# VANETs: Basics, Issues and Challenges in its Practical Deployment

Shubham Kapoor [#1], Surjeet [#2]

[1,2]*Bharati Vidyapeeth's College of Engineering*
*New Delhi. India*

**Abstract:** *Wireless networks are the networks that do not require any traditional cabling. These are of two types: Infrastructure networks and Infrastructure less or ad hoc networks. One type of ad hoc networks are Vehicular Ad Hoc Networks (VANETs). VANETs are used in vehicular domain to provide Intelligent Transport System (ITS). Such networks are used in real time scenarios. In VANETs, vehicles communicate with each other as well as the central unit with the help of On Board units (OBUs) and Road Side Units (RSUs). This paper provides a brief description about wireless networks especially about VANETs. Since the nodes in VANETs are mobile, routing algorithms used in normal networks are not applicable. VANETs are still an emerging technology due to lot of issues and challenges in its practical deployment. In this paper some of the major issues and challenges are discussed to provide insight knowledge.*

**Keywords:** *QoS, routing protocols, VANETs, V2V, V2I.*

## I. INTRODUCTION

RECENT advancement in network technologies has led to shift the interest of researchers from wired networks to wireless networks [1]. Wireless communication is the means by which users of the network can communicate with each other using radio waves instead of traditional cables. Its implementation takes place at the physical level. In many aspects, wireless networks are advantageous than wired networks like free movement within the network, not having to lay lots of cables, low cost for network establishment, increased scalability etc.

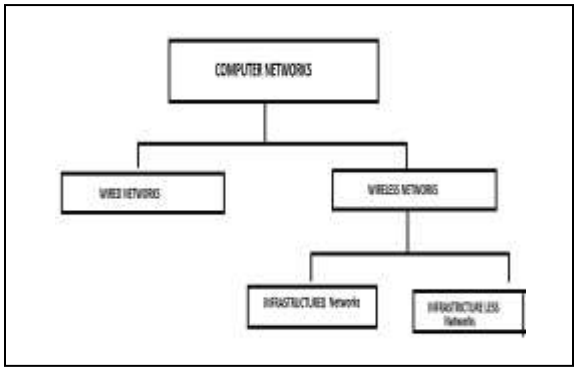



Figure 1: Types of computer networks

Classification of computer networks is as shown in Figure 1. One type of wireless networks are Infrastructure-based networks [2] in which the nodes cannot communicate directly with each other. They need a central access point for the same as shown in Figure 2. The access points have a wired structure and support radio communication between network nodes. The old cellular based scheme is an example of such topology.

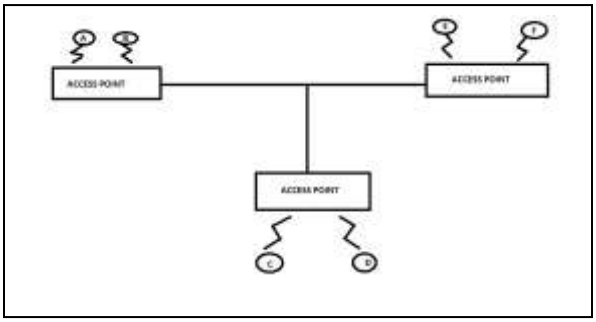


Figure 2: Infrastructure Based Wireless Network

Another type is Infrastructure less or Ad Hoc networks [3] which do not require any fixed access points. The nodes communicate directly with each other through

radio networks as shown in Figure 3. For example: Ad-Hoc networks.

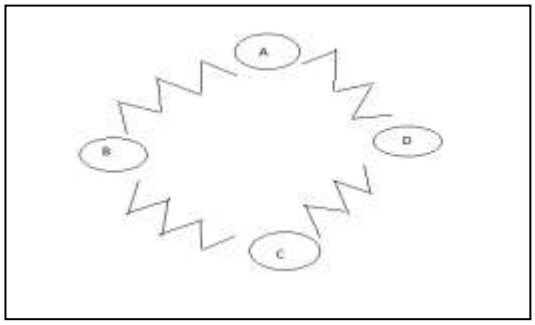



Figure 3: Wireless Ad-Hoc Network

These networks can be applied to different real time scenarios depending on the application like Mobile Ad Hoc Networks (MANETs) [4], Vehicular Ad Hoc Network (VANETs) [5] and Static Ad Hoc Networks (SANETs) [6].

MANETs [4] consist of transportable devices having wireless communication capabilities that can join together dynamically. In this type of network, mobile hosts are connected to one another by wireless links as shown in Figure 4. They can easily move randomly within the network, hence network topology dynamically change.

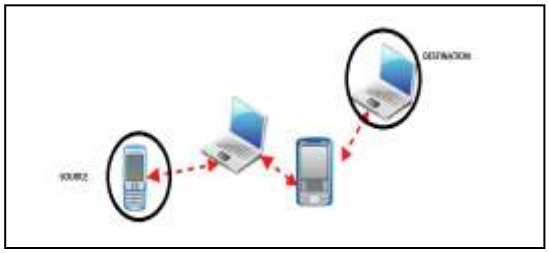


Figure 4: Mobile Ad Hoc Network

Vehicular Ad Hoc Networks (VANETs) are a type of wireless network which do not require any fixed infrastructure. These networks are used in vehicular domain to develop an Intelligent Transport System (ITS) [5]. It takes help of On Board units (OBUs) and Road Side Units (RSUs) to communicate.

Static Ad Hoc Networks (SANETs)[6] are a type of wireless network which works on the same principle as MANETs. The networks also nodes connect wirelessly and dynamically. The only difference is that nodes are static rather than mobile in SANETs.

This paper gives a brief introduction about wireless networks and its types. Further an emerging technology in ad hoc networks i.e. VANET is discussed. VANET being a recent technology has lots of issues and challenges which are hindrance to its success. Some of the major issues are briefly discussed in this paper.

Rest of the paper is organized as, section II describes some of the network parameters which are considered in networks performance. Section III provides a deep insight knowledge about VANETs and its types namely Infrastructure to Infrastructure, Vehicle to infrastructure, vehicle to vehicle communication. Section IV defines the different routing protocols in networking. Further section V describes some issues and challenges in practical deployment of VANETs. Finally in section VI the paper is concluded.

## II. NETWORK PERFORMANCE PARAMETERS

A network's performance is analyzed by taking into account certain parameters such as:

**Throughput**: It [6] is the maximum data rate that is observed during complete transmission. It is measured in terms of bits per second.

**End-to-End Delay**: It [7] is the time taken by a packet to travel from source to destination. It is also called as one way delay.

**Jitter**: The variation [8] in delays of the received packets is called as jitter. It is caused due to congestion in a network or network connection failure etc.

**Packet Delivery Ratio (PDR)**: It [9] is defined as the ratio of packets actually delivered to total packets sent by the source.

## III. VEHICULAR AD HOC NETWORKS

VANETs [5] are used in vehicular domain for cooperative traffic management. They are a subclass of MANETs with some additional protocols and services applicable to vehicles.

VANETs [7] turn every participating car into a wireless router or node. Thus, allowing cars approximately 100 to 300 meters of each other to connect depending on capability of transceiver system characteristics, in turn, creating a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created.

The nodes in the network consist of On Board Units (OBUs) [8] which reside in the vehicles and fixed Road Side Units (RSUs) . RSUs provide access to a wider area fixed network. Vehicles with OBUs along with RSUs form the ad hoc network. Vehicles or groups of vehicles may or may not be in range of RSU(s). In support of safety based applications, vehicles periodically broadcast a Basic Safety Message (BSM). The BSM contains information such as vehicle location, speed, heading, etc. This is used by applications such as collision avoidance and detection . VANETs are a type of MANETs with some additional features and protocols.

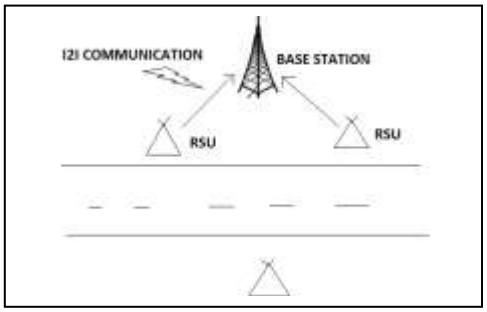
VANETs make use of roadside units (RSU) to directly communicate with the vehicles. The information from the Internet is provided to the RSUs via wired networks and is further transferred to the vehicles wirelessly [5]. On Board UNIT(OBU's) is deployed in a vehicle to make it work as a VANET node. VANET is a advance network having real time applications.

VANETs follows three types of communication i.e. Infrastructure to Infrastructure (I2I), Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V).

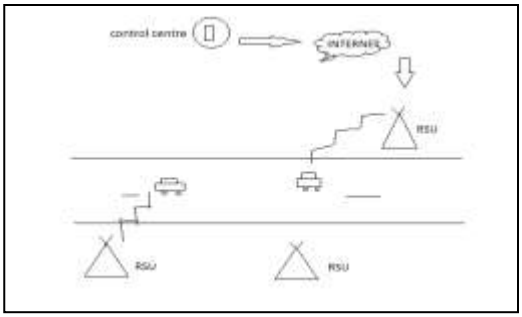
I2I [8] is in which the road side units (RSUs) communicate with each other. In some areas it is difficult to connect all the units to the background network. In such case those units are connected to a central RSU which further sends the information to the background network as shown in Figure 5(A). V2I [9] is in which the vehicles communicate with the roadside units (RSUs) to provide information about vehicles to control unit to manage its functioning. As shown in Figure 5(B) the control unit communicates with the RSU's over internet. These RSU's further transfer the information sent to them to the nodes via radio interface as and when required. V2V [10] in which nodes in a network range of 300 meters share information with each other directly. The information can be like about traffic jams accidents etc. As shown in Figure 5(C) the nodes which comes in a desired range communicates directly with each other wirelessly. Once the nodes goes out of range the connections are automatically broken .The nodes does it with the help of On Board Units deployed in them.

VANETs aim at making the transport system intelligent. Various functionalities that they provide are: provision of entertainment facilities like WIFI, gaming, internet services to a person in a vehicle, traffic monitoring and switching the router to avoid jams, prevention of accidents etc.

A. ***I2I COMMUNICATION:***
Several RSUs connected to one base station.




B. ***V2I COMMUNICATION***:
(i) Connection between control Centre and RSUs is through INTERNET (wired).
(ii) RSUs communicate with Vehicle via radio communication



C. ***V2V COMMUNCIATION***:
Vehicles within a range communicate wirelessly.

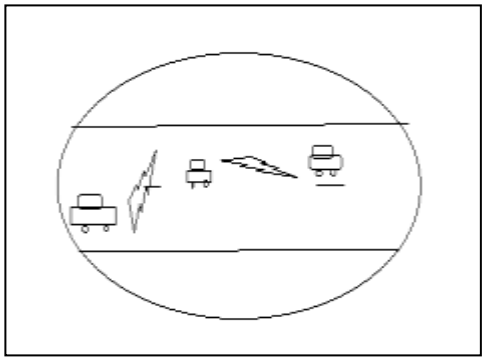


Figure 5: VANETs subparts

Infrastructure support deployed within VANETs [5] provides the efficient exchange of information between additional endpoints (traffic signals etc). They also provide access to additional resources (entertainment etc). Thus, VANETs provide intelligent services to the transport system. With a VANET, vehicles tend to be constrained by roads, geographic features and traffic laws.

## IV. ROUTING PROTOCOLS

There are two types of protocols which are used to route the packets from source to destination.

**Proactive/Table Driven Protocols**: In this type of routing protocol [5], each node in a network maintains one or more routing tables which are updated regularly. Each node sends a broadcast message to the entire network if there is a change in the network topology. It incurs additional overhead cost due to maintaining up-to-date information. Destination Sequenced Distance Vector (DSDV) protocol is the example of one of the standard Proactive protocols. In VANETs, communication between control centers to road side units is carried out using these protocols. They are not suitable for dynamic scenarios as they increases the overheads and leads to wastage of bandwidth. In DSDV each table entry has a sequence number that is incremented every time a node sends an updated message. Routing tables are periodically updated when the topology of the network changes and are propagated throughout the network. Each DSDV node maintains two routing tables: one for forwarding packets and one for advertising incremental routing packets. The routing information sent periodically by a node contains a new sequence number, the destination address, the number of hops to the destination node, and the sequence number of the destination. As the topology of a network changes, the detecting node sends an update packet to its neighboring nodes. On receipt of an update packet from a neighboring node, a node extracts the information from the packet and updates its routing table. As shown in Figure 6, the routing table for node 2 is defined.

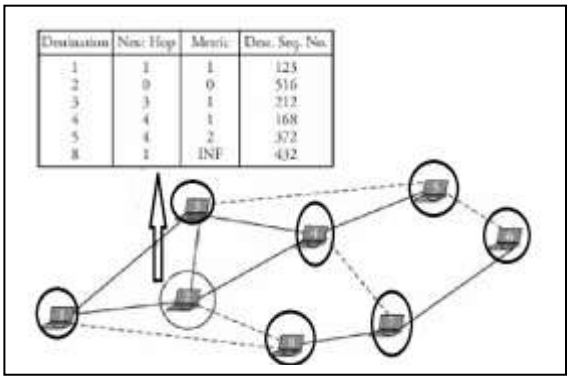



Figure 6: DSDV

**Reactive/On Demand Protocols**: In this type of routing protocol [5], each node in a network discovers or maintains a route based on demand. It floods a control message by global broadcast for route discovery and use bandwidth for data transmission upon route formation. The main advantage is that these protocols need less routing information to be updated as route is discovered on demand. However, it produces huge control packets due to route discovery for rapidly changing topology. The examples of some standard protocols are Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV). In VANETs, the communication between RSU's to vehicle and vehicle to vehicle is done using these protocols. VANETs use these protocols as it leads to less overhead and provide better working in mobile environment. In AODV whenever a node wishes to send a packet to some destination : It checks its routing table to determine if it has a current route to the destination , If yes, forwards the packet to next hop node ;if no, it initiates a route discovery process . Route discovery process begins with the creation of a Route

Request (RREQ) packet which is created by the source node. The packet contains – source node's IP address, source node's current sequence number, destination IP address, destination sequence number. It also contains the broadcast id number and broadcasting is done via flooding. If there is a path which the intermediate node knows it unicasts a Route Reply(RREP) to the source. It contains the destination sequence number, hop count and its life time. After receiving the RREP the source begins transmission. As shown in Figure 7 node 1 is the source and node 7 is the destination. Each intermediate node is sending a RREQ and RREP messages to determine the route.

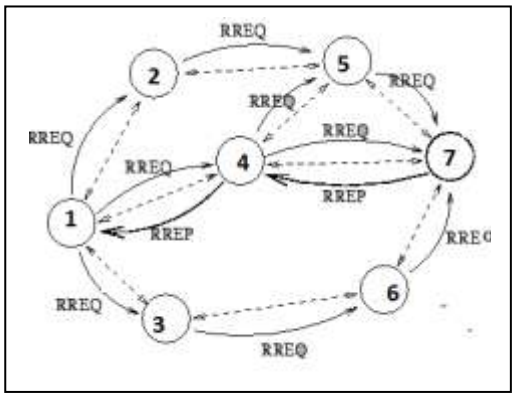



Figure 7: AODV

## V. ISSUES AND CHALLENGES IN VANETs

VANETs although being an important area for researchers in recent years but they have many issues and challenges in their practical deployment. Some of these are discussed below:

**Routing**: As the nodes in VANETs are mobile, frequent changes in routes occurs due to its dynamic nature. Thus normal routing algorithms [5] fail in this domain. As shown in Figure 8 as node B is taking a turn it breaks the old connection. Similarly as new node D is entering the zone D-A-C connection is formed dynamically. Because of this dynamically change in topology normal routing algorithms fails. Thus reactive protocols are required as the routes are formed on demand, dynamically.

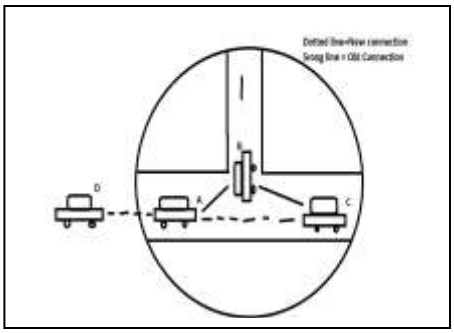


Figure 8: Routing Problem In VANETs as new nodes are added and old ones are broken

**Safety and Privacy**: VANETs being wireless networks have a major problem in providing safety [11] after its deployment. There are various attackers in the way which may affect the transmission of signal. To secure the communication, the data must be authenticated. Privacy on the other hand is to hide user profile, thus making it anonymous. Leaking private profiles could lead to serious consequences such as abductions or automobile thefts.

**Delay**: Because of mobile nodes in VANETs, there is a problem of delay [12] in the delivery of packets. A vehicle has to spend time in conducting back off. The time would be long if the target vehicle's neighbor size is large. The second type of delay relates the limited transmission range. Providing lesser delay is the issue that needs to be resolved.

**Scalability**: If the number of nodes in VANETs increases [13], the data distribution to certain required nodes is a difficult task. Efficient data dissemination [14] to a desired number of receivers in VANET having high number of nodes is a new issue. Due to rapid topology change, routing protocols do not scale well with increasing network size. Thus, messages are mostly disseminated in a broadcast fashion rather than routed to one dedicated communication partner. Thus scalability is an issue to be considered to avoid hindrance to VANETs success.

**Quality Of Services**: Quality of services (QoS)[15] is a challenge that needs a consideration after the deployment of ad hoc network due to its dynamic nature. Various factors that affect the QoS are delay, transmission rates, duration of connectivity etc. QoS is

one of the important parameter to be considered as it leads to success of a network. Through QoS only one can determine how good a network performs in every situation.

**Bandwidth Availability**: Throughput capacity is measured in VANET by the amount of information sent between a node and nearest RSU. Because of limited bandwidth availability packet drops may occur. Thus effecting the throughput[16] of the network. This issue to utilize the bandwidth efficiently to provide higher throughput is an important issue in VANET.

**Channel Allocation**: In VANETs, same wireless channel is shared by different nodes using same frequency. Thus inappropriate use of channel results in collision and wastage of bandwidth . Traditional wireless MAC protocols are not suitable for use in VANETs. Providing efficient protocols for transmission of multimedia [17] files like video, images etc. needs to be developed. Thus describing protocols to efficiently utilize a channel is an important issue in context of VANETs.

## VI. CONCLUSION

Different types of wireless networks have been briefly discussed. Further, a type of wireless ad hoc network i.e. VANETs and issues in their practical implementation have been discussed. VANETs are the type of networks which are used in real time vehicular scenarios. They are used to provide ITS by traffic monitoring, entertainment services etc. Because it is still an emerging technology there are lot of challenges which are roadblock to its success. Some of the major issues being delay, safety and privacy, bandwidth availability etc have been explained. In near future, VANETs will be the backbone of an advanced intelligent transport system.

## REFERENCES


[1] A.Awang, K.Husain, N.Kamel and S.Aissa, "Routing in vehicular ad-hoc network: A survey on single and cross layer design techniques and perspective", *IEEE Access*, vol.5, pp. 9497-9517, April 2017.

[2] H.Nguyen, G.Scalosab and R.Zheng, " On Quality of Monitoring for Multichannel Wireless Infrastructure Networks", *IEEE Transactions on Mobile Computing*, vol. 13, no. 3, pp. 664-677,March 2014.

[3] M.Kiskani and H.Sadjadpour ,"A Secure Approach for Caching Contents in Wireless Ad Hoc Networks", *IEEE Transactions on Vehicular Technology*, vol. 66, no. 11, pp. 10249-10258,Nov. 2017.

[4] D.Smith, J. Wetherall and A. Adekunle, "SUPERMAN: Security Using Pre-Existing Routing for Mobile Ad hoc Networks", *IEEE Transactions on Mobile Computing* , vol. 16, no. 10, pp. 2927-2940, Oct. 2017.

[5] T.Taleb, E .Sakhaee, A.Jamalipour and K.Hashimoto and N.Kato, "A stable routing protocol to support IT Services in VANETs", *IEEE Transactions on Vehicular Technology*, vol. 56, no .6, pp. 3337-3347, Nov. 2007.

[6] D.Li, X.Jia and H.Liu," Energy efficient broadcast routing in static ad hoc wireless networks", *IEEE Transactions on Mobile Computing*, vol.3, no. 2, pp. 144-151, June 2004.

[7] K.Sjoberg, P.Andres,T.Buburuzan and A.Brakemeier,"Cooperative Intelligent Transport Systems in Europe: Current Deployment Status and Outlook", *IEEE Vehicular Technology Magazine*, vol.12 , no. 2, pp. 89-97,June 2017.

[8] L.Huang, H.Jiang, Z.Zhang, Z.Yan and H.Guo, "Efficient Data Traffic Forwarding for Infrastructure-to-Infrastructure Communications in VANETs", *IEEE Transactions on Intelligent Transportation Systems*, vol. PP, no. 99 ,pp. 1-15, March 2018.

[9] J. Gozalvez, M. Sepulcre and R. Bauza, " IEEE 802.11p vehicle to infrastructure communications in urban environments", *IEEE Communications Magazine* , vol. 50, no. 5, pp. 176-183,May 2012.

[10] G.Tasseron, K.Martens and R. Heijden, " The Potential Impact of Vehicle-to-Vehicle Communication on On-Street Parking Under Heterogeneous Conditions", *IEEE Intelligent Transportation Systems Magazine*, vol. 8, no. 2, pp. 33-42, May 2016.

[11] F.Qu, Z.Wu, F.Wang and W.Cho, "Security and privacy review of VANETs", *IEEE Transactions on Intelligent Transportation Systems*, vol. 16, no. 6, pp. 2985-2996,Dec. 2015.

[12] X.Cao, L.Liu, Y.Cheng, L.Cai and C.Sun, "On Optimal Device-to-Device Resource Allocation for Minimizing End-to-End Delay in VANETs", *IEEE Transactions on Vehicular* Technology, vol. 65, no. 10, pp. 7905-7916,Oct. 2016.

[13] T.Kosch, C.Adler, S.Eichler, C.Schroth and M.Strassberger, "The scalability problem of vehicular ad hoc networks and how to solve it", *IEEE Wireless Communications*, vol. 13, no. 5, pp. 1-7,Oct. 2006.

[14] T.Yan, W.Zhang and G.Wang, "DOVE: Data Dissemination to a Desired Number of Receivers in VANET", *IEEE Transactions on Vehicular Technology*, vol. 63 ,no. 4 , pp. 1903-1916, May 2014.

[15] G.Li, L.Boukhatem, and J.Wu,"Adaptive Quality-of-Service-Based Routing for Vehicular Ad Hoc Networks With Ant Colony Optimization", *IEEE Transactions on Vehicular Technology*, vol. 66, no. 4, pp. 3249-3264, April 2017.

[16] M.Wang,H.Shan,T.Laun,N.Lu,R.Zhang,X.Shen and F.Bai "Asymptotic Throughput Capacity Analysis of Mobility Diversity VANETs Exploiting", *IEEE Transactions on Vehicular Technology*, vol. 64, no. 9, pp. 4187-4202,Sept. 2015.

[17] M.Hadded,P.Muhlethaler and A.Laouiti "TDMA-Based MAC Protocols for Vehicular Ad Hoc Networks: A Survey, Qualitative Analysis, and Open Research Issues", *IEEE Communications Surveys & Tutorials*, vol. 17, no. 4, pp. 2461-2492,April 2015