Review of various Handover Classification and Heterogeneous Wireless Network Architecture in VANET

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Abstract—**Vehicular Ad hoc Network (VANET) is most active research area that provides wireless communication between moving vehicles and road side units without using any communication infrastructure. VANET is a subclass of MANET but with a different property of having vehicles as nodes. These networks are self-organized in nature and a key component for intelligent transportation system (ITS). Some characteristics of VANETs are high mobility of vehicles, constrained mobility, highly dynamic topologies, frequent disconnections of networks, bandwidth limitation, no power constraints, sufficient storage and unpredictable node density. This paper presents the study of handover types. The paper also presents the architecture for heterogeneous network and a routing protocol for heterogeneous networks.**

***Keywords*— Vehicular Ad hoc Network (VANET), Handover, Heterogeneous wireless network, routing algorithm**

I. INTRODUCTION

Vehicular Ad hoc Network (VANET) is a fast growing technology [3] that provides wireless communication between vehicles and road side units (RSUs) without using any communication infrastructure [8]. It is a key component for intelligent transportation system (ITS) [10] and a subclass of mobile ad hoc network (MANET). VANET is distributed, self-organizing and infrastructure less where vehicles and RSUs can communicate with each other without using any infrastructure. In VANET vehicles are equipped with wireless and data sharing capabilities and vehicles can create a spontaneous network while moving along the roads.

In VANET the communication is done among nearby vehicles or nodes and road side units. Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) are two categories of communication in VANET [3]. In V2V communication vehicles can communicate directly with another vehicle [5]. This communication is efficient and cost effective and it is based on dedicated short range communication (DSRC) [1]. In V2I communication a vehicle can communicate with Road Side Unit (RSU). It is based on GPRS/3G, Wi-Fi or Wi-Max and can be used for internet access [1].

VANET helps the vehicles by providing the road traffic information and increases the safety of vehicles by exchanging safety relevant information with each other. Some applications [2] of VANETs are traffic information system, safety related information, weather information, emergency warning system, lane changing assistant, traffic sign/signal violation warning, road-traffic condition, and interactive communication such as Internet access. Vehicles share safety related information to provide safety and prevents road accidents [10].

Some unique characteristics [7] of VANETs include, highly moving vehicles on road, highly dynamic topologies, mobility modelling, frequent disconnections of networks, no power constraints, bandwidth limitation, and stringent delay constraint [5].

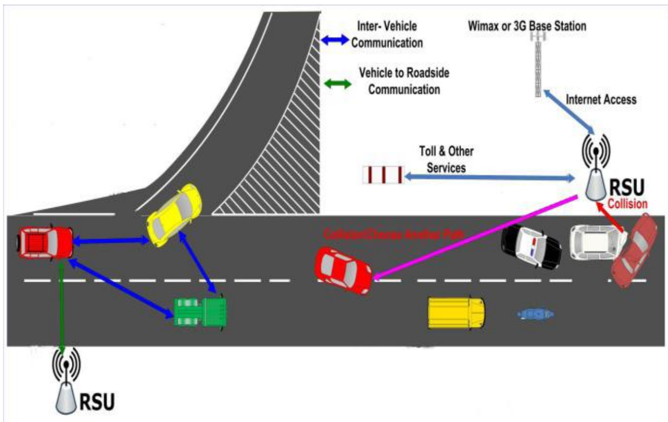

Fig 1: Vehicular ad hoc networks

Two mobility models for VANET are Macro mobility model and Micro mobility model. Macro mobility discusses the vehicular traffic which includes road topology, traffic flows, traffic density and initial vehicle distribution and motion constraint which includes streets, roads, crossroads, number of lanes, speed limits, traffic light and traffic signs. Micro mobility focuses on the behaviour of a driver based on the driver's personal aspect like age, gender, and mood while driving, when interacting with other drivers or with road infrastructure.

The rest of the paper is categorized into subsections as follows, the second section describes the handover classification. The third section is the heterogeneous wireless architecture. The fourth section is the routing algorithm for heterogeneous networks. The fifth section is the conclusion of this paper.

II. HANDOVER CLASSIFICATION

This section describes the study of handover classification [6] in vehicular ad hoc networks. Handover classification depends on many factors like network types involved, frequencies engaged, number of connections involved, and administrative domains involved.

On the basis of network types involved, handover is classified in two types: Horizontal handover and Vertical handover. In horizontal handover mobile terminal supports the same network technology between access points. Example, transition of mobile terminal from one base station to other base station and both base stations use same network technology. In vertical handover mobile terminal among access points supporting different network technologies. Example, the changeover of signal transmission from an IEEE 802.11 base station to an overlaid cellular network.

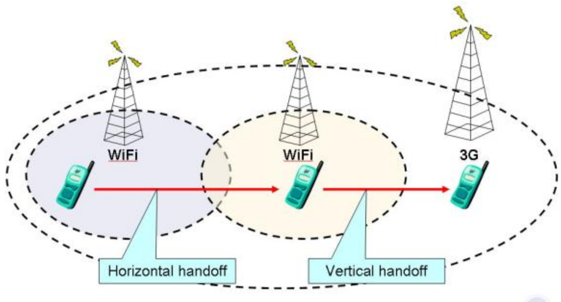

Fig 2: Horizontal and Vertical Handover

On the basis of frequency engaged, handover is classified in two types: Intra-frequency handover and Inter-frequency handover. This handover occurs with the switching of signal from one frequency to another. In intra frequency handover mobile terminal operates on same frequency across access points. While in inter frequency handover mobile terminal operates on different frequencies across access points.

On the basis of number of connection involved, handover is classified into two types: Hard Handover (Break Before Make) and Soft Handover (Make Before Break) [6]. In hard handover the existing connection is released before making the connection with the new base station. In this handover type a mobile node is allowed to maintain a connection with only one base station at any given time. While in soft handover a mobile node maintains a connection with no less than two base stations in an overlapping handover region and does not release any of the signals until it descents below a definite threshold.

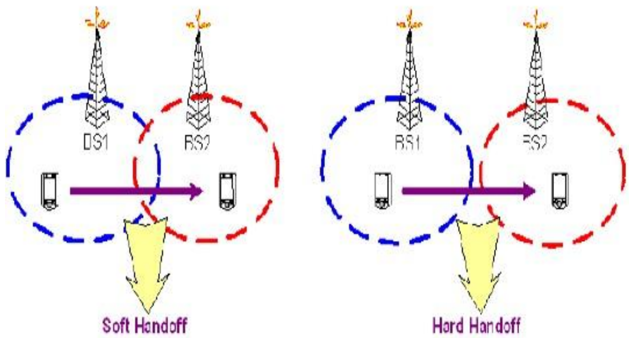

Fig 3: Hard and Soft Handover

On the basis of administrative domain, handover is classified in two types: Intra-administrative handover and Inter-administrative handover. In intra administrative handover mobile terminal relocates between same or different networks that are managed by the same administrative domain. While in inter administrative handover mobile terminal relocates between same or different networks that are managed by different administrative domains.

III. HETEROGENEOUS WIRELESS NETWORK (HWN) ARCHITECTURE

The heterogeneous wireless network [14] consists of cellular network and vehicular ad hoc networks. It is assumed that each Vehicular Node (VN) equips with cellular interface and Ad-Hoc interface. There are many companies offering dual-mode integrated interface recently. Therefore, the routing protocol can make a decision of selecting the correct mode or interface to deliver the packets.

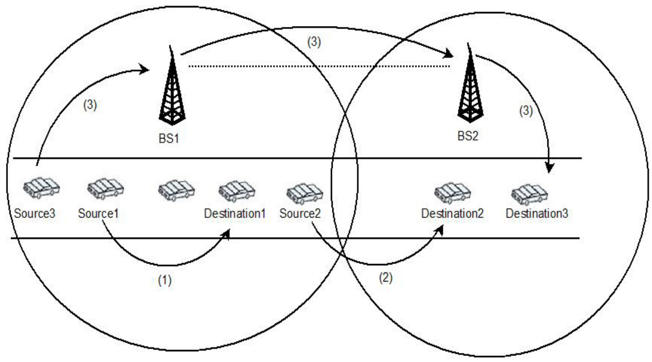

Fig 4: Various Source and Destinations in HWN Architecture

Two types of communication possible for vehicular networks:

A. Communication between specific source Vs and destination Vd:

It can further divided into three sub-categories:

1) *Vs and Vd are under same BS:* Source1 can deliver packets to Destination1 by using its own vehicular Ad-Hoc networks without using base station (BS).
2) *Vs and Vd are under different BS and form an Ad-hoc region:* If Source2 and Destination2 are in different cells (BS) but form their vehicular Ad-Hoc region, then Source2 can deliver packets to Destination2 through their vehicular Ad-Hoc networks without using BS.
3) *Vs and Vd are under different BS:* when Source3 under BS1 wants to deliver packets to Destination3 which is under BS2 then, Source3 will use the cellular network to deliver data packets. Source3 will first send the data packets to the BS1. Then, packets from BS1 are delivered through the fixed network to BS2. Finally, BS2 will deliver the data packets to Destination3.

The communication between two vehicles under case (i) and (ii) are considered as a communication in homogeneous network while communication done in case (iii) will be treated as communication in heterogeneous network.

B. Communication between Vs to Internet:

VN can also request to connect to the Internet (fixed network) through the cellular network to access internet applications.

IV. ROUTING ALGORITHM

This section discusses the routing algorithm for HWN architecture [14]. The requirements of traffic load are classified into two parts: *(i)* the routing path from the specific source and destination traffic and, *(ii)* the routing path from VN to Public networks.

If the application of VN can decide the requirement of the Internet access, the VN can send the Route Request message (RREQ) messages by using cellular interface to the cell (BS) in which it is registered, without flooding the RREQ messages.

However, if the application of VN is not able to decide the type of data traffic for the Route Request message (RREQ), it can send the RREQ message to its BS. BS can check the destination in VLR (Visitor Location Register) or HLR (Home Location Register). If the check successes, the specific source and destination traffic is chosen. Otherwise, the destination is the server connected to fixed network. Thus VN must transmit data to destination through BS and fixed network. We call such kind of data traffic as “Internet Access”, and the Internet access traffic is chosen.

A. Routing path for specific source and destination:

If VN initiates the routing path to specific destination in HWN, the Route Discovery process starts to find the specific destination by using dual-mode (vehicular ad-Hoc and cellular) interface.

If a reachable routing path is found, the proposed routing algorithm evaluates the route metric for each reachable route and selects one routing path with minimum route metric to transmit data.

If no such reachable path exists, then the request is blocked.

B. Routing path for Internet Access:

When VN wants to access the internet, it connects itself to the registered cell by using cellular interface. Then, BS runs the bandwidth capacity test to check whether it has enough bandwidth for this request.

If the capacity test is succeeded, then the BS sends ACK message back to VN. The ACK message indicates that the bandwidth is reserved by BS for requesting VN. Next, the VN establishes the routing path to BS for data transmission. Finally, the VN accesses the Internet through fixed network via BS.

If the capacity test fails, the BS starts a "Load Distribution Process" to find a reachable routing path from the neighboring BS. VN receives a Route Ack (RACK) message from registered BS. The RACK message sent by BS includes cell IDs of its neighboring BS. Thus, VN triggers Route Discovery process for specific available cells IDs sent by its BS. Now, VN can use a dual mode interface to flood RREQ message to find the destination by using communication between specific source and destination in heterogeneous wireless network. If VN find a reachable path with in a limited time, than it evaluates the route metric for the reachable path. Next, the VN select the path with the minimum route metric to forward the data. If VN does not find any reachable path within a limited time, the route request (RREQ) message is blocked.

C. Route Discovery Process

During route discovery process, the RREQ message will be broadcasted to all the VNs that are in the Ad-Hoc region of initiating VN as well as to the BS in which initiating VN is registered. The RREQ message received by VNs and BS can also rebroadcast RREQ message to their neighboring VNs and BS. This broadcasting continues until destination node is found. Route discovery process is divided into two phases: Route discovery phase and route selection phase.

D. Route Discovery Phase:

In routing discovery phase, we assume that BS (Base Station) will act as a VN during routing discovery process. When some VNs initiate to access the HWN, then BS as well as VN participate in the routing discovery process. Therefore, when node (VN or BS) receives the RREQ message, it checks all the route field of RREQ to determine that whether all fields contain information. If the incomplete routing path exists in routing table of node, then node will discard the RREQ message. Otherwise, it re-floods the packet to reachable neighbors and appends the host id (neighboring id) as destination in the complete route field. The process of re-flooding of packets continues until destination is found. If the destination is reachable,

Source ID	Request ID	Destination ID	TTL	Complete Route	Bandwidth Request

the RREP message contains the complete routing path information toward the source. Hence, the routing path is established.

E. The RREQ Message Format

When BS receives the RREQ message, it can check the VLR (Visitor Location Register) to find the reachable destination (VN) to avoid re-flooding of RREQ message. If the destination VN is found in its VLR or in HLR, then it can send the RREQ message to the reachable VN. Otherwise it forwards the RREQ message to other BS through cellular network. The same process continues till destination is found.

The source node can be any VN in the HWN. When the source node initiates the route request, it checks the route cache. If there is a route in route cache that contains the destination ID, the destination is reachable. Then, the source node writes the routing path in the packet header and forwards the packet to next-hop node. If the route in route cache does not exist, the source node buffers the forwarded data and floods RREQ messages to reachable neighboring nodes (VNs or BS) until receiving the RREP (Route Request Reply) messages in a limited time (message TTL).

The request of data transmission that is initiated earlier by the source node is processed first. The intermediate node can be either a VN or BS.

When the intermediate node (VN) receives the RREQ message, it checks the "TTL" fields in RREQ message to decide whether the message will be discarded or not. If the incomplete route is recorded in "Complete Route" field or host ID is not a destination ID, then the host discards the RREQ message. When the intermediate node that receives the duplicate RREQ message from the same source ID, then it discards the RREQ message to minimize Route Request Packet Overhead. If the host ID is same as the destination node for the request, the host sends the RREP message backward to the source node. Otherwise, the VN appends host id and available bandwidth in "Complete Route" field in RREQ message and forward to reachable next-hop by dual-mode interface. When the intermediate node receives the RREP message, it updates its available bandwidth and forwards the RREP message to next-hop recorded in the RREP message.

If the intermediate node is BS, it checks the VLR and HLR. The VLR (Visitor Location Register) database to find the reachable VNs in its record as well as it also checks the bandwidth request to serve the RREQ initiated by source. If the destination is reachable, then BS updates a host ID and available bandwidth in the source ID and bandwidth request field respectively in the RREQ message. The updated RREQ message is then sent to destination VNs. The HLR (Home Location Register) find whether the VN is registered in it or not. If VN is registered in its HLR, then it sends the RREQ message to reachable destination VN. For sending the message, it appends the host ID and available bandwidth in complete route field in RREQ message. Otherwise, BS check the neighboring BS to forward the RREQ message through fixed network to find the destination node.

F. *Route Selection Phase:*

Routing metric function is used for considering the transmission time and number of intermediate nodes in route discovery phase. We select the route with higher average value of available to the bandwidth. Generally, lower transmission time helps to complete data transmission faster. If the transmission time of two discovered routing path are same, then routing path can make the source node to select the path with minimum intermediate nodes. If intermediate nodes in the routing path change the location, the route error (RERR) message to send toward the source node. When the source node receives the RERR message from the intermediate nodes, the source node reinitiates the RBRDP if the data transmission is not completed.

G. *Load Distribution Process*

The capacity of BS is usually limited. The capacity check of BS refers to the available bandwidth of BS to fulfill the incoming request.

Bandwidth request by VN <= (Total bandwidth - Reserved bandwidth)

If capacity test is failed, the BS becomes Hot Spot. VS cannot access Internet through BS, then the load distribution process initiates. The goal of the process is to find out another available routing path to access the Internet through some other available BS. There are 4 steps in the load distribution process:

1. *When BS becomes "Hot Spot" (congestion spot), it find neighboring BS which is available to fulfill the request.*

2. *The "Hot Spot" BS fills the neighboring cells ID in RACK (Route ACK) message. Then it sends RACK message to the source node.*

3. *The source node initiates the routing discovery process through Vehicular Ad-Hoc network to find the other path that can access the neighboring cells ID recorded in the RACK message.*

If step 3 success, the routing path selected by routing metric of route discovery process to the neighboring cells is established. Otherwise, the request will be blocked.

V. CONCLUSIONS

VANET is an emerging technology in wireless communication. It is useful to provide safety related applications for vehicles moving at high velocity on the road. Various routing protocols have been proposed for VANET. This paper deals with the study of handover classification and a heterogeneous wireless network architecture. In this a routing protocol is discussed for the heterogeneous network architecture.

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