# A Survey on Protocol Stacks for Vehicular Ad hoc Networks

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**Abstract:** VANETs is embryonic equipment with encouraging future including great challenges. As of late vehicular correspondences frameworks entranced much consideration, fuelled to a great extent by the rising enthusiasm for Intelligent Transportation System. (ITS) It focuses at the basic issues like Safety of public and congestion of traffic by assimilating data and communication technologies into infrastructure of transportation and vehicles. It also includes the challenges along with the characteristics faced at the VANETs. Standard used in VANETs is also conversed in the paper. This paper discusses about the various layers in OSI model and the challenges occurred at layers and also present the possible outcomes to overcome those challenges.

***Keywords: VANETs, PHY layer, MAC layer, Cross-Layer***

## 1. INTRODUCTION

**V**ANETs are an uncommon event of versatile impromptu system with predefined courses (streets). It provides an efficient solution for the traffic jam by merging Technology and improvements. Regardless, the immediate connection among vehicles utilizing an Ad Hoc arrange, alluded to as IVC (Inter vehicle communications) or vehicle specially appointed systems (VANETs). The Significant objectives of these activities are to enhance road safety and transportation efficiency and to lessen the influence of transportation on environment as well. [13] VANETs have an important class of application for instance reducing the no. of miss-happenings or accidents can in turn reduce the traffic congestion, which could reduce the height of environmental impact. [13] Due to essentiality of these goals for both the person and nation various projects are on-going, or recently were completed and various consortia were held to discover the budding of VANETs. [13] Despite of the way that VANET is a kind of wireless ad hoc networks, it has its remarkable features by its high movement of nodes and unreliable channel connections. These attributes present many testing issues including routing, data dissemination, data sharing and security issues. For instance, finding and updating routes becomes exceptionally different in VANETs. [30] VANETs Support two forms of communications i.e. Vehicle-to-Vehicle (V2V) communication and Vehicle-to-Infrastructure (V2I) while V2V is within the vehicles, and V2I is transmitting information between a vehicles and Road Side Units (RSU's) that is installed in road. The communication prerequisites for cooperative security applications are the most stringent for VANET. The first necessity is low-latency dissemination of messages amid vehicles and in between vehicles and Infrastructure VANETs can be employed as various safety and Non-Safety applications which include road safety, improve efficiency of traffic and also provide entertainment to the passengers. [20]


Fig 1 Depicts communication in VANETs

**Safety Applications:** Most alluring gathering of uses for VANETs is safety applications. To preserve a planned distance from the mischances, road safety applications can assume a critical job. Indeed, even for the situation if the mishap is unavoidable, these merits of VANETs can minimize the consequence of mischances. Safety applications are delay sensitive and they mainly depend on reliable Vehicle communication. All safety-based applications entail the trading of messages with different vehicles. The information in these applications is acquired from sensors or different vehicles. The information is handled in every application and after preparing it sends messages to adjacent vehicles or to the infrastructure.

**Non-Safety Applications:** It can be detached into various sub-classes like traffic suitability efficiency applications, infotainment applications and comfort/entertainment applications it may include infotainment. [20] The following work is organised as Section 2 presenting the characteristics and the challenges that occur in VANETs. Section 3 presents the wireless standards used in VANETs. an then in section 4 talk over the protocol stacks for VANETs and some challenges that is faced by each layer Section 5 talks about possible approach and as well the proposed algorithm to overcome the problems in layered architecture of VANETs. Finally section 6 accomplishes this work.

## 2. Characteristics of VANETs

It has a very bizarre characteristics and special behaviour in comparison to other communication networks:

**Unrestrained Transmission Power**: Not at all like MANET node where energy is a chief restriction consideration, VANETs have enough vitality and figuring power. [23]

**Higher Computational Capability**: Operating vehicles afford substantial computing, communiqué and sensing capabilities. [23]

**Availability of Geographical Location:** With the availability of GPS, as it can provide real position (Latitude, Longitude and altitude) direction, velocity and precise time. [23]

**Mobility Model:** One of the most significant issues used to analyse the protocol behaviours in VANETs and gives the real and accurate information. [23]

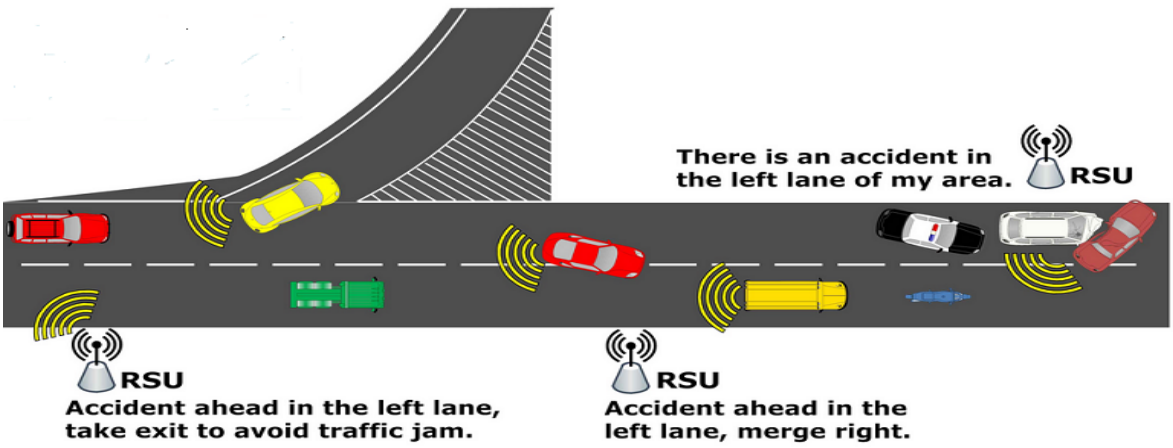


Fig 2 Safety and Non- Safety messages are exchanged

### 2.1 CHALLENGES IN VANETs

**Dynamic Topology:** By the perpetually dynamical development of automobiles in VANETs, the system topology changes quickly and habitually, and accordingly, the quality of channel and the reliability of link is influenced radically, rendering the conventional MANET incompetent. Moreover, the variation in the topology of VANETs which brings erratic wireless resource contention resulting in difficulty in transmitting safety messages. [30].

**Lack of Central Coordination:** As it is infrastructure-less network, no access point or central coordinator is available.

**Frequently disconnected network**: The linkage between VANETs could be altered often. Particularly once the density of vehicles is low it has advanced likelihood that the network is detached. In few solicitations, such as ample Internet access, the problem should be abolished. [30]

**Hard delay constraints**: VANETs based area, the network need not need high data transfer rather it has hard delay constraints. For example, in an automatic highway system, when brake is applied it should be transmitted within a specified time so that it may avoid car crash event happens, the message should be transported and arrived in a certain time to avoid car crash. [30]

## 3. STANDARDS FOR WIRELESS ACCESS IN VANETs

Standards simplify development of product helps reduce cost and empowers users to look at the contending items. With help of Standards, the approach of new items can be confirmed to allow the rapid execution of innovative technologies. Several standards that narrate to wireless access on vehicular environment are-

### 3.1 Dedicated Short-Range Communication (DSRC)

DSRC is a short-range communication service that was support to vehicle-to-vehicle communication and vehicle-to-roadside communication. Such Communication concealment a widespread choice of applications including vehicle-to-vehicle safety message, traffic information, toll collection and several others. Its chief area is to avail High-Data transfer with lower latency in communication. [31]

### 3.2 Wireless Access in Vehicular Environment (WAVE)

It uses orthogonal frequency division multiplexing (OFDMA) to break the signal into various narrowband channels to provide data payload communication capability. [31].

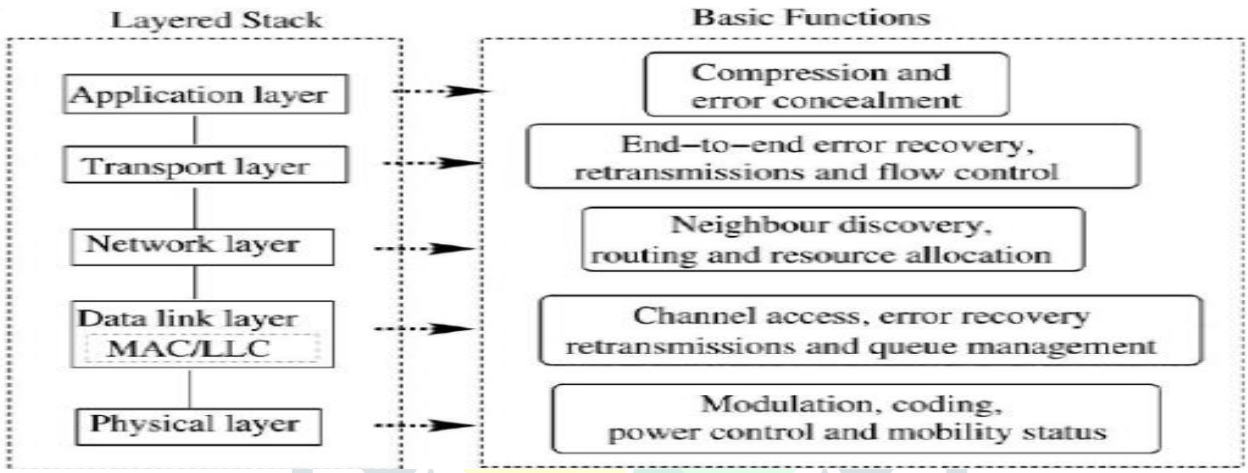


Fig 3 Layer Stack and the functions at each layer (25)

## 4. LAYERED ARCHITECTURE IN VANETs

The OSI display is outstanding to most peruse which bunches communications functions into the seven logic layers. The session and presentation layers are excluded here and mentioned layer can be further classified in this architecture as discussed below, generally design of VANETs may contrast from region to region. [20]

**4.1 PHYSICAL LAYER :** The PHY layer signifies the edge between MAC layer and the media that permits sending and receiving frames. PHY is basically dependable of specification of hardware, conversion of bits, signal coding and data formatting. It made out of two substitute layers The first is the Physical Layer Convergence Protocol (PLCP), it is likewise an intermingling procedure that changes the Packet Data Unit (PDU) touching base from the MAC layer to form an OFDM outline. The second is the Physical Medium Access (PMD) or, in other words physical transmission medium, for example, radio channels and fiber joins. Its assignment is to handle encoding of data and accomplish the modulation. [1] The PHY layer necessity is requesting a direct result of its special nature VANET is a solid and powerful in a quick moving condition to decrease the impact of signal that mutations in high speed bring (especially Doppler effect produced at high speed). Though, it must support high speed transmission to support multi-hop connection and. guarantee sufficient data trade. The current Physical layer technolgy based upon 802.11 and UTRA-DD techniques. [1]

### 4.2 IEEE 802.11p

The IEEE 802.11p consents use of 5.9GHz with spacing of channel 20MHz. 10MHz and 5MHz. IEEE operates on 9 channels. It is the enhancement of 802.11 which is utilized in Intelligent Transport system. This incorporates the information trade between

fast vehicles and between the Vehicles and the roadside foundation, supposed V2X correspondence. It provides a method of separating traffic streams in many priority classes in support of QoS. It is also useful to automobiles: a more advanced handoff scheme, mobile operation. Enhanced security, identification, and peer-to-peer authentication and most highly communications in automotive-allocated 5.9 GHz. [26]

Table1 IEEE 802.11p Physical Layer [26]

| PARAMETER | VALUE | SPECIFICATIONS |
|---|---|---|
| Frequency | 5.9GHz (5.850-5.925GHz) | The choice depends upon interoperability and propagation tests. |
| Channel Bandwidth | 20,10,5 MHz | |
| Transmit Power | 20dBm | Recommended value for V2I within a range of 1km. |
| Default Rate | 3Mbps-27Mbps | Robust modulation scheme. |

### 4.3 CHALLENGES AT PHYSICAL LAYER

The challenges which occur at physical layer are due to the mobility of vehicles:

**Doppler shift:** After a source vehicle and a destination vehicle are contact to each other frequency of the received will not be same as the source, once moving towards each other, frequency of received signal is greater than that of source and it decreases when approaching each other. This is known to be Doppler shift which has an extraordinary consequence in vehicular networks because of VANET movement characteristics. Amount of frequency changes due to Doppler depends upon the relative motion between vehicles and the propagation velocity of the signal. [1]

**Multipath fading:** When radio wave follows multiple route to get from to get from a transmitter A to a receiver at point B there is a chance that a signal will experience positive or else negative interference at point B due to difference in travelling time along the different routes. Negative interference reduces the signal level, positive interference increases the signal level which results in varying signal at the receiver. This is referred as Multipath fading due to mobile nature of VANETs. [1]

**Network Coverage:** In accordance with the WAVE the maximum coverage area is about is 1km, so when we use VANETs in different environment where the quantity and vehicle's density is very low. In this multi hop communication won't be pertinent. Apparently, a more communication distance is needed between the vehicles. [1].

**4.4. MAC LAYER:** MAC protocol straightforwardly controls packet sent and received via channel. The protocol specifically influences the efficiency of utilization of constrained radio resource thus VANET execution plays a conclusive role. The MAC layer needs to address the common problems and resource allocation of the hidden and exposed terminals. The specific applications environment and business needs of VANETs faces one particular problem: cars usually move fast. Hence, the highly dynamic structural alters the network topology need to facilitate high priority real-time traffic safety. Based on the vehicle communication network system, MAC protocols requisite to have following characteristics 1. Supports high –speed mobility vehicle 2. Reliability of Communication 3. Good scalability 4. Support high bandwidth utilization 5. Support fully distributed networking 6. Provide fair communication opportunities for each user and 7. Provide well-organized and updated broadcasts mechanism. Various MAC problems in VANET are there such as Priority-based issues, random response and dependability. [10]

**MAC Approaches** In 2008, Ehsan et.al talked about the new scheme in MAC which is centred on the 802.11 DCF which adapts the minimum contention of each node according to variations in speed this was proposed because of problem of fairness in VANETS raised owed to fluctuating speed of nodes. [17] Then, in the same year M.J. Booysena et.al overviewed the various approaches of MAC layer for V2V communications. And he also presented various Self-Organizing approaches such as TDMA which is used in aviation and Marine environments. [3] Recently, in 2014 Duc Ngoc Dang (2014) introduces a new technique named as HER-MAC (Hybrid multi -channel) which combines the two access techniques such as TDMA and CDMA access techniques which provides reliable and safety messages which broadcasts through TDMA scheme without collision in Control Channel (CCH) in the reserved time slots. [22] In 2015, Mohamed Hadded (2015), discussed about the improvement of safety applications which requires reliable MAC protocols and these MAC protocol had a dependency on TDMA schemes. And deeply studied the MAC protocols and draws a conclusion that cluster-based MAC protocols reached the QoS (Quality of Service) required. [11]Recently in 2016, Vandana Jayraj discussed about the challenges occurred at the Vehicular ad hoc network such as lack of central co-ordinator, scalability author draws a conclusion that Hybrid MAC use of characteristics of two channel schemes and increases the performance when traffic load is generated. It provides an extensive outline of Hybrid MAC protocols. [1]

### 4.6 CHALLENGES AT MAC LAYER OF VANETs

**Dynamic topology:** Because of the endlessly unique development of vehicles in ad hoc network, the system topology changes quickly and every now and again, and subsequently, the quality of channel and connection quality is influenced. [16] [19]

**Exposed and Hidden terminal:** The hidden terminal problems where two nodes are outside of each other's range, but both try to communicate with a node which is in transmission range. This problem is expected in pure V2V environments, there is no centralized communication coordination. The hidden terminal problem results in message collisions. [3]

**Distribute Communication:** The boundary of centralized communication providing by RSUs is so obvious that maximum requirements in VANETs rest on distributed multi-hop inter vehicle communications. However, this network is more probable to be detached because to the random mobility of vehicles, marks in the unscrupulous information exchange that cannot see the state of main requests. [19]

**Redundancy:** In direction to decrease the redundant information while transmitting driving related messages to the vehicles, seeing the importance of information goes along way, such as transfer information only to vehicles in a specific range, which enables the transmission to be efficient and effective. If a definite data is transferred globally it will create a plenty of redundant message which create a problem [19].

**4.7 NETWORK LAYER:** On the topmost PHY and MAC of the specific wireless technologies, the network layer facilitates wireless multi-hop communications centred on geographical addressing as well routing and implements purposes definite to vehicular communications alike congestion control also vehicular movement dissemination. In respect to come across the necessities in heavy vehicle densities, network layer should deliver appropriate algorithms and schemes. Several applications of VANETs censoriously trust on routing protocols. The Network Layer is more concerned with the getting the packets from source to the destination. Network layer is the lower layer and deals with the end to end transmission. The purposes of the Network layer are: to provide IP addresses to end hosts, also to establish a path between source as well as destinations, proactively or reactively. [29]

### 4.8 CHALLENGES AT NETWORK LAYER:

***Security and Privacy:*** As we know the security and privacy are serious challenges in Network Layer, so we should send data in an encrypted form. [14]

***Routing Issues:*** The algorithm used in routing must agreement by the subsequent issues-Correctness Simplicity, Stability and Fairness and optimality. [14]

***Congestion:*** Network layer agreements with the congestion problem, when the packets in the network are not properly routed. [14]

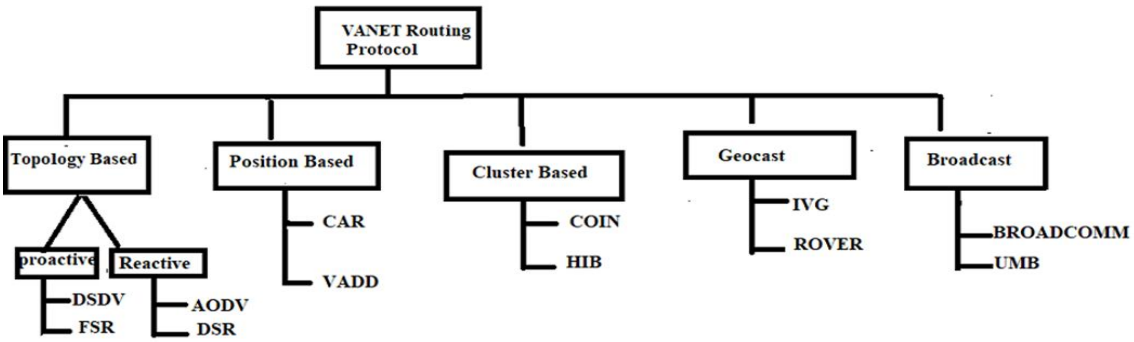


Fig 4 Taxonomy of VANET Routing Protocol

Table 2 Routing Protocols

| *Classifications of Routing Protocols* | *Merits* | *Demerits* | *Examples* |
|---|---|---|---|
| ***A. Topology Based*** | | | |
| ***Proactive*** | Table-driven<br>Low Latency.<br>No Route Discovery.<br>Experience a min delay.<br>[8] [4] [24] | More Bandwidth utilization.<br>High Capacity.<br>Large overhead. [8] [4] | Destination Sequenced Distance Vector (DSDV), Fish eye state Routing (FSR). |
| ***Reactive*** | Routes on-demand.<br>Routing overhead is less.<br>Less Bandwidth. [8] [4] | Delay can substantially large.<br>High Latency. [8] [4] | Ad-hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR). |
| ***Hybrid*** | Higher Efficiency.<br>Scalability. | Maintenance is required. | Zone Routing Protocol (ZRP), |
| ***B. Position Based*** | Based upon the geographic location.<br><br>Suitable for high mobility ambience, Less overhead.<br>[8] [4] [24] | Need of a position finding services. [8] [4] [24] | Connectivity Aware Routing (CAR), Vehicle Assisted Data Delivery (VADD) |
| ***C. Cluster Based*** | Cluster head broadcasts the packets to all nodes results in improved scalability.<br>Packet Delivery Ratio is good.<br>Minimum Routing Overhead. [8] [4] [24] | Delays are experienced in highly dynamic networks.<br>[8] [4] [24] | Clustering for Open IVC Networks (COIN), Hierarchical Cluster based Routing (HCB) |
| ***D. Broadcasts Based*** | Performance is better in small no. of nodes.<br>Broadcasts safety related messages quickly and efficiently. [8]<br>[4] [24] | Redundancy.<br>Hidden node problem.<br>High probability collision of message. [8] [4] [24] | BRAODCOMM, Urban Multi Hop Broadcasts (UMB). |
| ***E. Geo cast Based*** | Delivers messages from source to destination with in a specific geographic region.<br>Routing collision is reduced. [8] [4] | High latency.<br>Applicable for large networks.<br>Packet transmission delay due to network issues. [8] [4] [24] | Inter vehicle Geo cast (IVG),<br>Robust Vehicular Routing (ROVER). |

**4.9 TRANSPORT AND APPLICATIONS LAYER:**

The Transport layer is centre of convention pyramid. The Transport layer forms on network layer to distribute data transport from a process on source machine to a process on destination machine with a desired level of reliability. The Transport layer should care end-to-end connection with VANETs. TCP and UDP are the protocols used at this layer. In contrast of extra ad hoc networks, VANETs current more liable mobility pattern. TCP considered delivering a dependable end-to-end byte stream over unreliable internetwork. In VANETs, numerous unicast applications require a comparative benefit as given by TCP, i.e. a dependable and all together information conveyance. Lamentably, TCP displays a poor execution in case of high movement and successive topology changes. Vehicle Transport Protocol (VTP) is a protocol for unicast applications in ad hoc networks that tests the network and utilizes the factual information to increase the performance when a connection is broken. Mobile control Transport protocol (MCTP) is another protocol centred on the principles of ad hoc TCP protocol and its main area to deliver end-to-end QoS between a vehicle and an internet and through roadside infrastructure. The above discussed Transport Protocols are planned for the application that requires unicast routing, But VANETs new approaches requires multicast communication which is not centred on outmoded transport protocols. Main challenging issue is to design multicast communication which provides reliable transport protocol. [7] Application layer is a reflection layer that indicates a shared communication among protocols and interface methods utilized by the hosts in a communication network. In application layer protocol it should reduce the delay on end-to-end communication. Application Protocols may likewise be intended to create showcasing devices for business. For Example-eateries, lodgings, can communicate their data in VANETs and intrigued drivers or travellers can share an inquiry to get more data. Applications conventions may likewise be utilized in Business exchanges. Over again it requires Delay-efficient and

reliable systems. Vehicular Information Transport Protocol is an application layer communication protocol painstaking to care the formation of a distributed, ad hoc service infrastructure in VANETs. The VITP infrastructure can be utilized to give activity arranged administrations to drivers, utilizing data recovered from vehicular sensors. [7].

## 5. CROSS LAYER DESIGN FOR VANETs

In Traditional OSI display it strict the limits among layers and are implemented to keep the information with a given layer. Cross Layer enhancement expels such bounds to permit correspondence between layers by letting one layer to get the information of another layer to trade data and empower cooperation. The Paradigm of cross layer configuration is acquainted as an option with the unadulterated layered design to create correspondence conventions. Customary layered design neglected to address the difficulties in VANETs.

Table 3 Proposed Various cross Layer Design Approaches

| Cross Layers | Proposed Algorithm | Objectives |
|---|---|---|
| PHY-MAC Layers | SNR triggered and loss triggered was Proposed by Camp and Knightly. [25] | SNR based achieves the higher throughput and loss triggered determines the packet loss rate. [25] |
| PHY-MAC-Network Layers | 1. Link Residual Time (LRT) Proposed by Sofra et.al. [5]<br>2. Signal Assessment Based Route Selection for OLSR (SBS-OLSR) Proposed by Singh et.al. [28] | 1. Link Residual Time (LRT) used to assess life-span of link. [5]<br>2. In SBS-OLSR uses Multi-point Relays (MPRs) links fast broadcasts topology information. [28] |
| Network-MAC Layers | 1. Cross Layer Ad-hoc On-demand Multipath Distance Vector (R-AOMDV) Proposed by Chen et.al. [6]<br>2. PROMPT Proposed by Jarupan et.al. [15]<br>3. CVIA Protocol Proposed by KorKmaz et.al. [18]<br>4. Dynamic Backbone Assisted MAC (DBAMAC) Proposed by Bononi et.al. [2] | 1. Better than AOMDV, but not appropriate for VANETs and experience high packet delays. [6]<br>2. Provides better flexibility to regular changes in network topology. [15]<br>3. Resolves hidden terminal issues and interference effectively. [18]<br>4. It aims to resolve the latency and overhead problems. [2] |
| Transport-MAC Layers | 1. TCP Contention control (TCTC) Proposed by Hamadani et.al. [12] | Change the measure of information in the framework dependent on the contention level and throughput experienced. [12] |
| Transport-Network Layers | 1. Explicit Link layer notification (ELFN) Proposed algorithm.<br>2. Ad-hoc TCP Proposed by Liu et.al [21]<br>3. Vehicular Transport Protocol cross layer design protocol. [27] | 1. Aware sender about Link Failure.<br>2. To enhance the throughput of the TCP. [21]<br>3. It makes utilization of data procured by the relay nodes to congestion control mechanism.[27] |

**6. Conclusion:** Improving the safety of road in VANETs requires efficiency and consistency of protocols. The initiation of vehicular networks comprise of vehicles fortified with the verge to made the wireless communications and self-organize into a collaborative mesh, which turns up into a numerous of applications that can make road travel safer, more efficiently. The distinct features of VANETs lead to specific networking problems, demanding design which is of fully distributed Protocols. In this of work it brought the discussions on the main characteristics of vehicular networks, architecture details, constraints of layers, protocols, Applications and also discussed about the challenges occurred at each layer. The exchange of information through wireless in VANETs is more apt to the mistakes, way misfortune, Hand-offs. To overcome these issues Cross layer Design is the key to minimize these errors in traditional layered structure, Cross-layer design provides high performance of improvement and make it more demandable. Cross-layer configuration gives genuine answers for the difficulties happened at the layered structure. There are certain challenges in research field that essential to be assimilated into a deployment of real scenario since innovation heavily requires the acceptance of technology.

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