defined a "Basic Set of Applications" (BSA) which is composed of three main application classes [6, 11]:

- **Road/Traffic Safety Applications**: Aim at reducing the risk of car accidents and at minimizing the damage of unavoidable accidents;
- **Traffic Efficiency Applications**: Aim at improving traffic fluidity;
- **Other Applications (Value-Added)**: Aim at providing comfort and entertainment for the users.

Each of the aforementioned classes exhibit different levels of quality of service (QoS) that must be provided so as to ensure their correct operation. For example, due to their nature, safety related applications typically require maximum guaranteed latencies under 100 ms, while most infotainment applications prioritize high data rates. Besides latency, safety applications also require a high level of determinism and reliability in their communications. For example, a vehicle involved in an accident should be able to access the medium in a timely manner in order to transmit warning messages even in congested road scenarios. Thus, a proper management and design of vehicular networks is essential.

The mobile units of a vehicular network are equivalent to nodes in a traditional wireless network. Besides the ad-hoc implementation of a network consisting of neighboring vehicles, commonly known as Vehicular Ad hoc NETworks (VANETs), in which participants engage in Vehicle-to-Vehicle (V2V) communication, there is also the possibility of a more traditional wireless network setup with base stations along the road sides. These stations act as access points, managing the flow of information of Vehicle-to-Infrastructure (V2I) communications. They can also provide access to external networks and services. Devices that enable the aforementioned types of communication and host ITS applications are called On Board Units (OBUs), Springer

http://www.springer.com/978-3-319-28181-0

Intelligent Transportation Systems
Dependable Vehicular Communications for Improved Road Safety
Alam, M.; Ferreira, J.; Fonseca, J. (Eds.)
2016, XIV, 270 p. 141 illus., 102 illus. in color., Hardcover
ISBN: 978-3-319-28181-0