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Survey on Handover techniques in VANETs

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Abstract- The ITS (intelligent transport system) is working on designing intelligent vehicles with the help of Vehicular Adhoc Networks (VANETs). The motivation behind the VANETs is to provide a safe journey to the passenger by avoiding hazardous situations on the road like accidents and to provide communication between the vehicles on the move in order to transfer different types of messages, be it emergency or infotainment messages. VANETs consists of V2V (vehicle-to-vehicle), V2I (vehicle-to-infrastructure) and hybrid communication with unique features like Rapidly Changing Network Topology, Unbounded Network Size, Delay-sensitive Data Exchange, Potential Support from Infrastructure which makes it different from the other adhoc networks like MANETs. Due to these features the routing protocols used for other adhoc networks cannot be directly used for VANETs. Various new modified routing protocols are designed for VANETs. In this paper we will be discussing a little about the routing protocols for VANETs, covering almost all the major protocols being used in VANETs. The major issue which we are dealing in this paper is handover. Handover is a technique for mobility management in fast changing VANET which makes it important topic for research, since mobility management is always been a major issue in adhoc networks. There is a good amount of research information available on the mobility management for adhoc networks and for VANETs but we have not found much information about handover in VANETs. So in this paper, we have discussed about different handover techniques used for VANETs and improvements in those techniques from time to time. We have covered almost all the handover strategies and improvements made in them in the past one decade. We have represented all the handover techniques in a tabular form based on the different characteristics and features. In the end we have also given the scope which will help future researchers in their research. The paper is going to be a help to the researchers new in the field.

Keywords- V2V, V2I, DAD, RA, RSU, proactive, reactive, hybrid, unicast, multicast.

I. INTRODUCTION

Vehicular adhoc networks as the name specifies is the form of adhoc network which is used in enhancing road safety and driving comfort. The vehicles are used as nodes to form a mobile ad hoc network using which the various messages such as safety messages or entertainment messages are disseminated. VANET is characterized by features like self-organized, self-managed, short radio transmission range, delay sensitive data exchange and low bandwidth network [13]. It is similar to adhoc networks with a few different features like enough energy and computing power, highly dynamic topology which frequently keeps on connecting and disconnecting , predicted mobility model and communication environment. Within Vehicular Networks a vehicle is considered as a node of the network which is equipped with multiple interfaces. VANETs provide access to different technologies such as Global Positioning System (GPS), Wi-Fi, WiMAX and UMTS. In VANETs vehicles are able to communicate among them under adhoc mode also known as V2V communication and with their base stations (access points or point of attachments) under the infrastructure mode (known as V2I communication [1]). The V2V communication is based on the dedicated short range communications (DSRC) technology; while the V2I communications based on GPRS/3G, Wi-Fi or WiMAX. Another kind of communication known as hybrid vehicle communication is also there in which communication occurs among vehicles as well as between vehicle and nearby fixed infrastructure of RSUs. VANETs are broadly covered under the area of ITS (Intelligent Transportation Systems) on which a large amount of research is going on in different parts of the world. There are a number of projects undertaken by different countries like Japan, U.S, Europe which are working on ITS [13]. The applications of using vehicular communication networks includes not only improving road safety by passing the critical information in time but these networks can also be used for entertainment purposes like VoIP call, browsing web, download data, watch TV, and get road traffic information or real-time weather report from Internet through wireless communications [14]. VANETs can also be used to provide location based information like fuel pumps, first-aid, local commercial information like sale in the specific area, restaurants. Due to all these applications VANETs have received a considerable attention both from industry and academia. There are a number of research challenges in VANETs like low latency architecture, mobility management, privacy and security etc.

The paper below is distributed as: unit II is going to discuss about various types of routing protocols being used in VANETs since the routing protocols used for MANETs can't be used for VANETs. Unit III is going to give the classification of various handover schemes available with VANETs. After that there is a table which gives the list of various handover techniques in VANETs along with their features, pros and cons. Unit IV provides a conclusion and the future work which can be done in this specific area.

II. ROUTING PROTOCOLS FOR VANET

The available routing protocols used for MANETs can also be used for VANETs but VANETs require a technique that will assign distinctive logical addresses to vehicles which these routing protocols don't assure. Thus, in an exceedingly VANET atmosphere, various existing addressing algorithms employed in MANETs are rarely appropriate and requires modifications to the existing protocols or some new protocols to be designed. The routing protocols in VANETs can be categorized into several types [2] [3]: unicast routing, broadcast routing, position based routing (geographic routing), cluster-based routing, multicast and geocast routing, and topology-based routing. These categories further consist of sub categories as described below:

- Broadcast routing protocols broadcasts the packet over the entire network inside a domain [17]. These protocols are used in safety related issues or emergency situations. Ex:- Distributed vehicular broadcast protocol (DV-CAST), Position aware reliable broadcasting protocol (POCA), Preferred Group Broadcast Routing Protocol (PGB) and Density aware reliable broadcasting protocol (DECA), Distributed Vehicular Broadcast Routing Protocol (DVCAST), BROADCOMM, Urban Multi-hop Broadcasting Routing Protocol (UMB), Vector Based Tracing Detection Routing Protocol (V-TRADE), Edge-Aware Epidemic Routing Protocol (EAEP), Parameter Less Broadcasting in Static to Highly Mobile Wireless Ad-hoc Routing protocol (PBSB).

- Position based routing also known as geographic routing use the position based information to carry on the forwarding of the packets [15]. These protocols mostly come under the category of unicast routing protocols which transmit data from single source to a single destination via carry-and-forward or wireless multi-hop transmission techniques. These protocols use GPS for deciding the position of the nodes and for packet transmission. These protocols are further divided into two sub categories: position based greedy V2V protocols and delay tolerant protocols. Position based greedy V2V protocols are also known as min delay protocols. These protocols requires that the node must have knowledge about the position of the neighbor and the destination node. The main aim is to transmit packets between the source and destination as early as possible. Ex- Greedy Perimeter Coordinator Routing (GPCR), Diagonal-Intersection-Based Routing Protocol (DIR), Connectivity Aware Routing Protocols (CAR), Anchor-Based Street and Traffic Aware Routing Protocol (ASTAR), ROMSGP (receive on most stable group-path), GVGrid, Vehicle Assisted Data Delivery (VADD). The delay tolerant protocols are used in sparse networks having fewer number of nodes for communication. These protocols satisfies user defined delay requirements with a low level of channel utilization. Ex- Motion Vector Routing Algorithm (MOVE), , Static Node Assisted Adaptive Routing Protocol (SADV), Distance routing effect algorithm for mobility (DREAM)

- Cluster based routing protocols works on the principle of cluster head and provides good scalability in large networks. Ex- Clustering for Open IVC Network Routing Protocol (COIN), Cluster-Based Directional Routing Protocol (CBDRP), Cluster Based Routing Protocol (CBR), Hierarchical Cluster Based Routing Protocol (HCB) and LORA_CBF.

- Geocast routing is a location based multicast routing [16]. It works on the concept of ZOR (Zone of reference), ZOF (Zone of forwarding) and packets are delivered to all the nodes in ZOR. Ex:- Inter-Vehicle Geo-cast Routing Protocol (IVG), Direction-Based Geo-cast Routing Protocol for Query Dissemination (DG-CASTOR) and Robust Vehicular Routing Protocol (ROVER), Dynamic Time–Stable Geo-cast Routing Protocol (DTSG), Distributed Robust Geo-cast Routing Protocol (DRG), Mobicast routing.

- Topology based routing protocols decides packet forwarding on the basis of the links of the network. These topologies are of further divided into two types' proactive routing protocol and reactive routing protocol. Proactive is the one in which the routes are maintained all the time irrespective of the communication requests. Ex: - FSR, LSR, Destination- Sequenced Distance Vector (DSDV), optimized link state routing (OLSR), topology broadcast based on reverse-path forwarding (TBRF). Reactive is the one in which the routes are created only when required either by the receiver or by the sender. Ex- Dynamic supply Routing (DSR), Temporally Ordered Routing Protocol (TORA), Ad hoc On-demand Distance Vector Routing (AODV), PGB, zone routing protocol (ZRP).

A few researchers have classified routing protocols on other criteria also like height based routing protocols, geographical cluster based protocol, type of communication between nodes but the above defined are the most commonly used and researched protocols

III. HANDOVER TECHNIQUES FOR VANET

In communication handover is a process of switching from one area of coverage or cell to another area of coverage or cell in case of weakening of a call in current state. In case of VANETs handovers means change in the point of attachment (PoA) of a mobile node (vehicle) [4]. Handover management aims to maintain the active connections when MN changes its point of attachment. Handover is the technique used for improving the mobility in ad hoc networks. Vehicle communicates with road side units (RSUs) directly or through other relay vehicles (RVs) in V2I and HV communication modes respectively. When a vehicle enters a new area of RSU/RV leaving its current coverage area of associated RSU/RV handover is required. Handover is also used as a process for improving the QoS of adhoc networks.

A basic handover process consists of three main phases: measurements, decision and execution.

- Measurement phase also known as network analysis phase is the phase in which a Mobile station can discover several wireless networks based on broadcasted service advertisements from these wireless networks. The mobile unit scans for these messages on assigned channels and creates a list of APs prioritized by the received signal strength [5] [6]. The scanning method here is categorized into two standards: passive and active. In active scanning the station will not only listen to the messages coming from the access points but also send messages to them. Passive scanning is the one where the station just listen to the messages from someone else. A lot of research is there on the scanning techniques that can be used for scanning the access points.
- The next phase in handover is decision making, in this phase the station will decide when and to whom the handover should be performed.
- The last step is the execution in which the actual transfer of control takes place. The present network transfers the necessary routing information and other contextual information about the station to the next network.

Handovers are not a new area of research in adhoc networks. Since decades researchers are working on improving the handover process for improving the mobility management. Although VANET is the new field of adhoc networks so handovers in VANET is not much discussed. Researchers have ignored the topic of handover assuming that handover doesn't take significant time and doesn't affect the overall process of management. No doubt since the last decade a lot of work is going on in this field. In this section, we will discuss different handover schemes and improvements on those schemes. In the next section we will present a tabular representation of various protocols used for improvement of handover. Before that let us discuss about the classification of handovers. Handovers can be classified broadly on different criteria's. A few classifications are given below:

•Imperative handover and alternate handover: Imperative handovers occur due to technological reasons only and are necessary to perform, otherwise there can be loss of connection or performance. Imperative handovers can be of two types: proactive or reactive. Reactive handover responds to changes in the low-level wireless interfaces. Reactive handover is further of two types: anticipated and unanticipated handovers [50]. Anticipated handovers are soft handovers that describe the alternative base-stations to which the mobile node may handover. In unanticipated handover there is no alternate base station for a mobile node to handover in the situation when it is heading out of the range of the particular point of access.

Proactive handover are the soft handover techniques which can be of two types: knowledge based and mathematical model. Knowledge-based are the ones which mostly involves physical reading of the area involved. In these models the mobile node attempts to know beforehand the signal strength of available wireless networks over a given area such as a city. In the mathematical model mathematical calculations are done on the basis of velocity and direction of a point for calculating the point when handover should occur and the time that the mobile would take to reach that point. Proactive handover is known to generally outperform reactive handover. Since the proactive approach basically depends on predictive information which may be unreliable in some cases the reliability and practicality of this approach is questionable.

Alternate handovers are the ones which occurs due to some other reasons other than technological discussed above. It can be on the basis of preferences of the network like prices or incentives or user defined issues.

• Horizontal handover and Vertical handover: In case of horizontal handovers, the next point of access is of the same technology as the previous. For example, WiMax to WiMax or WiFi to WiFi. But, in vertical handovers the new point of access is of different technology compared to the previous one. Vertical handovers comparatively gained more attention because of the QoS issues involved between the two networks.

• Hard handover and Soft handover: Hard handovers, are the one's in which the connection to the new PoA is made only when the connection to the previous PoA is broken that's they are also known as break before make. But, in case of soft handovers the connection to the new PoA is made before the connection to the previous PoA is broken also known as make before break. Hard handovers leads to more disruption comparatively. Hard handover has less handover time compared to soft handover. Hard handover provides lee reliability compared to soft handover.

• Downward handover and Upward handover: Download handover is the one in which communication in the mobile node is going from network of large coverage area to a network of smaller coverage area ex: from 4G network to WLAN. Upward handover, is the one in which the communication on the Mobile node is moving from smaller coverage area to network of larger coverage area. Ex: from a WiFi network to a 3G network.

- Network-based handover and Client-based handover: client-based handover is the handover in which client is responsible for execution of handover. Network-based hand over is the one in which the network is responsible for execution of the hand over. There is another type of handover known as client assisted handover which is combination of the two. In this handover the client takes the handover decision in cooperation with the network.

There can be other types of handovers based on the characteristics of the networking device, like RV (relay vehicle) handover, Source vehicle handover. There can be intra RSU (road side unit) handover and inter RSU handover [18].

To provide handover support for VANET, many traditional mobility management protocols, such as mobile internet protocol version 4 (MIPv4) [20], mobile internet protocol version 6 (MIPv6) [20] and NEMO basic protocol [11] [12] have been proposed. Along with security in handover is also an issue which needs research, there is very less research data which has discussed about security in Handovers.

VANET protocol used/modified	**Year**	**OSI layer**	**Characteristics**	**Advantages**	**Disadvantages**
HMIPv6 [51]	2001	Network layer	• MAP agent is there which divides handover management into Macro and micro mobility management • Macro mobility management uses the same algorithm used for MIPv6	• Reduces the signaling load and improve handover speed of MIPv6	• Significant delay still occurs in macro mobility management
Fast handover algorithm for HMIPv6 macro mobility management[52]	2003	Network layer	• Modified the HMIPv6 using the multicast technique • MN now can receive packet faster and transparently than HMIPv6	• Minimize the service disruption delay that occurs during macro mobility management • Fast handover is achieved	• Deals specifically with macro mobility
Prediction based fast handover [38]	2003	Network layer	• Prediction based fast handover scheme is proposed which uses network mobility and mobility characteristics of public vehicles to predict handover. • The scheme supports broadband wireless access in fast moving vehicles	• Reduces packet loss across discontinuous cells. • Supports seamless handover across continuous cells • Reduces handover delay	• Beneficial only for mobile users which deals with large volumes of data on fast moving public vehicles
DRIVE based on SLP [19]	2003	Network layer	• Discovery of Internet gateways from Vehicles is developed and introduced • has the ability to select the most suitable Internet gateways among multiple	• Increased scalability and efficiency • Able to select most suitable gateways from the choices list	• Security issue is not taken into consideration

			available choices		
MSCTP[9]	2004	Transport layer	• internet mobility support	• internet mobility support without changing the internet architecture. • Low signaling overhead	• large overhead and mobility • not suitable for further upper layers
MIPv6 [20]	2004	Network layer	• Provides host mobility solution at network layer • The movement of mobile node away from its home link is transparent to higher layer protocols and applications	• Suitable for both homogenous and heterogeneous media • Doesn't require special routers in the form of foreign agents	• long handoff delay • high packet lost , signaling overhead and non scalability
FMIPv6[7]	2005	Link layer, Network layer	• depends upon the network predation • early binding fast handoff (EBFH) was proposed	• Handover latency is reduced • packet loss is low	• High signaling overhead • depends upon the network predation
Location based handover [34]	2005	Network layer	• mobile stations derives the likely prospective access points to be used in the near future using the information from the server • server provides a provision for MN to directly associate with the APs	• Reduces handover latency in IEEE802.11 • AP selection can be done by the network side	• Can be used for location specific proactive protocols only
Fast handover support in WLAN [46]	2005	Link layer, network layer	• Studied the implications of link layer agnostic operation of IP handover control on handover performance • FMIPv6 is taken as a reference protocol for study • Also discussed the improvements in fast handover support	• Showed that the behavior of protocol is highly dependent on timely availability of link layer information	• Only the study is given no implementation results are mentioned as a proof
NEMO BS [11]	2006	Network layer	• fast RA mechanism used • Optimistic duplication address detection (ODAD) used to reduce DAD delay • the binding update overhead is reduced by a adaptive NEMO support protocol based on the HMIPv6	• due to the less change in the infrastructure the overall cost of the NEMO network is low as compare to the other network. • Heterogeneous mobility support	Handover latency is high Signaling overhead is high Deployment cost can be reduced
IEEE802.11 handover assisted by GPS information[36]	2006	Cross layer	• Uses a GPS based system to which predicts the next mobile node point of attachment and the associated sub-network using the position of the mobile nodes.	• reduces the handover delay for link layer and network layer • bandwidth can be saved by reducing the frequency of Router	Dependent on geolocation system like GPS

			• Uses geolocation system for improving the link layer and network layer handover	Advertisements	
Early Binding Fast Handover for high speed MN on MIPv6 [48]	2006	Link layer, network layer	• proposed a EBFH that considers high-speed moving mobile nodes • a MN performs early fast binding update with its current access router before a trigger which informs a MN is closed to handover	• reduce the unreliability of the anticipation of high speed mobile nodes	More traffic overhead compared to original fast handover Size of router advertisement is not considered
cooperative mobile router based handover (CoMoRoHo) [49]	2006	Not considered	• it considers a CoMoRoHo scheme which during a handover enables different mobile routers to access different subnets and cooperatively receive packets destined for each other • the performance of the scheme remains unchanged even when if the access network is overloaded, which makes it scalable.	• this scheme performs better than FMIPV6 in terms of packet loss and signaling overhead • this scheme imposes less packet delivery overhead	• Handover latency is much decreased compared to the FMIPv6
Reactive handover optimization in IPv6 based MN[50]	2006	Cross-layer	• Analyzed the movement detection and address configuration schemes of reactive handover procedure • Proposed a novel reactive handover procedure based on the novel optimized movement detection scheme and address configuration scheme • It doesn't need any predictive information	• Requires minimum number of signaling messages • Reduces the signaling load on networks • Reduces handover latency to support seamless service for real time applications	• It is assumed that AR and MAP generates its pool of conflict free addresses, which is different to say
PMIPv6 (Proxy) [44]	2007	Network layer	• Introduces a new entity called a Mobile Access Gateway(MAG) that acts as a relay node between MN and a local mobility agent • Does not require any involvement by the MN in over the air communications	• tunneling overhead is eliminated for over the air communications	• there is a period in which the MN is unable to send or receive packets because of link switching delay, handover latency and data loss
Fast scanning and handover in WiMAX/802.16 [25]	2007	Cross layer	• two strategies have been proposed to reduce the scanning operations while attempting to establish network connectivity with neighboring stations. • Most recently used and most frequently used	• MRU and MFU strategies have reduced the scanning time for a WiMAX/802.16 MS	• No issues are not considered like packet loss rate, security.

			approaches are used by these strategies		
Mobile WiMAX standard IEEE 802.16e based handover scheme [27]	2007	Cross-layer	• Scheme is proposed which uses information from different layers of OSI to speed up the layer 2 handover • Layer 3 is used to transmit MAC control messages between the MS and BS during the handover	• Decreases handover latency significantly • Performance does not degrade when the load increase	• Timer vale need to be specific based on other parameters
Time Before Vertical Handover TBVH mechanism for proactive policy management [32]	2007	Cross layer	• Gives a predictive mathematical model for calculating the estimated (TBVH) component from available network parameters	• Helps QoS management policies in providing application specific facilities	Specific to proactive policy management
Improved Fast handover algorithm based on HMIPv6 [8]	2007	Network layer	• MAP(mobility anchor point) must be selected reasonably because it affects the performance of entire network. • Two tasks are performed : Improving MAP choice algorithm and binding update operation based on multicast	• Less frequency of macro-mobility handover • More reliable communication • Reduced handover delay and increased bandwidth utility because of multicast mechanism	• More complicated network configuration and more protocol data in core layer • Upper and top layer performance is badly affected by large volume of MNs moving along a single path together
Cross-layer design of Fast handover IPv6 in IEEE802.16e [10]	2007	Cross layer: Network layer and link layer	• Works in two modes i.e- predictive mode and reactive mode. • A cross-layer design is created to enable proper FMIPv6 with IEEE 802.16e handover process • Provided three events and one command for interaction between the IP layer and MAC layer handover	• Eliminates delay on IPv6 movement detection and address configuration	• Does not considered link layer security issues
Optimized FMIPv6 using IEEE802.21media independent handover(MIH) [47]	2007	Link layer, network layer	• Tackles various issues of FMIPv6 like radio access discovery and candidate access router (AR) discovery • An information element container is used to store layer2 and layer3 information of neighboring access networks • A cross-layer mechanism for making intelligent handover decisions using IEEE 802.21 is introduced	• Uses special cache to reduce the anticipation time in FMIPv6 • Increases the probability of predictive mode of FMIPv6 operation. • Overall handover latency is significantly reduced • Outperforms NEMO Basic support and original FMIPv6 protocol	• Various extension to NEMO are required • Various pre assumptions are made like selecting the appropriate PoA with a cross-layer mechanism which must be necessarily followed to implement this algorithm
SIP-NEMO [12]	2008	Application	• has the three main	• can be deployed	• Handover latency is

		layer	components SIP home server (SIP-HS), SIP foreign server (SIP-FS) and SIP network mobility server (SIP-NMS). The SIP-FS is used for handover management • route the packet directly between SIP clients	without change to the internet architecture. • reduces the setup cost	high • Large message size
Simultaneous handover support for mobile networks on vehicles [42]	2008	Network layer	• Proposed a proxy-aided simultaneous handover mechanism • It solves addressing problem of SIP-NEMO • A Fast route/local route reestablishment algorithm was developed	• Improves the speed of reestablishment process of routing path • Ensure successful delivery of signaling messages	• Handover latency and packet loss is not given due consideration
Fast handover scheme using multicast group in PMIPv6 networks [53]	2008	Link layer, Network layer	• A scheme is proposed to setup the multicast group made up of MAG existing in each cell and neighbor MAGs • Proposed scheme provides seamless internet services	• Reduces the handover delay using the cache • Prevents packet loss in the PMIPv6	• Supports intra-domain handover only.
Global mobility management for inter-VANETs [62]	2008	Link layer, network layer	• Global mobility management for inter-VANETs handover of vehicles is proposed • Use layer2 triggering and route optimization for packet transmission	• Supports fast handover process • Lower latency time • Less packet transmission delay	• Transmission time is assumed to be same for all schemes
Enhanced fast handover with low latency for MIPv6 [59]	2008	Network layer	• A scheme is proposed in which each access router(AR) maintains a care of address (CoA) table and generates the new CoA for MN that will move to its domain • Binding updates are to be performed from the time point when new CoA for MN is known by previous AR	• The schemes has low handover latency and low packet delay as compared to existing schemes	• Layer 2 handover issues are not considered • Security is not taken care of
Fast handover solution using multi-tunnel in HMIPv6 [60]	2008	Network layer	• A fast handover scheme is proposed using multi-tunnels between mobility anchor points (MAP) and neighbor ARs in HMIPv6 network. • It includes a concept of proxy mobile IP for creation on CoA and duplicate address detection. • It eliminated the difficulties to know the new AR	• Reduces handover latency • Saves periods of service disruption and prevents packet loss in ping-pong	• Chances of handover failure can be there if a high speed MN moves in.

NEMO for VANETs [58]	2009	Network layer	• Proposed scheme includes two algorithms: NEMO scheme for real bus , NEMO for virtual bus • NEMO real bus is the bus which is equipped with two mobile routers. One to perform handoff another to maintain MN's Internet connectivity	• IP address passing among vehicles improves handover latency	• Complexity is increased as compared to earlier versions
Handover in IEEE802.11p based delay sensitive V2I communication[35]	2009	Cross layer	• Introduces a fast, position based proactive handover mechanism • Allows MAC protocol to support safety-critical V2I applications in dense highway scenario	• Enhances the handover procedure • Overhead is limited	• No guarantee of timely delivery of real-time data packets can be given • Only CSMA/CA random access scheme is assumed
Vehicular fast handover scheme(VFHS) [24]	2009	Cross layer	• the physical layer information is shared with the MAC layer, to reduce the handover delay • Concept of broken vehicle (BV) is there. • The oncoming side vehicles collect the two layer information of passing through Relay Vehicles and broadcast the information to BVs	• significantly decreases handover latency and packet loss as compared to WiMAX handover model in high velocity devices • provides acceptable handover latency and packet loss for most real-time applications	• Performance is totally dependent on Oncoming side vehicles (OSVs) • Adopts explicit cross-layer design to provide signaling message to cross MAC and physical layer • Security is not considered
PFMIPv6 [45]	2009	Network layer	• Performs the handover initiate process for data forwarding from pMAG to nMAG	• Reduces handover latency and data loss caused in PMIPv6	• PFMIPv6 does not consider the impact of geographic restriction on mobility
Speed-based Vertical Handovers [30]	2010	Network layer	• Designed an analytical model and simulation setup for vertical handover in heterogeneous VANETs • Proves a counterintuitive result that when a vehicle encounters a new network with higher data rate, a connection switch will not necessarily yield in an increased throughput.	• promote vehicle safety applications • increased throughput and delay compared to other counterparts	• restricted by the speed limit of the vehicle in order to maintain acceptable levels of throughput, delay and jitter
Distributed Routing Protocol and Handover Schemes in Hybrid VANETs [18]	2011	Network layer	• vehicle registration is required • a source vehicle can efficiently search for the location of a destination vehicle using RSUs • a handover request to RSUs to adjust the routing path. • Intra RSU & inter RSU	• High packet delivery ratio • Long route lifetime. • Outperforms existing approaches in terms of packet delivery ratio, control overhead and route lifetime.	• Dependent on RSU infrastructure. • Vehicles would perform handover with RSUs

			handover is there		
IP passing protocol with network fragmentation [21]	2011	Network layer	• Information collection is done in the beginning then IP acquisition takes place • Make before break technique is used • IP lifetime extension phase is also there	• Reduces handoff latency • reduce IP acquisition time, packet loss rate, and extend IP lifetime	• Can't solve the network fragmentation problem • extra message overhead.
optimal vertical handoff (VHO) in a vehicular network [23]	2011		• assumed a vehicular heterogeneous network made of WLAN and cellular systems • cost of communication or communication time can be minimized by the use of VHO in lower speeds, • it would be better to avoid VHO and stay in the cellular network at higher speeds	• WLAN plus cellular plus ad hoc networking outperforms any other networking strategies in terms of transmission times and transmission costs	• Focused on V2I networks specifically
Seamless proactive vertical handover algorithm [39]	2011	Cross layer	• The proposed algorithm selects a candidate network for handover which is stable and can provide necessary services required by the applications • It is safe from ping-pong effect • It saves the battery power of MS	• improves handover performance by minimizing signaling overhead and delay	• dependent on GPS or some location finding system • no simulation based evaluation is carried out
Fast handover with low latency for PMIPv6 for VANETs [61]	2011		• a scheme is proposed in which each Mobile Access Gateway (MAG) along the road pre-configures the tunnel with the neighboring MAGs and activate it whenever required	• Reduces handover latency	• The assumed scenario is just one-dimensional roads
PMIPv6 with partial bicasting for seamless handover [56]	2011	Link layer	• the proposed scheme by making use of the PMIP tunnel performs partial bicasting of data packets to the new Mobile Access Gateway (MAG) as well as to the old MAG when a MN moves into a new network • the update is performed by the Local Mobility Anchor (LMA) • the data packets are buffered by N-MAG	• reduces handover delays and packet losses • scheme makes good use of network resources of wireless links compared to other schemes	• specific to the particular part of the PMIPv6
Seamless vertical and horizontal mobility for VANETs[33]	2012	Network layer	• Used three technologies IEEE 802.11p, IEEE802.11g,3G for implementing seamless	• elects the best technology to maintain the vehicle connected	• specific to the three mentioned technologies only. • Require V2I

			handover mechanism for VANETs, • It integrates extended mobility protocols based on MIPv6 and PMIPv6, with a mobility manager for providing seamless communication between V2I.	without breaking any active sessions • performs seamless handover with low delay and no packet loss if both V2I uses IEEE802.11p	communication only
Fast handover for proxy mobile IPv6 (ePFMIPv6)[43]	2012	Network layer	• Enhanced PFMIPv6 is proposed which allows the serving mobile access gateway(MAG) to pre-establish a tunnel with candidate next MAG • Packets are immediately forwarded to next MAG using the tunnel	• Significantly reduces the packet loss and handover latency of PFMIPv6 in VNs	• Signaling overhead is high
Seamless handover in IEEE wave [37]	2013	Link layer	• Using a multicast-based forward technique the buffered packets of the OBUs are transferred to the new candidate RSUs from the old RSU • Proactive caching of data packets are done by the RSU • IEEE802.11f-Move-notify message is used by the new selected RSU to request cached packets from the rest of RSUs in order to avoid waste of resource	• Gives good performance as compared to the simple multicast-based scheme • Has lower end-to-end and handover delay • Gives higher throughput and delivery ratio	• Suites better only for diversion roadways or crossroads if proactive caching works efficiently
Fast handover management in IP-based Vehicular networks [54]	2013	Network layer	• A network layer handover scheme called Vehicular Fast Handovers for Mobile IPv6(VFMIPv6) is proposed • It assigns permanent global IPv6 address on each MN thus eliminating DAD process • Binding update process is done before link layer handover execution	• Improves QoS by minimizing handover latency, packet loss problems and overhead cost effects • Signaling cost and packet delivery cost is reduced compared to FMIPv6	• Not implemented on a physical testbed • Suited only to real life applications where periodic packets are sent at higher rates
PMIPv8 handover scheme for VANET[57]	2013	Network layer	• Early Binding Update Registration- PMIPv6 is proposed. • Impact of vehicle speed and vehicle density parameters on handoff latency, packet loss and IP acquisition time is measured.	• Reduces handover latency • Reduces packet loss rate	• Vehicles need to be equipped with GPS device
Seamless handover in VANET using network dwell time [14]	2014	Cross-layer	• Analyze the effect of various parameters like velocity of vehicle, size of beacon, beacon	• Showed the cumulative effect of beaconing, velocity of vehicle	• Restricted to proactive handover techniques only. • Entertainment

			frequency on the handover process and as a whole on the VANET operation • Provides more insight into use of proactive handover techniques for supporting life critical applications	and probability of successful reception	applications of VNAETs are not taken into consideration
VANET handover with metaheuristic algorithms [40]	2014	Application layer	• Metaheuristic algorithms like PSO, GA are used for inter VANET sensor data handovers • a model is designed for analyzing the relationship between the throughput and the reliability with Inter VANET handovers.	• Shows the need of studying vehicular applications and services before employing data transfer improvements in multi VANET systems	• Metaheuristic algorithms are particularly appropriate for networks with applications that require short transmission delays
Cross layer handover scheme for IPv6 based VANET [41]	2015	Cross layer	• A cross-layer mobility scheme is proposed which gives a three hierarchy architecture for VANETs. • Consists of multiple road domains, a road segment including multiple clusters • Cluster generation algorithm is based on link duration time	• Layer 3 handover delay and packet loss rate is reduced • Layer 2 handover speed is improved	• Architecture specific results. • Dependency of layer 3 and layer 2 on each other.
Handover decision algorithm based on multiple criteria [22]	2017	Network layer	• This paper consists of several methods of vertical handover decision algorithm • Consists of three technology interfaces LTE, WiMAX and WLAN. • employs three types of vertical handover decision algorithms: equal priority, mobile priority and network priority	• three types of decision algorithms outperform the traditional network decision algorithm in terms of handover number probability and the handover failure probability	• It is specific to heterogeneous networks
Optimum Handover Decision Technique VANET -LTE [31]	2017	Cross-layer	• OHDT proposed to understand different parameters effecting the VANET and their consequences • Specifically considers the effect of the statistical properties of vehicle availability and velocity on the handover probability	• Provides a QoS solutions in all scenarios, conditions and velocity	• Considers only specific LTE based VANET models
Improved handover algorithm to avoid DAAA authentication in PMIPv6 [55]	2018	Link layer, network layer	• An handover algorithm is proposed which does not need authenticating again if MN moves within the same PMIPv6	• Reduce the handover latency • Reduce the ratio of packet loss and improve network	• It only works for intra domain handover • Security issues are not taken care of.

			domain • A structure of PMIPv6 based on AAA server is designed using NS-2. • Intra-domain handover is taken into consideration	performance	

IV. Conclusion and Future Enhancement

In the table given above, we have discussed the characteristics, advantages and disadvantages along with the publication year of almost all the protocols specific for handover process of vehicular adhoc networks. From the above review, we can conclude that the most researched topic in approximately one decade, in VANETs is handover and the techniques to improve handover process. In most of the cases the handover used is a vertical handover. There are number of open research issues for handovers in VANETs like providing seamless handover, decision making algorithms, the scanning techniques used for scanning the access points, network fragmentation, security in handover, tunneling, packet loss rate, automatic address configuration, use of cluster based architectures for handover management. Various cross layer techniques are already implemented for improving handover process, using these new techniques can be evolved.

In the actual implementation of VANETs number of issues must be taken into account like QoS, scalability, resource, mobility management and handover management. This paper is going to help researchers by providing them a lot information about handovers and other important issues of VANETs.

References

[1]. K. Zhu, D. Niyato, P. Wang, E. Hossain, D.I. Kim, “Mobility and handoff management in vehicular networks: a survey”, Wireless Communications and Mobile Computing (2009).

[2]. Surmukh Singh, Sunil Agrawal , “VANET Routing Protocols: Issues and Challenges”, IEEE (2014)

[3]. Shivani Rana, Swati Rana, Kamlesh C. Purohit, “A Review of Various Routing Protocols in VANET”, International Journal of Computer Applications (0975 – 8887)

[4]. J. Dias, A. Cardote, F. Neves, S. Sargento, and A. Oliveira. “Seamless horizontal and vertical mobility in vanet”, Vehicular Networking Conference (VNC), 2012 IEEE, pages 226–233, Nov 2012.

[5]. Montavont N, Noel T, “Handover management for mobile nodes in ipv6 networks”, IEEE Communications Magazine 2002; 40(8): 38–43.

[6]. Choi S, Hwang G, Kwon T, Lim AR, Cho DH., “Fast handover scheme for real-time downlink services in ieee 802.16e bwa system”, In Proceedings of IEEE VTC 2005-Spring, 2005; 3: 2028–2032.

[7]. Koodli R. “Fast Handovers for Mobile IPv6”. RFC 4068, Jul 2005.

[8]. Song Jian, Zhang Bao-jie, Sun Wei, Che Rong and Yu Yong, “An Improved Fast Handover algorithm based on HMIPv6”, International multi-conference on computing in global IT, IEEE,2007.

[9]. Koh SJ, Chang MJ, Lee M., “Msctp for soft handover in transport layer”, IEEE Communications Letters 2004; 8(3):189–191.

[10]. Han YH, Jang H, Choi JH, Park BJ, McNair J, “A cross-layering design for ipv6 fast handover support in an ieee802.16e wireless man”, IEEE Network 2007; 21(6): 54–62.

[11]. Petander H, Perera E, Lan KC, Seneviratne A, “Measuring and improving the performance of network mobility management in ipv6 networks”, IEEE Journal on Selected Areas in Communications 2006; 24(9):1671–1681.

[12]. Chiang WK, Chang WY and Liu LY, “Simultaneous Handover support for Mobile Networks on Vehicles”, In Proceedings of IEEE WCNC, 2008, 2771–2776.

[13]. Car-to-Car Communication Consortium, “C2C-CC Manifesto,” Version 1.1, August 2007, available at http://www.car-to-car.org/fileadmin/ dokumente/pdf/C2C-CC manifesto 2007 09 24 v1.1.pdf.

[14]. Arindam Ghosh, Vishnu Vardhan Paranthaman, Glenford Mapp and Orhan Gemikonakli, “ Exploring efficient seamless handover in network dwell time”, EURASIP Journal on Wireless Communications and networking 2014

[15]. Yun-Wei Lin, Yuh-Shyan Chen and Sing-Ling Lee, “Routing protocols in vehicular ad hoc networks: A survey and future perspectives”, Journal of Information and Engineering 26, 913-932 (2010)

[16]. A.Bachir and A.Benslimane, “A multicast protocol in ad-hoc networks inter-vehicle geocast”, in Proceedings of IEEE Semiannual vehicular technology conference, Vol,4,2003, pp.2456-2460

[17]. T. Fukuhara, T. Warabino, T. Ohseki, K. Saito, K. Sugiyama, T. Nishida, and K. Eguchi, “Broadcast methods for inter-vehicle communications system,” in Proceedings of IEEE Wireless Communications and Networking Conference, Vol. 4, 2005, pp. 2252-2257.

[18]. Jang-Ping Sheu, Chi-Yuan Lo, and Wei-Kai Hu, “A Distributed Routing Protocol and Handover Schemes in Hybrid Vehicular Ad Hoc Networks”, in Proceedings of IEEE 17th International Conference on Parallel and Distributed Systems, 2011, pp. 428-435

[19]. Bechler M, Wolf L, Storz O, Franz WJ, “Efficient discovery of internet gateways in future vehicular communication systems”, In Proceedings of IEEE VTC 2003-Spring 2003; 6: 965– 969.

[20]. D. Johnson, C. Perkins, and J. Arkko, Mobility support for IPv6, RFC 6275, June 2004

[21]. Yuh-Shyan Chen, Chih Shun Hsu, Wei-Han Yi, “An IP Passing Protocol for Vehicular Ad Hoc Networks with Network Fragmentations”, 2011 Fifth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing, 2011.IEEE DOI 10.1109/IMIS.2011.67

[22]. Radhwan Mohamed Abdullah and Zuriati Ahmad Zukarnain, “Enhanced Handover Decision Algorithm in Heterogeneous Wireless Network”, www.mdpi.com/journal/sensors, Sensors 2017, 17, 1626.

[23]. Kaveh Shafiee, Alireza Attar, Victor C. M. Leung, “Optimal Distributed Vertical Handoff Strategies in Vehicular Heterogeneous Networks”, IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 29, NO. 3, MARCH 2011.

[24]. Kuan-Lin Chiu, Ren-Hung Hwang, Yun- Shyan Chen, “A Cross Layer Fast Handover Scheme in VANET”, IEEE ICC 2009 proceedings, 978-1-4244-3435-0/09,2009

[25]. P. Boone, M. Barbeau, and E. Kranakis, “Strategies for fast scanning and handovers in WiMAX/802.16”, In Proc. Second International Conference on Access Networks & Workshops AccessNets ’07, pages 1–7, 22–24 Aug. 2007

[26]. J. Chen, C.-C. Wang, and J.-D. Lee, "Pre-Coordination Mechanism for Fast Handover in WiMAX Networks", In Proc. 2nd International Conference on Wireless Broadband and Ultra Wide band Communications AusWireless 2007, pages 15–15, 27–30 Aug. 2007.

[27]. L. Chen, X. Cai, R. Sofia, and Z. Huang, " A Cross-Layer Fast Handover Scheme For Mobile WiMAX", In Proc. VTC-2007 Fall Vehicular Technology Conference 2007 IEEE 66th, pages 1578–1582, Sept. 30 2007–Oct. 3 2007.

[28]. J. H. Park, K.-Y. Han, and D.-H. Cho, " Reducing Inter-Cell Handover Events based on Cell ID Information in Multi-hop Relay Systems", In Proc. VTC2007-Spring Vehicular Technology Conference IEEE 65th, pages 743–747, 22–25 April 2007.

[29]. R. Rouil and N. Golmie, "Adaptive Channel Scanning For IEEE 802.16e", In Proc. Military Communications MILCOM 2006, pages 1–6, 23-25 October 2006

[30]. Esposito, Flavio, " On Modeling Speed-based Vertical Handovers in Vehicular Networks "Dad, slow down, I am watching the movie"" , Technical Report BUCS-TR-2010-032, Computer Science Department, Boston University, September 7, 2010

[31]. Siti SAbariah Salihin, Rafidah Md Noor, Liyth Ahmed Nissirat, Ismail Ahmedy,"VANET handover based on LTE-A using decision technique", FCSIT, 2017, pp 9-17

[32]. Ftaem Shaikh, Glenford Mapp, Aboubaker Lasebae, "Proactive policy management using time before vertical handover mechanism in heterogeneous networks", The 2007 International Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST 2007), IEEE

[33]. Dias J, Cardote A, Neves F, Sargento S, Oliveira, "A: Seamless Horizontal and Vertical Mobility in VANET", *Vehicular Networking Conference (VNC), 2012, IEEE* 2012, 226-233

[34]. Tseng C-C, Chi K-H, Hsieh M-D, Chang H, "H: Location-Based Fast Handoff for 802.11 Networks", *Commun. Lett. IEEE* 2005, 9(4):304-306

[35]. Bohm A, Jonsson M, " *Handover in IEEE 802.11p-based Delay-Sensitive Vehicle-to-Infrastructure Communication",* Technical Report IDE - 0924, Halmstad University, Embedded Systems (CERES); 2009

[36]. Montavont J, Noel T, "IEEE 802.11 Handovers assisted by GPS Information", *Wireless and Mobile Computing, Networking and Communications, 2006. (WiMob'2006). IEEE International Conference On* 2006, 166-172.

[37]. Lee H, Chung Y-U, Choi Y-H, " A seamless Handover Scheme for IEEE WAVE Networks based on multi-way Proactive Caching", *Ubiquitous and Future Networks (ICUFN) 2013 Fifth International Conference On* 2013, 356-361.

[38]. Paik EK, Choi Y, "Prediction-based fast handoff for Mobile WLANs", *Telecommunications, 2003. ICT 2003. 10th International Conference On* 2003, 748-7531. doi:10.1109/ICTEL.2003.

[39]. Salam T, Ali M, Fida M-R, "Seamless Proactive Vertical Handover Algorithm", *Information Technology: New Generations (ITNG) 2011 Eighth International Conference On* 2011, 94-99

[40]. Pravin Wararkar, S.S. Dorle, "Vehicular adhoc networks handovers with metaheuristic algorithms", International conference on electronic systems, signal processing and computing technologies, 2014, IEEE . pp.160-166.

[41]. Wang Xiaonan, Le Deguang, Yao Yufeng, "A cross-layer mobility handover scheme for IPv6 based vehicular networks", International journal of electronics and communications, 2015,pp- 1514-1524

[42]. Chiang WK, Chang WY, Liu LY, "Simultaneous handover support for mobile networks on vehicles", In Proceedings of IEEE WCNC, 2008

[43]. Kim ms, Lee SK, Golmie N, "Enhanced fast handover for proxy mobile IPv6 in VANETs", Wireless Networks 2012,pp-401-411

[44]. Gundavelli, S., "Proxy Mobile IPv6", RFC 5213, 2007

[45]. Yokota, H., Chowdhury, K., Koodli, R., Patil, B., & Xia, F, "Fast Handovers for PMIPv6",December 2009 draft-ietf-mipshop-pfmipv6

[46]. Dimopoulou L, Leoleis G, Venieris IO, "Fast handover support in a wlan environment: challenges and perspectives" IEEE Network 2005; pp-14–20

[47]. Mussabbir QB, Yao WB, Niu ZY, Fu XM, "Optimized fmipv6 using IEEE 802.21 mih services in vehicular networks", IEEE Transactions on Vehicular Technology 2007; 56(6): 3397–3407.

[48]. Kim H, Kim Y., " An early binding fast handover for high speed mobile nodes on mipv6 over connectionless packet radio link", In Proceedings of Seventh ACIS International Conference on Software Engineering, Artificial Intelligence, Networking, and Parallel/Distributed Computing, 2006; 237–242

[49]. Kafle VP, Kamioka E, Yamada S, "CoMoRoHo: cooperative mobile router-based handover scheme for long-vehicular multihomed networks", IEICE Transactions on Communications 2006; pp- 2774–2784

[50]. Han YH, Choi J, Hwang SH, "Reactive handover optimization in ipv6-based mobile networks", IEEE Journal on Selected Areas in Communications 2006; pp-1758–1772

[51]. H. Soliman, C. Castellucia, K. Elmalki, L. Bellier, "Hierarchical MIPv6 Mobility Management (HMIPV6)". Internet draft, July 2001, drafl-ietfmobilcip-hmipv6-OS.

[52]. Indra Vivaldi, Mohd Hadi Hahaebi, Bcirhanuddin Mohd Ali, V. Prakash, "Fast Handover Algorithm for Hierarchical Mobile IPv6 macro-mobility Management", IEEE 2003

[53]. Hyunwoo Hwang, Ju-Hyun Kim, June Sup Lee, Kyung-Geun Lee, "Fast handoff scheme using multicast group for intra-domain in PMIPv6 networks", IEEE CCNC 2010 proceedings.

[54]. Laurence Banda, Mjumo Mzyece, Guillaume Noel, "Fast handover management in IP-based Vehicular networks", IEEE 2013,pp-1279-1284

[55]. Hewei Yu, Meiling Zhou, "Improved handover algorithm to avoid duplication AAA authentication in PMIPv6", IJCNC, Vol.10, No.3,2018

[56]. Jin In Kim, Seok Joo Koh, "Proxy Mobile IPv6 with partial bicasting for seamless handover in wireless networks", IEEE 2011 pp-325-356

[57]. Amirhosein Marovejosharieh, Hero Modares, "A Proxy MIPv6 handover scheme for VANET", Springer 2013.pp

[58]. Chen, Y. S, "Network mobility protocol for vehicular ad hoc networks", IEEE 2009

[59]. Ruidong Li, Jie Li, Kui Wu, Yang Xiao, Jiang Xie, " An enhanced fast handover with low latency for IPv6", IEEE transactions on wireless communications vol.7,no1,2008

[60]. Dong cheol Shin, Sung-gi Min, "Fast handover solution using multi-tunnel in HMIPv6", IEEE2008

[61]. SangeDae Moon, Mun-Suk Kim, Sukyoung Lee, " Fast handover with low latency for proxy MIPv6 Vehicular networks", ICUIMC 2011 ACM

[62]. Jong Min Lee, Myoung Ju Yu, Young Hun Yoo, and Seong Gon Choi, "A new scheme of global mobility management for inter-VANETs handover of vehicles in V2V/V2I network environments", International conference on networked computing and advanced information management IEEE2008.pp-114- 119