Investigating the Suitability of Different Routing Strategies In Specific VANET Application Class

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Abstract

Vehicular Ad-hoc Network (VANET) is the new technology that holds the opportunity to create potential applications that directly impact peoples' safety, traffic management, and infotainment services. VANET allows vehicles on the roads to communicate with each other through message exchange; hence proper routing of these messages plays an important role in the successful implementation of any VANET application. Understanding VANET applications and the available routing protocols can help to infer the most appropriate protocols that satisfy VANET application requirements. This paper develops a systematic classification methodology to classify VANET applications from a routing-level perspective. Each application class has different network requirements which are laid down by VANET Projects conducted in different countries. Some of these requirements are related to the routing aspects, this paper study routing strategies (proactive and reactive) used by routing protocol as one aspect related to routing process. The paper identifies routing strategies performance metrics related to each application class requirement, to efficiently guide the development of these routing strategies towards promising satisfactory performance for the applications under a wide variety of realistic VANET scenarios. It is also worth mentioning that minimum delay is a requirement needed by time and event-driven application classes. On the other hand, high reliability is a requirement needed by on-demand applications. This paper uses end-to-end delay as a performance evaluation metric to analyze the delay requirement; and Routing Overhead (RO) to assess the reliability requirement. This paper aims to provide a comparative study on the performance of routing strategies in different VANET Application classes, to identify which routing strategies have better performance in specific VANET Applications class. Simulation results showed that proactive routing protocol had a lower delay, which means that it could be adapted for delay-sensitive applications such as time-driven application class and event-driven application classes. The results also showed that the reactive routing protocol outperformed the proactive routing protocols in terms of RO, which means that reactive routing protocols can be nominated as proper routing strategies that satisfied the reliability requirement of the On-demand driven application class.

Key words- V2V, V2I, VANET Applications, Messages, Routing Strategies, V2V Applications

I. INTRODUCTION

The advancement in the automotive industry composed with the recent improvement in wireless communication technologies appeals to a new emerging technology known as VANET (Vehicular Ad-hoc Network) [1]–[22]. Vehicles are now coming with on-board units, equipped sensors, and many other communication capabilities. VANET system design and implementation come across many difficulties, such as routing, security, connectivity, privacy, and quality of services (QoS), however routing messages generated by VANET applications are considered as one of the biggest challenges in this type of network [10], [28]. Successful operation of any VANET application; requires appropriate routing protocol [3]–[5]. For that reason, studying the VANET applications and different routing protocols to find the best relationship between them is essential for VANET optimization and the facilitation of future VANET researches. The contribution of this paper is to select appropriate routing strategies for each VANET application class. To achieve this goal this paper classifies VANET applications according to application trigger mode criteria. Accordingly, VANET applications can be classified into three classes: time-driven applications class, event-driven applications class, and ondemand-driven applications class. On the other hand, to make the evaluation of routing protocol in VANET application scenario more efficient, it is better to study

each routing aspect separately, this paper takes a systematic approach to analyze one aspect in the routing process which relates to routing strategies, according to this aspect routing protocols are classified into proactive and reactive routing protocols [4]–[8]. Furthermore, this paper abstracts some requirements for each previous class of VANET applications from a routing perspective, in order to select appropriate routing strategies that satisfy some of the requirements of the VANET applications. Then these routing-level requirements are used as a reference to select performance metrics for the performance evaluation of routing strategies. This paper presents a performance comparison of two prominent routing protocols based on results analysis obtained by running simulations with different scenarios in OMNet++. The rest of this paper is organized as follows: Section II introduces the related works. VANET applications classification is done in Section III. Section IV presents the characteristics of routing strategies. In section V the scenario for each VANET Application class is simulated and the performance metrics are identified, also this section shows the result of our simulation. The result is analyzed in section VII. Finally, section ?? concludes this work and specifies possible directions for future work.

II. RELATED WORKS

A variety of researches [1-28] and several excellent papers in the literature had appeared in the area of routing protocols procedure and evaluation [4], [6]. However, in order to have effective evolution of these routing protocols, it is preferred to consider a realistic mobility model for each VANET applications scenarios. Few works of literatures have considered this issue, for example in [1] the performance of AODV, DSDV and OLSR had been evaluated only in a safety application scenario without considering other VANET applications. The simulation is conducted using NS-3, which is out of date simulator and does not have a separate traffic simulator that adds reality to the application scenarios. The simulation results showed that maximum packet delay performed below 0.09 seconds in any density, mean that the maximum delay verified to be not a big concern, but an average end to end delay and route discovery delay can be as important metric for VANET applications. Moreover, this paper used a small number of cars (3-12 cars) which cannot reflect the effect of the number of cars in routing protocol performance. Also in [19] the Distributed Robust Geocast scheme had been chosen and adapted as another type of routing protocol in the Post Collision Notification (PCN) application which is also a safety application. DRG is a protocol based on the location information of the vehicle, these information need to be send reactively or proactively during the routing process need to be consider. The implementation of Geocast routing protocol for PCN application had shown good performance in a safety application without considering the effect of routing packets in satisfying the requirements of safety messages. In the above-mentioned papers, the evaluation and comparison of various routing protocols were conducted for a single VANET application scenario and the vast majority of them had focused on applications related to safety on the road, which does not reflect the performance of these protocols under different VANET applications scenarios. Most of the research contributions in performance evaluation of routing protocols related to routing procedure aspects as all, without considering route acquisition phase, route maintains or even data forwarding separately [4], [21]–[26].

III. VANE APPICAION CLASSIFICATION

The Vehicle Safety Communication Project [12] is one of several projects that identified a large number of applications for potential deployment. VANET applications vary significantly in terms of characteristics and requirements. Analyzing and developing large numbers of applications are inefficient tasks. Toward this objective, we go through characterization and classification for some of VANET applications.

A. VANET' APPLICATION CHARACTERISTICS

First, we focus on represent and defining some VANET applications. The communication in these applications can be V2V or V2I, the latter type is out of the scope of this paper. Road Feature Notification Application (RFNA) is a VANET application; that allowed vehicle to detect a road feature (e.g., road curve, hill) and then notifies approaching vehicles in their neighborhood periodically. Another application is Cooperative

Collision Warning (CCW), in which the vehicle periodically monitors kinematics status messages in its neighborhood to warn for potential collisions. Also, V2V Post Crash Notification Application (PCN), which allows vehicles involved in an accident (event) to send notification warning messages to vehicles in their neighborhood. On other hand, Internet access, custom information services, file sharing, and video streaming are another set of applications adopted for VANET.

There are a lot of key criteria that cover various aspects related to VANET Application design. Concerning routing level (routing the message generated by application), this paper characterizes VANET applications according to application trigger mode criteria. This criterion was selected in this paper to analyze the relationship between the way that an application starts sending messages (trigger) and the way that routing protocols start finding a path to that application message (routing protocol initiation mode).

In RFNA and CCW [13]–[15], [17] a safety message would be periodically generated by these applications but in PCN safety message would be generated when an abnormal condition or imminent danger is detected, failure in routing these messages to their intended destination within time constraints could make them useless and the applications fail to achieve their goals. On the other hand messages in user initiation services applications normally bear important pieces of information needed by the user; failure in routing these messages to their intended destination within reliable constraints could decrease user satisfaction. The characterization process not only supports our understanding of the applications but also sets the stage for the classification step since it introduces several application consistencies. Thus, we have categorized the given applications into three generic classes, with the consideration of using the similarities of many applications as possible while preserving their differences.

B. VANET' APPLICATION CLASSIFICATION AND REQUIREMENTS

In this paper, VANET applications are generally classified into time-driven applications class, event-driven applications class, and on demand-driven applications class. In the time-driven application class, the vehicle is activated periodically and sends messages to share information among vehicles on the road, enable more efficient traffic flow control, and maximize vehicle throughput on the road. RFNA and CCW are applications for this class.

In the *event-driven application class*, the vehicle sends warning messages only in case of an event accrued, such as panic events, but not periodically as in the time drive applications. PCN application is an example of event-driven application class.

In *both previous application classes*, time is a significant factor for these applications which relates to safety and accident avoidance, therefore they can be considered as delay-sensitive and the routing-level metric such as delay can be adopted as the most important performance metric for these classes of applications.

In *on demand-driven applications*, the user initiates request

messages for on-demand convenience services. The communication in this class can be V2V or V2I communications; however, most of them are V2I communications. Messages for on-demand applications are uncorrelated with each other; this is similar to many traditional Internet applications. Hence, the network design should strive to deliver the transmitted packets successfully despite some link failures. Generally speaking, this type of application is delay-tolerant since it does not involve real-time communications. On the other hand, these applications are typically loss-sensitive, since packet loss may hinder the successful data transfer and thus damage the reconstructed data file. Therefore, we believe that routing-level metrics, such as Routing Overhead (RO) is the most relevant metric to capture the performance of the routing protocol in these applications, because this metric evaluates the congestion in bandwidth generated by the routing packets. On the contrary to the above-mentioned on-demand application requirements, as a special case, interactive or real-time applications such as video, VoIP, streaming applications are normally delay-sensitive. Thus, we argue that the delay metric is the most important routing-level metric for such types of applications.

IV. CHARACTERISTICS OF ROUTING STRATEGIES

Topology in VANET is changing dynamically due to the mobility of vehicles, which infers that the network connections are established for a single period and routes must frequently be rediscovered [2]. Routing strategies determent the time needed by the specific routing protocol to start sending routing messages (*packets*) to advertise the presence of the vehicle (the period before forwarding the application message) [1], [3]. The most popular classification method is based on how routing information is acquired and maintained by mobile nodes. According to this method (routing strategy criteria) routing protocols is classified into proactive and reactive [3]–[8].

A. Proactive Routing Protocol:

When using proactive routing protocols, also called “*table-driven*” protocols, mobile nodes periodically find routes to all nodes and try to maintain consistent and up-to-date routing information, regardless of whether data traffic exists or not. The advantages of this type of protocol are the using of the shortest path through the network and the availability of routes at the time of need, which reduces route acquisition delay. The lack of proactive routing protocols appears in using large number of routing messages to maintaining correct route information; a node must periodically send routing messages. This results in a constant overhead of routing traffic. The various types of proactive routing protocols are DSDV, LSR, and FSR.

B. Reactive Routing protocols

also called “on-demand” protocols, when mobile nodes use reactive routing protocols; route discovery operation is performed only when arequired route does not exist. The advantages of this type of protocol are efficiency, reliability,

and less control overhead. However, a major lack is a long delay caused by a route acquisition operation. The various types of reactive routing protocols are AODV, PGB, and DSR. This paper will not study the hybrid routing protocols such as Ordered Routing Algorithm (TORA) [23] and Zone Routing Protocol (ZRP) [24] which are the third part of routing strategies that combine reactive and proactive routing strategies [25]–[27]. The proposed method in this paper different from the existing hybrid routing protocols. This paper depends on gathering up all the advantages of reactive and proactive routing protocols related to routing acquisition and route preserves, considering delay and routing overhead as alarming metrics that satisfy the requirement of specific VANET application class. some hybrid routing protocols such as TORA tend to be the same as existing reactive routing protocol. Also most of the existing hybrid routing protocols source code is not available in network simulators such as OMNeT++ in to be evaluated simply [18]. Two routing protocols have been studied in this paper. Destination Sequenced Distance Vector (DSDV) [13] is selected as the proactive routing protocol and Ad hoc On-demand Distance Vector (AODV) [14] as a reactive routing protocol. The rationale for selecting these routing protocols is because they are approved by the Internet Engineering Task Force (IETF) [15] and the source code for these protocols are available in many VANET simulators.

V. SIMULATION

Simulation of VANET requires two types of simulators: Mobility (Traffic) simulator and Network simulator. In most cases mobility and network simulators are separate. This paper use SUMO (Simulation of Urban Mobility) [16], [17] as a mobility simulator to model the vehicular driving environment as close as possible to the real-world environment. On other hand for appropriate evaluation of routing protocols within the given circumstances of VANET application this paper use OMNeT++ (Objective Modular Network Test bed using c++) [18] as a network simulator. To add more reality to the application scenarios in the simulation, this paper also uses VEINS (Vehicles In-Network Simulator) [9] which is an open- source framework for running vehicular network simulations. VEINS offers a comprehensive suite of models for VANET simulation by extending OMNeT++ and SUMO.

A. VANET’ APPLICATION SCENARIOS

In the simulation set-up, the transmission range for each vehicle is 100m and the road is a one-way road with two lanes. For more details of the simulation environment, refer to Table I. These simulation parameters setup will be adapted

TABLE I
SIMULATION ENVIRONMENT SETUP.

PARAMETERS	SPECIFICATIONS
Operation System	Ubuntu Linux 20.04
Mobility simulator	SUMO 1.3.1
Network simulator	OMNET++ 5.6.2
Simulation time	25 seconds
Simulation area	100mx1000m
Number of vehicles	100 vehicles

Fig. 1. Slow Vehicle Warning Application

Fig. 2. Emergency Electronic Brake Lights Application

for all VANET applications scenarios.

This part will identify one application scenario from each VANET application class. For the sake of simplicity, this paper omits in this simulation the effect of other factors that affect the mobility and performance of routing protocols like road obstacle, traffic light and even driver behaviors.

To analyze the simulation scenario of time-driven and event-driven application, we need first to distinguish between vehicles in warning mode and vehicles in normal mode, vehicles in warning mode facing the abnormal issue and attempt to send messages to the vehicle in normal mode, after normal vehicles receive the message it takes action according to that message. The alteration trajectory of normal is out of the scope of the simulation.

This paper chooses the Slow Vehicle Warning (SVW) Application as an example for this class (Fig. 1), in this application vehicle in warning mode which is here the slow vehicle sends messages about its presence (vehicle type) to other vehicles which are in normal mode. To simulate this scenario, the slow vehicle starts moving at a low speed of 14 m/s, and the other vehicles moving at a normal speed of 30 m/s. From zero seconds (simulation started) the slow vehicle starts sending it is the first message to the approaching vehicles, messages will be sent periodically every 10 seconds.

Emergency Electronic Brake Lights (EEBL) Application is an example of event driven-application class (Fig. 2). In this use case vehicle in the warning mode signal its hard braking to approaching vehicles. Warn approaching vehicles about a sudden slowdown of the traffic limit the risk of longitudinal collision. To simulate this application scenario, all vehicles at the beginning of the simulation are moving at a normal speed of 30 m/s, after 5 seconds the first vehicle enters the simulation, suddenly stops (speed of 0 m/s), and starts sending messages.

This paper chooses Chatting Application as a use case of this class (Fig 3); at this application the first vehicle enters the simulation starts the conversation by sending a welcome message to approaching vehicles after 5 seconds from the start

of the simulation.

B. PERFORMANCE METRICS

Various performance metrics have been used to examine the performance of the routing protocols in VANET Applications scenarios [20]. This paper chose end-to-end delay to examine the performance of routing protocols in time and event-driven applications classes and Routing Overhead (RO) as a performance metric to evaluate the performance of the routing protocols for on-demand applications class. RO is defined as the total number of routing messages transmitted over the network, expressed in bits per second or packets per second. The average end-to-end delay is the time taken for packets to be transmitted across a network from source to destination. This delay covers all of the potential delays such as route discovery, buffering processes, variations in between queuing stays, forwarding, recovery, etc. during the entire trip of packet transmission. This paper observes the behavior of the routing strategy in the first steps of packet transmission, but it is difficult to measure route acquisition delay for a proactive protocol in simulation using special metric because DSDV source code is a partial / unfinished implementation in OMNeT++. For that reason, the paper took simulation time as a parameter to determine the time taking by the routing strategy in the first steps of packet transmission using the main OMNeT++ simulation runtime GUI.

The evaluation performance will be for AODV as it is a reactive routing protocol and for DSDV as an example of a proactive routing protocol. The simulation is done for both time and event-driven application scenarios using end-to-end delay performance metric. Furthermore, the evolution of AODV and DSDV routing protocol is conducted in on demand-driven application scenario using the Routing Overhead. These metrics are performing as function of simulation time. Scenarios in this paper are conducting irrespective of the density of node, pause times, movement speed, or even sending rate, it depends on observing the performance of the protocol in all the simulation period especially in the routing perpetration period (in route acquisition period and preserves period), which is the period before sending the application message.

C. SIMULATION RESULTS

The results obtained from modeled traffic and environment of the vehicular network using SUMO and OMNeT++ simulators respectively are presented in this section. The simulation result showed that delay for DSDV was lower than

Fig. 3. Chatting Application in VANET

Fig. 4. Average end-to-end delay of AODV and DSDV in Slow Vehicle Warning (SVW).

Fig. 5. Average end-to-end delay of AODV and DSDV in Emergency Electronic Brake Lights (EEBL) Application.

Fig. 6. Routing Overhead of AODV and DSDV in Chatting Application.

delay in AODV when simulating in time and event-driven application scenarios as showed in (Fig. 4 and Fig. 5). Furthermore, the routing overhead for AODV outperformed DSDV when simulating on demand-driven application scenario as shown in (Fig. 6).

VI. RESULT ANALYSIS

This paper studied the ability of proactive and reactive routing protocols in satisfying some requirements of VANET applications. After conducted the simulation based on the evaluation of DSDV and AODV in a realistic scenario of VANET applications, it was observed that DSDV had a low

delay since the route discovery phase is not required in this type of routing strategy. Maintenance of routes at all times can result in much higher Routing Overhead. On the other hand, the delay of AODV is higher than DSDV because AODV is a reactive routing protocol that consumes more time in the route discovery phase when the source node initiates a route request. Furthermore, AODV protocols achieve lower Routing Overhead compared to DSDV, because in AODV protocol the path uses to forward the packets routes are maintained only on a demand basis but not periodically as in proactive routing protocol.

From the above results, we can argue that reactive routing protocols are more applicable to carry on-demand user service messages, but it fails in the scenario where the transmission time should be less since it has higher delay. On the other hand, proactive can be adopted to carry sensitive information related to safety purposes.

VII. CONCLUSION

Successful operation of any VANET application requires adopting appropriate routing protocol, hence studying VANETs' applications and different routing protocols to find the best relationship between them is essential for VANET optimization and also for the facilitation of future VANET researches. Traditional routing protocols such as AODV and DSDV cannot be applied directly in VANET owing to their limited performance in VANET application scenarios. Moreover, using different routing protocols for different VANET application scenarios might not be a acceptable option. Therefore, future research may focus on adopted a combination solution. We intend to combine suitable routing strategies with geographic routing information instead of topology information, which leads to the existence of new routing protocols with optimized performance in every VANET application scenarios. It is recommended to take into consideration the features of the lower layer in the identification of the three classes of VANET applications.

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REFERENCES

- [1] G. Z. Santoso and M. Kang., Performance analysis of AODV, DSDV, and OLSR in a VANETs Safety Application Scenario. 14th International Conference on Advanced Communication Technology (ICACT), 2012. pp. 57-60.
- [2] Kashif Naseer Qureshi, Abdul Hanan Abdullah. TOPOLOGY BASED ROUTING PROTOCOLS FOR VANET AND THEIR COMPARISON WITH MANET. Journal of Theoretical and Applied Information Technology, 2013. Vol. 58 No.3
- [3] Pavan Kumar Pagadala Saravana N M Ramachandran .A Survey on Topology based Reactive Routing Protocols. Global Journal of Computer Science and Technology: ENetwork, Web & Security, 2018 .Volume 18 Issue 4 Version 1.0
- [4] M. M. Mohammed Nasr, A. M. S. Abdelgader, Z.-G. Wang, and L.-F. Shen. VANET clustering based routing protocol suitable for desert-s. Sensors, 2016. vol. 16, p. 478

- [5] Uma Nagaraj and Poonam P. Dhamal. Performance Evaluation of Proactive and Reactive Protocols in VANET. IJIET,2012 .Vol.2(5): 434-438 ISSN:2010-3689 DOI: 10.7763/IJIET.2012.V2.171.
- [6] H. Hartenstein and K. P. Laberteaux. A tutorial survey on vehicular ad hoc networks. Communications Magazine, IEEE, 2008.vol. 46, pp. 164-171
- [7] Bian PaulMd, IbrahimMd, Abu Naser Bikas .VANET Routing Protocols: Pros and Cons.International Journal of Computer Applications,April 2011.(0975 8887)Volume 20No.3
- [8] Basu Dev Shivhare,Charu Wahi ,Shalini Shivhare .Comparison Of Proactive And Reactive Routing Protocols In Mobile AdhocNetworkUsing Routing Protocol Property.International Journal of Emerging Technology and Advanced Engineering,March2012.ISSN 2250-2459,Volume 2, Issue3
- [9] C. Sommer, D. Eckhoff, A. Brummer, D. S. Buse, F. Hagenauer, S. Joerer, et al.Veins: The open source vehicular network simulation framework. in Recent Advances in Network Simulation, ed: Springer, 2019. pp. 215-252.
- [10] Shilpi Dhankhar1, Shilpy Agrawal2. VANETs: ASurvey onRouting Protocols andIssues. International Journal of Innovative Research in Science, Engineering and Technology(An ISO 3297: 2007 Certified Organization),June 2014.Vol. 3, Issue 6.
- [11] Papadimitratos, A. de La Fortelle, K. Evenssen, R. Brignolo, and S. Cosenza.Vehicular Communication Systems: Enabling Technologies, Applications, and Future Outlook on Intelligent Transportation. in IEEE Communications Magazine,November 2009. Vol. 47, Issue 11, pp. 84-95,
- [12] N. Admin.Vehicle Safety Communications Project-Final Report. Tech. Report, DOT HS,2006.vol. 810, p. 591,
- [13] M. Altayeb and I. Mahgoub.A survey of vehicular ad hoc networks routing protocols.International Journal of Innovation and Applied Studies, 2013.vol. 3, pp. 829-846.
- [14] C Perkins, E. Belding-Royer, and S. Das.Ad hoc on-demand distance vector (AODV) routing. ed: RFC 3561, july, 2003.
- [15] S. Bradner.The Internet Engineering Task Force (IETF).DiBona et al.[144],1999,pp. 47-52.
- [16] M. Behrisch, L. Bieker, J. Erdmann, and D. Krajewicz.SUMOSimulation of urban mobility: an overview. in Proceedings of SIMUL 2011, The Third International Conference on Advances in System Simulation, 2011.
- [17] D. Krajewicz, G. Hertkorn, C. Rssel, and P. Wagner.SUMO (Simulation of Urban MObility)-An open-source traffic simulation. in Proceedings of the 4th middle East Symposium on Simulation and Modelling (MES-M20002), 2002. pp. 183-187.
- [18] T. Chamberlain, Learning OMNeT++.Packt Publishing, 2013.
- [19] Ana Mara Orozco1&Sandra Cspedes 2,3 & Roger Michoud 4 & Gonzalo Llano. Design and simulation of a collision notification applicationwith geocast routing for car-to-car communications. Eur. Transp. Res. Rev, 2015 7: 36DOI 10.1007/s12544-015-0185-1
- [20] Mohammed Erritali,Bouabid El Ouahidi. Performanceevaluation of ad hoc routing protocols in VANETs. IJACSA Special Issue on Selected Papers fromThird international symposium on Automatic Amazigh processing(SITACAM 13)
- [21] Kaur, Ravneet, and Haramandar Kaur. Performance evaluation of routing protocols in VANET .International Journal of Future Generation Communication and Networking 8.6 ,2015: 239-246.
- [22] Memon, Irshad Rahim, et al. Performance evaluation of routing protocols in VANET on highway: Police cars communication scenario. Engineering Science and Technology International Research Journal 1 ,2017.
- [23] Obinna Okoro.Mobile Ad - hoc Network (MANET) Routing Protocol Comparison between Temporary Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR) A Review.International Journal of Engineering & Technology Sciences 2(4):371, August 2014
- [24] Beijar, Nicklas. Zone routing protocol (ZRP). Networking Laboratory, Helsinki University of Technology, Finland 9 (2002): 1-12.
- [25] Al-Sanjary, Omar Ismael, et al. An investigation of the characteristics and performance of hybrid routing protocol in (MANET). International Journal of Engineering & Technology 7.4.22. 2018. 49-54.
- [26] Meenakshi, Vinod Kumar Mishra, and Kuber Singh. Simulation & Performance Analysis of Proactive, Reactive & Hybrid Routing Protocols in MANET. International Journal of Advanced Research in Computer Science and Software Engineering, vol2,2012.
- [27] Bilandi, Naveen, and Harsh K. Verma. Comparative analysis of reactive, proactive and hybrid routing protocols in MANET. International Journal of Electronics and Computer Science Engineering 1.3 .2012. 1660-1667.
- [28] Tomar, Ravi, Manish Prateek, and G. H. Sastry. Vehicular adhoc network (vanet)-an introduction. International Journal of Control Theory and Applications 9.18 ,2016. 8883-8888.