	مجـلـة الـتــربـوي Journal of Educational	معامل التأثير العربي 2.23 لسنة 2025 العدد 28 ـــ يناير 2026

مجلة التربوي

مجلة علمية محكمة تصدر عن كلية التربية الخمس

جامعة المرقب

العدد الثامن والعشرون (28)

يناير 2026م

- المجلة ترحب بما يرد عليها من أبحاث وعلى استعداد لنشرها بعد التحكيم .
- المجلة تحترم كل الاحترام آراء المحكمين وتعمل بمقتضاها .
- كافة الآراء والأفكار المنشورة تعبر عن آراء أصحابها ولا تتحمل المجلة تبعاتها .
- يتحمل الباحث مسؤولية الأمانة العلمية وهو المسؤول عما ينشر له .
- البحوث المقدمة للنشر لا ترد لأصحابها نشرت أو لم تنشر .

مجلة التربوي
Journal of Educational
معامل التأثير العربي 2.23 لسنة 2025
العدد 28 ــ يناير 2026

ضوابط النشر:

يشترط في البحوث العلمية المقدمة للنشر أن يراعى فيها ما يأتي :

- أصول البحث العلمي وقواعده .
- ألا تكون المادة العلمية قد سبق نشرها أو كانت جزءا من رسالة علمية .
- يرفق بالبحث تزكية لغوية وفق أنموذج معد .
- تعدل البحوث المقبولة وتصحح وفق ما يراه المحكمون .
- التزام الباحث بالضوابط التي وضعتها المجلة من عدد الصفحات ، ونوع الخط ورقمه ، والفترات الزمنية الممنوحة للتعديل ، وما يستجد من ضوابط تضعها المجلة مستقبلا .

تنبيهات :

- للمجلة الحق في تعديل البحث أو طلب تعديله أو رفضه .
- يخضع البحث في النشر لأولويات المجلة وسياستها .
- البحوث المنشورة تعبر عن وجهة نظر أصحابها ، ولا تعبر عن وجهة نظر المجلة .

Publication Guidelines:

Research papers submitted for publication must adhere to the following:

- The principles and rules of scientific research.
- The material must not have been previously published or be part of an academic thesis.
- The research must be accompanied by a linguistic endorsement according to a prepared template.
- Accepted research will be edited and corrected according to the reviewers' opinions.
- The researcher must comply with the journal's guidelines regarding the number of pages, font type and size, time periods granted for modifications, and any future guidelines established by the journal.

Notices:

- The journal reserves the right to edit the research, request modifications, or reject it.
- The publication of research is subject to the journal's priorities and policies.
- Published research reflects the views of the authors and does not represent the views of the journal.

مجـلة التـربـوي
Journal of Educational

معامل التأثير العربي 2.23 لسنة 2025
العدد 28 ـــ يناير 2026

Comparative Analysis of Delay and Energy Consumption: Poisson vs. Markov in Vehicular Networks

Kamal A. Tawer[1], Sami F. Alahmar[2], Abdualruof ali aburawy[3], Ali Ahmad Milad[4], Mustafa Almahdi Algaet[5]
Department of Networks, Faculty of Information Technology, Elmergib University[1,2,4,5]
Department of Information Technology, the Higher Institute of Science and Technology[3]

tawerkamal@elmergib.edu.ly[1] sfalahmar@elmergib.edu.ly[2] aba2106@gmail.com[3]
alimilad@elmergib.edu.ly[4] malgaet@elmergib.edu.ly[5]

Abstract

VANETs are spontaneous development of wires networks for data exchange in vehicular transport domain. VANET is a component of ITC. VANET (Vehicular Ad-Hoc Network) has continued to attract more attention in research, development and standardization contexts. This is due to the guaranteed potentialities in improving motor and road safety, passengers and driver's comforts and traffic cohesiveness and conveniences. In this study, research work on VANET focuses on area involving: routing, the service quality, televising and security. This study identifies, examines and shows how delay and energy can be improved and indicates approaches that can be adopted in regard to vehicular networks. The findings reveal significant improvements in both delay reduction and energy efficiency, highlighting the benefits of adopting Poisson and Markov models in VANET applications.

Keywords: Vehicular Networks, Ad hoc Networks, Efficiency and Delay in Vehicular Networks, VANETs.

I. INTRODUCTION

When studying the vehicular networks, the aspect of ICT cannot be overlooked nor ignored. Use of ICT in the transport sector is referred to as intelligent transport systems (ITS). Through intelligent transport systems, issues of accidents, inefficiencies and inconveniencies are handled accordingly. Notably, communication is fundamental across the vehicular networks and their immediate infrastructures within the intelligent transport systems (ITS). Similarly, communication will allow critical information sharing between vehicles transiting across varying or same routes. The information details could include the road conditions during rainy seasons, high traffic and traffic police check-points. Overall, the information is meant to intensify and maintain traffic Coherence and safety [1]. Challenges in vehicular network communication seem to be on the increase regardless of the great promises of its improved safety. Hence, the need for these challenges needs to be addressed. Long traffic of vehicles especially in rush hours is an example of challenges describing these natural dynamics of vehicular networks. In respect to this, the high mobility incarcerates connectivity to a short duration of time that in turn affects the information delivery. Assured network capacity is also a challenge. Now and then, the participating vehicles count does change depending on active communications count and road traffic changes. For instance, during traffic congestion this is more common in urban centers. Many vehicles including the Public Service Vehicles (PSVs) are concentrated at the same road for a long time. This would mean that the vehicular network is not convenient for public passengers who are tired from a long day's work to get home on time for their rest and some quiet environment [2].

A. Overview of Vehicular Network

When using different ITS applications, three communicate modes apply in the vehicular network. They include: vehicle-to-vehicle (v2v) communication, vehicle –to-infrastructure (V2I/I2V) communication and infrastructure to infrastructure (I2I) communication. Vehicle to vehicle communication facilitates information sharing among and between other vehicles in a given area. Each vehicle televises independent speed and route to mainly avoid accidents or collisions potentialities. Vehicle to infrastructure communication takes place in between road units' infrastructures and vehicles. Most ITC apps use this mode of communication to incorporate long and short range wireless technology. The said type of communication can incorporate Wi-Fi, 3G etc. to contact the larger network like the internet. The third communication, which is the infrastructure to infrastructure mode, facilitates orderliness across all roadside infrastructures. For example, when an ambulance is transiting in a certain road, the first roadside unit i.e. the traffic enforcers, will inform all presiding roads of the incoming through ambulance. This sort of communication may occur when a scenario of distant vehicles want to communicate via roadside unit (RSU) channels [3].

The reason why the growth of Vehicular Ad Hoc Networks (VANETs) has emerged is the ultimate demand to support the significant increase of mobile and wireless products to be used in the vehicular networks [3]. The said products include: laptops, mobile phones, personal digital assistants (PDAs) and remote keyless data entry devices. Predictable apps of VALETs comprise road safety and security, traffic control as well as infotainments. For channel or medium access control, IEEE 802.11p protocol based on CSMA is used in VANETs. Nevertheless, with CSMA, there are associated downsides that lead to poor performance in reference to packet delivery delay and output [4].

II.RELATED WORK

Through research, VANETs covers a wide range of subjects and among the most salient ones are: the routing protocols relay or broadcast transmissions, multimedia services and multicasts. The study takes a brief general review of the most up- to-date development on each and so as to outline where our study is highlighted. In respect to routing protocols, Spyropoulos et al. [4] recognizes taxonomy of opportunistic protocols for delay-tolerant networks (DTNs). The aim of the study is to generate guidelines for designers to be enlightened when choosing a network routing protocols well appropriate for implementations. The main pinpointed relevant criteria for the routing activities in that work are node heterogeneity, mobility patterns and network density.

In [5], the authors emphasizes on saving energy and proposes DRSS (directional routing and scheduling scheme), as a routing protocol that utilizes a Nash Q-learning approach in DTNs. This will help to improve energy efficiency in tandem with network congestion, screening and delay occupation. The proposal is applied on the NS-2 simulator. This demonstrates the ability to focus energy efficiency and the ratio of its data delivery. This will in turn predicts the network environment with a well-defined learning mechanism.

In addition, the work in [6] improves on energy –efficient protocols and also suggests an information gathering method that the authors call Energy-Efficient, Delay-Aware, and Lifetime-Balancing Data Collection (EDAL) protocol. Regardless of whether EDAL is especially for wireless sensor networks, the authors justifies that the problem formulation is NP-hard and the method might be of use for networks like VALETs.

Hossein Pishro-Ni and his colleagues [7] ascertained that from their analytical findings, VANETs (in the perspective of road geometry) have got unique characteristics. The road geometry through observation does play out a significant role in the VANETs magnitude. Notably, VANET mode is illustrated in form of chain-like structure of nodes lining parallel along the roadsides.

III.COMMON ISSUES AND CHALLENGES

Overpopulation and sudden increase of motor vehicles products has encouraged the increase rate of accidents and traffic jams. Hence, the management involved in the transportation industry is a major issue in recent times. Many projects have been described to focus on the quality of service in transportation sector [8]. Subsequently, vehicles will be in a position to share information with other vehicles as well as road-side infrastructure units in avoiding dangerous eventualities. The information can be communicated over Dedicated Short-Range Communication (DSRC) spectrum. This is due to the possibility of high-range televising and slow latency communications [8].

Traffic jams or congestion would leads to delays. Similarly, this decreases he flow rate of vehicles overall and fuel consumption heightens thus proving to be an environmental hazard. Economic adversities emerge and experienced in road traffic congestions specifically in the urban centers. According to USDOT, the estimated revenue loss due to traffic congestion in rural and urban areas is around $1 trillion per year [9]. As a safety application in vehicular ad-hoc networks VANETs necessitates the wide spread of safety information to as many vehicles within a televised range and in a televised style. Every vehicle is to relay its state information at a safety range within itself to prevent unforeseen accidents or collisions. Failure to do so, a congestion channel especially in multi –lane roads will be developed and to ultimately cause performance reduction [10].

IV.SYSTEM MODELS TO IMPROVE DELAY AND ENERGY IN VANETS

Recently, modern ITS managing of traffic control is receiving quite of the research attention in the industry. The vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) exudes future analytical and developmental potential that can help enhance traffic inconveniences. Much of the focus has shifted to spreading informatics to build safety applications in the vehicular communication system. Different kinds of communication technologies are under rigorous evaluation in the hope to design more complex or classic vehicular ad hoc networks VANET applications. A well-known intelligent transportation system ITS and advance travelers information system AITS [9] are very influential in reducing traffic congestions on the roads. This is done through the intelligent traffic light control systems and vehicular ad hoc networks VANETs safety [11].

This study presented a comparison between Poisson and Markov models, in terms of delay reduction and energy efficiency for a certain vehicle density count, which can be used to improve Intelligent Transportation Systems (ITS) applications, such as intelligent traffic management, congestion management, traffic monitoring, etc.

A. LTE based Traffic Management System

A conceptual paradigm of the network has been illustrated in Figure 1 in order to show the informatics flow. To be able to apply the intelligent traffic management system, it’s crucial to examine the vehicular flow statistics that establishes the feasibility of the developed application. The model proposal will evaluate the traffic flow metrics for a fixed cycle of traffic signal intersections and compare the service rates needed for a certain vehicle density count [7]. However, research done recently, proposes the use of existing cellular infrastructure (LTE) for vehicular communication [12].This is evidently helpful in improving performance delays, spectrum efficiencies as well as posting and maintenance costs accordingly [12]. Nonetheless, it’s interesting to know that LTE does not support V2V communication. As well, unicast communication puts a stumbling block in achieving delay constraints. A multicast method for LTE termed as evolved

Multimedia Broadcast Multicast Service (eMBMS) is proposed to aid multicasting effectively [13]. By this technique, Data can be shared between authorized users while eliminating the criterion for unicasting individually.

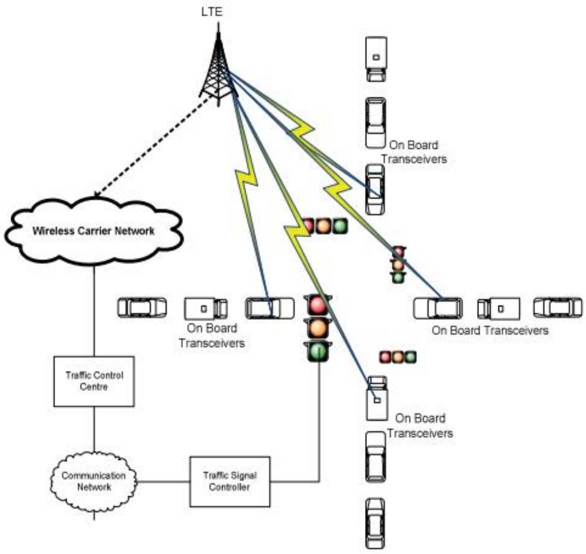

Figure 1: LTE Based Traffic Flow Management

B. Poisson distribution based Analytical Model

Several measurement studies support the use of Poisson distribution for modeling in the distribution of vehicles. Each and every vehicle is in a position to directly share information with close vehicles independently by a total Euclidean distance R away. Meaning, the following similar model as that used in [13]. This analytical model relies on the following core assumption:

- Nodes enter the highway in time interval [0, t] following a Poisson distribution with arrival rate
- A highway segment with length = [0, L].
- Nodes choose their speeds according to fv (v).

It is shown in figure above [1] that if vehicles select their speeds different from other vehicles, at any constant time (e.g. t); the spatial distribution of the vehicles follows a similar or alike Poisson process with variation.

and $\lambda_s = \lambda_t \int_{v_{min}}^{v_{max}} \frac{f_V(v)}{v} d_v$. Where, *Vmax* and *Vmin* represent the minimum maximum speeds in the highway, respectively.

C. *Markov Model*

Prior to the previous models, the computed Markov model allows us to obtain the probability of packet obsolescence before televising from the probability malfunction of service delay. As well, we can assess the performance of tracking applications for short or large size contention windows. To confirm our model accuracy is the extensive simulations conducted in this study [14]. The MAC layer behavior in broadcast-based CSMA is attributed by back-off processes of the basic access mechanisms [15].

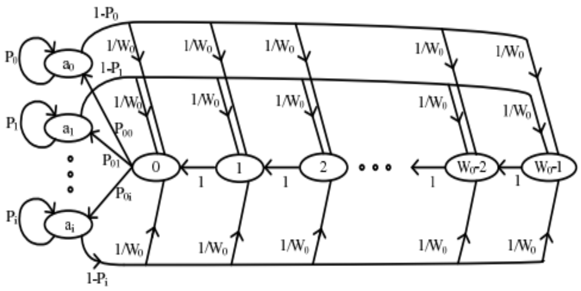

Figure 2: Markov Model of a mode’s MAC layer behavior.

In this section, as indicated in Fig. 2 by the multi- dimensional Markov Chain (MC), we model this behavior for a solid packet arrival process with the rate of μ packets per second. We generally quantify the assumptions made to simplify the analysis. Assumptions made are that all the nodes have equal carrier sense range, as well as equal vehicle densities on all lanes. Same to [6, 11], the negligible effect of vehicles’ mobility on the network connection was overlooked during the time interval a short message was being televised. To contrast with developments made in [16], the contention window size remained constant as there is no retransmission or delivery recognition in televising domains.

Furthermore, the unsaturated condition in tracking scenarios holds as a new packet arrival will render the old one obsolete i.e. the old packet gets discarded on the arrival of a new one. Hence, after televising, the string is empty and the node waits for a new packet arrival to contend the cycle again.

V. SIMULATIONS AND MODULE PARAMETERS:

In this section, we outline the simulations conducted to evaluate the performance of different network models based on Poisson and Markov processes. The parameters used for simulations include:

Number of Nodes: Ranging from 1 to 100.

Traffic Model: Poisson and Markov processes to represent network traffic.

Simulation Duration: Set to a fixed time period to ensure consistency.

Metrics: Average delay (in milliseconds) and energy consumption (in Joules) are the primary metrics evaluated.

In Table 1, the simulation parameters used in the analysis of delay and energy consumption are presented, where Poisson and Markov methods are compared in vehicular networks.

Table 1**:** *Simulation parameters*

Parameters	**Details**
Simulator	NS2.35
Area of simulation	250 m * 250 m
Node Placement	Moving
MAC protocol	802.11
Radio Propagation	Two Ray Ground
Routing Protocol	DSR
Simulation Time	150 sec
Packet Size	1000 Byte
number of mobile	1 -100
Transmission Rate	1 Mbps
Node speed	20 m/s – 60m/s
Traffic Type	TCP
Initial Energy	1000 J

VI. PERFORMANCE EVALUATION

Simulation were conducted by using Network Simulator NS-2, which use widely in field of Ad-hoc networks. The performance of the network models is evaluated based on two main criteria:

- **Average Delay**: This metric indicates the time taken for packets to traverse the network. Lower values signify better performance.

- **Energy Consumption:** This reflects the energy used by nodes during data transmission. Efficient energy consumption is crucial for battery-operated devices.

VII. Results and Discussion

The following graphs illustrate the results of the simulations:

I. Delay Comparison:

- The first graph compares the average delay for both Poisson and Markov models across different numbers of nodes (see Figure 3).

  ✓ **Poisson Model:**

- The delay is presented as a smooth, increasing curve, indicating that the delay gradually rises with the increase in the number of nodes.
- This reflects the behavior of the Poisson process, where an increase in the number of vehicles leads to greater interference, consequently increasing the delay.

  ✓ **Markov Model:**

- The delay exhibits significant fluctuations, suggesting that the delay can vary considerably with the number of nodes.
- This reflects the random nature of the Markov process, where different interferences and paths can lead to unexpected delays.

The Poisson model generally exhibits higher delay values, especially as the number of nodes increases, while the Markov model shows a more stable performance with lower average delays.

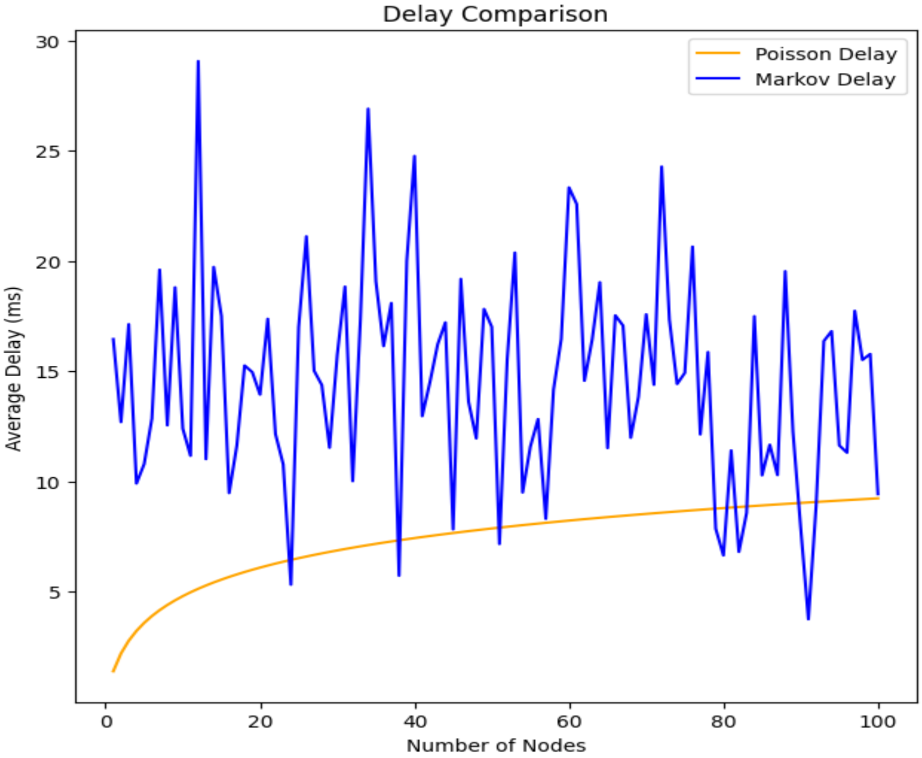

Figure. 3: Delay Comparison between Poisson and Markov Models, showing Average Delay (ms) against Number of Nodes.

II. Energy Consumption Comparison:

- The second graph compares energy consumption between the two models (see Figure 4).

  ✓ **Poisson Model:**

- Energy consumption shows a gradual increase with the number of nodes, indicating that energy usage rises predictably as the number of vehicles increases.

  ✓ **Markov Model:**

- Energy consumption displays greater variability, indicating that energy usage can change significantly based on random conditions and factors within the network.
- There may be instances of high energy consumption due to unexpected interferences or changes in movement.

Similar to the delay results, the energy consumption for the Poisson model tends to be higher compared to the Markov model, particularly as the number of nodes increases.

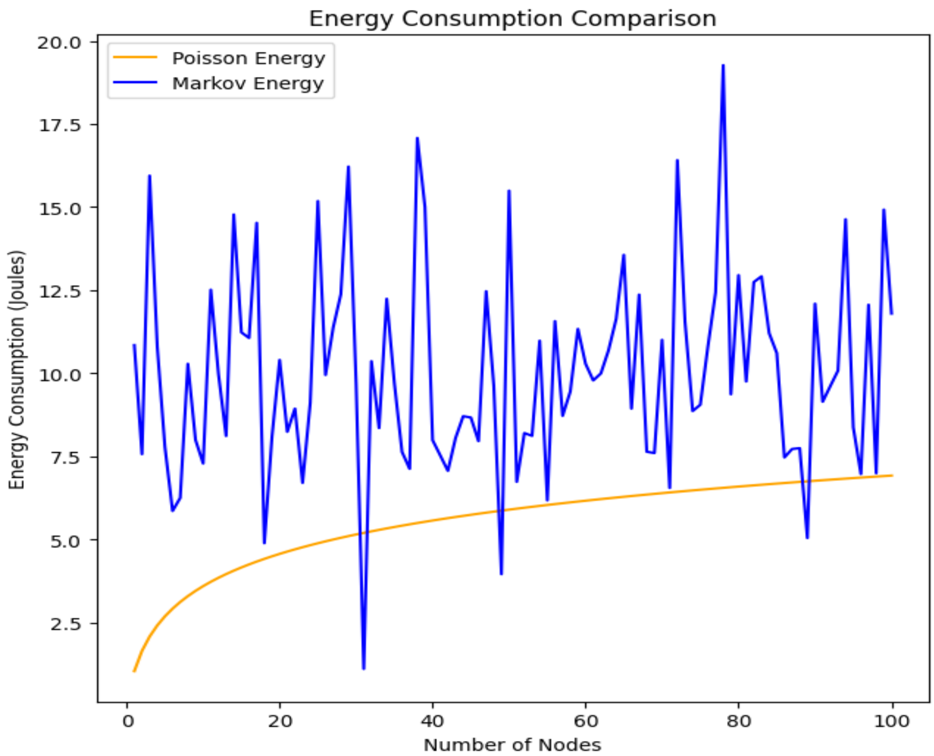

Figure. 4: Energy Consumption Comparison for Poisson and Markov Models, showing Energy Consumption (Joules) against Number of Nodes

CONCLUSTION AND DISCUSSION

VANETs as known as intelligent transport systems continue to guarantee the: safety of drivers and passengers, increased efficiency of road transportation and services. The systems promise to make the transportation experience less hazardous for the passengers. The management has secured several services as applications to realizing some of these promises. They include: collision warning, speed limit notifications, intelligent navigation and road traffic control, lane change assistance and multimedia content deliveries. Apart from effectiveness of VANETs there are always some challenges that need to be addressed. Thus, in our study we shed light on major issues such as delay and lack of energy. We have gone through a detailed research in this domain and presents related work done by other researchers. There are dozens of proposed models and conceptual framework or analysis to improve delay and efficiency in VANETs.

However, we chose few of them which seem more useful in this case, to mention in our study.

Poisson Model: Offers a more predictable and smoother behavior, making it suitable for analyzing delay and energy consumption in stable or expected environments.

Markov Model: Reflects unexpected behavior with larger fluctuations, making it appropriate for analyzing conditions that involve random or unpredictable behavior in the network.

The simulations reveal that the Markov model outperforms the Poisson model in both average delay and energy consumption as the number of nodes increases. This suggests that the Markov model may be more suitable for scenarios with high node density, offering better efficiency in network performance.

FUTURE WORK

May involve exploring hybrid models that combine the strengths of both approaches or further refining the parameters to optimize performance in various network scenarios.

REFERENCES

[1] Raya, M, Papadimitratos, P. & Hubaux, J., "Securing Vehicular Communications", IEEE Wireless Communications, Special Issue on Inter-Vehicular Communications, Vol. 13, No. 5, October 2006, pp. 8–15.

[2] Harsch, C., Festag, A. & Papadimitratos, P., "Secure Position-Based Routing for VANETs", in Proceedings of IEEE 66th Vehicular Technology Conference, VTC-2007, Fall. 2007. Baltimore, September 2007, pp 26 – 30.

[3] Kashif Dar, Mohamed Bakhouya, Jaafar Gaber, and Maxime Wack, "Wireless Communication Technologies for ITS Applications" IEEE Communications Magazine, Vol. 48, issue.5, pp. 156-162, 2010.

[4] T Spyropoulos, RNB Rais, T Turletti, K Obraczka, A Vasilakos, Routing for disruption tolerant networks: taxonomy and design. Wireless Netw.16(8), 2349–2370 (2010). doi:10.1007/s11276-010-0276-9.

[5] Y Zeng, K Xiang, D Li, AV Vasilakos, Directional routing and scheduling for green vehicular delay tolerant networks. Wireless Netw.19(2), 161–173 (2012). doi:10.1007/s11276-012-0457-9.

[6] Y Yao, Q Cao, AV Vasilakos, EDAL: An energy-efficient, delay-aware, and lifetime-balancing data collection protocol for heterogeneous wireless sensor networks. IEEE/ACM Trans. Netw.23(3), 810–823 (2015). doi:10.1109/tnet.2014.2306592.

[7] Nazmus Shaker Nafi M. K. Hasan, Aisha H. Abdallah, Traffic Flow Model for Vehicular Network. International Conference on Computer and Communication Engineering (ICCCE 2012), 3-5 July 2012.

[8] Proceedings of the national conference on traffic incident management: a road map to the future, June 2002.

[9] Kim H., Fujimoto R., "A simulation-based investigation of a dynamic advanced traveler information system", Proceedings of the 2009 Winter Simulation Conference, IEEE, 2009.

[10] Sou s., Tonguz O., "Enhancing vanet connectivity through roadside units on highways," Vehicular Technology, IEEE Transactions on , vol.60, no.8,pp.3586-3602,Oct2011.

[11] Mohammed Ali,"Simulation and Analysis of Vehicular Network Capacity", June 2013.

[12] D. Jiang and L. Delgrossi, "IEEE 802.11p: Towards an international standard for wireless access in vehicular environments," in Proceedings of the IEEE Vehicular Technology Conference - Spring, May 2008, pp. 2036–2040.

[13] S. Kaul, M. Gruteser, V. Rai, and J. Kenney, "Minimizing age of information in vehicular networks," in Proceedings of the 8th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks, June 2011, pp. 350–358.

[14] S. Panichpapiboon and W. Pattara-atikom, "Exploiting wireless communication in vehicle density estimation," IEEE Transactions on Vehicular Technology, vol. 60, no. 6, pp. 2742–2751, 2011.

[15] G. M. Zijie Zhang and B. Anderson, "On the information propagation process in mobile vehicular ad hoc networks," IEEE Transactions on Vehicular Technology, vol. 60, no. 5, pp. 2314 – 2325, 2011.

[16] Niloofar Toorchi, Mahmoud Ahmadian Attari, Mohammad Sayad Haghighi, & Yang Xiang. A Markov Model of Safety Message Broadcasting for Vehicular Networks. source: http://web.science.mq.edu.au/~msayad/all_my_docs/WCNC13_draft.pdf.