BAJOPAS Volume 14 Number 2, December, 2021
http://dx.doi.org/10.4314/bajopas.v14i2.17

Bayero Journal of Pure and Applied Sciences, 14(2): 150 - 156
Received: March, 2021
Accepted: July, 2021
ISSN 2006 – 6996

ENTROPY-BASED QOS ROUTE STABILITY TECHNIQUE FOR VEHICULAR AD HOC NETWORK

Abubakar, A. M. and Ibrahim, A. L. [2]
[1]Department of Computer Science, Umaru Musa Yar'adua University Katsina,
[2] Department of Information Technology, Bayero University Kano, Nigeria,
abubakar.muazu@umyu.edu.ng

ABSTRACT
Vehicular ad hoc network (VANET) has received significant considerations with the prominent introduction of real-time application that triggers research activities on area of Quality of Service (QoS). QoS provisioning for guaranteeing a data route to be available and stable for a longer period remains the most challenging tasks VANET. Therefore QoS of routing is highly affected by mobility features of vehicles in VANET environment. We propose simple QoS routing strategies capable of providing optimal paths with certain QoS requirements route stability based on received entropy. Extensions were added to the messages used during route discovery/reply with route stability information for optimal and stable route. Results obtained indicate improvements in terms of average network throughput, average network delay and percentage of packet drop.
Keywords: Quality of Service, Stable Route, entropy, VANET

INTRODUCTION

The main goal of vehicular network is to deliver a message for it to be valid due to the intermittent connection between two or more vehicles. VANET is affected by the rapid topology changes that make it difficult to transmit data within shortest possible time. Data could be transmitted data in the VANETs as real-time applications for safety related messages or the non-real-time applications which impose the varied Quality-of-Service (QoS) needed for VANETs designs. The rationale behind VANETs is actually the safety, comfort driving and infotainment application for passengers. The routing of data packets in this rapid changing network is always the subject of intensive research.

Majority of ad hoc network QoS routing protocols are based on on-demand routing in such a way that whenever a path is not valid, the route recovery process and maintenance operations tend to be established (Saritha, Krishna, Alagiri, Viswanatham, & Obaidat, 2018). Such processes take up a significant number of resources and bring in additional delay within QoS sessions. Route with longer time need to be discovered in order to minimize the likelihood of route breaks at the time of data propagation. Usually the shortest path is the route with short lifetime due to edge effects (Kulla, Morita, Katayama, & Barolli, 2019) especially in a high dense environment. However, larger packet transmission error rate determines by the transmission distance of a wireless link which perhaps extents the transmission area of mobile nodes. With such a movement, the percentage of packet loss as well as packet collision increases drastically.

In addition, the packets usually tend to be dropped as a result of external factors such as wireless interference. Stable route signifies exactly how link connection might sustain a longer duration. However, one of the primary approaches is to minimize the amount of route discoveries which could possibly be depending on the selection of more stable routes, meaning that the paths which are most likely to provide a longest lifetime.

Subsequently, the concept of entropy introduced in (Nabil, Hajami, & Haqiq, 2018) provides the level of doubt with a measurable amount of affliction in a network environment. Usually at this point, there exist quite a few common features amongst self-healing, entropy, and also the node location that present uncertainty in wireless ad hoc networks.

The key idea our proposed idea is to introduce a new metric called entropy in VANET and to be able to select the stability of a path by making use of this metric to eliminate the amount of route maintenance by providing QoS guarantee in the vehicular environment. This paper aims in designing a routing protocol using entropy-based routing intended for QoS guarantees, in order to minimize the protocol's complication with the local transmission attribute in VANET. The scheme employs clustering approach with a cluster head elected as the leader responsible for communication between inter-cluster and intra cluster. However, algorithm for formation as well as maintaining the cluster is not under this research, scope, so we adopt (Ding & Zeng, 2009) with modifications.

Traditional routing protocols employed in MANETs ought to be modified in order to support such unique characteristics of VANETs. The main aim of our work is to design a QoS routing protocol for VANETs capable on identifying optimal and stable route for effective routing in high dynamic ad hoc network. Therefore the routing scheme would be designed and implemented based on DSRC specifications (Kenney, 2011) and IEEE 802.11p MAC. To provide QoS to the routing algorithm, extensions are included in the messages during route setup process. These extensions however, establish the service specifications which in turn ought to be satisfied by any node retransmitting the QoS route request or transverses a route reply to a source node.

MOTIVATION FOR QOS ROUTING

Quality of Service (QoS) was utilized in the 1980s with the introduction of ATM system. The term QoS refers to the measurement of service that is used to express the level of performance provided to users (Lin & Liu, 1999; Zeadally, Hunt, Chen, Irwin, & Hassan, 2012). The primary objective of providing QoS is to obtain considerably amount of deterministic network behavior and maintaining network information to be delivered much better and network resources could very well be utilized. However, there still remains a tremendous concern to provide QoS solutions and keep end-to-end QoS along with mobility in VANETs.

QoS routing approach is not really accompanied by any conventional MANET routing protocols. However there are some researches that make an effort to incorporate such strategies within VANET routing protocols.

The conceptual complications by using QoS usually begin along with the specific description, and also the precise supports for a subpart of QoS. Therefore, for any routing problem, each link $u-v$ in a given graph is characterized by a link weight vector $w(u \to v) = [w_1, w_2, ...w_n]$ with q positive real numbers $w_i(u\_v) \geq 0$ as components. The problem requires a path P from source node to destination node satisfying equation (I) below, for every $1 \leq i \leq q$ QoS metrics, with l_i representing the QoS constraints on the route.

$$w_i(P)^{def} = \sum_{(u \to v) \in P} w_i(u \to v) \leq L_i \qquad (1)$$

The major issues associated with QoS routing is highly relevant to by using the approach employed for the data dissemination and accumulation of routing information.

A. *Stable QoS routing*

Stability of Routing algorithm determines the performance of routing packet in VENET. Instability can occur whenever the receptiveness of the protocol results in being exaggerated, therefore presenting an unwanted re-routing of data packet traffic that degrades the traffic performance especially. The challenging issue is in case when the network is congested as the data delivery indulges in the limited bandwidth resources and however, the router processor becomes loaded by applying the path computation algorithm.

Several factors influence the instability issues which could be the type of metrics used for computing the optimal route to destination (Wang, Cheng, Lu, & Qin, 2019). These include, rapid topology changes in VANET, route computed algorithm, control policy among others. However, the shortest path routing depends on a link congestion metrics that prone to instability under heavy loads traffic. The control mechanism to reduce the aforementioned instability could either be related to the metrics distribution mechanism, optimal route selection or traffic differentiation with QoS constraints. The classified ad of quantified metrics stands out as the initial technique to refrain from routing instability which could be obtained employing a simple average of the calculated metrics (Al-Mayouf et al., 2016).

At this extent, any routing protocols that treat traffic flows based on their connection duration and perform route computation of mix QoS sensitive traffic, tend to improve the stability and overall routing performance (Al-Mayouf et al., 2016).

The specified customization of QoS Routing techniques can not in any way result in instability. In spite of this, both these objectives could be unclear and also solutions for one refuse the fulfillment on the other side. New QoS Routing protocols needs to be developed in a way that routing hand shake are avoided, while providing adequate data delivery with a high quality and stable route in the network.

ENTROPY As A METRIC

The principle concept guiding the proposed components is to investigate a diverse amount of reliable routes as a result of quantification of the uncertainty level associated with routing of ad hoc communication environment. The concept was adopted in mobile ad-hoc networks (*MANET*s)(Mejri & Ben-Othman, 2014) (Ahizoune & Hafid, 2012) which is used to maintain a certain level of network-based stability.

Given that *h* be the optimum number of links of feasible routes within the sending vehicle *s* to the receiving vehicle *d*. let *n* be number of mobile nodes in the network, then $h \leq n$-1.

$P_j^i \in [0,1]$ where the possibility of the jth node to take the i^{th} place of the valid path is the possibilities of the connection response time.

$$\sum_{j \in N} P_j^i = 1, \quad 2 \leq i \leq h \qquad (2)$$

Let $\{P_j^i\}$ be the set of possibilities that a connection can be used to quantify the uncertainty involve in the discovery of optimal route.

Ultimately, the concept of entropy was initially proposed by Shannon [7] as a measure of uncertainty for statistical models.

Let $(p_1, p_2 ...... p_n)$ be the probability distribution of the valid path, and assuming that the probability distribution is complete i.e $\sum_{i=1}^{n} p_i = 1$, therefore, the Shannon entropy is defined as

$$H(p_1, p_2 ... p_n) = \sum_{i=1}^{n} p_i \log_\theta p_i \qquad (3)$$

Obtained from the definition of the connected entropy, it might be proven that $0 \leq H(P) \leq \ln$ *n*. however; the connected entropy is reduced if and only if the entries P_j^i of *P* take on values from the set {0, 1}. In such a case, $H(P) = H_{\min} = 0$ and $\{P_j^i\}$ define the least uncertain route. The connection entropy reaches its optimum value if and only if $P_j^i = 1/n, \forall i, j$. In such a case, $H(P) = H_{\max} = 1n$ n and $\{P_j^i\}$ define the most uncertain route.

RELATED WORKS

The most used way of geographic routing is simply forwarding data packets for the neighbor geographically that are the nearest to destination. Despite the fact that the greedy technique is effective often times, packets might get routed to where no neighbor is closer to the destination in comparison to current node, thus result in a void circumstance. Void problem occurs when there is no any vehicle in the direction of the destination. Probability theory is frequently employed in dynamical techniques to refer to the possibility of certain events, for example the possibility of link to be invalid with a certain transmission power or a certain mobility parameter. Protocols, such as, such as, (Niu, Yao, Ni, & Song, 2007; Sun, Yamaguchi, Yukimasa, & Kusumoto, 2006; Taleb et al., 2007) apply the probability to build the routing protocol in the selected region or cluster. Link stability can easy be calculated by using quite a few parameters. Signal strength was used in SSA, and pilot signals were used in (Toh, 1997)ABR (Al-Mayouf et al., 2016). Establishing stable route between connected nodes in VANETs is extremely important using stable links and challenging due to cost of the rerouting in such network without infrastructure.

A novel approach was proposed by (Sharshembiev et al, 2019) that perform real-time detection of node misbehavior using selective flow sampling and entropy change. Their wor explore the sampling methods to calculate the entropy using p-persistence routing protocol. They employ selective sampling and entropy-based detection techniques in the context of VANET broadcasting traffic. Analysis of small flows within the VANET network will help them identify any anomalies in terms of packet traffic, thus leading us to detect any misbehavior

PROPOSED STABLE ROUTING PROTOCOL

A. Protocol Procedures

In the proposed system, every vehicle is associated with one of the three potential state; Cluster Head (CH), gateway and ordinary member (OM). Within the next sub-sections, we'll introduce how the algorithms for the source node, CH and immediate node as well as the destination node work. The propose protocol intend to exploit the cluster based approach for achieving optimal routes as show in the figure 1 below;

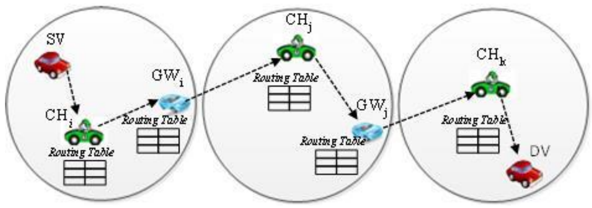

Figure1: Network Scenario

i. QoS Route Request

We are considering a full-connected, single source hierarchical network (cluster-based) concept to get a better delivery ratio as well as to reduce broadcast issue. The source node *s* send a request message *p* and node *s* sends a frame to the CH node *i* with feasible path QoS requirement over data channel as specified in (Mu'Azu, Jung, Lawal, & Shah, 2013) and (Ding & Zeng, 2009).

a. Source Node Algorithm

In source node algorithm, the source node will start to check its resources accessibility. In the event of adequate resources, optimum route is chosen in storage cache, and the resources are reserved while data packets are being transmitted. If there is no any suitable route that is stored in cache, then the cluster head forward data to other adjacent clusters over data channel. When source node wants to send data packet to destination, to avoid wasting of resource, the source will search in its route cache if it the location of the destination as in the algorithm

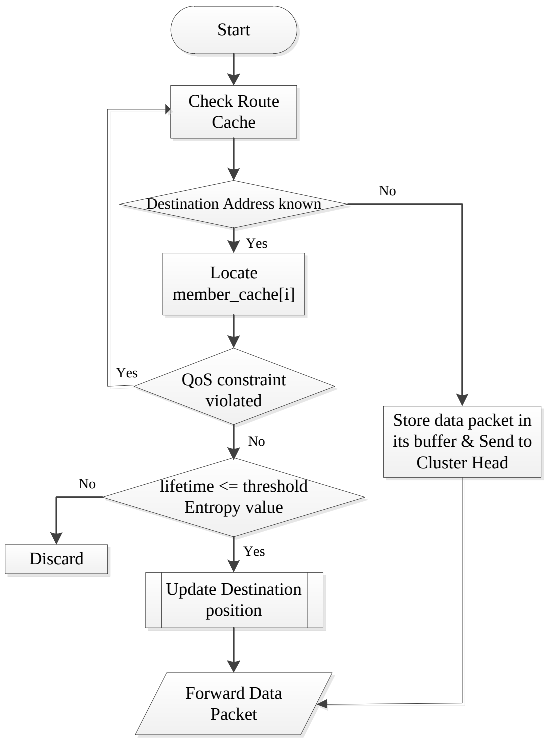

Figure 2: Source Node Algorithm

SIMULATION EXPERIMENT

The proposed scenario is implemented in NCTUns-6.0 simulation environment that provides a quick feedback loop in the simulation process.

The traffic classes considered in our simulation is UDP and also constant bit rate (CBR). Among the important parameters that should be tested for performance of any routing protocol is the throughput.

A. Simulation Scenario

In this paper, we model and simulate two (2) network scenarios which are considered in an urban-like environment with respective variable number of vehicles. Vehicle speeds decreases as congestion on road increases with addition of more vehicle nodes on the road. Our simulation model a network parameters that are used as default values unless of course otherwise specified are listed in Table 2.

We present here a preliminary of result obtained in the urban situations having 100 nodes at random situated within the roads. Adhere to the DSRC's seven-channel bandplan, we use Ch174 as the Inter-Cluster Data (ICD) channel as defined in the appropriate functions of the seven channels defined (Su, Technology and 2007) spanning 10 MHz bandwidth each.

Table 2 Simulation Perameter

Number of nodes	100
Transmission Area	500m ×500 m
Transmission range	250 m
Packet size	1400 bytes
Simulation time	400 seconds
Node's mobility speed	0-18 m/s
MAC Specification	IEEE 802.11p
Channel bandwidth	3 Mbps
Traffic Type	CBR
Propagation Model	Two Ray Ground Model
Data payload	512 bytes/packet
Examined routing protocol	AODV
Route Request Retransmit Interval	500m

We simulated two scenarios by generating UDP packets flows with particular packets size distribution and inter- transmission time distribution.

Table 3: Parameters of Simulation Scenarios

Grid Scenario	No. of Nodes	Highest Node Speed
3x3 grid	50	36 m/s
5x5 grid	100	18 m/s

B. Simulation Result

The performance shown in the graphs below is measured in terms of network throughput rate packet drop rate and Average delay for UDP protocols flows.

Two CBR flows are sent to have identical scenarios between hierarchical AODV where node are grouped based on their moving direction and AODV and to show clearly the bandwidth obtained using these solutions by considering throughput (Kb/sec) and simulation time (Sec). The performance is evaluated in the graphs below

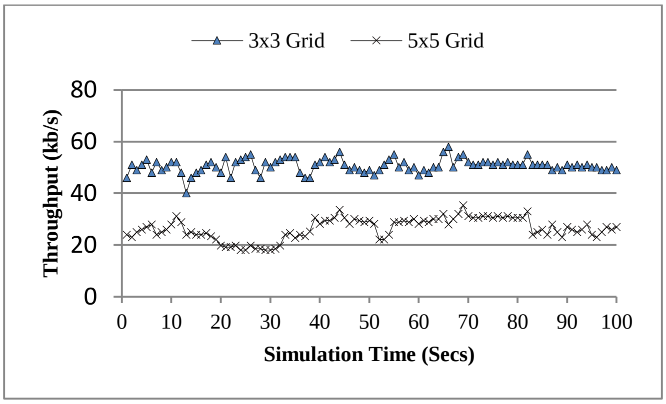

Figure 3: Network Throughput Performance for the two Scenarios

The simulations experiment runs 100 seconds for both the scenarios. However, UDP was used as the real-time traffic which indicating the network performance. CBR flows of 1400 bytes packets were transmitted for every five seconds and randomly selects some packets per session. This defined the entire network throughput of CBR flows which gradually increase at higher speeds. Therefore the Overall throughput is significantly high with scenario 1 connection as in comparison to scenario 2.

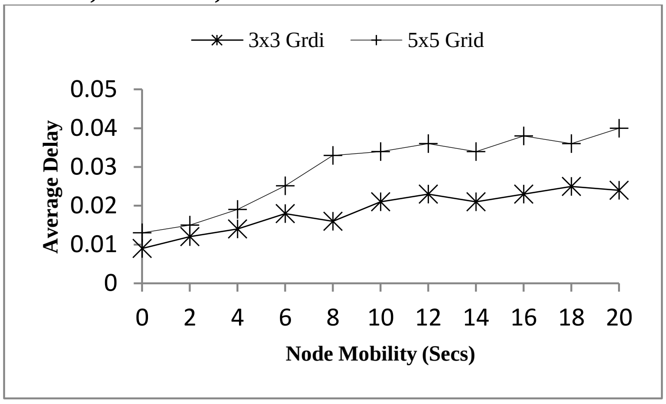

Figure 4: Network Average Delay vs Node Mobility

However, the experienced delay in *ms* for the reception of real-time safety messages for both environments is shown in fig. 4. It is observed that the delay for both cases begins with a low and gradually increase with vehicles number increasing. We noticed that scenario 2 starts well as compared with the other situation but the performance of both cases degrades as the vehicle number and interferences increase.

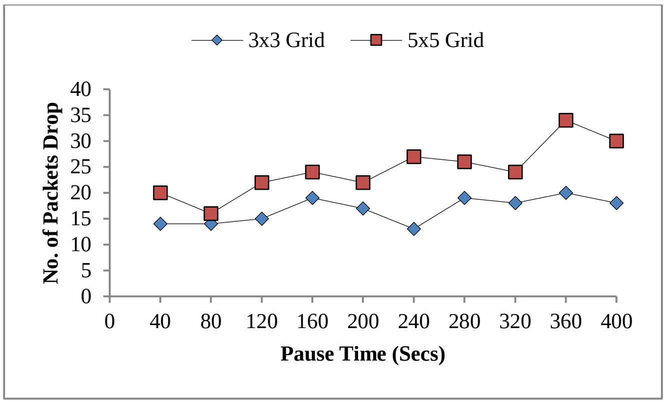

Figure 5: Number of Packet Drop VS Pause Time

We analyzed the packet drop as a function of pause time for where the UDP communication is simulated for the real-time flow against the two scenarios. Fig. 6 shows the packet drop rate with the increase of the number of mobile nodes contending for the same channel in both scenarios. This leads to higher packets drop rate as compared to scenario 1 than the scenario 2, due to the increase in congestion level and topology changes, thus decreases the network throughput as well.

CONCLUSION

The QoS routing is considers as a difficult task which could be address using the concept of bio-inspired network routing design. Coupling with the sensitive transmission of the real-time safety messages VANETs environment, in this paper, we proposed a model.

The focus of this paper is on the stability of routing traffic and to explore the difficulty of providing packet level QoS for prioritized real-time message over VANETs. This however is achieved by adhering to the DSRC seven channels bandplan to set the priority queues over separate channels (Control Channel and Service Channel). More so our routing path deals with the dynamic nature of high mobile vehicles by reducing the delay and connection duration in QoS due to retransmission of packets. We avoid flooding the entire network; therefore we opt to investigate location aided CH-based algorithms approaches in order to design optimal and stable routes. The results show that using the proposed scheme, the network throughput measured and less packet drop rate are guaranteed for providing the quality of service for nodes running the IEEE802.11 MAC.

REFERENCES

Ahizoune, A., & Hafid, A. (2012). A new stability based clustering algorithm (SBCA) for VANETs. In *Proceedings - Conference on Local Computer Networks, LCN* (pp. 843–847). https://doi.org/10.1109/LCNW.2012.6424072

Al-Mayouf, Y. R. B., Ismail, M., Abdullah, N. F., Wahab, A. W. A., Mahdi, O. A., Khan, S., & Choo, K. K. R. (2016). Efficient and stable routing algorithm based on user mobility and

node density in urban vehicular network. *PLoS ONE*, *11*(11). https://doi.org/10.1371/journal.pone.0165966
Ding, R., & Zeng, Q. A. (2009). A clustering-based multi-channel Vehicle-to-Vehicle (V2V) communication system. In *2009 1st International Conference on Ubiquitous and Future Networks, ICUFN 2009* (pp. 83–88). https://doi.org/10.1109/ICUFN.2009.5174290
Fazio, P., & Tropea, M. (2021, June). A New Metric for Routing Optimization in Mobile Networks Based on The Entropy Concept. In 2021 Wireless Days (WD) (pp. 1-4). IEEE.
Kenney, J. B. (2011). Dedicated Short-Range Communications (DSRC) Standards in the United States Article in Proceedings of the IEEE. *Ieeexplore.Ieee.Org*. https://doi.org/10.1109/JPROC.2011.2132790
Kulla, E., Morita, S., Katayama, K., & Barolli, L. (2019). Route lifetime prediction method in VANET by using AODV routing protocol (AODV-LP). In *Advances in Intelligent Systems and Computing* (Vol. 772, pp. 3–11). Springer Verlag. https://doi.org/10.1007/978-3-319-93659-8_1
Lin, C. R., & Liu, J.-S. (1999). QoS routing in ad hoc wireless networks. *IEEE Journal on Selected Areas in Communications*, *17*(8), 1426–1438. https://doi.org/10.1109/49.779924
Mejri, M. N., & Ben-Othman, J. (2014). Entropy as a new metric for denial of service attack detection in Vehicular Ad-hoc Networks. In *MSWiM 2014 - Proceedings of the 17th ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems* (pp. 73–79). Association for Computing Machinery, Inc. https://doi.org/10.1145/2641798.2641800
Mu'Azu, A. A., Jung, L. T., Lawal, I. A., & Shah, P. A. (2013). A QoS approach for cluster-based routing in VANETS using TDMA scheme. In *International Conference on ICT Convergence* (pp. 212–217). IEEE Computer Society. https://doi.org/10.1109/ICTC.2013.6675342
Nabil, M., Hajami, A., & Haqiq, A. (2018). Determining and evaluating the most route lifetime as the most stable route between two vehicles in VANET. In *Advances in Intelligent Systems and Computing* (Vol. 735, pp. 125–132). Springer Verlag. https://doi.org/10.1007/978-3-319-76354-5_12
Niu, Z., Yao, W., Ni, Q., & Song, Y. (2007). DeReQ: A QoS routing algorithm for multimedia communications in vehicular ad hoc networks. In *IWCMC 2007: Proceedings of the 2007 International Wireless Communications and Mobile Computing Conference* (pp. 393–398). https://doi.org/10.1145/1280940.1281025
Saritha, V., Krishna, P. V., Alagiri, I., Viswanatham, V. M., & Obaidat, M. S. (2018). Efficient multipath routing protocol with quality of service for mobile Ad Hoc Networks. In *IEEE International Conference on Communications* (Vol. 2018-May). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICC.2018.8422385
Sharshembiev, K., Yoo, S. M., Elmahdi, E., Kim, Y. K., & Jeong, G. H. (2019, July). Fail-Safe mechanism using entropy based misbehavior classification and detection in vehicular Ad Hoc networks. In 2019 International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData) (pp. 123-128). IEEE.
Su, H., Technology, X. Z.-I. T. on V., & 2007, undefined. (n.d.). Clustering-Based Multichannel MAC Protocols for QoS Provisionings Over Vehicular Ad Hoc Networks. *Ieeexplore.Ieee.Org*. Retrieved from https://ieeexplore.ieee.org/abstract/document/4357429/
Sun, W., Yamaguchi, H., Yukimasa, K., & Kusumoto, S. (2006). GVGrid: A QoS routing protocol for vehicular ad hoc networks. In *IEEE International Workshop on Quality of Service, IWQoS* (pp. 130–139). https://doi.org/10.1109/IWQOS.2006.250460
Taleb, T., Sakhaee, E., Jamalipour, A., Hashimoto, K., Kato, N., & Nemoto, Y. (2007). A stable routing protocol to support ITS services in VANET networks. *IEEE Transactions on Vehicular Technology*, *56*(6 I), 3337–3347. https://doi.org/10.1109/TVT.2007.906873
Toh, C. K. (1997). Associativity-Based Routing for Ad-Hoc Mobile Networks. *Wireless Personal Communications*, *4*(2), 103–139. https://doi.org/10.1023/A:1008812928561
Wang, H., Cheng, W., Lu, X., & Qin, H. (2019). A improved routing scheme based on link stability for VANET. In *Proceedings of the 14th IEEE Conference on Industrial Electronics and Applications, ICIEA 2019* (pp. 542–546). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICIEA.2019.8834026
Zeadally, S., Hunt, R., Chen, Y. S., Irwin, A., & Hassan, A. (2012). Vehicular ad hoc networks (VANETS): Status, results, and challenges. *Telecommunication Systems*, *50*(4), 217–241. https://doi.org/10.1007/s11235-010-9400-5