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Comparative Analysis of IEEE 802.11p and IEEE 802.16-2004 Technologies in a Vehicular Scenario

Raúl Aquino-Santos, Antonio Guerrero-Ibáñez
and Arthur Edwards-Block
Faculty of Telematics, University of Colima,
Av. Universidad 333, Colima
México

1. Introduction

A major challenge of the automobile industry and safety authorities is how to improve the way cars can communicate either among themselves or with infrastructure designed to assist drivers. Sichitiu and Kihl in [1] describe a taxonomy based on the way nodes (in this case, cars) exchange data. Their work involves two forms of vehicular communication: vehicle-to-vehicle communication (IVC) and vehicle to roadside communication (RVC). IVC can employ either a one hop strategy between two cars (SICV) or multi-hop strategy between many cars (MIVC). It is important to note that multi-hop strategies begin with one car but use several other cars to relay the information to the car requiring the information. Furthermore, the communication strategy can also be either ubiquitous (URVC) or scarce (SRVC). Because of the highly dynamic nature and multiple demands inherent in Vehicular Communication Networks (VCN), these networks have their own very unique requirements:

- The radio transceiver technology must provide omni-directional coverage.
- Rapid vehicle-to-vehicle communications must keep track of dynamic topology changes.
- Highly efficient routing algorithms need to fully exploit network bandwidth.

The increased interest in vehicle-to-vehicle (IVC) and vehicle-to-roadside communication (RVC) is due, in part, to the need to expand the amount of information relayed to vehicles. As previously mentioned, the information relayed today is no longer limited to cellular telephone service. As the need to transmit more information grows, so must the technology used to carry that information from car to car or from communications tower to tower. Some applications are more suitable for vehicle-to-roadside communications in applications that involve automatic payment, route guidance, cooperative driving and parking management, just to name just a few. However, there are other applications that are more appropriate for vehicle-to-vehicle communications, including intelligent cruise control, intelligent maneuvering control, lane access and emergency warning, among others. Basically, there are three main categories of applications that have been targeted: (i) road safety applications, (ii) traffic efficiency applications, and (iii) value-added applications. Each

application or service possesses different requirements in terms of coverage area, message delay and throughput (Table 1).

Application category	Latency tolerance	Range	Delay requirements
Road safety	Low latency	Local range	Pre-crash sensing/warning (50 ms). Collision risk warning (100ms).
Traffic efficiency	Some latency is acceptable	Medium range	Traffic information – Recommended itinerary (500 ms).
Value-added services	Long latency is accepted	Medium range	Map downloads update – Point of interest notification (500ms).

Table 1. Application categories: examples and requirements.

In RVC and IVC, vehicles require on-board computers and wireless networks to allow them to contact other similarly-equipped vehicles in their vicinity or to roadside access points which, in simpler terms, is a specific point where the information is first introduced into the network. By exchanging information, in the near future, RVC and IVC will be able to provide information about the local traffic situation, real-time vehicle diagnostics and a variety of value-added services to improve comfort and safety.

Future developments in automobile manufacturing will also include new and expanded communication technologies in the area of entertainment, context awareness information, and remote diagnostics of both the vehicle and its occupants. The major goals of IVC and RVC are to provide increased automotive safety, to achieve smooth traffic flow, and to improve passenger convenience by offering passengers both information and entertainment. Vehicle-to-vehicle communication (IVC) systems based on wireless ad-hoc (dynamically self organizing) networks represent a promising solution for future mobile communication because they minimize communication costs (licensed frequency spectrum and mobile communications based on VoIP, etc.) and guarantee the low delays required to exchange safety-related data between cars. IVC will soon allow vehicles to self organize themselves locally in ad-hoc networks without any pre-installed infrastructure. Having cars carry all of the communications infrastructure in them will require fewer unsightly communications towers and permit each vehicle to be a tower in itself, in the sense that they will be able to transmit, relay and receive information without any visible infrastructure. Communications in future IVC systems will not be restricted to neighbored vehicles travelling within a limited radio transmission range, as is currently the case in wireless scenarios. Future IVC systems will provide multi-hop communication capabilities to relay data and information by employing intermediate vehicles located between any specific sender and receiver as relay nodes.

One of the most obvious issues relating to IVC or RVC is the velocity of the mobile devices. One of the effects of velocity is to make signal strength extremely variable. Chu and Stark show in [2] that fading (interference) is a direct function of velocity. Based on simulations, they observed that signal strength is best maintained between vehicles that travel at lower velocities because the signal strength varies more slowly, thus creating much less

interference between any two consecutive transmissions. Of course, with less fading, there is a smaller chance of the signal suffering communications breakdown.

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 (when the signal splits into many signal that come from different directions) than in a freeway scenario. Multi-path interference is very important because if the signal is split and arrives at a specific location from different angles, they will not arrive at the same time, and this will make understanding the signal sent difficult or impossible. Multi-path interference is primarily caused by 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 because reduced spacing due to 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 that predictable maintain lower speeds and spacing, along with many predictable stops, can transmit greater uninterrupted information streams. The speed and spacing factors lead us to consider 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.

This work analyzes two emerging wireless technologies that can be employed in RVC communication, IEEE 802.1p and IEEE 802.16-2004, in an urban scenario.

The remainder of this chapter is organized as follows: Section 2 describes research related to IEEE 802.11p and IEEE 802.16-2004 technologies and Section 3 describes the simulated scenario simulated and results we obtained. Finally, Section 4 provides a summary of our work and offers suggestions for future research.

2. Related work in IEEE 802.11p and IEEE 802.16-2004 technologies

Numerous researchers have worked to overcome issues related to IVC and RVC communication (e.g. [3-10]). In 2004, the IEEE group created the IEEE 802.11p (Wireless Access in Vehicular Environments, (WAVE)) task force [11]. The workforce established a new standard that essentially employs the same PHY layer of the IEEE 802.11a standard, but uses the 10 MHz bandwidth channel instead of the 20 MHz bandwidth of IEEE 802.11a. With respect to the MAC layer, WAVE is based on a contention method (i.e. CSMA/CA), similar to other standards in this group. The purpose of this standard is to provide the

minimum set of specifications required to ensure interoperability between wireless devices attempting to communicate in potentially rapidly changing communications environments and in situations where message delivery must be completed in time frames much shorter than the minimum in 802.11-based infrastructure or ad-hoc networks [12]. The used frequency spectrum in an 802.11p network is divided into one control channel (CCH) and several service channels (SCHs), as shown in Figure 1. The CCH is dedicated for nodes to exchange network control messages while SCHs are used by nodes to exchange their data packets and Wave Short Messages (WSMs). The link bandwidth of these channels is further divided into transmission cycles, each comprising a control frame and a service frame. The draft standard suggests that the duration of a frame (either a control or a service frame) is set to 50 milliseconds.
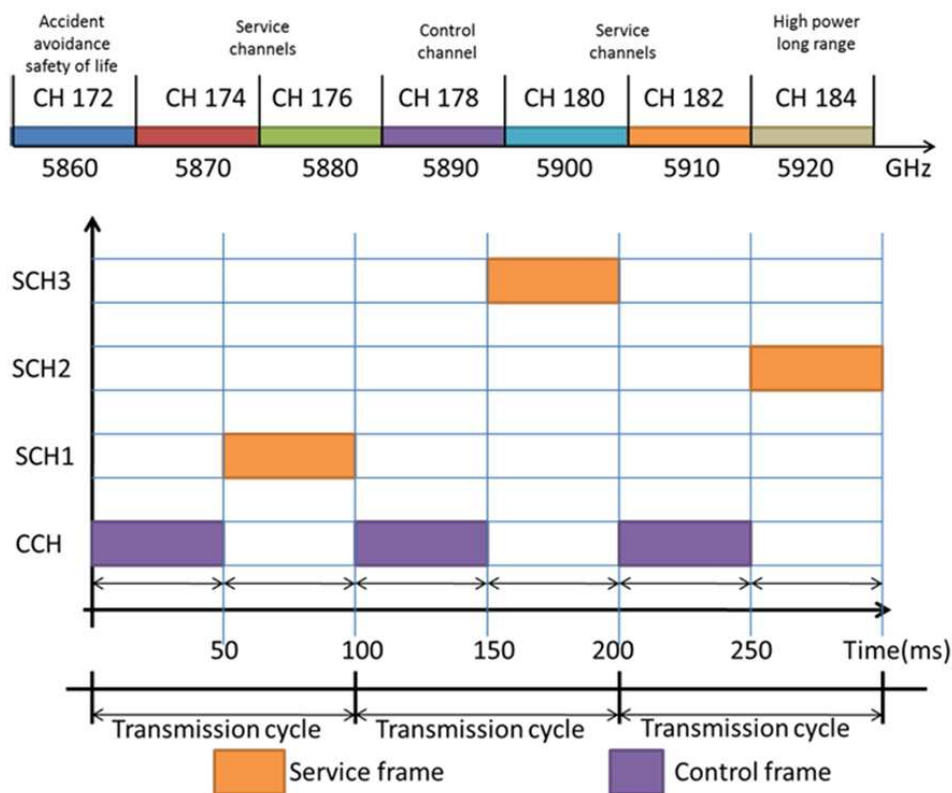
Fig. 1. Channels available for 802.11p

Authors in [13] evaluated the Packet Error Rate (PER) performance degradation of the WAVE PHY layer due to the time-varying channel and the Doppler Effect. They conclude that the estimation process is significantly affected by rapid changes of the channel, severely affecting the PER performance, while the Inter-Carrier Interference (ICI) has little or no impact on the performance at small data rates. WAVE also has a limited transmission range; simulations carried out by [14] show that only 1% of communication attempts at 750m are successful in a highway scenario presenting multipath shadowing.

The MAC layer in IEEE 802.11p has several significant drawbacks. For example, in vehicular scenarios, WAVE drops over 53% of packets sent according to simulation results [15]. Furthermore, results in [16] show that throughput decays as the number of vehicles increases. In fact, throughput decreases to almost zero with 20 concurrent transmissions.

The authors thus conclude that WAVE is not scalable. Additionally, IEEE 802.11p does not support QoS, which is essential in Vehicular Ad hoc Networks (VANETs).

Authors in [17] report that the probability of collisions grows significantly as the number of nodes sending Access Classes (AC3) increases. It is important to remember that a higher number of collisions can cause increased dead time, in which a channel is blocked and no useful data can be exchanged. Also, the continuous switching between the Control Chanel (CCH) and the Service Channel (SCH) use different packet cues, which amplifies the affects of collisions. As a result, packets destined for the CCH form longer cues which result in greater SCH intervals and higher end-to-end delay. WAVE technology can not ensure time critical message dissemination (e.g. collision warnings), especially in dense scenarios or in the case of filled MAC queues.

Authors in [18] developed a simulation framework for the Wireless Access in Vehicular Environments (WAVE) standard using the NS-2 simulator. Their framework included a handoff mechanism, but they did not employ realistic vehicular traffic models.

Recently, the IEEE 802.16-2004 taskforce [19, 20] actualized this standard to better permit it to handle QoS, mobility, and multi-hop relay communications. Networks using the Worldwide Interoperability for Microwave Access (WiMAX) -MAC layer now can potentially meet a wider range of demands, including VCN. WiMAX is a nonprofit consortium supported by over 400 companies dedicated to creating profiles based on the IEEE 802.16-2004 standard. The first IEEE 802.16-2004 standard considers fixed nodes in a straight line with line of sight between the base station and each fixed remote node [21]. Later, the IEEE 802.16e task force (TF) amended the original standard to provide mobility to end users (Mobile WiMAX [18]) in non-line-of- sight conditions. The most recent modification to IEEE 802.16e was in March, 2007. This modification, IEEE802.16j (approved in 2009), permits multi-hop relay communications [20].

IEEE 802.16j operates in both transparent and non-transparent modes. In transparent mode, mobile stations (MS) must decode the control messages relayed from the base station (BS). In other words, they must operate within the physical coverage radius of the BS. In non-transparent mode, one of the relay stations (RS) provides the control messages to the MS. The main difference between the transparent and the non-transparent mode architecture is that in transparent mode, RS increases network capacity while in non-transparent mode, the RS extends the BS range. Additionally, the RS can be classified according to mobility and can be fixed (FRS), nomads (NRS) or mobiles (MRS) [22].

In [23] the authors propose a cross-layer protocol called Coordinated-External Peer Communication (CEPEC) for Internet-Access services and peer communications for vehicular networks. Their simulation results show that the proposed CEPEC protocol provides higher throughput with guaranteed fairness in multi-hop data delivery in vehicular networks when compared with the purely IEEE 802.16-2004 based protocol.

Authors in [24] examine the IEEE 802.16j multi-hop relay (MR) technology that improves vehicle-to-infrastructure communications.

Finally, there are few studies that show comparative analysis between WiFi and WiMAX. In [25] authors report that while WiMAX can offer a longer communication range than WiFi, its latency can be significantly larger than that of WiFi at a short distance (e.g. less than 100m). Additionally, authors show the frame size´s value has a strong impact on the performance of WiMAX.

3. Scenario simulated and results obtained by simulations

In this section, we perform a simulation study to verify the efficiency and performance of both technologies as a communication media applied into a vehicle-to-infrastructure (V2I) communications environment. The performance of the two systems was evaluated for different vehicle speeds and traffic data rates.

In order to evaluate the performance of both technologies, we carried out several simulations in the NCTUNs network simulator and emulator [26], which is a free network simulation tool that runs on Linux. The reason behind the decision to use this tool is that NCTUns provides reproducible and traceable results. The simulator tightly integrates network and traffic simulations and provides a fast feedback loop between them. Simulation models for mobile WiMAX with the support of several features (such as PHY OFDMA, PMP and TDD modes, QoS scheduling services, among others) and for 802.11p that supports IEEE 802.11p On Board Units (OBUs) and Road Side Units (RSUs) are defined in NCTUns simulation tool.

As the metrics of performance evaluation, we mainly use the throughput, the packet loss rate and the packet end-to-end delay sent from the source node to the receptor node. The aim of these metrics is to quantitatively determine the packet loss average during the overall communication session, the average packet end-to-end delay sent from the source node to the receptor node and the average throughput obtained for the overall communication process.

3.1 Simulation environment and setting

As previously mentioned, for our simulations, we use the NCTUns network simulator. We ran the simulation to verify if 802.11p and WiMAX can ensure an acceptable performance for different speeds and traffic data rates.

To evaluate and compare the performance of both 802.11p and 802.16-2004 technologies in a Vehicular-to-Infrastructure (V2I) context, we consider the scenario shown in Figure 2. We define a 13km zone that is fully covered by base stations. For 802.11p technology, several Road-Side-Units (RSUs), which represent fixed devices with a Dedicated Short Range Communication (DSRC) radio, are mounted on road sides. For 802.16 technology, one base station (BS) is mounted in the scenario where twenty-five vehicles are randomly distributed on the road. The vehicles are equipped with a wireless communication device depending of the evaluated scenario either 802.11p or IEEE 802.16-2004.

As shown in Figure 2, for the case of 802.11p, each base station has a coverage area of 1000 m and a common coverage area of around 100m. The RSUs are connected to the router by means of links with a capacity of 100Mbits (to avoid any bottleneck outside the considered WiMAX/802.11p V2I networks). Each RSU is configured to provide the service in channel 174.

The movement of all vehicles on the road is generated randomly by the simulator. In NCTUns, each vehicle can be specified with different auto-driving behaviors. A driving behavior is defined by a car profile. After inserting vehicles, one can specify what kind of profile should be applied to an Intelligent Transportation System (ITS) car. We use the car profile tool included in NCTUns to define the behavior of the cars. An overview of the information of car profiles used for the simulation is shown in Table 2.
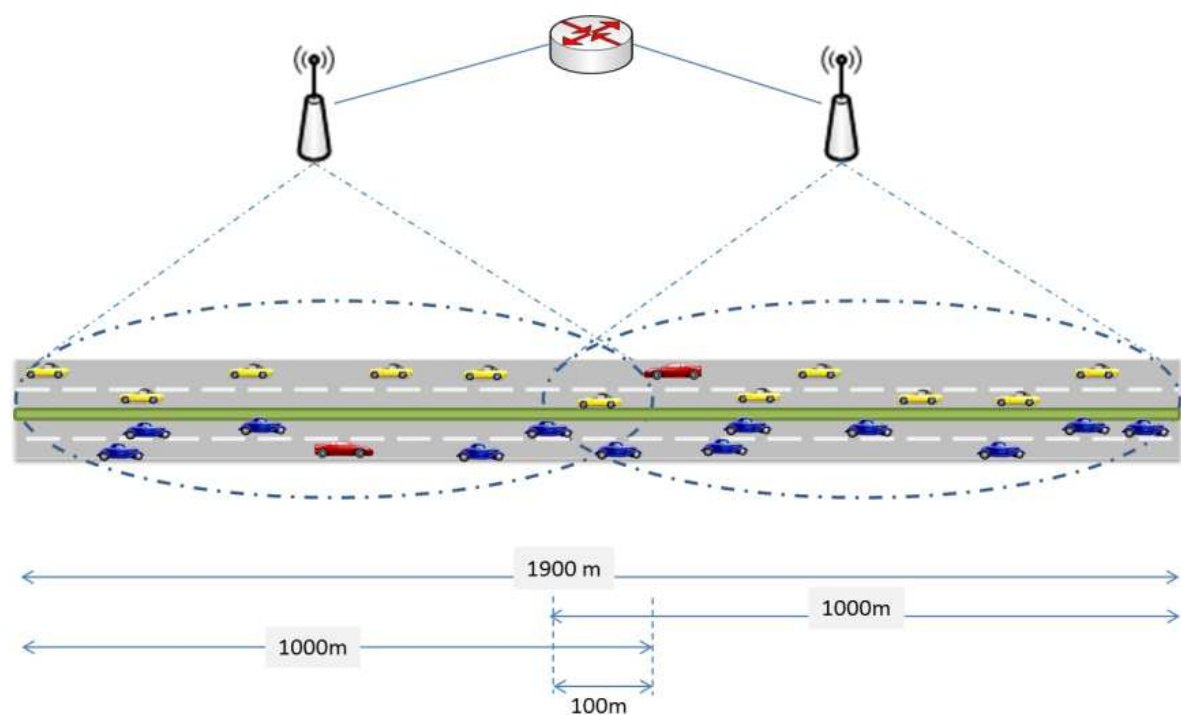
Fig. 2. Simulation scenario

	Profile1	Profile2	Profile3	Profile4	Profile5
Maximum speed	50km/h	60km/h	90km/h	100km/h	200km/h
Maximum acceleration	1.2 m/sec	1.34 m/sec	4.5m/sec	5m/sec	12m/sec
Maximum deceleration	2 m/sec	2.24 m/sec	8.9m/sec	10m/sec	20m/sec

Table 2. Car profiles

The simulation is divided into two scenarios. In both scenarios, we present a communication model between two vehicles moving in opposite directions.

Our first scenario studies the impact of vehicle speed on performance of both technologies into a V2I communication environment. This scenario consists of a constant bit-rate application running over User Datagram Protocol (UDP), and we have set the source data rate to 1Mbps. In this scenario we vary the average speed of the vehicles to 60km/h, 100km/h and 200km/h. The first speed reflects the typical mobility within an urban region, while the second and third speeds are meant to meet the IEEE 802.11p set requirements. In this scenario we examine the impact of varying the vehicle speed on the average throughput and the end-to-end delay.

The second scenario studies the impact of the source data rate on the performance of both technologies into a V2I communication environment. This second scenario consists of a variable bit-rate application with an increased traffic flow, consisting of exponential UDP traffic varying from 1Mbps to 6Mbps, in which we evaluate the impact of varying the source data rate on both the throughput and the end-to-end delay. In this scenario we set the average speed of the vehicles to 100 km/h, which is a realistic value of vehicles on the highway. An overview of the parameters used for the simulation configuration is shown in Table 3.

Parameter	802.11p	802.16-2004
Antenna settings		
RSU/BS Frequency	5.9GHz	5.4GHz
RSU/BS Transmission power	28.8 dBm	33dBm
RSU/BS Antenna height	2m.	30m
RSU/BS Antenna gain	3dBi	15dBi
Range	1000m	13Kms
Simulation environment		
Average building height	10m	10m
Street width	30m	30m
Road	13kms	13Kms
Nodes		
Channel bandwidth	10 MHz	10MHz
OBU transmission power	23dBm	23dBm
OBU antenna height	1m	1m
Type of antenna	Omnidirectional	Omnidirectional

Table 3. Simulation parameters

3.2 Simulation results

As previously mentioned, the first simulations study the impact of vehicle speed on performance of both technologies into a V2I communication environment. Figure 3 shows the impact of speed in the rate of packet loss. Results show there is an increase in the rate of packet loss when there is an increase in speed and the 802.11p technology is used. Results also show that when the vehicle speed increases, the connectivity time to the 802.11p RSU decreases, which, in turn, reduces the amount of data received by vehicles. As a consequence of the increased speed, the number of handovers increases, resulting in a greater number of packet losses. However, we observe that when the 802.16-2004 technology is used, as there are no handovers, the percentage of packet loss is almost null.
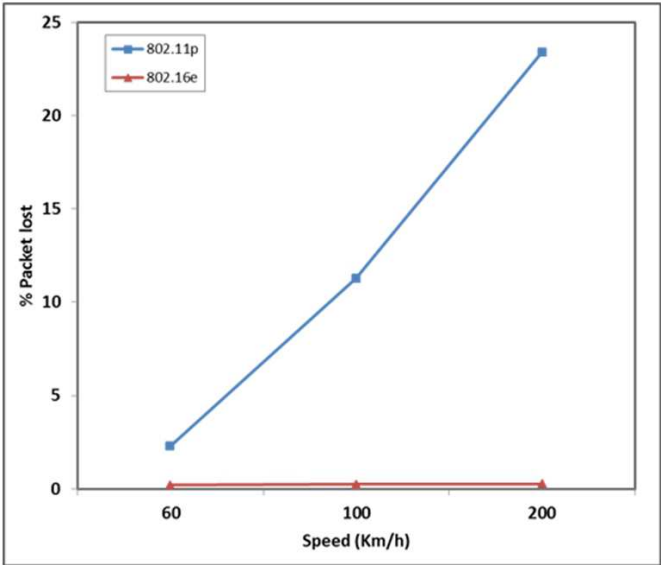
Fig. 3. Impact of vehicle speed on the rate of packet loss.

Figure 4 shows the impact of the vehicle speed on the average end-to-end delay. We can observe that for 802.11p, when vehicle speeds increase, difficulties related to handover increase, which then introduces a considerable delay in the communication process. However, in the case of 802.16-2004, there is no required time for the handover execution, which explains why it maintains a low average delay. The data presented in Figure 4 shows that the end-to-end delay for both technologies is less than 100 ms, which meets the minimum requirement of most ITS applications.
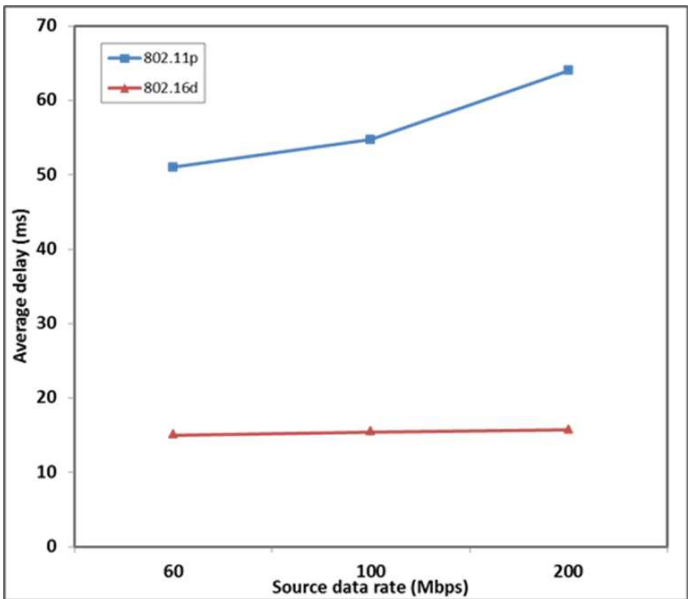
Fig. 4. Impact of vehicle speed on the average end-to-end delay.

Figure 5 shows the impact of different vehicle speeds on the average throughput. When 802.11p technology is used, the connectivity time to the RSUs decreases which, in turn, reduces the amount of data received by the vehicle. Additionally, a fraction of this period is
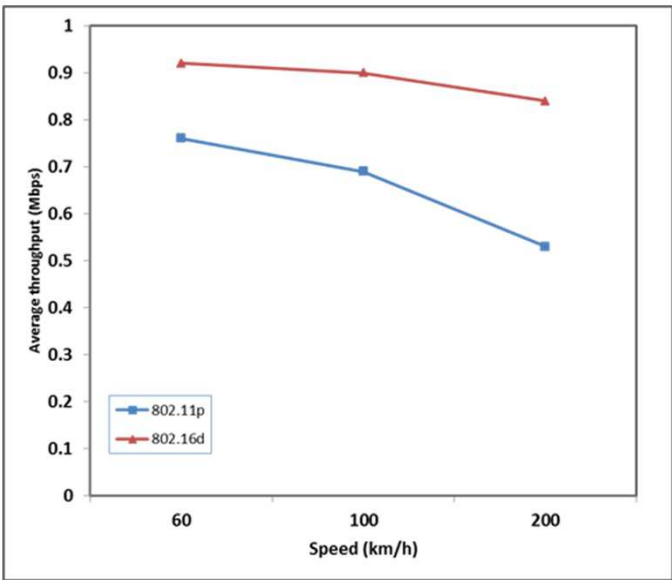
Fig. 5. Impact of vehicle speed on the average throughput.

required to switch from one RSU to another. As can be seen, the throughput is reduced up to 30% at higher speeds (200 km/h) in comparison to lower speeds (60km/h). On the other hand, in the case of 802.16-2004, the impact of speed on the average throughput is minimal (less than 9%).

The following section will analyze the impact of varying the source data rate on the performance of both technologies. Figure 6 presents the average throughput obtained for each communication technology. The results show that for 802.11p, the maximum throughput is approximately 1.2 Mbps while 802.16-2004 covers the maximum throughput demanded in each situation.
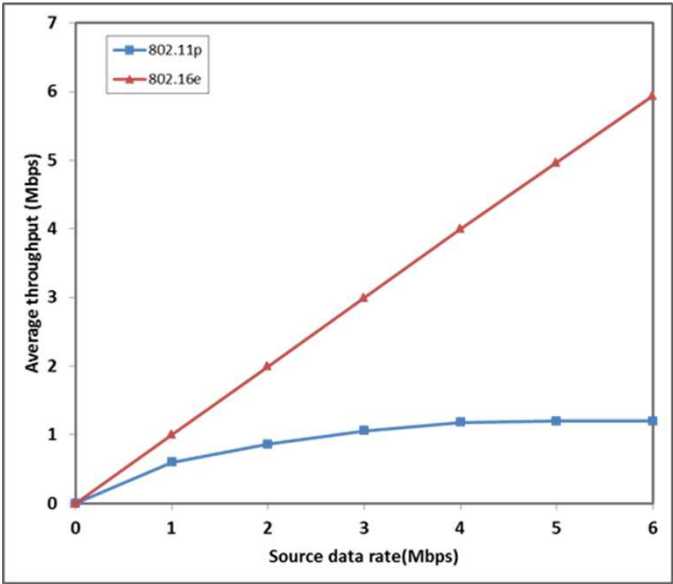
Fig. 6. Impact of the source data rate on the average throughput.

Finally, Figure 7 shows the impact of varying the source data rate on the average end-to-end delay. The results show that 802.11p technology experiences shorter delays when the source
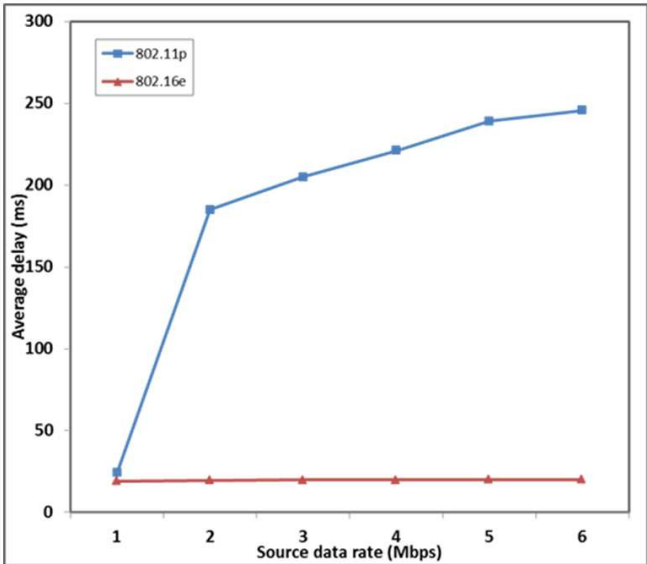
Fig. 7. Impact of the source data rate on the average end-to-end delay.

data rate is less than 1.5 (which we denominated as low data rate condition). However, when the source data rate increases to more than 1.5Mbps, delay increases by almost 600%, when compared with low data rate condition. As mentioned before, this result shows how the handover process greatly affects the performance of 802.11p.

On the other hand, in the case of 802.16-2004, the impact of various data rates on the average end-to-end delay is not very significant. The average delay for 802.16-2004 does not exceed 20 ms, which even meets the stringent demands of most emergency applications.

4. Conclusion

This work compared simulations of two important technologies for roadside communication in an urban scenario. This comparison is relevant because of the many obstacles that affect communications in cities or highly congested areas. Results show that IEEE 802.16-2004 technology outperforms IEEE 802.11p technology in terms of throughput (network capacity), packet loss (the percentage of information that is transmitted but not received) and end-to-end delay (the time necessary for the information to be delivered from the transmitter to the receiver). Therefore, we conclude that IEEE 802.16-2004 technology is more suitable for roadside applications including road safety, traffic efficiency and value-added services in urban settings, where there are many obstacles that can potentially cause attenuation or the entire loss of the transmission.

Our proposed future work will evaluate the Location-Based Routing Protocol with Cluster-Based Flooding (LORA-CBF) using IEEE 802.16-2004 technology.

5. Acknowledgment

6. References

[1] M. L. Sichitiu and M. Kihl. Inter-vehicle communication systems: a survey. Communications Surveys & Tutorials, IEEE, 10(2):88-105, 2008.

[2] Michael J. Chu and Wayne E. Stark. Effect of Mobile Velocity on Communications in Fading Channels. IEEE Transactions on Vehicular Technology, vol. 49, no. 1, 2000.

[3] X. Yang, J. Liu, F. Zhao, and N. Vaidya. A Vehicle-to-Vehicle Communication Protocol for Cooperative Collision Warning. Proceedings of the 1st Annual International. Conference on Mobile and Ubiquitous Systems: Networking and Services, pp. 1–4, 2004

[4] J. Yin et al., "Performance Evaluation of Safety Applications over DSRC Vehicular Ad Hoc Networks," Proceedings of the 1st ACM Workshop on Vehicular Ad Hoc Networks, pp. 1–9, 2004

[5] R. Rajamani and S. Shladover. An Experimental Comparative Study of Autonomous and Co-Operative Vehicle-Follower Control Systems. Transportation Research Part C, vol. 9, pp. 15–31, 2001

[6] P. Varayia. Smart Cars on Smart Roads: Problems of Control. IEEE Trans. Automatic Control, vol. 38, no. 2, pp. 195–207, 1993

[7] A. Brown et al. Vehicle to Vehicle Communication Outage and Its Impact on Convoy Driving. Proceedings of the IEEE Intelligent Vehicle Symposium, 2000, pp. 528–33

[8] SAFESPOT, http://www.safespot-eu.org

[9] COMeSafety, http://www.comesafety.org

[10] Car2car Communication Consortium, http://www.car-tocar.org

[11] IEEE 802.11p,

[12] "IEEE 802.11p/D3.0," IEEE Standards Activities Department, July 2007.

[13] Iulia Ivan, Philippe Besnier, Matthieu Crussiere, M´hamed Drissi, Lois Le Danvic, Mickael Huard, and Eric Lardjane. Physical Layer Performance Analysis of V2V Communications in High Velocity Context. 9Th International Conference on Intelligent Transportation Systems Telecommunications, pp. 409-414, 2009.

[14] Yi Wang, Ahmed A, Krishnamachari B, and Psounis K. IEEE 802.11p performance evaluation and protocol enhancement. IEEE International Conference on Vehicular Electronics and Safety, ICVES 2008, pp. 317 – 322, 2008.

[15] Katrin Bilstrup, Elisabeth Uhlemann, Erik G. Strom, and Urban Bilstrup. Evaluation of the IEEE 802.11p MAC Method for Vehicle-to-Vehicle Communication, 2008. Vehicular Technology Conference, pp. 1-5, 2008.
[Online].Available: http://dx.doi.org/10.1109/VETECF.2008.446

[16] L. Stibor, Y. Zang, and H.-J. Reumerman. Evaluation of communication distance of broadcast messages in a vehicular ad-hoc network using IEEE 802.11p. In Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC '07), pp. 254-257, March 2007.

[17] Stephan Eichler. Performance Evaluation of the IEEE 802.11p WAVE Communication Standard. 66th IEEE Vehicular Technology Conference (VTC-2007 Fall), pp. 2199-2203, 2007.

[18] Balkrishna Sharma Gukhool and Soumaya Cherkaoui. Handoff in IEEE 802.11p-based vehicular networks. IFIP International Conference on Wireless and Optical Communications Networks, pp. 1-5, 2009.

[19] IEEE 802.16e-2005,

[20] IEEE 802.16j,

[21] IEEE 802.16-2004,

[22] The Future of WiMAX: Multihop Relaying with IEEE 802.16j

[23] Kung Yang, Shumao Ou, Hsiao-Hwa Chen, and Jianghua He. A Multihop Peer Communication Protocol with Fairness Guarantee for IEEE 802.16-based Vehicular Networks. IEEE Transactions on Vehicular Technology, vol. 56, no. 6, pp. 3358-3370, 2007.

[24] Yu Ge, Su Wen, Yew-Hock Ang, and Ying-Chang Liang. Optimal Relay Selection in IEEE 802.16j Multihop Relay vehicular Networks. IEEE Transactions on Vehicular Technology, vol. 59, no. 5, pp. 2198-2206, 2010.

[25] Chien-Ming Chou, Chen-Yuan Li, Wei-Min Chien, and Kun-Chan Lan. A Feasibility Study on Vehicle-to-Infraestruture Communication: WiFi Vs. WiMAX. Tenth International Conference on Mobile Data Management: Systems, Services and Middleware, pp. 397-398, 2009.

[26] SIMREAL technology Homepage, NCTUNS network simulator and emulator, http://nsl10.csie.nctu.edu.tw/.
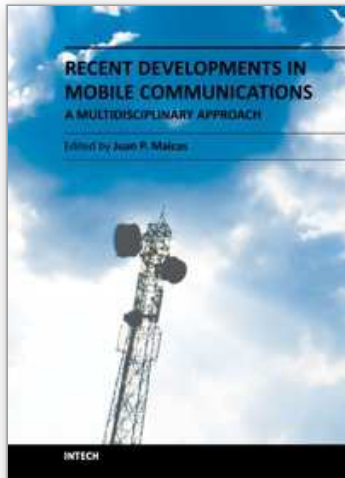
Recent Developments in Mobile Communications - A Multidisciplinary Approach

Edited by Dr Juan P. Maícas

Recent Developments in Mobile Communications - A Multidisciplinary Approach offers a multidisciplinary perspective on the mobile telecommunications industry. The aim of the chapters is to offer both comprehensive and up-to-date surveys of recent developments and the state-of-the-art of various economical and technical aspects of mobile telecommunications markets. The economy-oriented section offers a variety of chapters dealing with different topics within the field. An overview is given on the effects of privatization on mobile service providers' performance; application of the LAM model to market segmentation; the details of WAC; the current state of the telecommunication market; a potential framework for the analysis of the composition of both ecosystems and value networks using tussles and control points; the return of quality investments applied to the mobile telecommunications industry; the current state in the networks effects literature. The other section of the book approaches the field from the technical side. Some of the topics dealt with are antenna parameters for mobile communication systems; emerging wireless technologies that can be employed in RVC communication; ad hoc networks in mobile communications; DoA-based Switching (DoAS); Coordinated MultiPoint transmission and reception (CoMP); conventional and unconventional CACs; and water quality dynamic monitoring systems based on web-server-embedded technology.

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