International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

# Routing and Scheduling Issues in Vehicular Ad-hoc Networks

**Shridevi Jeevan Kamble, Manjunath R Kounte**

***Abstract: VANETs has picked up as one of the largest potential topics in the field of automotive industries with promising and challenging futures in various aspects. VANETs permit intelligent vehicles to generate their own organized network without the need of the stable network. In this paper we introduce VANETs and its comparison with MANETs, standard wireless technology in VANETs like WAVE model partly based on OSI model. We present a comprehensive study on routing protocol in VANETs like position-based routing, Geo-Cast based routing, etc. and scheduling in VANETs like deadline-based scheduling, hybrid-based scheduling, etc. This paper presents open research issues in VANETs highlighting challenges like security and privacy issues, network congestion control issues, etc. numerous routing and scheduling issues in VANETs.***

***Keywords: VANETs, MANETs, Routing, Scheduling, WAVE***

## I. INTRODUCTION

VANETs is a technology that integrates the advanced generation of wireless networks to vehicles. VANET build a powerful ad-hoc network between mobile vehicles and road side unit (RSU) in a form establishing the communication link. [1] - [71]. Ad-hoc network does not depend on the base station for the stream of information to reach all vehicles in the network structure. But it creates a spontaneous network to connect the devices. Thus, efficient communication in VANET can be achieved by using different ah-hoc networking tools like IEEE802.11b/g, WiMAX IEEE802.10 Bluetooth, etc. **Fig 1** shows the scenario of VANETs [2]. Inter-vehicles Communications structure uses multi-hop or Broadcast to transfer the data over multi-hops to groups of receivers. It also operates on a single hop broadcast in which the RSU transmits the information to all its surrounding acquaintance [21]. Inter-Roadside Communication composition requires a high bandwidth link for communication between roadside units, to enabling the data transmission.

VANET engaged nodes are armed with wireless onboard units (OBU) to establish the link of communication between vehicles and roadside unit (RSUs) [68]. As shown in **Fig 1** the configured scheme of vehicular ad-hoc network (VANET) [4], in which every smart vehicles and infrastructure communicate to each other. VANET functions providing awareness to the vehicle driver in case of traffic jam, awareness of the situation of the road traffic to avoid rear-end collision on the highway.

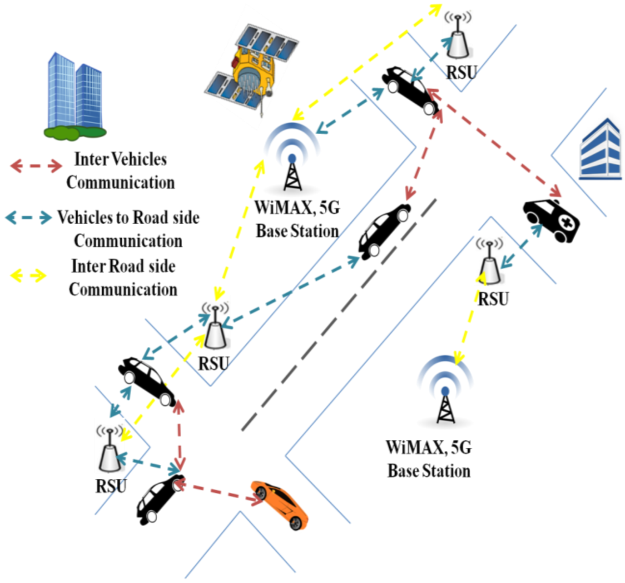


**Fig.1. VANETs Scenario**

**Table-1: Comparison of VANET and MANET**

| Parameter | VANET | MANET |
|---|---|---|
| Application | Related to vehicles Safety. | Related to internet accessed through Internet. |
| Node Mobility | Higher | Lower |
| Network Topology | Nodes moves very Fast | Slow movement of Nodes |
| Node Density | Varies frequently due to high mobility of vehicles | Higher in particular area at time. |
| Communication Range of Nodes | Up to 500 meter | Up to 100 meter |
| Broadcasting | Multicast | Unicast |
| Bandwidth | Around 1000kbps | Around 100kbps |
| Power | Depends upon the | Depends upon the |
| Resource | life span of Vehicles. | Capacity of battery. |

The communication in VANET is achieved from the WAVE as a wireless medium [22]. One of the critical subject in VANET is the preference of relevant broadcast media to establish link of communication, by examining the type of traffic and concentrating on reducing the inter-node interference.

Manuscript published on 30 September 2019
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VANET provides challenging opportunities to increase the performance of the network as that of mobile ad-hoc network [MANET]. VANET differ from MANET [56] by some features like speed, bandwidth, and communication range so on. **Table 1** shows the comparisons of VANET and MANET [3, 9].

## II. STANDARD WIRELESS ACCESS IN VANETS

In Intelligent internet of vehicles, vehicular communication systems are networks in which vehicles and RSU communicates with each other, providing each other with information related to road traffic and safety. The associated technologies with Vehicular communication are Dedicated Short-Range Communication (DSCR), Wireless Access in the Vehicular Environment (WAVE), IEEE802.11p and IEEE 1609 are the standards for DSRC and WAVE network) [22]. DSRC is a standard which was developed to support the link communication with vehicles and vehicles-to-road unit communication. DSRC convey the communication over hundreds of meters, a short distance than cellular and WiMAX a service basically supports. DSRC operates on 5.9 GHz of radio frequency spectrum and is effective over short to medium distances. In 1999, the United States Federal Communications Commission allocated 75 MHz spectrum in the 5.9 GHz band for DSRC communication [23].

### A. WAVE Family Standard

DSRC which is mainly stated as WAVE. DSRC uses WAVES to exchanges information between the smart vehicles and road units. DSRC network is built on two entities, RSU and OBU and the wireless connection are based on WAVE standards. **Fig.2** shows the WAVE channel arrangement [24]. WAVE devices engaged in architecture that supports a predefined Control Channel (CCH) and Multiservice Channels (SCHs). The CCH is used to transmit WAVE short messages (WSM) and to announce WAVE services, and SCH is can be opted commercial applications interactions and data exchange [25].

### B. WAVE Architecture

WAVE architecture depends on two stacks of protocol: Internet Protocol Version Six (IPv6) and WAVE Short Message Protocol (WSMP). **Fig.3** shows WAVE approach IEEE 1609, IEEE802.11p and OSI model. Both the stack used the look-alike Physical Layer and Data-Link layer and differ each other in Network Layer and Transport Layer. **Table 2** gives the list of protocol belonging to the WAVE communication stack [26]. IEEE 802.11p and IEEE 1609.4 describe the PHY and MAC layer of the system respectively, and IEEE 1609.3 supports IPv6 stack and WAVE short Message Protocol (WSMP) stack are used to describe network layer and transport layer of TCP stack. Security services and resources management are described by IEEE 1609.2 and 1609.2 respectively [25].

## III. ROUTING PROTOCOL IN VANETS

Routing protocol [5, 6] is an important part of any network, and highly challenging in VANETs essentially as due to speed of vehicles forming topology of networks and causing frequently links disconnections. The main need of routing protocol is that it specifies how exactly router communicates with each other, the information which is being distributed on the network benefits them to identify routes between two points of communication link on the computer network. Routing is a very important part of vehicles communication

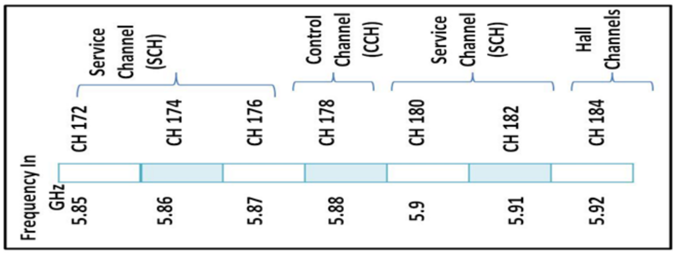


**Fig.2. WAVE Classification by United States**

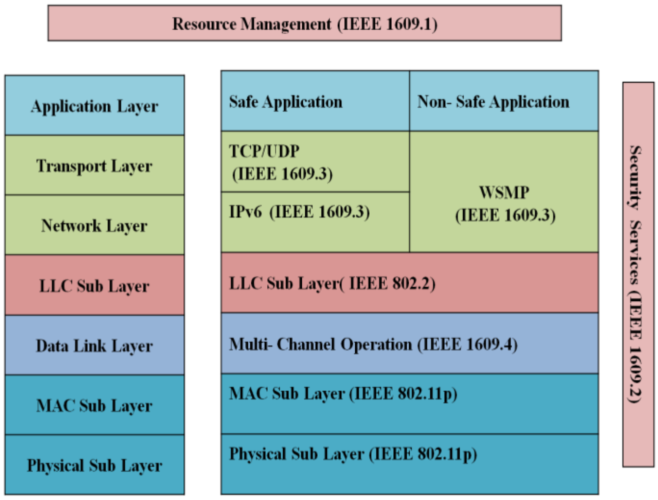


**Fig.3. WAVE Model partly based on OSI Model**

**Table-2: List of Protocol belonging to WAVE**

| OSI Model Layer | Standard | Protocols | Description |
|---|---|---|---|
| Transport Layer | IEEE 1609.3 | Wave Network Services | Determines addressing a routing services within a WAVE system. |
| Network Layer | | | |
| LLC Sub Layer | IEEE 802.2 | Wave Short Messages | The Data Link Layer wants to send some data over the network, then IEEE 802.2 LLC sub Layer help makes possible. |
| Data Link Layer | IEEE 1609.4 | Multi Channel Operation | Determines improvement to IEEE 802.11p MAC to backup multichannel operation. |
| MAC Sub Layer | IEEE 802.11p | WAVE MAC and PHY | Determines the MAC and PHY actions needed by IEEE 802.11 gadget to perform in VANET. |
| Physical Sub Layer | IEEE 802.11p | | |
| Resource Manage ment | IEEE 1609.1 | WAVE Resource Management | Determines the application that allows to communicate between OBU and the complex system outside. |

*Retrieval Number: C5168098319/2019©BEIESP*
*DOI:10.35940/ijrte.C5168.098319*
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|---|---|---|---|
| Security Services | IEEE 1609.2 | WAVE Security Services | Covers Security Messages and Processing. |

to broadcast the information. The network topology changes in VANET as the location of the node changes regularly. The node in VANET does not have restriction unless in the range of radio propagation to receive and transmit information to other vehicles or RSU. The time factor is very important issue to respond and share information accordingly. The routing is a software and routing algorithm determines the communication path between the network nodes. And topology means the way in which the networks are connected in some logical pattern. The routing Protocols [7] are classified into communication stack. **Fig. 4** shows VANET routing protocol classifications. Routing in VANET is classified into 5 categories, based on routing techniques aspects: Topology-Based routing, Position-Based routing, Geocast Based routing, Cluster-Based routing, and Broadcast-Based routing [8].

### A. *Topology Based Protocol*

Topology-based protocol is an arrangement of the network containing nodes for connection. It stores the information in the form of the table and transfers the data in the network by making use of present channel accessible in the network. It always finds the shortest line of communication for transmission of information from source to destination. Topology-based protocol is classified into 3 categories as highlighted in **Fig. 5**. They are Proactive routing topology, Reactive routing topology, Hybrid routing topology.

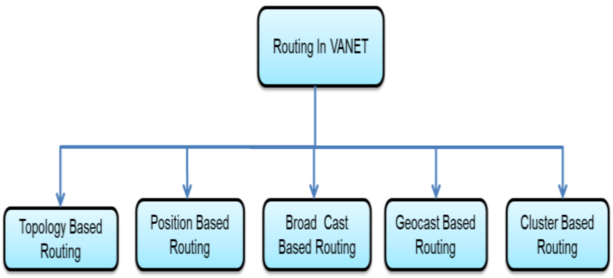


**Fig.4. VANET Routing Protocol**

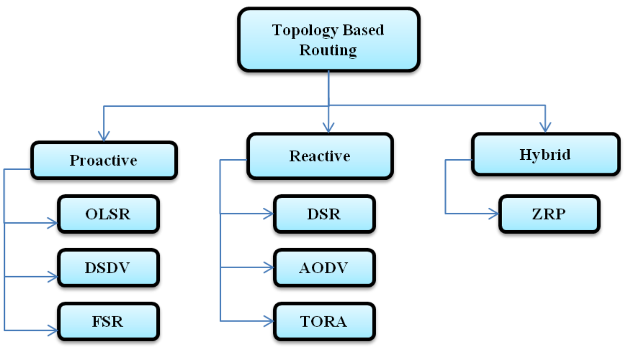


**Fig.5. Types of Topology Based Routing**

#### a. Proactive routing topology

In this topology every node maintains the broadcast table which keeps tracks of node entering or leaving the network, and also these network tables are maintained regularly, the timely routing report is maintained regularly regarding the connectivity of each and every node present and participating in the network. Hence all nodes are able to take the instant decision regarding the specific packet forwarding. It is also known as the table Driven routing. Essential types of Proactive routing topology are explained in further section [10].

#### i. DSDV-Destination sequence distance vector

DSDV is dependent on Bellman-Ford routing mechanism and is table directed proactive routing protocol. Always maintained by updating the routing table periodically and send them periodic updates and update with the sequence numbering system to distinguish old routes from the new one. Importance of DSDV algorithm is that it is very relevant for establishing ad-hoc network for the small number of nodes. And drawback of DSDV is, it requires the updates of network periodically, hence it uses the battery and few chunk of bandwidth, when the network is idle [11].

#### ii. OLSR-Optimized link state routing

OLSR is developed for MANET and its optimization of class link state algorithm can be suitable for VANET and it is the proactive link state routing protocol. The access used in this protocol is multipoint relay (MPRs). MPRs are the selected node which means the exchanges of information among the nodes of the network are in the usual manner during the flooding process. MPR elects the nodes and only these elected nodes generate the OLSR link state information. This approach simply decreases the overhead of messages as compared to the classic approach. One of the drawback of OLSR, it requires the respective amount of data for maintenance and there is always a slow reaction on failure and restructuring [12].

#### iii. FSR-Fisheye state routing

FSR is Proactive routing topology adapted for wireless ad-hoc network and communicate on link state protocol, also has the ability to contribute routing path information by preserving a topology map at each node. FSR improves the scalability of the routing protocol by laying all the efforts in gathering the data that is most likely to be needed immediately. FSR uses "Fisheye" technique, the size of the information required to represents the graphical data is reduces and only relevant information is only stored. Fisheye captures the accurate data near the focal point with great accuracy but as the width from the focal point expands the amount of captured details also decreases [13].

#### b. Reactive routing topology

Reactive routing topology follows to set up paths on appeal i.e. if any node wants to set the link of communication between the other nodes, the protocol establishes the link between the nodes by generating route request message (REQ). It is also recognized as the on-demand routing protocol. Also suitable for VANETs network and creates on-demand routes, some of the reactive routing topologies are: AODV, DSR and TORA routing protocol.

It only maintains the path that are presently in use, and due to this the hardship on the network is reduced. This topology also opens a path which is fundamental for a node to communicate with other nodes [47].

**i. Ad-hoc On demand Vector (AODV)**

AODV is a reactive routing that searches the route on request and transfer the data packet from one point to other. Also known as on-demand route acquisition system. Therefore, it always intend to forward the RREQ (Route request) information to find route and one's packet is reaches end point it will acknowledge back with Route Reply (RREP). The convenience are the paths are well-established on-demand and destination sequence numbers are used to find the latest route destination. Delay in connection set is also low. Disadvantage with AODV is the immediate nodes can guide to uncertain paths if the source sequence is not good and also the multiple path respond to single route request leading to heavy overhead. The regular beaconing [57] leads to useless bandwidth consumption [14].

**ii. Dynamic Source Routing (DSR)**

DSR is a well-organized routing protocol, in terms of send and receive the information from source node to destination node. It will firstly check for the route, ones the route are discovered it will broadcast RREQ with unique ID from source node where the data is sent and ones the node receives the unique ID then it will identify where the data packet needs to be sent in the network and broadcast the data until it is delivered to the correct destination. If any path failure occurs, the node will send RERR (Route Error) information to network [47].

**iii. Temporally Ordered Routing Algorithm (TORA)**

TORA is recommended for highly dynamic mobile, for routing the data across the different type of Network like Wireless Mesh Network, Sensor Network, Mobile Ad-hoc Network, and VANET, etc. This is also on-demand routing protocol and the nodes in the network finds multiple paths from source to destination. It also uses the non-hierarchical routing algorithm and attempts to accomplish a greater degree of scalability. TORA develops and preserve a Directed Acyclic Graph (DAG) with the principle of no two nodes may have the same height [47].

**c. Hybrid Routing Topology**

This topology is merge of Proactive and Reactive Routing Protocol into a new protocol. The main truth is that every node make use of proactive routing in its local region and reactive routing is applied in between the region called as zones. With this concept, the control actions are reduced, since the network is coordinated in the local region in which these nodes share the limited number of revelation packets in a proactive manner. And on the other hand, the packets which are sent between the regions are secured by reactive routing. Therefore this type of routing topology is very suitable for the very large and scalable network. In [HAS 99], this protocol is called as zone Routing Protocol (ZRP) was proposed [57].

**i. Zone Routing protocol (ZRP)**

It is wireless network routing protocol, it addresses the problem by using both proactive and reactive routing protocol during broadcasting the information over the network, it is mainly designed to accelerate transmission and cut down the processing overhead by choosing the most effective type of protocol to use all through the route. ZPR is branches into two parts Intra-zone and Inter-zone routing. Intra-zone routing in which the parcels will be sent within the routing zone of source node to external node and Inter-Zone in which the routing packet is sent from the external node to destination node [58].

**B. *Position Based Topology***

Position based topology contribute the property of using geographical positioning knowledge to select the nodes. The packet is sent to the neighboring node without any route map information. Ones the packet is sent to the destination, the header of the data packet helps in forwarding the information parcels to the destination. Position based routing is believed to be beneficial, convenient and balanced for highly mobile VANETs for situation with topology-based routing protocols, because no global route is needed to establish and maintain from source to destination [15, 16]. The classifications of Position-based routing are DTN (Delay Tolerance Network), Non-DTN (Non Delay Tolerance Network) and Hybrid protocols. Few of position based topology is Greedy Perimeter stateless routing (GPRS) and Distance routing effect algorithm for mobility protocol (DREAM). **Fig. 6** shows the type of Position Based Routing Protocol [48].

**ii. Delay Tolerance Network (DTN)**

The network make use of DTN in case of lack of connectivity and no spontaneous end-to-end paths. Here protocol takes "store and forwards" approaches to deliver the packets. The packets of information are incrementally moved and stored over the network until it comes across the destination node [60].

**iii.**

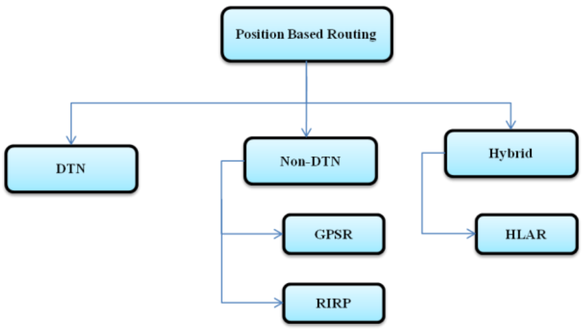


**Fig. 6. Position Based Routing Protocol**

**iv. Non Delay Tolerance Network (Non-DTN)**

It uses Greedy approaches to forward the packets. A node leads the data information to the nearest node to the destination node and then to its neighbor. Here the communication may be unsuccessful or may fail if no such neighbor exists accept itself. This routing protocol has its own readjustment mechanism to deal with such failure [48].

**v. Greedy Perimeter stateless routing (GPRS)**

GPRS is effective routing protocol for VANETs in vehicular communication. It operates on greedy algorithm which allows the nodes to find the nearest neighbors, therefore it also calculates the path and forward the path detailed message to the destination node by making use of the most effective route to be found. If GPRS protocol fails to forward the information to the nodes, then it uses the perimeter forwarding in the network [8].

**i. Reliability Improving Position-Based Routing (RIPR)**

RIPR algorithm solves the problem of the link failure, it identifies the direction and speed of vehicles moving on the road. Here in RIPR routing scheme the source node selects a nearby neighboring node and sends the data to the nearest intermediate nodes. Thus algorithm aids to select the next forward node, position of nodes and the routes are determined after the message is exchanged. The main advantage to RIPR protocol is that it does not allow link failure and due to which the drawback occurs mainly due to the data storage of the wrong intermediate node. It uses two techniques RIPR protocol: greedy technique and perimeter technique like the GPSR protocol [48].

**a. Hybrid Position-Based Routing**

HPBR cut down the traffic and does not maintain or manage the table, as they utilize information about the neighbor's nodes and destination node, which make HPBR more scalable. Limitations of HPBR are: Exact region is always a cause to have an exceptional achievement and if there are no nearest node to destination exists, position routing leads to link failure [61].

**i. Hybrid Location-Based Ad-hoc Routing (HLAR) Protocol**

It is a scalable protocol which makes use of the position knowledge and there by helps in reducing the routing control overhead in correlation to on-demand routing. It also perform on-demand routing i.e. when data is finite regarding the position and if the information is not ample enough and can defeat problems in case of non-existence of near neighboring nodes. It still works as a reactive routing protocol and aids in the route discovery process [62].

### C. *Geocast Based Topology*

The main task of Geocast routing topology is to transmit the data from the source to all the nodes within the defined geographical region which is known as a Zone of Relevance (ZOR). Thus, it is location-based multicast routing. In Geocast Based Topology the vehicles beyond ZOR are not alarmed [17]. It is considered as the multicast service within the ZOR as it directs the forwarding zone and controls the packets to flow to avoid flooding and congestion. Initially this routing protocol was proposed for MANETs and hence adapted for another network like Mesh Network, Wireless Sensor Network (WSN) and VANETs [59]. Geocast topologies are classified as Beacon-Based protocol and Beaconless-based Protocol [3]. Some Geocast Based Topology is IVG, DG-CASTOR ROVER and DRG. **Fig. 7** shows the classification of Geocast based Routing Topology.

**a. Direction-Based Geocast (DG-CASTOR)**

DG-CASTOR is the network connectivity established on Vehicular ad-hoc network based on Geocast protocol, availability estimation is made based on the free link path. Geocast routing range is established depending on forecast destined location to establish the communication link of opportunity among flowing vehicles on road. Importance's is that it cut down the of network congestion by bypassing the transmission of rejected and unwanted packets on the whole network [18].

**b. Distributed Routing Geocast (DRG) Routing**

The DRG passes the information packets to the vehicles present in the defined static geographic region. These vehicles receives or sends a packet if it is located in the geographical region of ZOR. The intelligent vehicles have inbuilt with GPS receivers and connected to digital map. The vehicles receive a message only if the vehicles is in ZOR. It also includes Zone of Forwarding (ZOF) which adds both Source and ZOR. Vehicles in ZOF region are considered for routing process and only these vehicles in the ZOR convey the information to their application layer [19].

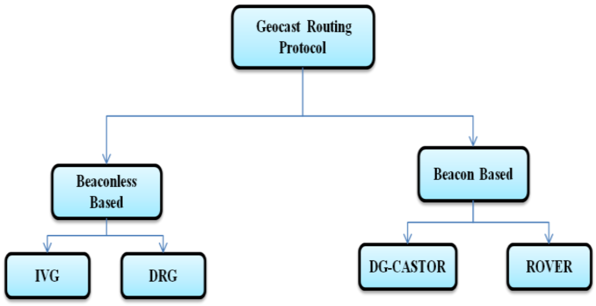


**Fig.7. Classification of Geocast Based Routing Topology**

**c. Reliable Geographical Multicast Routing (ROVER)**

ROVER is a reliable geographic multicast algorithm proposed for the VANETs. AODV is technique approach in which only those restricted packets are transmitted in network. The important objective of ROVER is to transfer the data packets to all the vehicles located within ZOR. ROVER assumptions for vehicles are, vehicle is determined by an identical number, every vehicle is connected to GPS receiver and have access to digital map, and thus ZOR is considered as a rectangular area [3, 49].

**d. Inter-Vehicular Geocast (IVG)**

The main task of Inter-vehicles Geocast protocol is to update about the vehicles located and positions in a risk area i.e. any danger on the highway, in such case the neighbor receives the message alert from the damaged vehicles. All the neighbors belonging to the risk areas are calculated and time takeoff which promotes the furthest node to relay on the broadcast the message. This makes use of beacons technique [63].

### D. *Cluster Based Topology*

Cluster-Based topology segregates the network into clusters, here the nodes has equivalent qualities such as the look alike direction or same velocity, and hence forms the clusters.

*Retrieval Number: C5168098319/2019©BEIESP*
*DOI:10.35940/ijrte.C5168.098319*
*Journal Website: www.ijrte.org*



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All clusters have the Cluster Head (CH) and are responsible for intra-cluster and inter-cluster authority operations, nodes within the cluster connects with other using direct link communication. The network also provides good scalability in case of a large network but however, it will expand the network overhead and delays in the highly dynamic network [14]. Selection of cluster head usually depends on the cluster algorithm used. The size of cluster are based on the range of communication device which are used by the cluster node.
Highly dynamic environment stability of cluster is one of the challenging issues in the field of research. Stability can be measured by the frequency of CH and the stability of CH can be upgraded by selecting the CH and cluster nodes [27]. **Fig. 8** shows the general approach to clustering in VANETs [57].

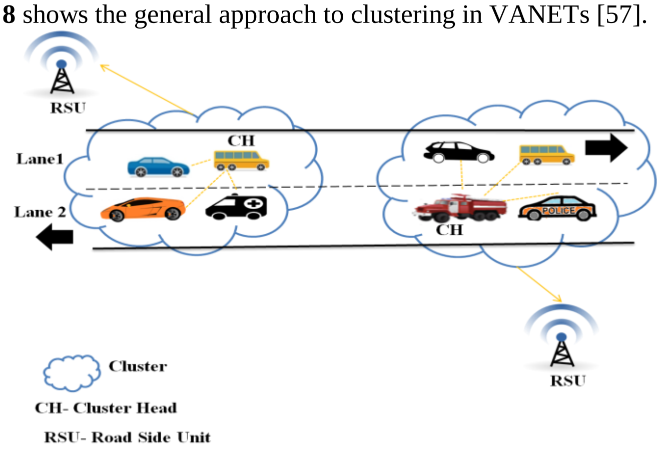


**Fig. 8.General Clustering approach in VANETs**

**a. Clustering for open Inter-Vehicles Communication network protocol (COIN)**

COIN develops the network scalability by selecting cluster in preference to three parameter i.e. nodes positions, behavior of nodes and mobility of nodes. In order to decrease overhead each cluster in the network is provided with unique time which is a time to live [8].

**b. Cluster-Based Directional Routing Protocol (CBDRP)**

CBDP branches/ clusters moving vehicles in similar way in the network. In CBDP source origin node transmits packets to its CH and then the CH transmits the packets to head of same cluster with the destination. From destination header the message is sent to the destination. The care of cluster header is same to the CBR but the velocity and direction of the vehicles are taken into examination [14].

### E. *Broadcast Based Topology*

Broadcast based topology is an efficient access for transmission of safety-related messages like traffic condition, accident, traffic service, road blocked etc. Thus the announcement are sent to each and every nodes in the network to accomplish coordinated driving in VANET [8].

**a. Distributed Vehicular Broadcast Protocol (DVCAST)**

The main component of DVCAST is the detection of nearby nodes, where the protocol are furnished with local topology information. DVCAST protocol analyzes these vehicles into three different ways based on vehicles local connectivity, i.e. strong connected, moderately connected and completely disconnected vehicles [64].

**b. Urban Multi-hop Broadcast Protocol (UMB)**

This protocols are designed to operate without exchanging local information among neighbor nodes and are designed for Inter-Vehicles communication system. In UMB the source node tries to identify the farthermost node in the broadcast order to transmit and acknowledge the data packet without any previous topology information. The main importance of this protocol is, it has the mechanism for minimizing hidden nodes problems; during the time of message distribution the protocol avoids collisions and overcoming interference. The protocol performs its best at higher loads and vehicles traffic densities [39].

## IV. SCHEDULING IN VANET

VANET make use of wireless technology to creating the network ad-hoc in essence. The network topology changes due to moving vehicles at high speed. Scheduling of data is crucial in the vehicular environment. There are some parameters which have to be taken care and they are fairness, reliability, responsiveness, time constraints, data size, and service ratio and data quality [32]. And based on these parameters different scheduling schemes are introduced. Each vehicle which needs a specific data sends the request to RSU, the request inserts into the queue of RSU. A VANETs consists of high speed moving vehicles, RSU, GPS and cloud with each RSU and can act as a server, storage and router to transmit the data to the client and to receive the data from the other vehicles and to maintains region bound [67]. Scheduling technique is applied to request the data R item stored in the form of queue considering time bound provided to each request. **Fig. 9** shows the data scheduling in terms of the time interval for each R and broadcast the data according to the time t [33]. **Fig. 10** shows the different scheduling scheme w.r.t different scheduling parameter [34] belonging to the risk areas are calculated and time takeoff which promotes the furthest node to relay on the broadcast the message. This makes use of beacons technique [63]. There are mainly five major categories in data scheduling namely priority-based scheduling, request based scheduling, time based scheduling, deadline based scheduling, and hybrid based scheduling.

### A. *Request Based Scheduling Algorithm*

RBSA composes of algorithm which permits the link of communication for transmission of data from RSU to Vehicles only after receiving , based on the appeal only, this scheduling schemes comprises of four algorithm and they are FCFS, MRF, MRFL, and RXW. First Come First Serve (FCFS) is the most transparent scheduling algorithm. Early arrival rate will be served first [69]. Most Request First (MRF) involves the requests which are in pending or in a queue, along with pending data (cold data) and new data (hot data). Most Request First Lowest (MRFL) activity is identical to MRF and the distinction is that its selects the page with the higher number of pending request and breaks ties in favor of the page with lowest access probability and the MRFL with no ties behaves as MRF [35]. RXW scheduling algorithm is introduced by D.Aksoy et al [36].

RXW algorithm works on pull-based technique in which the server delivers the data to the client using pre-determined scheduling based on predicated access profile of data and is uninformed about the actual client requests [34].

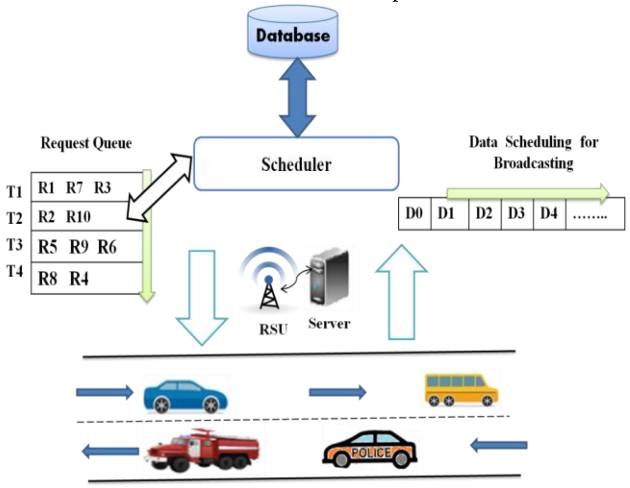


**Fig. 9. Data Scheduling in VANETs**

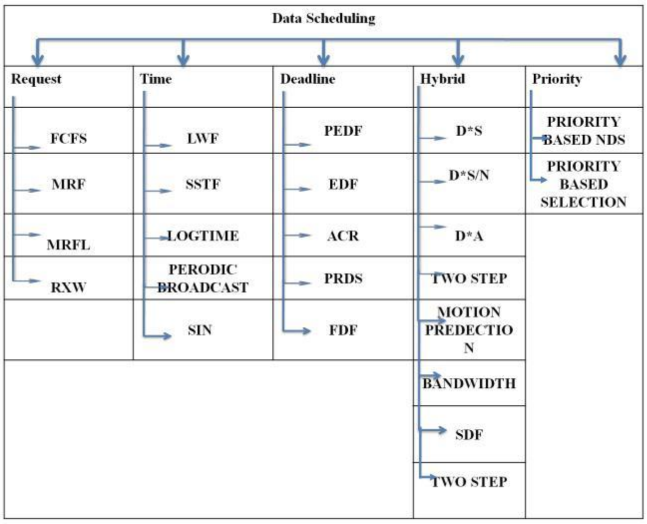


**Fig. 10. Categories of Scheduling Algorithms**

## B. *Time Based Scheduling*

This algorithm consists of the transmission of data from RSU to smart moving vehicles on road, based on vehicles arriving time, waiting time, delay etc. based on the appeal. LWF, SSTF, SIN, Long time and Periodic Message are the time-based scheduling algorithms. Longest Wait First (LWF) algorithm selects the page having the longest delay time. Here the algorithm determines all pending requests of data, i.e., sum of all requests waiting time and longest waiting time is counted for all pending request and largest waiting time is selected to broadcast next. This algorithm is designed to minimize the mean waiting time and provides more bandwidth to hot pages. This algorithm avoids the starvation of cold pages [37]. In Shortest Service Time First (SSTF) the packets items are chosen by the servers to broadcast. The aim of this algorithm is to pick the packets item for service with the short service time to broadcast first [38]. Slack Time Inverse (SIN) completely reverse to SSTF, it takes the pending request at each network and ticks the packets data with lowest SIN values broadcast.

## C. *Deadline Based Scheduling*

This algorithms deals with the deadline of the tasks, and also one of the method of improving packet transmission performance in VANETs by considering the deadline of the vehicles call. Types of deadline based scheduling algorithm are EDF, PEDF, ACR, PRDS and FD. Earlier deadline first (EDF) algorithms, here server will broadcast the task which has the earlier deadline [36, 40]. Preemptive Earliest Deadline First (PEDF) algorithm is the preemptive version of EDF. Aggregated Critical Request (ACR) algorithm is a system of production scheduling that pulls the packets from value streams in a continuous flow rather than pushing through branches and hence based on pull scheduling real-time broadcast system. It ensures the timely deliver by minimizing the missed deadline. Preemptive Request Deadline Size (PRDS) scheduling is real time preemptive based scheduling. It depends on the factors like data size, deadline constraints of data requests, response time, stretch and computational overhead, etc. [38]. First Deadline First (FDF) scheduling algorithm, here the most urgent request for data will be served first and parameter considered for scheduling decision is deadline of the request data [33, 40].

## D. *Hybrid Based Scheduling*

Hybrid based is the class of mix scheduling mechanism with different scheduling discipline and criteria like size of data, deadline of request, time, and so on. [69]. In order to schedule the data over the VANET, it make use of scheduling algorithms like are SDF, D*S/N, D*A, Two-Step and Motion Prediction Based, Bandwidth based algorithms. Smallest Data Size (SDF) algorithm, the smallest data size will be distribute first always. Data Size and Deadline (D*S) scheduling algorithm deals amongst the one and other, i.e. data size and deadline to schedule the packet approaches from vehicles to RSU and the smart device across roadside to deliver and distribute the request one at a time [40]. D*S/N is extension of D*S and also improves the broadcast efficiency. This algorithm serves the more pending request first. D*S algorithm have additional inputs i.e. N to same service and indicates as total number of pending requests. The service value can be calculated as DSN_Value = (Deadline –Current Cock)*S/N. They mainly use three parameter and they are deadline (D), data Size (S) and pending request (N). The value of S and N are combined as single S/N list, so that if a new request comes the value of S/N data is updated [41]. Data size and Arrival time (D*A) algorithm provides the highest priority to the processes with the lower data size and also called as small data size first scheduling [42, 33]. Two-Step algorithm is the combination of FCFS and D*S/W (Deadline, Size of Data and Waiting time). This algorithm serves multiple requests and the priority set to fill full the request is having the short deadline. Also this algorithm is performed in two steps, in step one the data is divided into normal or emergency category and depending upon the basis of category the requests are separated, in step two, there are two queues maintained and managed to insert the request in FCF manner[43]. Motion Prediction Based (MPB) and Motion Prediction optimization (MPO) permits the harmonious performance with RSUs and MPO also allows the cooperative interaction between multiple MPO.

MPO is better as compared to FCFS, EDF and SDF [44]. Bandwidth scheduling algorithm makes use of the concept of replica management and reduces the infrastructure requirements, mainly to improve the delivery rate [45]. Two-Step scheduling algorithm grant's the vehicles to presume and login from a new RSU.
It performs the operation in two steps. In stage one it executes upon the requests. It naturally evaluates the data based on the presumed data or the data first time requested by vehicles. The schemes also maintain two progress, first for emergency demand and data request, second part is that it selects one of two progress queues for the distribution with D*S scheduling schemes [41].

### E. *Priority Based Scheduling*

The priority is given to the first preference of necessary information-packets rather than that for the one which has least emergency information packets. Mainly similar sort of data services are used in emergency services like Emergency help line, Hospital, Road Map information, Emergency information broadcast and so on. Priority based NDS and Priority based selection algorithms are described in this section. Priority based NDS algorithm works over vehicles to hotspot communication. Priority based NDS Selection algorithm is categories into emergency and non-emergency. This algorithm schedules data for those vehicles which are in the coverage area. It also provides the priority to vehicles before completion of its deadline and performs over bandwidth utilization and fairness [46].

## V. APPLICATIONS OF VANETs

The main aim of VANET is adapt to changing topology of moving vehicles. VANET permits the moving smart vehicles to build a model of self-organization network without the need for a long-lasting infrastructure. Hence finding, established and preserving efficient route between network nodes is a challenging task. The bottom-neck of VANET is to maintain safety on road among moving vehicles in certain case leads to collision, and collision takes place due to imp-proper communication, to overcome this problem researchers have introduced with VANETs. Applications of VANETs are safety relate issues, commercial orientation, convenience oriented and product application. Based on the classifications VANETs applications are briefly mentioned in **Fig.11** applications of VANETs [3, 20].

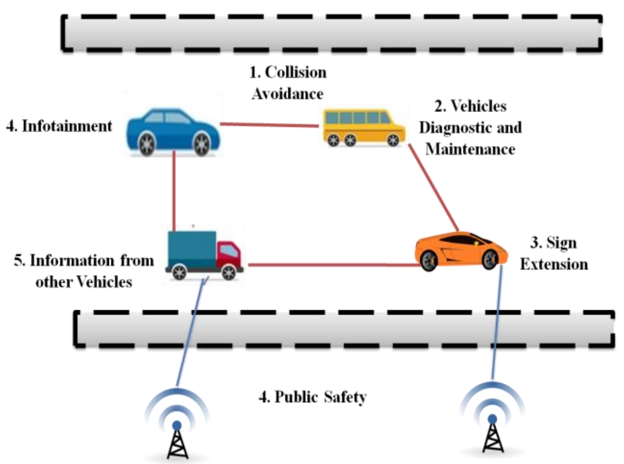


Fig. 11. Applications of VANETs

## VI. OPEN ISSUES IN VANETs

### A. *Challenges in VANETs*

VANETS are the fastest developing technology in ITS. VANET permits the vehicles to exchange information with each other primarily for safety reason i.e. information about accident, traffic jam, real-time information, break events in vehicles etc. Thus in such case evaluating credibility or receiving message and maintaining the trust becomes very important. **Fig.12.** shows the VANETs challenges in various categories [51]. VANET make use of wireless technology for creating the network ad-hoc in nature and due to changing network topology there are numbers of problems in VANETs. VANET has huge potential to solve day to day traffic problem and if any attack on VANET is a great challenging task. A few challenges of VANETs are as follows.

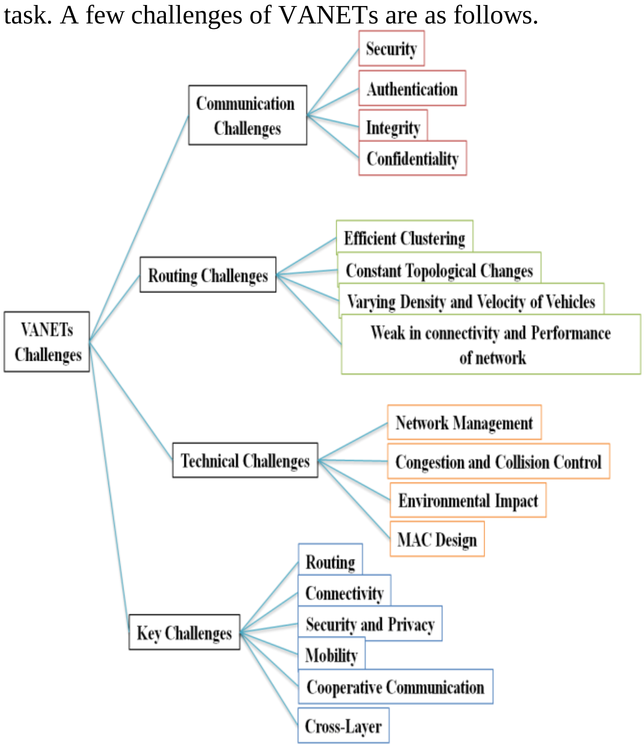


**Fig. 12. VANETs Challenges**

#### a. Security and Privacy issues in VANETs

Vehicles communicating with RSU should allow the users to select and choose the proper data that need to be exchanged and the data which is not required must be kept private. Since the network are publicly available in any road at any time. And more over the data must be secure and must not be leaked. Privacy can be maintained in vehicles by confidentiality vehicles Identification. VANETs security must satisfy the requirements as authentication, integrity, non-repudiation, access control, privacy, data confidentiality and real-time guarantee [28]-[55].

*Retrieval Number: C5168098319/2019©BEIESP*
*DOI:10.35940/ijrte.C5168.098319*
*Journal Website: www.ijrte.org*



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b. **Heterogeneous vehicles Management issues in VANETs**

In future there will be large heterogeneous vehicles and their uneven connections area biggest computational issues of future VANETs.

c. **Network congestion control issues in VANETs**

The best way to avoid congestion in network is to exploit the availability of network resources to sustained overloads of network node and links. The impact of carrying packets or data, fast moving vehicles, higher rate of topology changing, higher variability in node changing, high variability in communication of network ensures the presence of congestion and its draw backs within the vehicular ad-doc networks [29].

d. **Network Volatility issues in VANETs**

In internet of vehicles the link of communication between vehicles is well-established for a period and the connections terminates as the vehicles network expands [66]. Thus, the possibilities of acquiring long connectivity of moving vehicles in VANETs are very low. Thus, imposing secure approaches depends on verifying identities are hard [30].

e. **Delay Constraints issues in VANETs**

Applications of VANETs related to safety and user comfort are very sensitive are time constraints and they shall have value of setback along with some amount of tolerance. Safe objectives can be developed to increase the Quality of Service (QoS) for VANETs [30].

f. **Co-operative Scheduling issues in VANETs**

Key issues in VANETs build link of exchange information between the different nodes. In co-operating scheduling which nodes should swap information between themselves, is the main challenging research areas in the VANETs design [31].

### B. *Routing Issues in VANETs*

Due to dynamic nature of moving vehicles in VANETs routing is always a key concern. Identifying of path and maintaining these paths in VANETs is also a very demanding task. VANETs go through a lot of internal and external tests due to dynamic nature. Internal challenges are highly moving vehicles and frequent changes in network topology etc. and External factors like effect of environment, effect of obstacles such as building etc. there are several routing algorithms and approaches proposed to overcome these routing issues. The concern in the routing area are defined to routing in VANETs are listed as following [8]-[50].

a. **Efficient Clustering**

Clustering is method of breaking down the network into groups of vehicles. These smaller groups of vehicles are known as clusters. Each and every cluster has a cluster head which mainly enables the communication link between cluster member and between different clusters. The nodes that provide the communication link to different cluster heads are called Gateway nodes. Therefore, clustering is responsible for end to end delivery and also decreases the delay, proper and timely transfer of data from one node to other node. Hence valuable Clustering is always the challenging issue in VANET and many clustering algorithm, there is always a need for efficient routing as these provides a routing scheme with very less delay, system scope, and lower computational complication. Designing such algorithm is an active research area in VANETs [31].

b. **Constant Topology Changes**

Key challenging issues in VANETs are designing of scalable and robust network. Many design have failed when the network sparse form high density mode to low density mode. An entire VANET scheme is scalable to different network and tough to topological changes and hence it's one of the emerging topic for the VANET routing situation [31].

c. **Varying Density and Velocity of Vehicles**

VANETs needs to broadcast protocol to speared information efficiently and reliably at specified location for Safety applications. The network sparse form high density mode to low density mode of traffic or from high mobility to low traffic mode. The unbounded network is also objective of research. The traffic load is low in rural areas. The network barriers occurs heavily due to this reason, mainly in peak hours the traffic is very high and thus network is congested and collision occurs in the network nodes.

d. **Weak in Connectivity and Performance of Network**

Weak in Connectivity and performance of Network is related to quality of service (QoS). A network with low delay for packet transmission, low retransmission and higher connectivity time can maintain QoS with distinct user and dynamic network platform is a concern task in VANET routing [27].

e. **High Mobility of Vehicles**

Moving vehicles are considered as nodes, connectivity between the nodes for data transmission is a challenging issue. Routing protocols for VANETs exists with the segregation and blending of network. A key challenging issue is establishing the link of communication between the nodes, different concept of supportive communication from wireless network theory may be applicable to VANET routing [31].

### C. *Scheduling Issues in VANETs*

A technique used on roadside data units to reduce the data access delay is called scheduling. The main aim of scheduling is the transmission of requests without any overhead. The various parameters like data size, data type, deadline etc. are used for scheduling algorithms. In order to access the data requests from a moving vehicle and to schedule these data in the RSUs various vehicle to RSU scheduling techniques were proposed. Data scheduling scheme is used to process the vehicle request with proper quality of service. In VANETs the user sends request to the roadside units RSU, in turn the RSUs designate the packet for every request. The RSUs process the data and sends the requested packet to the users based on the different QoS criteria. There are four major categories in data scheduling namely Request based scheduling, Time based scheduling, Deadline based scheduling, Hybrid based scheduling, and Priority based scheduling algorithms. Scheduling issues are stated below [52].

**a. Survival of the fittest**

This leads to the situation where the user with the good conditions gets frequent access to the shared resources, and also the location near to the base station gets more access and the location fare away from base station starve for resources in-spite of good channel condition and thus resulting in unfair scheduling in channel dependent techniques. Thus, an advance reserved scheduling technique which contributes to the fairness in the network is always the approach of scheduling algorithm [70].

**b. Delay in Reporting the Channel Quality Indicator (CQI)**

One of the very important issues of channel dependent scheduling is the high-performance operation of CQI. An appropriate awareness of channel quality is very important for high and quality performance scheduler operation. An active user repeatedly sends its CQI information to Base station (BS) in the network. The channel quality information is provided by CQI periodically by the terminals to eNodeB. Thus, eNodeB makes decision on resource allocation based on the terminal CQI information. The time taken by the user to send CQI information and time take to receive by BS differs. The time differs benefits the BS to get a very good knowledge of the channel condition and performance of scheduling. This can also create an overhead for users with limited power consumption. This is a problem for the location where the user is no longer present, and BS keeps on sending the channel condition [53].

**c. Average end-to-end delay**

The average end-to-end delay can be achieved by computing the mean of all successfully delivering packets. Suppose the path keeps on increases between the source and destination node, so the possibility of data drops ration increases. The average end-to-end delay includes the possibilities of delay in network including buffering route discovery latency, retransmission delays at the MAC, propagation and transmission delay [54].

**d. Average throughput**

Average number of successfully delivered data packets to the destination node per second on a communication network is called average throughput [54].

**e. Routing overhead**

Average ratio of routing-related to transmissions of data is known as routing overhead [53].

**f. Bandwidth Bound**

It determines the minimum rate at which the packets are transmitted [53].

**g. Delay Variance Bound**

The time difference of the arrivals of two successive packets at the destination node [70].

**h. Packet delivery ratio**

It gives the threshold of performance and evaluation pattern is determined by the ratio of the number of packets reached to the destination node to number of packets forwarded by source node.

**i. Load Information**

Load Information is used to indicate congestion and is determined by the ratio of the measured arrival rate and service rate.

## VII. CONCLUSION

In this paper we introduced to VANETs which are the applications of MANETs. We also explained the difference between VANETs and MANETs. Section 2 presents Standard wireless WAVE, Section 3 presents types of routing topology and its advantages and disadvantages. Section 4 presents challenges in VANETs and these challenges are also new area of research. Section 5 presents applications of VANETs and the main aims of this application are related to maintaining safety on road, and Section 6 Explains Routing Issues , Scheduling Issues and VANETs challenges which are the fastest emerging area of research on intelligent internet of vehicles .

## ACKNOWLEDGEMENT

The authors would like to thank Dr P Shyamaraju, Chancellor, REVA University for all the facilities provided to carry out the research activities. Also, the authors would like to thank Dr Mohammed Riyaz from school of ECE, REVA University for their continuous support and encouragement.

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*Retrieval Number: C5168098319/2019©BEIESP*
*DOI:10.35940/ijrte.C5168.098319*
*Journal Website: www.ijrte.org*



*Published By:*
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**Dr. Manjunath R. Kounte** is an Associate Professor in School of Electronics and Communication Engineering, REVA University, Bangalore, India. He has over 12+ years of Teaching, Research and Administrative experience. His teaching interests are Mathematical Oriented and Programming Subjects like Circuit Analysis. Dr. Kounte has received "Best Teacher Award" from REVA University for the Year 2017. He has over 16 Publications in International Conferences and over 8 Articles Published in reputed International Journals. His research interests include Machine Learning, Neuromorphic Vision Systems, Cognitive Neuroscience, and Signal Processing. Dr. Manjunath R Kounte is a Senior Member of IEEE, USA, Life Member of ISTE, India and Life Member of IETE, India. Dr. Kounte has mentored over 12 UG Projects and 12 PG Projects. One of the Student group under his guidance has received a grant for research project from Vision Group of Science and Technology, Govt of Karnataka. He has also guided a student group who received grant from Karnataka State Council of Science and Technology (KSCST). Currently he is guiding 4 research scholars and looking for active researchers interested to do PhD under in his guidance in the area of Machine Learning, Deep Learning, Artificial Intelligence, Internet of Things, Computer Vision, Machine Vision, and Computational Cognitive Neuroscience. More details about him can be found in his website https://www.kountesir.com/.