Chapter 17
Methodology for Development of Logistics Information and Safety System Using Vehicular Adhoc Networks

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Abstract The Intelligent Transportation System (ITS) addresses issues regarding traffic management and road safety in the domain of Vehicular Ad hoc Networks (VANETs). With the evaluation of new applications, new goals regarding efficiency and security have been added for logistics and general user application, which demand time-bounded and reliable services. In this paper, we evaluate VANET with regard to its suitability in logistics scenarios. We simulated VANET by considering different application scenarios for logistics and transportation using varying parameters such as speed, number of nodes, traffic load and bit error rate etc. We observed that it performs well in most of the scenarios due to its highly suitability in vehicular environment.

Keywords VANET · Routing protocols · IEEE 802.11p · Logistics · Transportation

17.1 Introduction

In commercial applications, Vehicular Adhoc Networks (VANETs) (I. S. Association 2010) are used in traffic management applications to alert drivers of traffic jam, balance traffic flow and reduce traveling time (Olariu and Weigle 2009; Akbar et al. 2015), road safety (Yin et al. 2004) and efficiency. Furthermore, it helps in logistics by offering a number of applications like inbound/outbound traffic control for delivery of goods from ports and warehouses. Moreover, it also helps to provide commer-

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M. Freitag et al. (eds.), *Dynamics in Logistics*, Lecture Notes in Logistics,
DOI 10.1007/978-3-319-45117-6_17

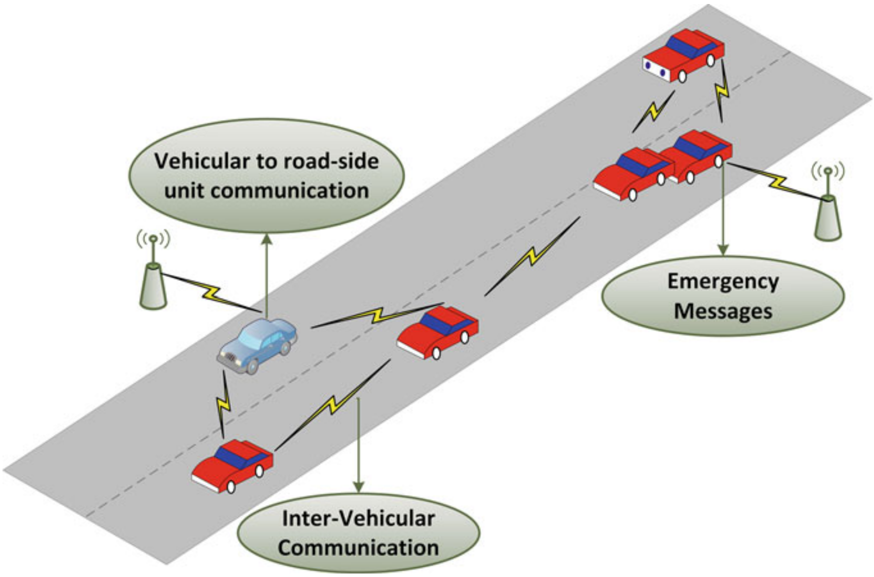

Fig. 17.1 Vehicular Adhoc Networks (VANET)

cial services on the road and offers attractive applications for infotainment (Amadeo et al. 2012), multimedia and online gaming applications (Akbar et al. 2014).

In the vehicular environment as sketched in Fig. 17.1, three types of communication may occur: Vehicle-to-vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Infrastructure (I2I). IEEE recommends 802.11p as MAC and PHY layer standard for VANET and the use of it has been frequently proposed for vehicular safety applications. The Crash Avoidance Metrics Partnership Consortium helped in the standardization of the SAE J2735 Basic Safety Message (BSM). These messages include information which is important for safety applications for vehicles state like position, speed, and acceleration (Ahmed-Zaid et al. 2011). By using such applications, a potential safety benefit is generated, but disseminated information is not always relevant for each participating node. For example, in the case of an emergency report, a distant vehicle is unlikely to be effected. Therefore, the estimation of relevance information is required to avoid incorrect alerts or to help ignore warnings. However, the determination of relevance can be uncertain as it may depend upon different factors like weather, road characteristics, positions, speeds, and accelerations of vehicles. Considering all these parameters, it can be difficult to develop a tool that estimates suitable conditions for new applications. For the channel access, IEEE 802.11p uses CSMA/CA at MAC layer. For safety applications, as safety messages are usually small in size and IEEE 802.11p uses 10 MHz channel which is enough for transmission of safety messages. Research shows that IEEE 802.11p performs well for safety application in vehicular environment (Katrin et al. 2008). The reason for its popularity is its claims about time bounded and high throughput services.

ITS was initially driven by the concept of safety applications, but the next generation ITS adds the use of bandwidth hungry applications like Video on Demand (VoD), Voice over IP (VoIP), video conferencing, online gaming and file transfer etc., which require less delay and high bandwidth (Akbar et al. 2015). The new trend in the current decade is to apply technologies in different areas to get the maximum benefits of them in real environment.

To get the competitive strength in market, logistics management is a key source and it has potential for cost reduction and the opportunity to increase market share, if it is used effectively (Christopher 1998). Here, in the urban environment, with its increasing population, its congestion of freight transport and impact on the environment is of particular interest. In this scenario, where the objective is to develop a more efficient and effective freight transport system with reduction of environmental issues such as pollution, noise, etc., a new concept of city logistics (Crainic and Feillet 2015; Taniguchi and Thompson 2014) has emerged. It has three main objectives; first, mobility of traffic to maintain smooth and reliable flow. Second, sustainability to make cities more environment friendly. Third, livability which consider risen residence of elderly people within city. Considering all these objective Intelligent Transport System (ITS) is one of the methods that used to solve this complicated problem. The scenarios in urban areas are considered a high priority because the half of the world's population lived in cities (Sands 2015) and it is estimated that this figure will increase to over 60 % by 2030 (Olsson and Head 2015). In this regard, VANET can help to design an efficient solution which will help to maintain information system and also provide road safety with reduction of the cost. As with the dense transport population, congestion will increase due to expansion in demand of home delivery of goods and services, specially to elderly people. With the help of a social concept, negotiation for services and quick (shortest path) delivery can lead to efficient and cost-effective solutions. The communication concept between vehicles not only helps to make vehicles able to communicate with other vehicles for road safety, but also they altogether form a cooperative network through which the services can be achieved in a more efficient way.

The rest of paper is organized as following; Sect. 17.2 gives an overview of the city logistics and Sect. 17.3 describes the evaluation of VANET for logistics applications, and also discusses the results in this scenario. Section 17.4 explains the methodology, which uses VANET as key technology to provide the solution for freight transport systems to provide efficiency, safety on road and information management for logistics and Sect. 17.6 concludes the paper.

17.2 State of the Art

VANET plays an important role for safety and traffic management applications. The authors in Martelli et al. (2012), Shakeel et al. (2015) performed field test for the real world scenarios for comfort and road safety. The paper (Anand et al. 2015) presented a review of urban freight transportation modeling efforts for analysis in particular environment and covered the fundamental aspects in selection process of modeling and review the trends of city logistics for relevance. The authors also attempted to identify gaps in modeling, specially for the city logistics domain.

In Taniguchi (2015), the authors presented concepts of city logistics for sustainable and liveable cities. City logistics can contribute to create more efficient and environmentally friendly urban freight transport systems. The application of innovative technologies of Information and Communication Technology (Tan et al. 2012; Perego et al. 2011) and ITS (Perego et al. 2011; Mondragon and Mondragon 2012), the change in mind-sets of logistics managers, and public-private partnerships can promote city logistics policy measures. The authors in Taniguchi et al. (2013) discussed the basic concept of logistics, and use of ICT and ITS in logistics. The authors also included methodologies to minimize incorporating risk in urban freight transport. The relationship between city logistics and quality of life is discussed in Witkowski and Kiba-Janiak (2012) using theory and a reference model. The authors discussed the survey results at the end that "moving around the city" does not improve the quality of life because of the heavy traffic movement in the city. In the current scenario, the need of proper methodology that not only consider economics factor, but also includes the environment, safety and management factors that can improve quality of life in city.

17.3 Evaluation of VANET for Safety Applications

For the simulation of VANET in logistics safety and infotainment applications, we selected open source network simulator NS-2. Table 17.1 describes parameters of our simulation setup. Simulations were performed Linux distribution Fedora and Constant-Bit Rate (CBR) traffic flows are used with UDP. The Table 17.2 shows

Table 17.1 General simulation parameters

Operating system	Linux distribution Fedora Core 17
NS-2 versions	NS-2.34 for IEEE 802.11p
Radio-propagation model	Two-Ray-Ground
Traffic environment	Urban area street traffic scenario
Traffic flows	Constant-bit rate (CBR)
CBR flow rates (Mb/s)	Varies from 1 to 40 Mbps
Transport layer protocol	UDP
Number of nodes	Varies from 1 to 600
Speed of nodes	Varies from 40 km/h to 100 km/h
Packet size	200–500 bytes

Table 17.2 Simulation parameters setting for MAC

Slot time	13 nano s
SIFS interval	32 nano s
Contention Window Min (CWMin)	15 slots
Contention Window Max (CWMax)	1023 slots
Transmission range	50–1000 m

the parameters settings for 802.11p. For the comparison, we kept the values of MAC layer parameters constant for each standard. For the comparative analysis, we selected Application traffic load, Node density, Inter-node distance, on Goodput simulation scenarios for urban areas with traffic load in single direction and for the comparison we calculated goodput and packet delay.

For evaluation, we examined the effect on the goodput and delay by varying traffic loads. Constant-bit Rate (CBR) traffic flows were used in the simulation with packet size of 256 bytes, which was kept constant. We imposed two other CBR flows of 500 Kbps, which acted as background traffic. 15 nodes were used in the scenario, which were moving at 100 km/h. CBR traffic rate was varied to check its effect on goodput and delay.

17.3.1 Goodput and Delay

Results are shown in Fig. 17.2a, b. We observe that the goodput decreases with increase in number of vehicles in the network. A constant goodput is observed in case of small sized packets, and when we increase the packet size, the decreases due to greater number of vehicles and number of hops involved. As we mentioned, the packet size in safety applications are small. Therefore, the graph shows a constant line for small packets with increased number of vehicles.

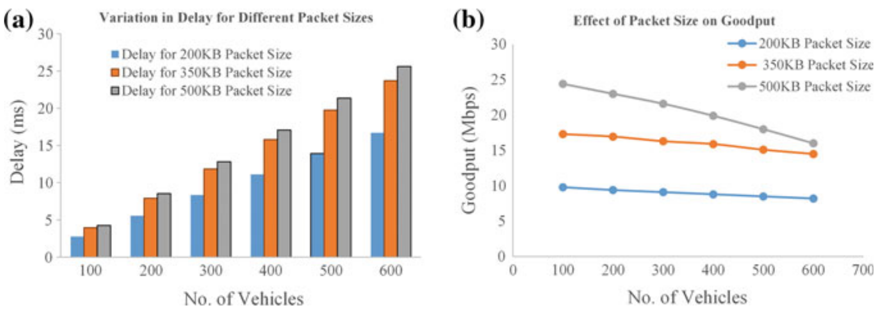

Fig. 17.2 **a** Variation of delay for different packet sizes; **b** Effect of packet size on goodput

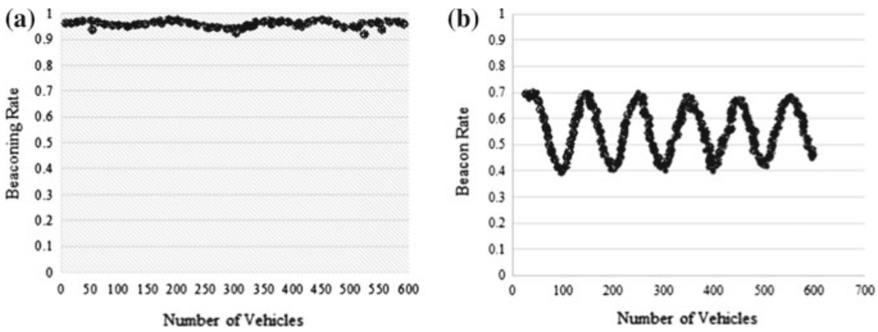

Fig. 17.3 **a** Beaconing rate when range is 50 m; **b** Beaconing rate when range is 250 m

17.3.2 Beacon Dissemination and Transmission Range

To provide safety in vehicular environment by deploying VANET safety applications, it is necessary to evaluate important parameter for success. In literature, the delivery rate and delay are common metrics used for the evaluation of performance. For safety applications, the latest information dissemination is important. For such applications, the individual vehicle is critical and should be monitored for message dissemination protocols. Both the message originating node to message receiving node are important for safety applications. Therefore, the communication range between these nodes or number of hops involved between these nodes are the relevant metrics for evaluation. As vehicles are also moving with high speed, though this movement is static with respect to each other (if they are in the same lane at the same speed) in highway scenarios, but in city these movement is more dynamic because the frequent change in neighboring vehicles gives dynamic topology. It may cause communication link breakage between sending and receiving vehicles. Within the vehicle range, the communicating vehicles can receive beacons for information sharing in safety applications i.e. alarm based and beacon based safety application. In this scenario, the success of safety application depends upon the fair beacon.

Figure 17.3 shows the relationship of beacon transmission and change in transmission range. It shows by increasing transmission range, there is an increasing trend in application's effective range until the delivery rate of its corresponding beacon dissemination protocol falls below the desired threshold. Beyond that threshold, increasing vehicle's transmission range leads to decreasing application's effective range.

17.4 Methodology

There are several steps involved from the problem statement to the implementation of proposed method. To get the best solution for a problem, it is necessary to review the previous facts. System requirements and strategies are important functions in any

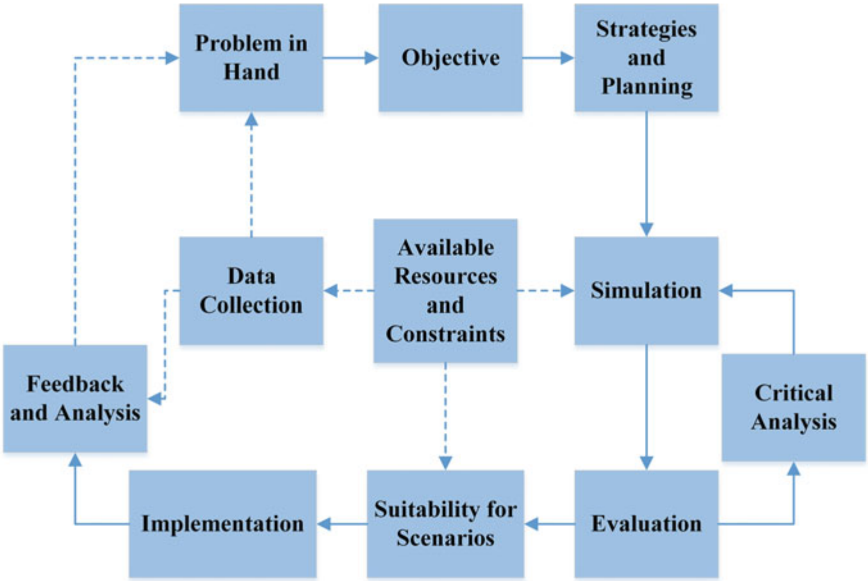

Fig. 17.4 Methodology to reach appropriate solution

kind of methodology. On the basis of objectives and requirements, we can model the system, and for required results simulation and evaluation are the next steps. These results help to implement the model in real world. Figure 17.4 sketches the flows of the city logistic system from data collection, problem statements to implementation. Each step has its own importance. For the logistic system, we identified objectives and requirements.

17.4.1 Objectives and Planning

In order to get the objective of safety on road and efficiency in city supply chain, planning plays a vital role in methodology. For planning several measures can be used. This may include following activities that play an important role:

1. Identify the objective and requirements
2. Identify the key performance indicator
3. Identify and define planning scenarios including simulation

apart from the objectives of the transportation (key performance indicator, scenarios), there are several other factors that can be part of the planning to achieve goal. There are different factors that are important for industries to achieve in long term; amongst them some are as following.

Economy: Economy as the improvement in the economic output of the study area is the important factor for both industry and end consumer. By applying VANET on city logistics, there is setup cost but after installation it will help to improve the economic output by reducing the network transportation and logistic costs (e.g., distributors, wholesalers, carriers, retailers, end consumers). Furthermore, it will also reduce selling prices of goods for end consumers.

Safety: For the transportation and traffic management, safety has high priority while finding solutions. The objective is to reduce road accidents linked to the freight and general transport. VANET enables the vehicles to communicate to others vehicles, and manage the traffic via negotiation. Therefore, there are less chances of road accidents and improved usage of shared resources.

Efficiency and Availability: From production of goods to the delivery of the goods, efficiency and availability are of importance. Industries are required to deliver their products at the right time to the right customer, and customers want to receive their shipment at the desired destination on time.

Environment: The objective is to develop the transport system for improvement of quality of life, but also consider its effect on the environment.

17.4.2 Strategies and Measures

In urban scenarios, citizens expect lively environment and easy access to the city. With the increase of population of the cities, the requirement for transportation also increases. In absence of good public transport, most of the people prefer to have individual transport. Hence, the population of vehicles in a city environment increases and effects city sustainability and livability. In addition to that, inventory management and shopping also produce negative impacts on the later. For city logistics, several measures can be implemented to reduce this impact; First, the requirement is to reduce the number of vehicles and the need to make it environmentally friendly. The freight transport should use optimized loading and unloading operations to reduce traffic congestion and interference with other vehicles.

17.4.3 Proposed Strategy

Considering strategies and measurement, we divided the system into three layers for understanding and implementation. Each layer has its own specific task. Figure 17.5 shows system layers, specific task of each layers and actors involves in the system. The first layer is called physical layer and involves the hardware requirement. For VANET implementation, each vehicle should have interface for communication and which type of vehicle mode to use (Which time to begin and end tour? which vehicle is suitable for delivery?). The second layer, i.e., management layer, contains tasks like location choices, planning (which type of retail type to buy and from where),

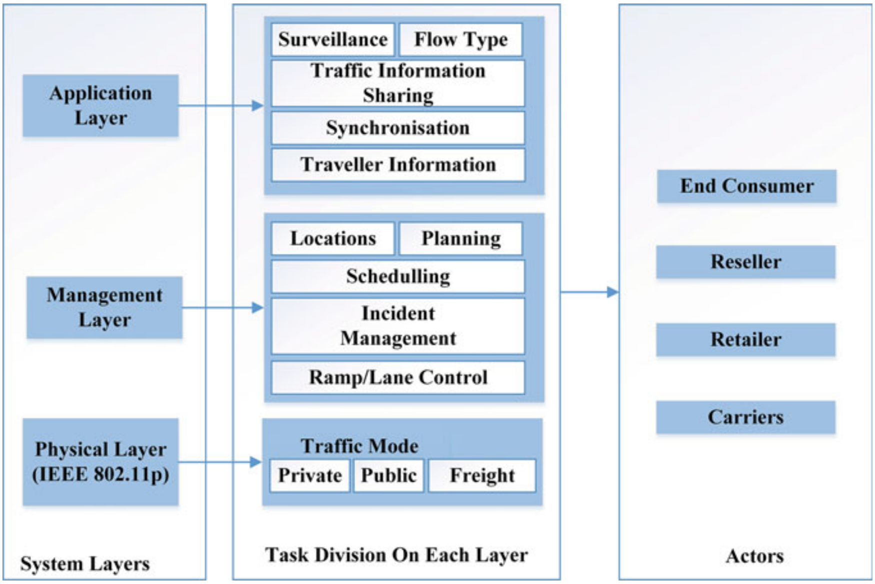

Fig. 17.5 Proposed system layers

scheduling (start and end time, total number of tours) for the transport. The incident management, lane control during traveling, and optimized path to follow are also the responsibility of this layer. The third layer is application layer, where applications are required to manage information of travelers, trips, which type of traffic flow is (How to share the traffic information? their synchronization and central control). These layers altogether lead to system for traffic.

17.5 Acknowledgment

This research was supported by the European Commission in the framework of Erasmus Mundus and within the project cLINK.

17.6 Conclusion

The integration of emerging technologies in different areas to get benefits is poplar since last many decades. Vehicular ad hoc network is one the wireless technology that is used in different traffic management applications, safety and multimedia applications. City logistics is the process of managing and optimizing the involved activities considering many factors. In this paper, we proposed a methodology for optimizing the city logistics and proposed strategy through which we can apply VANET technology to get best results. We evaluated the suitability of VANET for safety applications for city scenarios as well, where we achieved good results. According to our analysis, VANET can help to improve economy by manage the traffic via communication and improving the facility of shared resources.

References

Ahmed-Zaid F, Bai F, Bai S, Basnayake C, Bellur B, Brovold S, Brown G, Caminiti L, Cunningham D, Elzein H et al (2011) Vehicle Safety Communications–Applications (VSC-A) Final Report. Technical Report

Akbar MS, Khaliq KA, Qayyum A (2015) Vehicular MAC Protocol Data Unit (V-MPDU): IEEE 802.11 p MAC protocol extension to support bandwidth hungry applications. In: Vehicular ad-hoc networks for smart cities. Springer, pp 31–39

Akbar MS, Qayyum A, Khaliq KA (2015) Information delivery improvement for safety applications in VANET by minimizing Rayleigh and Rician fading effect. In: Vehicular ad-hoc networks for smart cities. Springer, pp 85–92

Akbar MS, Khan MS, Khaliq KA, Qayyum A, Yousaf M (2014) Evaluation of IEEE 802.11 n for multimedia application in VANET. Procedia Comput Sci 32:953–958

Amadeo M, Campolo C, Molinaro A (2012) Enhancing IEEE 802.11 p/WAVE to provide infotainment applications in VANETs. Ad hoc networks 10(2):253–269

Anand N, Van Duin R, Quak H, Tavasszy L (2015) Relevance of city logistics modelling efforts: a review. Transp Rev 35(6):701–719

I. S. Association et al 802.11 P-2010 IEEE Standard for Information Technologylocal and Metropolitan Area Networks specific Requirements part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments. http://standards.ieee.org/findstds/standard/802.11p-2010.html

Christopher M (1998) Logistics and supply chain management: strategies for reducing cost and improving service

Crainic TG, Feillet D (2015) Introduction to the special issue on city logistics. EURO J Transp Logistics 1–2

Katrin B, Uhlemann E, Store E, Bilstrup U (2008) On the Ability of the 802.11 p MAC Method and STDMA to support real-time vehicle-to-vehicle communication. EURASIP J Wirel Commun Networking 2009

Martelli F, Renda ME, Resta G, Santi P (2012) A Measurement-based study of beaconing performance in IEEE 802.11 p vehicular networks. In: INFOCOM, 2012 Proceedings IEEE. IEEE, pp 1503–1511

Mondragon AEC, Mondragon ESC (2012) Smart grid and wireless vehicular networks for seaport logistics operations. In: 19th ITS world congress

Olariu S, Weigle MC (2009) Vehicular networks: from theory to practice. CRC Press

Olsson L, Head BW (2015) Urban water governance in times of multiple stressors: an editorial. Ecol Soc 20(1):27

Perego A, Perotti S, Mangiaracina R (2011) ICT for logistics and freight transportation: a literature review and research agenda. Int J Phys Distrib Logistics Manage 41(5):457–483

Sands D (2015) An innovative scorecard for evaluating resiliency in our cities. In: Planet@ Risk, vol 3, no 1

Shakeel SM, Ould-Khaoua M, Rehman OMH, Al Maashri A, Bourdoucen H (2015) Experimental evaluation of safety beacons dissemination in VANETs. Procedia Comput Sci 56:618–623

Tan MII, Razali RN, Desa MI (2012) Factors influencing ICT adoption in Halal transportations: a case study of Malaysian Halal logistics service providers. Int J Comput Sci Issues 9(1):62–71

Taniguchi E (2015) City logistics for sustainable and liveable cities. In: Green logistics and transportation. Springer, pp 49–60

Taniguchi E, Thompson RG (2014) City logistics: mapping the future. CRC Press

Taniguchi E, Thompson RG, Yamada T (2013) Concepts and visions for urban transport and logistics relating to human security. In: Urban transportation and logistics: health, safety, and security concerns, p 1

Witkowski J, Kiba-Janiak M (2012) Correlation between city logistics and quality of life as an assumption for referential model. Procedia-Soc Behav Sci 39:568–581

Yin J, ElBatt T, Yeung G, Ryu B, Habermas S, Krishnan H, Talty T (2004) Performance evaluation of safety applications over dsrc vehicular ad hoc networks. In: Proceedings of the 1st ACM international workshop on vehicular ad hoc networks. ACM, pp 1–9