Interest in inter-vehicular and vehicle-to-roadside communication has significantly increased over the last decade, in part because of the proliferation of wireless networks. Most research in this area has concentrated on vehicle-to-roadside communication, also called beacon-vehicle communication, in which vehicles share the medium by accessing different time slots.

Some applications for vehicle-to-roadside communication, including automatic payment, route guidance, cooperative driving, and parking management, have been developed to function within limited communication zones of less than 60 meters. However, the IEEE 802.11 Standard has led to increased research in the areas of wireless ad hoc networks and location-based routing algorithms, (Morris et. al., 2000), (Da Chen, Kung, & Vlah, 2001), (Füßler, et. al., 2003), (Lochert, et. al., 2003), (Kosh, Schwingenschlögl, & Ai, 2002). Applications for inter-vehicular communications include intelligent cruise control, intelligent maneuvering control, lane access, and emergency warning, among others. In (Morris et. al., 2000), the authors propose using Grid (Li, et. al., 2000), a geographic forwarding and scalable distributed location service, to route packets from car to car without flooding the network. The authors in (Da Chen, Kung, & Vlah, 2001) propose relaying messages in low traffic densities, based on a microscopic traffic simulator that produces accurate movement traces of vehicles traveling on a highway, and a network simulator to model the exchange of messages among the vehicles. Da Chen et al. employ a straight bidirectional highway segment of one or more lanes. The messages are propagated greedily each time step by hopping to the neighbor closest to the destination. The authors in (Füßler, et. al., 2003), compare a topology-based approach and a location-based routing scheme. The authors chose GPSR (Karp & Kung, 2000) as the location-based routing scheme and DSR (Johnson, Maltz, & Hu, 2007) as the topology-based approach. The simulator used in (Füßler, et. al., 2003) is called FARSI, which is a macroscopic traffic model. In (Lochert, et. al., 2003), the authors compare two topology-based routing approaches, DSR and AODV (Perkins, Belding-Royer & Das, 2003), versus one position-based routing scheme, GPSR, in an urban environment. Finally, in (Kosh, Schwingenschlögl, & Ai, 2002), the authors employ a geocast routing protocol that is based on AODV.

In inter-vehicular communication, vehicles are equipped with on-board computers that function as nodes in a wireless network, allowing them to contact other similarity equipped vehicles in their vicinity. By exchanging information, vehicles can obtain information about local traffic conditions, which improves traffic control, lowers contamination caused by traffic jams, and provides greater driver safety and comfort.

Vehicle collisions represent the great majority of automobile deaths and injuries. Although great advances have been made regarding passive safety systems (seat belts, air bags), and these systems have significantly reduced the number of deaths and injuries on streets and roadways, active collision avoidance systems are still in the development stage, and there is still much research and development to be done before these systems can actually be deployed.
In the United States, the Transportation Statistics Annual report (Transportation Statistics Annual Report, 2006) states that “highway travel times increased between 1993 and 2003 in all but 3 of the 85 urban areas (98 percent)”, and “it took 37 percent longer, on average, in 2003 to make a peak period trip (from 6 to 9 a.m. and 4 to 7 p.m.).” The additional time spent commuting can cause greater fatigue or distraction as the attention span of drivers becomes taxed. Although the number of fatalities slightly decreased, “in 2005, 43,443 motorists and non-motorists were killed in crashes involving motor vehicles, up 1% compared with 2004, and about 2.7 million people were injured.” Finally, the report mentions that “there were 1.47 fatalities per 100 million vehicles-miles of highway travel in 2005.” One of the major causes of car accidents and fatalities is driver distraction. Distracted driving is defined by the United States Department of Transportation (USDT) (http://www.distraction.gov/) as: “any non-driving activity a person engages in while operating a motor vehicle. Such activities have the potential to distract the person from the primary task of driving and increase the risk of crashing.”

Future developments in automobile manufacturing will also include new communication technologies. The major goals are to provide increased automotive safety, to achieve smooth traffic flow on the roads, and to improve passenger convenience by providing them with information and entertainment. In order to avoid communication costs and guarantee the low delays required for the exchange of safety related data between cars, inter-vehicle communication (IVC) systems based on wireless ad-hoc networks represent a promising solution for future road communication scenarios. IVC allows vehicles to organize themselves locally in ad-hoc networks without any pre-installed infrastructure. Communication in future IVC systems will not be restricted to neighbored vehicles travelling within the radio transmission range, as in typical wireless scenarios, the IVC system will also provide multi-hop communication capabilities by using “relay” vehicles that are travelling between the sender and receiver.

Another important aspect of IVC or RVC communication is the environment in which the vehicles are moving. It is known that different physical environments lead to different performances. For example, in an urban scenario, vehicles will suffer more multi-path interference than in a freeway scenario. This is primarily because the presence of buildings and other obstacles (trees, communication towers, billboards, etc.) in urban environments cause diffraction and scattering. Moreover, researchers must also consider the different velocities implicit in different scenarios. Generally speaking, drivers require more time and a greater distance to come to a complete and safe stop. Vehicles will travel at a higher velocity and be more widely spaced in a freeway scenario because drivers require greater reaction times than in urban settings. Distance and relative velocity, therefore, are very important because they significantly influence communications. For example, in urban scenarios, inter-vehicular distances are very small for prolonged periods of time due to reduced spacing from merging and frequent stops. Consequently, closely spaced vehicles can exchange more data than in freeway scenarios, where the distances and velocities between vehicles are substantially greater. It is important to recall that in peer-to-peer communication, the distance between peers must be small enough for the entire duration of the communication. Therefore, vehicles predictably maintain lower speeds and smaller spacing, frequently stop, and transmit greater uninterrupted information streams. The speed and spacing factors lead to considering the dynamics of vehicular movements, particularly inter-vehicular distance and their relative velocity and position as they move along to streets or roadways. Consequently, different models must be developed to predict vehicular movement in highly dynamic and varied real-world scenarios. Another issue that can affect IVC or RVC communication is the technology employed; each technology prioritizes different features, such as frequency, bandwidth, and transmission power.
One of the most obvious issues relating to inter-vehicle ad-hoc routing protocols is the velocity of the mobile devices. One of the effects of velocity is to make the signal strength highly variable. Chu and Stark demonstrate in (Chu and Stark, 2000) that the fading signals are in function of velocity. Based on simulations, they observed that the best performance is at lower velocities because the signals vary more slowly, thus creating little channel attenuation between bits of information transmitted.

There are many problems that affect communications in mobile communication environments, but the two main ones are multi-path delay and Doppler Shift (Rappaport, 2002). Multi-path delay produces frequency selective fading, so that signals suffer interference, and Doppler can affect shifts suffered by the carrier frequencies. Fading is caused by interference between two or more versions of the transmitted signal that arrive at the receiver at slightly different times. The versions, also called multi-path waves, combine at the receiver antenna to give a resultant signal, which can vary widely in amplitude and phase, depending on the distribution of the intensity and relative propagation time of the waves and the bandwidth of the transmitted signal. The phenomenon is known as constructive or destructive interference.

In the estimation of the radio coverage area of a transmitter and receiver, two simple large-scale and small-scale propagation models can be used. Large-scale models characterize signal strength over large T-R separation distances (several hundreds or thousands of meters). Propagation models that characterize the rapid fluctuation of the received signal strength over very short travel distances (a few wavelengths) or short time duration (on the order of seconds) are called small scale, or fading models.

This book is organized as follows:

Section 1 describes current theories and applications of the physical and medium access layers. Section 2 analyses theories and their applications in the network layer. Section 3 discusses how to integrate theory into different applications in the application layer.

In greater detail:


Section 2 presents: Reactive Location-Based Routing Algorithm with Cluster-Based Flooding and Evaluation of the LORA-CBF Routing Algorithm with Selective Gateway in an Ad Hoc WiMAX network.

Section 3 includes: Development of Applications for Vehicular Communication Network Environments: Challenges and Opportunities; Communication Architectures and Services for Intelligent Transport Systems; Analyzing the Trade-Offs between Security and Performance in VANETs; Cooperative Positioning in Vehicular Networks; Data Dissemination in Vehicular Networks: challenges and Issues; Experience Developing a Vehicular Network Based on Heterogeneous Communication Technologies; and Unpredicted Trajectories of an Automated Guided Vehicle with Chaos.

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REFERENCES


