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A Survey on Vehicular Ad hoc Networks

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Abstract: *Vehicular Ad hoc Networks (VANETs), a subclass of mobile ad hoc network (MANET), is a promising approach for the intelligent transport system (ITS). VANET allows vehicles to form a self-organized network without the need for a permanent infrastructure. As the VANET has a potential in improving road safety, real time traffic update and other travel comforts, it turns attention of the researcher. Though VANET and MANET shares some common characteristics like self-organized network, dynamic topology, ad hoc nature etc, VANET differs from MANET by challenges, application, architecture, power constraint and mobility patterns, so routing protocols used in MANET are not applicable with VANET. New routing strategy for VANET has been proposed by many researchers in recent year. This paper provides focus on the various aspects of VANET like architecture, characteristic, challenges, glimpse of routing protocols, and simulation models used for VANET.*
Keywords: *Vehicular Ad hoc Networks; routing; position based routing; characteristics; transmission strategies*

I. Introduction

With the sharp increase of vehicles on roads in recent years, driving has not stopped from being more challenging and dangerous. Roads are saturated, safety distance and reasonable speeds are hardly maintained, and drivers often lack enough attention. As there is no sign of improvement in near future, government agencies and leading car company jointly works together for develop solutions. One of the developments has been a novel type of wireless access called Wireless Access for Vehicular Environment (WAVE) dedicated to vehicle-to-vehicle (V2V) and vehicle-to-roadside communications (V2I). VANET uses a dedicated short range communication (DSRC) IEEE 802.11a later it amended for low overhead operation to IEEE 802.11p. Then IEEE standardises whole as 1609 family referred as WAVE. These protocols are used for different type of information sharing between vehicle to vehicle and vehicle to road side unit (RSU), for example, safety information like accident prevention, navigation route selection for traffic jams, entertainment with internet service.

When mobile nodes (Vehicles) and roadside units (infrastructure) combine with WAVE communication devices, form a highly dynamic Vehicular Ad Hoc Network (VANET), which is a sub kind of Mobile Ad Hoc Network (MANET). The feature of VANET mostly inherited from the technology of MANET in the sense of low bandwidth, self-management, self-organization, and shared radio transmission criteria remain same. But the key hindrance in operation of VANET comes from the high speed and uncertain mobility [in contrast to MANET] of the mobile nodes (vehicles) along the path. This suggested, although countless numbers of routing protocols [2, 3] have been developed in MANETs, many do not apply well to VANETs. VANETs represent a particularly challenging class of MANETs. So the design of efficient routing protocol demands up gradation of MANET architecture to accommodate the fast mobility of the VANET nodes in an efficient manner. This warranted various research challenges to design appropriate routing protocol.

Several challenges are facing researchers and developer. Therefore, several papers and articles have tried to cover these issues. Such as routing protocols for VANET and challenges[4], communication and networking [5] ,categories of routing protocols in VANET and idea behind each of them [6].This paper covers different issues such as architecture, characteristics, challenges, routing protocols, simulation tools.

II. Architecture of VANET

Mainly two type of communication taken place in VANET, V2V (Vehicle to Vehicle) and V2I (Vehicle to Infrastructure), here infrastructure is mainly in form of Road Side Unit (RSU). This communication achieved from WAVE as a wireless medium. The main components are RSU (Road Side Unit), OBU (On Board Unit) and AU (Application Unit). Typically OBU is a peer device also known as user, mounted on nodes (vehicles) that use the services which provided by RSU. RSU host an application that provides services also known as provider. In addition of OBU a set of sensors also mounted on the vehicles for collection of various data and that data transmitted to other vehicle or RSU using WAVE. AU also mounted on nodes (vehicle) that use the application provided by provider (RSU) with the help of OBU, for example internet is the one kind of service provided by RSU and used by AU with the help of OBU.

2.1 Road Side Unit (RSU)

RSU is equipped with device for short range communication using IEEE 802.11p radio protocol technology. It is generally situated on the road side and other dedicated location such as junction, parking spaces. It provided to enhance communication range and other routing strategies of VANET.
According to C.C. Communication Consortium, the main functions and procedure associated with the RSU are:

1. Extending the communication range of the ad hoc network by re-distributing the information to other OBUs and by sending the information to other RSUs in order to forward it to other OBUs.
2. Running safety application such as a low bridge warning, accident warning or work zone, using infrastructure to vehicle communication (I2V) and acting as an information source.
3. Providing Internet connectivity to OBUs.

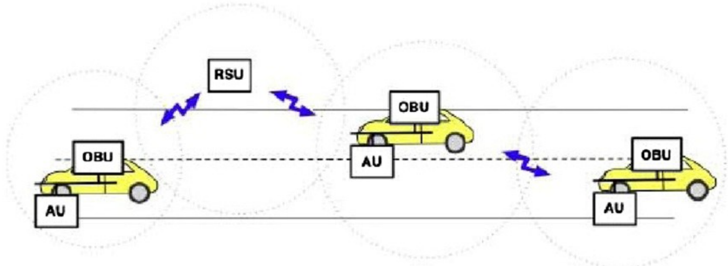

Fig 1 Range extension by RSU (C.C. Communication Consortium). [7, 8].

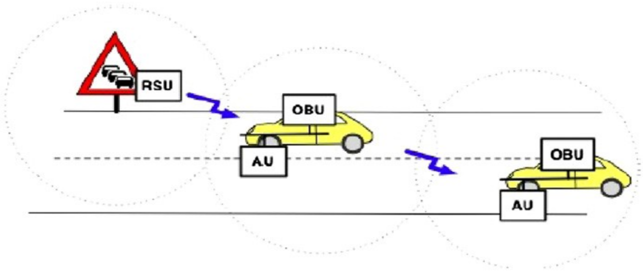

Fig 2 RSU work as information source (running safety application) (C.C. Communication Consortium.)[7, 8].

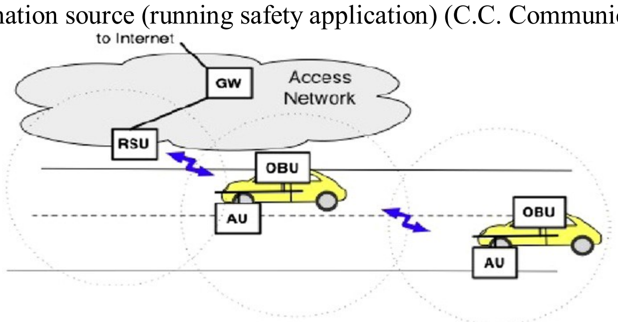

Fig 3 RSU extend the range of the ad hoc network by forward the data of OBUs (C.C. Communication Consortium.) [7, 8].

2.2 On Board Unit (OBU)

According to C.C. Communication Consortium the main function of the OBU are reliable message transfer, data security, wireless radio access, ad hoc and position based routing, network congestion control [7]. An OBU mounted on Vehicle consist of memory, resource command processor (RPC), a user interface, device for short range communication using IEEE 802.11p radio technology for non safety application IEEE 802.11a/b/g/n radio technology is used [8].

2.3 Application Unit (AU)

The AU can be a dedicated device for safety application or a normal device such as personal digital assistant (PDA) for internet [8]. According to C.C. communication consortium the distinction between the OBU and the AU is logical, The AU communicate with network solely via the OBU which takes responsibility for all mobility and networking functions [7].

III. VANET characteristics

Both MANET and VANET have some common characteristic, self organization, low bandwidth, self management, no centralization node. But above that VANET has some unique feature that makes it more challenging then MANET, such as frequent disconnected network, highly dynamic, traffic density, mobility pattern of traffic flow etc. Here some of them are discussed.

1. Highly Dynamic Topology: The speed and choice of path defines the dynamic topology of VANET. If we assume two vehicle moving away from each other with a speed of 60 mph (25m/sec) and if the transmission range is about 250m, then the link between these two vehicles will last for only 5 seconds ($250m/50ms^{-1}$). This defines its highly dynamic topology.
2. Predicated mobility: In MANET mobile nodes are free to move in any direction where as in VANET nodes must follows the particular path so mobility have pattern. Due to road topology and layout vehicles are constrained to follow path. Others things affects the mobility are traffic signals, road signs etc. [9]
3. Power constraint: Oppose to MANET, VANET have sufficient power supply from car battery, so that is not critical challenge for VANET. So there is no power constraint in VANET routing.
4. Variable vehicle density: some roads have high density of traffic and some haven't producing variable density of nodes in area. Even traffic lights, road signs, disaster taken placed areas, traffic jams are generating variable vehicle density. And that's turn into frequently disconnected network.
5. Frequently disconnected network: High dynamic topology and variable vehicle density generate rapid changes in topology which cause in frequently disconnected network. In high density area network disconnection is not a problem but in low density area no forwarding node available so network delay is grown up due to disconnectivity of seamless connection.
6. Large scale network: Dense area required large scale network such as highway, city centre etc. VANET routing strategies must outperform on large scale network.

IV. Scenario

A. MANET and VANET

A MANET is a wireless network without any fixed topology maintained in real time. Here each node has two roles to perform, as an end system and as a router. For routing multihop strategy used.
VANET, a special case of MANET, has set of unique property. Highways, junctions, traffic lights, avenues restrict movements of nodes. It generates specific mobility patterns opposed to MANET. Vehicles move very faster than nodes in MANET gives shorter connection time between nodes. So network disconnection taken place frequently and route maintenance is harder compared to MANET [10].

B. Urban and highway environment

Urban and highways environment scenarios carry different characteristics, so according to that VANET routing strategies developed. In Urban scenario obstacles are more due to city building, vehicle density is high, vehicle speed is low compare to highway, and vehicle density is high. Where as in highway scenario vehicle density is low, vehicle speed is high, obstacle is less, vehicle speed variance is low whereas it is high in urban. Due to these different characteristics highway and urban scenario have different routing strategies. Automatic adoptability of routing strategies according to environment is also a research area, as highway routing strategy less applicable in urban and wise versa. Below table shows scenario comparison for VANET.

Property	Highway	Urban
Speed	High	Low
Link connectivity	Maintain	Frequently disconnect
Speed variance	Low	High
Vehicle density	Low	High
Routing path options	Few	Many
Obstacle	Few	Many
Mobility prediction	Easy	Hard

Table 1 Comparison of environments in VANET

V. Challenges in VANET

1. Small effective diameter: Weak connectivity taken place due to small effective diameter, as nodes moves at high speed with rapid change in topology, resulted into impracticable global topology on VANET. Existing MANET routing protocol not applicable on VANET due to restricted effective diameter [11].
2. Signal fading: signal fading taken place with many obstacles in communication range. High rise buildings, houses, others vehicles etc restricts signals especially in cities create signal fading and affect the efficiency of routing.

3. Connectivity: Maintaining connectivity in rapidly changing topology is biggest challenge in VANET. High dynamic topology leads to frequent fragmentation in networks, and that leads to throughput degradation.
4. Security and privacy: Due to Ad Hoc nature of VANET, it requires more focus on security and privacy. Here security system must be secure and faster as routing must be fast for rapid changing topology. For trustworthy of message, sender information sharing must in VANET. This generates privacy issue. Keeping a reasonable balance between the security and privacy is one of the main challenges in VANET [12].

VI. Routing in VANET

Routing in VANET can be classified under transmission strategies or routing information. Unicast, broadcast, multicast are various transmission strategies. Topology based and position based routing protocols used various routing information, such as position based routing required preinstalled map or route information.

6.1 Transmission strategies based classification

According to transmission strategies routing can be classified under Unicast, broadcast and multicast. Multicast further partitioned into geocast and cluster based routing protocols.

In **Unicast routing** one to one communication take place using multihop scheme; where intermediate nodes are used to forward data. This is the widely used class in ad hoc network. For VANET many Unicast routing protocols are proposed; most of the topology based routings are Unicast such as AODV [28], DSR [29], GPSR [19] etc.

In **Broadcast routing** [30] one to all communication take place. Flooding, BROADCOMM, DV-CAST etc are broadcast protocols. This is most frequently used routing protocol in VANET especially to communicate the safety related message. Simplest of broadcast method is carried by flooding in which each node rebroadcast the message to other nodes. But with larger density of nodes, this causes exponential increase in bandwidth.

In **multicast routing** [30] one to many communication take place. This can be further partitions into geocast and cluster based. In cluster based routing, nodes automatic partitioned into cluster and one cluster head is selected and all outgoing and incoming communication taken place through it. COIN and CBDRP are cluster based routing. In geocast routing, message delivery to other nodes lie within a specific geographic area, like area where accident taken place. Mobicast, ROVER, ZOR (Zone of Relevance) are geocast protocols.

Transmission Strategies		Communication Type	Example	In Favour	Against
Unicast		Single source to single destination	AODV, DSR, GPSR	Less network overhead More privacy	Less reliable Link maintenance
Broadcast		Single source to all nodes inside broadcast domain	BROAD-COMM, DV-CAST	Reliable Less packet loss	Consume bandwidth Packet collisions Network congestion
Multicast	Geocast	Source to group of destination using geographic address	Mobicast, ROVER, ZOR	Efficient routing Less network consumption	Consume bandwidth
	Cluster	Network divides into clusters, and cluster head manage inside and outside communication	COIN, CBDRP	Less packet delivery	Overhead in dividing n/w into groups

Table 2. Transmission strategy based classification

6.2 Routing Information based classification

This class used link or position information for routing. Topology based routing used link's information stored in routing tables for forwarding packet to destination and position based routing used node's position for forwarding packets. This position information obtains from GPS.

6.2.1 Topology based routing protocols

Topology based routing protocols use links information that exists in the network to perform packet forwarding. Routing table, maintained at each node, are used to store the link information of all others node in given topology. As the nodes in VANETs are constantly moving, routing table must be maintained frequently.

Based on this updation of the routing table, topology based routing protocols can be further partition into Proactive, Reactive and Hybrid.

A. Proactive (Table-Driven)

Proactive routing maintained the next forwarding hop information in the background regardless of communication requests. For maintaining links information, Proactive routing uses control packets broadcast even though some of paths are never used. Each node maintains such a routing table in the background. The advantage of the proactive routing is that no route discovery requires upon the communication taken place, as it always available on lookup; this is useful for real time application. The main drawback proactive is that it requires maintaining unnecessary link information takes significant bandwidth. Also a propagation delay of links information creates hazards in the routing. As shown in [30], FSR (Fisheye State Routing) propagates link state updates with only immediate neighbouring nodes not with whole network, reduces bandwidth consumption. DSDV (Destination Sequence Distance Vector routing) uses shortest path algorithm to implement only one route to destination. OLSR (Optimized Link State Routing protocol) keeps a routing table which contains all possible to network node. OLSR sends updated information to selective node whenever network topology changed, and retransmission of information taken place from receiver node.

B. Reactive (On Demand)

Reactive Protocols also known as On Demand Routing Protocol reduces network overhead by updating routing table when source node starts a route discovery process. If route to non existence destination is required then network flooding is used for finding route and routing table is updated. Here the drawback of proactive routing is overcome by reducing unnecessary link information sharing, but route calculation time upon communication request is increase. As shown in [30], In AODV [28] (Ad hoc on demand Distance Vector), sender node uses broadcast query (RREQ) to find route, upon receiving (RREQ) query intermediate node offers low network overhead, it also flexible to high dynamic topology. Enhancement over AODV is also developed; AOMDV (Ad hoc on demand Multipath Distance Vector) used multipath generation from source to destination, SD-AOMDV used speed and direction factor over AOMDV to enhancing throughput.DSR (Dynamic Source Routing Protocol) provide a highly reactive routing process by routing mechanism with an extremely low overhead and fast reaction to the frequent network changes.

C. Hybrid

Hybrid Protocols used both proactive and reactive routing strategies; it aims to minimize the routing protocol control overhead and reduce the delay of the route discovery process within on demand routing protocols. As shown in [30], ZRP (Zone Routing Protocol) divides the network into zone based on many factors like signal strength, speed etc. Inside the zone proactive routing schema and for outside reactive routing schema is used.

Type	Strategy	Strength	Limitation
Proactive	Route table maintain in background by regular control packet broadcast	Route is always available on lookup	Takes significant bandwidth by maintaining unnecessary link information
Reactive	Route discovery by network flooding as communication requested	Less bandwidth requires compares to proactive	Route finding process create delay
Hybrid	Zone defines by similarities, inside zone proactive and outside reactive	Overcome limitation by above both strategies.	Zone creation and maintence is complex in VANET

Table 3 Topology based routing types

6.2.2 Position based routing (Geographic routing)

Before taking step into position based routing protocols, let us look at forwarding and recovery strategies used in geographic routing.

A. Forwarding strategies

Different forwarding strategies [15] are used in position based routing protocols. Each vehicle maintain information about neighbour nodes, normally that table contain information like geographic position, speed, direction of neighbour. Based on table, source forwards packets to next hop. The forwarding strategies are as follows [12, 13, 14.].

Greedy forwarding: Greedy forwarding strategy always forward packet to a node closest to destination. Here source 'S' forward packet to 'A', which is closest node to destination 'D'.

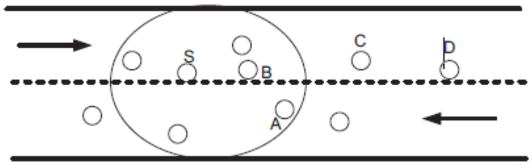

Fig 4.Forwarding strategies [15]

Improved greedy forwarding: source node first consults its neighbour table and computes new predicted position of all its neighbours based on direction and velocity and then selects anode which is closest to the destination .'S' computes new predicted position of its neighbours and suppose at time t2, vehicle 'B' over takes the vehicle 'A', then 'S' selects 'B' as its next hop instead of 'A'.[15]

Directional greedy forwarding: Directional greedy approach only considers those nodes which are moving towards destination. Thus, it selects vehicle 'B' as its next hop.

Predictive directional greedy forwarding: In this strategy, forwarding node maintains the information of its 2-hop neighbours. Before forwarding the packet, forwarding node consults its neighbour table and computes predicted position of all its neighbours (one-hop and 2-hop neighbours) and then selects a node whose one-hop neighbour is moving towards the destination and is closest to the destination. In this case, 'S' selects vehicle 'A' because its one-hop neighbour 'C' is moving towards destination 'D'.[15]

B. Recovery strategies

Recovery strategies [14] are use when greedy forwarding strategies run into a situation called local maximum, in which the sending vehicle finds itself as a closest vehicle to the destination than all of its neighbours and the destination is not reachable by one hop. But, this does not mean that there is no connectivity to the destination. So recovery strategy is used whenever a local maximum occurs. Most relevant recovery strategies used in position based routing are described below.

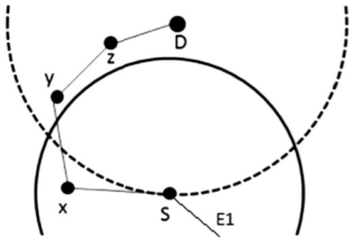

Fig.5 Local maximum situation [14]

Right-hand rule to traverse graphs is one of the widely used recovery-mode in position based routing. As shown in fig 2, node 'S' enter into local maximum situation as closest node to the destination is itself and destination not reachable via one hop connectivity. So forwarding strategy enters into recovery mode. According to right hand rule, if node 'S' receives the packet from edge E1 then it sends the packet through its next edge counter clock wise about 'S' here its node 'X'. Whenever, forwarding node is closer to the destination than the node that triggers the recovery strategy, routing jump back into forwarding mode. To use the right hand rule we must have a planar graph by Karp and Kung [16], who use Relative Neighbourhood Graph (RNG) computed at each node in order to planarize the graph by removing edges that cross. Since in VANETs the network nodes are constantly moving and at high speeds, this can lead to loops in the right-hand rule approach.
Other approach used is the ***carry-and-forward***. As the name suggests, when the local maximum occurs the node carries the packet until an eligible neighbour appears. This approach leads to bigger delays. Instead of using a recovery strategy, some algorithms ***recalculate the path*** when the local maximum occur, which can lead to higher delays and to a bigger number of hops. [14]

Strategy	Overhead	Latency	Availability
Right-hand rule	Low	Medium	Unknown
Carry-and-forward	None	High	High
Path recalculation	None	Unknown	Low

Table 4 Recovery strategies comparison [14]

C. Position based routing protocols

The usage of digital maps, GPS receivers, and a navigation system in modern vehicles inspired the study of position-based routing for vehicular network. Position based protocols assume that GPS device is equipped with vehicle in order to finds its own geographic position. In addition to that Location services also required for obtaining geographical position of destination vehicle. Without the use of location services, becomes very difficult to find destination position. In past, numerous location services have been proposed, for example, grid location service [17] or hierarchical location services [18].

GPSR (Greedy Perimeter Stateless Routing)

Greedy Perimeter Stateless Routing [19] used Greedy forwarding strategy, here no path calculation taken place for routing from source to destination. Destination node's position inserted into packet header and that packet sends to the next hop closer to destination, using greedy strategy. If local maximum occurs then right hand rule is used for recovery strategy.

GPCR (Greedy Perimeter Coordinator Routing)

Rather applying greedy forwarding strategy at each forwarding node, GPCR [20] uses restricted greedy strategy when nodes are in street and actual routing decision taken place at junction of streets. Here the packet is forwarded to a node in the junction rather sending it across the junction. GPCR has higher delivery rate than that of GPSR with large average number of hops and slight increase in latency.

GSR (Geographic Source Routing)

Geographic Source Routing [21] use Dijkstra's shortest path algorithm on a map obtains from GPS system. GSR carries out shortest path calculation on each junction and uses greedy forwarding strategy along the path to the next junction until destination is reach. As no real time traffic information is used for path selection of next node may stop at local maximum, then as a recovery it tries to select another vehicle outside that road using greedy forwarding rather than described recovery strategy.

A-STAR (Anchor-based Street Traffic Aware Routing)

The Anchor-based Street Traffic Aware routing [22] calculates full path for forwarding packet. Like GSR, it also use dijkstra's shortest path algorithm, but uses number of bus line on the road as weight parameter of road for selecting path. Considering the number of bus line on the road, it provides some sort of traffic awareness for better decision making towards path selecting, as better vehicle density lower the chances of local maximum situation. If local maximum occurs them road marked as 'out of service' and recalculation of path taken place.

GyTAR (Improved Greedy Traffic Aware Routing)

Improved Greedy Traffic Aware Routing [23] considers wireless router at each junction to increase connectivity. No path constructed from source to destination, and at each junction next best junction selection taken place by number of vehicle between them and the progress towards the destination in terms of distance. As shown in [14] suppose junction I is current junction and junction J is candidate for next junction then progress towards the destination proposed from Okada is given by [24]:

$D_p = D_j/D_i$

Where:

- D_p is the curve metric distance from J to destination
- D_i is the curve metric distance from I to destination

And the average vehicle per cell is given by:

$N_{avg} = N_v/N_c$

Where:

- N_v is the number of vehicle between I and J
- N_c is the number of cell between I and J

Between junctions an improved greedy forwarding is used, and as recovery mode GyTAR uses carry and forward approach. [14]

DGR (Directional Greedy Routing) and PDGR (Predicated Directional Greedy Routing)

Specifically, when a source vehicle sends a packet to a destination, the routing scheme should be able to efficiently route the packet with few hops and small delay. As the node movement in VANETs is more regular, Reduction in number of hops during routing is achieved in DGR by choosing the node moving toward the destination using the greedy forwarding strategy. Further enhancement over DGR achieve by predicting the mobility of vehicle. Such predictable mobility information can be derived from the traffic pattern and street layout, this approach is used in PDGR [25] for routing. In both routing carry and forward approach is used as a recovery strategy.

Protocols	Communication technology	Forwarding strategy	traffic awareness	recovery strategy	Simulator scenario
GPSR	V2V	Greedy forwarding	No	Right-hand rule	Highway
GSR	V2V	Greedy along path	No	Greedy	Urban
A-STAR	V2V	Greedy along path	Yes	Recalculate path	Urban
GPCR	V2V	Restricted Greedy	No	Right-hand rule	Urban, Real city model
GyTAR	V2V	Improved Greedy	Yes	Carry and forward	Urban
DGR	V2V	Directional Greedy	No	Carry and forward	Highway
PDGR	V2V	Predictive Directional greedy	No	Carry and forward	Highway

Table 5 Comparison of Position based routing protocols

VII. VANET simulation

In order to apply these routing protocols, the system performance needs to be evaluated. For these reason simulation tools are consider the best means with which to evaluate the performance. As compared to MANET, VANET has many distinct characteristic such as highly dynamic, restricted mobility, traffic regulation. So simulator must provide accurate results with all VANET characteristics. Below are some examples of VANET simulator from [26, 27].

MOVE (Mobility model generator for Vehicular networks)

MOVE is a java based application built on SUMO (Simulation of Urban Mobility) with GUI support. MOVE support a good visualization tool and mainly focuses on traffic level feature. MOVE is composed of a Map editor and a Vehicular Movement editor. Map editor is used for create topology for network and vehicular Movement editor generate traffic pattern in topology. MOVE also support random generated graph and user define graph. [26]

TraNs (Traffic and Network simulator)

TraNs, a Java based application specially designed for VANET. It integrate SUMO and NS-2 feature with a visualization tool. TraNs Lite, a separate version has been built without NS-2 network simulator supports up to 3000 nodes and can traces from TIGER database ot by using shape files. [27]

NCTUns (National Chiao Tung University Network Simulator)

NCTUns is built on C++ programming language with a good GUI support. NCTUns combines the traffic and network simulators in a single module, making a distinct vehicular network environment available. NCTUns can use 802.11a, 802.11b, 802.11g and 802.11 technologies. NCTUns supports other feature like automatic road assignment from SHARPE-format map file; vehicle movement controlled automatically, directional, bidirectional and omnidirectional antenna. [27]

VIII. Conclusion

We know that Intelligent Transportation System (ITS) is must in today's vehicular environment as the road safety and emergency are main concern in transportation. In the past years, many VANET projects and research have been undertaken and many standards have been developed in VANET. Though much more research is requires, as many fundamental issues like reliability of route, network fragmentation, and delay in routing must address to achieve practical applicability of VANETs. In this paper we presented basic fundamentals of VANETs like architecture, characteristics, challenges and fundamental of routing and various types of routing VANET. We hope this knowledge presented in paper helpful to other researchers in future. Finally, some of the challenges that still need to be addressed in VANETs are security, reliability, enchantment in routing strategies, and others services like internet and entertainment.

References

[1] A. K. Saha and D. B. Johnson, "Modeling mobility for vehicular ad hoc networks," in Proceedings of ACM International Workshop on Vehicular Ad Hoc Networks, 2004, pp. 91-92.

[2] Mauve, et al. (2001). A survey on position-based routing in mobile ad hoc networks. IEEE Network Magazine, November/December, 30-39.

[3] Mehran, et al. (2004). A review of routing protocols for mobile ad hoc networks. Ad Hoc Networks, 2, 1-22. Doi:10.1016/S1570-8705(03)00043-X.

[4] Li F, Wang Y. Routing in vehicular ad hoc networks: a survey. IEEE Vehicular Technology Magazine 2007;2(2):12-22.

[5] Hartenstein H, Laberteaux KP. A tutorial survey on vehicular ad hoc networks,Communication Magazine, IEEE 2008;46(6):164-71.

[6] Lin Y, Chen Y, Lee S. Routing in vehicular ad hoc networks: a survey and future perpectives. Journal of Information Science and Engineering 2010;26(3):913-32.

[7] C.C. Communication Consortium; IEEE trial-use standard for wireless access in vehicular environments; Olariu and Weigle, 2009.

[8] Al-Sultan S, et al. A comprehensive survey on vehicular Ad Hoc Network and Computer Application (2013), http://dx.doi.org/10/1016/j.jnca.2013.02.036i.

[9] Jakubiak J, Koucheryavy Y. State of art and research challenges for vanets. In: consumer communications and networking conference. CCNC 2008. 5th IEEE; 2008. P. 912-6

[10] Dahiya A, Chauhan R. A comparative study of MANET and VANET environment, Journal of Computing 2010; 2(7) ISSN 2151-9617.

[11] Hartenstein H, Laberteaux K. VANET vehicular applications and inter-networking technologies. Wiley Online Library; 2009.

[12] Bernsen J, Manivannan, D. Greedy routing protocols for vehicular ad hoc networks. In: Wireless communications and mobile computing conference, IWCMC '08. International, vol., no., pp. 632–637, 6–8 Aug. 2008.

[13] Cha SH, Min-Woo Ryu MW, Cho KH. A survey of greedy routing protocols for vehicular ad hoc networks. Smart Computing Review 2012;2(2).

[14] Fonseca A,Vazao T. Applicability of position-based routing for VANET in highways and urban environment. Journal of Network and Computer Applications JNCA1084-8045 2009.

[15] Sardar Muhammad Bilal, Carlos Jesus Bernardos, Carmen Guerrero; Position-based routing in vehicular networks: A survey; Journal of Network and Computer Applications 36(2013) 685-697.

[16] Karp B, Kung HT. GPSR: greedy perimeter stateless routing for wireless networks. In: MobiCom '00: Proceedings of the 6th annual international conference on mobile computing and networking, ACM, New York, NY, USA; 2000. p. 243–54. http://dx.doi.org/10.1145/345910.345953.

[17] Li J, Jannott J, Couto DD,Karger D,Morris R. A scalable location service for geographic ad hoc routing. ACM/IEEEMOBICOM02000 2000:120.130.

[18] Kiess W, Fubler H, Widmer J, Mauve M. Hierarchical location service for mobile ad- hoc networks. ACM SIGMOBILE Mobile Computing and Communications Review (MC2R) 2004;8(4):47–58 October.

[19] Karp B, Kung HT. GPSR: greedy perimeter stateless routing for wireless networks. ACM/IEEE MobiCom 2000.

[20] Lochert C, Mauve M, Fussler H, Hartenstein H. Geographic routing in city scenarios. In: SIGMOBILE mobile computing and communications review, vol. 9. ACM, New York, NY, USA, 2005. p. 69–72, http://dx.doi.org/http://doi.acm.org/10.1145/1055959.1055970.

[21] Lochert C, Hartenstein H, Tian J, Fussler H, Hermann D, Mauve M. A routing strategy for vehicular ad hoc networks in city environments. In: Proceedings of the intelligent vehicles symposium, 2003 IEEE; 2003. p. 156–61, http://dx.doi.org/10.1109/IVS.2003.1212901.

[22] Seet B-C, Liu G, Lee B-S, Foh C-H, Wong K-J, Lee K-K. A-STAR: a mobile ad hoc routing strategy for metropolis vehicular communications. Springer; http://dx.doi. org/10.1007/b97826.

[23] Jerbi M, Senouci S-M, Meraihi R, Ghamri-Doudane Y. An improved vehicular ad hoc routing protocol for city environments. In: ICC; 2007c. p. 3972–9.

[24] Okada H, Takano A, Mase K. A proposal of link metric for next-hop forwarding methods in vehicular ad hoc networks. In: Sixth IEEE Consumer communica- tions and networking conference, 2009. CCNC; 2009. p. 1–5, http://dx.doi.org/10.1109/CCNC.2009.4784925.

[25] Jiayu Gong, Cheng-Zhong Xu, James Holle. Predictive Directional Greedy Routing in Vehicular Ad hoc Networks, 27th International Conference on Distributed Computing Systems Workshops, IEEE 2007

[26] Sherali Zeadally, Ray Hunt, Yuh-Shyan Chen, Angela Irwin, Aamir Hassan, Vehicular ad hoc networks (VANETS): status, results, and challenges, Telecommum Syst, 2010

[27] Al-sultan S, et al. A comprehensive survey on vehicular Ad Hoc network. Journal of Network and Computer Application (2013), http://dx.doi.org/10.1016/j.jnca.2013.02.036i

[28] Perkins, C. E. And Royer, E. M. (1999), "Ad-Hoc On-Demand Distance Vector Routing," Proc. IEEE WMCSA '99, New Orleans, LA, Feb. 1999 ,pp. 90-100.

[29] Johnson, D. B. And Maltz, D. A. (1996). "Dynamic Source Routing in Ad Hoc Wireless Networks," Mobile Computing, T. Imielinski and H. Korth, Eds., Ch. 5, Kluwer, 1996, pp. 153-81.

[30] Marwa Altayeb, Imad Mahgoub, " A Survey of Vehicular Ad hoc Networks Routing Protocols," ISSR Journals, 2013, Vol. 3, No. 3, pp. 829-846.