HANDOFF SCHEMES AND MOBILITY MANAGEMENT IN VEHICULAR AD-HOC NETWORK

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ABSTRACT

There has been significant progress in the field of vehicular ad hoc networks (VANET) over the last several years which support vehicle-to-vehicle and vehicle-to-infrastructure communications. With the two types of communication modes, user can access the internet and existing mobility management can be reviewed. Mobility management and handoffs are the most challenging research issues for vehicular networks to support a variety of intelligent transportation system (ITS) applications.

The traditional mobility management schemes for Internet and mobile ad hoc network (MANET) cannot meet the requirements of vehicular networks, and the performance degrades severely due to the unique characteristics of vehicular networks (e.g., high mobility). Therefore, mobility management solutions developed specifically for vehicular networks would be required.

Also, Internet connection for vehicular ad-hoc networks faces a great challenge: vehicle is moving so fast that it may cause the frequent handoffs, which may cause packet delay and packet loss problem.

This paper presents an overview on mobility management for vehicular network and steps involved in a vehicular ad-hoc network handoffs process along with handoffs classification and reviews of some related studies which reduce the handoffs latency.

Keywords: VANET, Handoff, Network Mobility, Mobile Router, Mobility Management

I. INTRODUCTION

OVER the past decade, vehicular networking has gained a lot of popularity among the industry and academic research. In mobile-ad-hoc networks (MANET) where each user directly communicates with an access point or base station without the need for an infrastructure. VANET is a special type of MANET. Topologies of VANET are highly dynamic because of high mobility of vehicles. VANET has the following special features: (1) the mobility of vehicles is highly predictable; (2) communication devices have plenty of electric power provided by vehicles; (3)broadcast used to deliver messages instead of unicast. VANET supports two types of communication modes: vehicle-to-vehicle (V2V) communication and vehicle-to-infrastructure (V2I) communication modes (see Fig.1).V2V communication is for the direct and multihop communication, efficient and cost effective due to its short range bandwidth and ad hoc nature.V2I refers to the communication between vehicles and road side unit, e.g., base station and access point connected with a Internet. A typical VANET scenario is shown in Fig. 2. V2V communication is based on dedicated short range communications (DSRC) and V2I is based on GPRS, Wi-Fi or WiMAX.

The main purpose of VANET is to disseminate a low cost communication network for vehicles. VANET has two types of applications: (1) Safety related (such as collision alert, emergency warning stopped vehicle warning road condition warning etc. and (2) Internet connectivity related (such as web browsing, entertainment and mobile commerce etc.).Many internet related applications require continuous internet connection. To achieve seamless handover and continuous connection IP of the devices must be assigned and reassigned efficiently. Mobile internet protocol version 4 (MIPv4) was proposed in 2002 .however, because of the some problems, such as the shortage of IP addresses, triangular routing and weak security mechanism, mobile internet protocol version 6 (MIPv6) was proposed in 2004.

Originating from cellular networks, mobility management has been an important and challenging issue to support seamless communication. Mobility management includes location management and handoff management. Location management has the functions of tracking and updating current location of mobile node (MN). Handoff management aims to maintain the active connections when MN changes its point of attachment.

MIPv6 can provide enough IP addresses and better security mechanism than MIPv4, but not efficient enough. To improve the efficiency of MIPv6 hierarchical mobile internet protocol (HMIPv6) was proposed in 2005 .HMIPv6 uses a new component named as Mobility Anchor Point

(MAP) which manages user’s location. MAP provides two types of location management including the macro-mobility and micro-mobility managements. A mobile host (MH) with micro-mobility creates an on-link care-of-address (LCoA), and sends binding update message to MAP.A MH with macro mobility creates a regional care-of-address (RCoA), and sends binding update message to its home agent.MIPv4, MIPv6 and HMIPv6 are designed to handle terminal mobility, not for network mobility, NEMO (network mobility) protocol was proposed to handle network mobility in 2005. All users are not allowed to access the base station directly; mobile host can only be accessed through mobile router (MR). Each MR has its own home address. Whenever the MR moves to communication range of new Access router it acquires care-of-address (CoA) from visited network. After acquiring the CoA, it sends binding update message to its HA. The HA of the MR forward all data packets.

As discussed above, many mobility management protocols have been proposed to provide continuous internet connection but VANET handoff still faces the difficulty: due to the high mobility of vehicles creates frequent handoff, which may cause packet delay and packet losses.

In this paper, we examine the steps involved in a VANET handoff process and review of related studies. The rest of the paper is organized as follows. Section II provide an overview of mobility management schemes for both V2I and V2V communications. Section III includes the procedure of VANET handoff process. Section IV includes survey of the related studies, Section V concludes the paper.

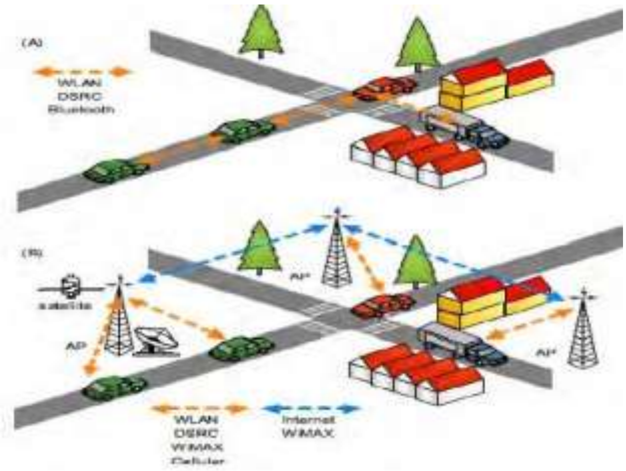

Fig 1: Two types of Communication Modes of VANET : (a)V2V Communication (b) V2I Communication

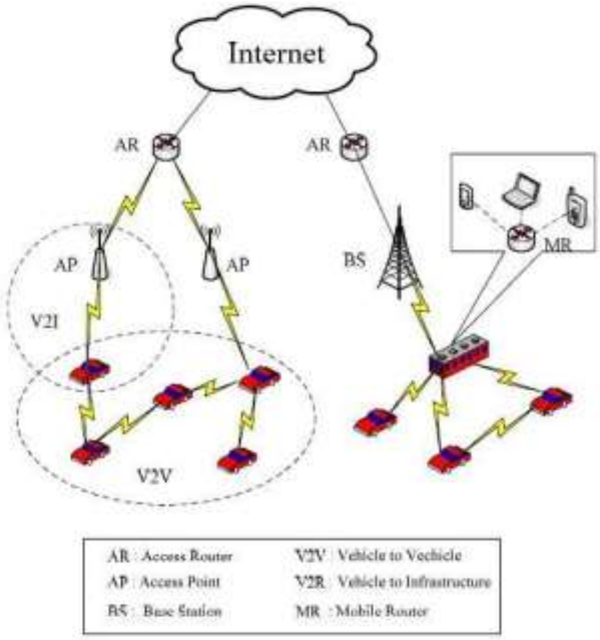

Fig 2: General Model of Vehicular Networks

II. OVERVIEW OF MOBILITY MANAGEMENT IN VEHICULAR

Networks

In this section, we discuss the mobility management issues in vehicular networks for V2I and V2V communications scenarios.

2.1 Mobility Management for V2I Communications

In a V2I communications scenario, some ITS applications require Internet access through an infrastructure or Internet gateway. The Internet gateway can provide global addressability and bidirectional Internet connectivity to the mobile nodes in a VANET. In a VANET, mobile nodes can be far away from an Internet gateway, and their traffic can be relayed through intermediate mobile nodes. This is referred to as multihop communications. However, in such a scenario, traditional MIPv6-based mobility management solutions cannot be applied directly since they require a direct connection between a mobile node and infrastructure. Therefore, when integrating MIPv6-based solutions into VANETs, many issues arise (e.g., movement detection and handoff decision). To support ITS applications, vehicular area network (VAN) can be established (e.g., fixed vehicle sensors, passengers' mobile devices or even personal area network (PAN) attached to the mobile routers located in the vehicle). In this scenario, network mobility (NEMO) basic support protocol was introduced to support mobility in a VAN. NEMO is an efficient and scalable scheme since the mobility management is transparent to the mobile devices (i.e., mobile device does not send and receive signalling message directly).

However, route optimization was not considered in NEMO BS. Triangular routing in MIPv4 becomes quadrangular routing in NEMO BS. Much work has been done to address the route optimization problem.

In addition, the vehicular network can be heterogeneous in which different wireless technologies are integrated into one service. This will enable seamless and high-speed connection, since the mobile node can select the most suitable network for data transmission. Mobility management should guarantee the reachability to correspondent nodes (CN) in the Internet as well as the global reachability to mobile nodes in a vehicular network. Therefore, the mobility management has to meet the following requirements:

(i) Seamless mobility: Mobility of vehicles should be seamless. Accessibility and service continuity should be guaranteed regardless of vehicle's location and wireless technology.

(ii) Fast and vertical handover: Fast handover is needed for delay-sensitive ITS applications (e.g., safety-related). Fast handover is also a crucial requirement for wireless networks with small coverage area (e.g., WiFi network), since the vehicle spends only short period of time at each point of attachment (e.g., access point). In a heterogeneous wireless environment, vertical handover of the mobile users' connections among different wireless technologies must be supported to achieve seamless service.

(iii) IPv6 support: The global reachability requires a permanent globally routable IP address for each mobile node. With large address space, IPv6 can support a unique address for each sensor or mobile device in the vehicles. In addition to the advantage in address space, IPv6 also has better support of security and quality of service (QoS) which are the essential requirements of ITS applications.

(iv) Multihop communication support: Multihop communication can extend the transmission range of the mobile nodes to reach the destination. Mobility management schemes for vehicular networks need to consider the multihop communications requirements, and therefore, need to be optimized accordingly.

(v) Scalability and efficiency: VANETs may be large in size which can consist of hundreds of vehicles and thousands of devices in one network. Furthermore, due to the high frequency of change of the point of attachment, the mobility management scheme must be scalable and efficient to support different types of traffic.

In traditional infrastructure-based mobile networks (e.g., cellular system), mobility management can be classified according to the following criteria:

(i) Network structure: Mobility management can be classified into mobility management in homogeneous networks and in heterogeneous networks .

(ii) Users' roaming area: Mobility management can be classified into macro-mobility and micro-mobility management solutions which provide global and local mobility management, respectively. Due to the hierarchical design of global and local management, performance of mobile users can be improved. For macro-mobility management, mobile IPv4 and mobile IPv6 were introduced. For micro-mobility management, fast handover for MIPv6 (FMIPv6), Hierarchical MIPv6 (HMIPv6) , Cellular IP, HAWAII , and Proxy MIPv6 (PMIPv6) were proposed.

(iii) Mobile host signalling: Mobility management can be classified into host mobility and network mobility management depending on whether or not the mobile host is involved in signalling for mobility management. If the signalling of mobility management is sent or received by the mobile host, it is called host mobility management, and network mobility management, otherwise.

(iv) OSI layers: The type of mobility management can be identified by the OSI layer which the mobility management belongs to. Mobility management can be implemented in data link, network, transport, application layer, or in cross layer fashion. For the review of mobility management for vehicular networks, more than one criterion will be combined to better characterize the schemes. In this case, the mobility management schemes for vehicular networks are first categorized into host mobility and network mobility. Then, the protocol layer criterion is applied for further classification.

2.2 Mobility Management for V2V Communications

For vehicular ad hoc networks (VANETs), mobility is managed through route discovery, maintenance and recovery. Efficient management of vehicular mobility is composed of topology control, location management, and handoff management.

(i) Topology management: Topology management can be proactive and reactive. Proactive schemes periodically send signalling messages to explore the topology information. On the other hand, reactive schemes obtain the topology information only when it is needed (e.g., when there is a new mobile node to join the network).

Since VANETs can be very large, purely host-based topology control does not scale well in such networks. The cluster-based topology control can solve this limitation. In this cluster-based topology control, vehicles are grouped into multiple clusters. Head of each cluster is responsible for intra-topology management. These cluster heads coordinate among each other to manage the entire ad hoc network topology. However, due to the high speed and constrained mobility (e.g., moving along a straight road) of vehicles, current clustering schemes developed for MANETs cannot achieve the optimal performance in VANETs and the clusters could be unstable. To address this problem, clustering for open intervehicle communication (IVC) networks (COIN) was proposed. The cluster head election is based on mobility information and driver intentions. Besides, COIN can accommodate the oscillatory nature of inter-vehicle distances. In, a prediction-based reactive topology control was proposed. The basic concept of this scheme is to increase the topology maintenance interval and to reduce the periodic beaconing process by mobility prediction. Updates are only needed when the predicted topology information is incorrect. A location-aware framework, i.e., kinetic graph, was introduced to support the use of standard ad hoc network protocols. With kinetic graph, the standard ad hoc protocols can perform efficiently in VANETs.

(ii) Location management: With unique mobility characteristics of VANETs, basic ad hoc routing protocols cannot be directly applied to VANETs due to the large latency and overhead. However, geographic routing was shown to be efficient and effective for VANETs. Using geographic routing (e.g., greedy perimeter stateless routing (GPSR), geographical routing algorithm (GRA)), communicating nodes are required to have the location information of each other. Therefore, location management scheme, which deals with the storage, maintenance, and retrieval of mobile node location information, is needed in VANETs . It is worth noting that, the location here refers to geographical location which is not the same as the addressing location in Internet.

Location management in VANET can be classified into flooding-based and rendezvous based approaches. Using a flooding based approach, the source floods the location query to the entire network which incurs huge overhead. On the other hand, in a rendezvous based approach, location servers are responsible for location management. Nodes update their location and query the location of destination from location servers. Many schemes were proposed for location management in MANETs. For example, region-based location service management protocol (RLSMP) which supports both scalability and locality awareness was proposed for VANETs. In RLSMP, message aggregation with the enhancement from geographical clustering was used for both location updating and querying to improve scalability. For locality awareness, local search was used to locate the destination node.

(iii) *Handoff management:* Handoff management in vehicular ad hoc networks is performed by rerouting to construct a new path to the destination. When a mobile node moves, a group of neighbors changes and hence the new route of data transfer needs to be established quickly for better handoff performance. Handoff management can be proactive and reactive which uses the same concepts as those in mobile ad hoc network routing. A survey of routing schemes in VANETs can be found in.

A simple taxonomy of mobility management solutions for vehicular network is shown in Fig. 3.

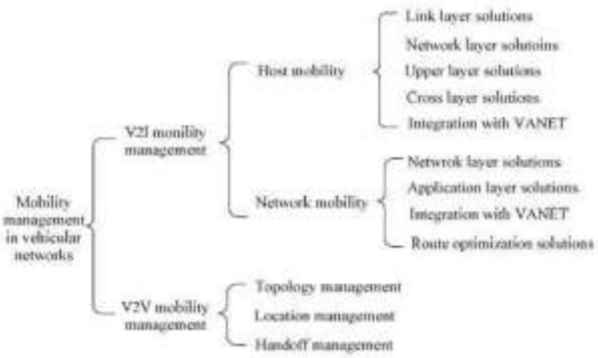

Fig 3: Taxonomy of Mobility Management Solutions for Vehicular Networks

III. HANDOFF: GENERAL CONCEPT

The term handover or Handover refers to the process in which transferring an ongoing call or data session from one channel connected to the core network to another. Satellite communication is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service.

3.1 Handoff Classification

Handoffs can be classified in several ways as discussed below:

1. Horizontal and Vertical Handoff: Depending on the type of network technologies involved, handoff can be classified as either horizontal or vertical. Traditional handoff, also called horizontal or intra-system handoff occurs when the MS switches between different BSs or APs of the same access network. On the other hand, vertical handoff or inter-system handoff involves two different network-interfaces representing different wireless access networks or technologies.

2. Hard and Soft Handoff: This classification of handoff depends upon the number of BSs and/or APs to which an MS is associated with at any given moment. Hard handoff, also called “break before make”, involves

only one BS or AP at a time. The MS must break its connection from the current access network before it can connect to a new one. In a soft handoff, also called "make before break", an MS can communicate and connect with more than one access network during the handoff process.

3. *Mobile-controlled, Mobile-assisted, and Network-controlled Handoff:* As the names suggest, these types of handoff classifications are based on the entity, MS or access network, which make the handoff decisions . Mobile-assisted handoff is the hybrid of mobile-controlled and network-controlled handoff where the MS makes the handoff decisions in cooperation with the access network.

3.2 Handoff process in VANET

The handoff procedure refers to the mechanism or sequence of messages exchanged by access points and a mobile unit resulting in a transfer physical layer connectivity and state information from one access point (AP) to another with respect to the mobile unit in consideration. The complete handoff process can be divided into three distinct logical steps:execution

1. Network Discovery: An MS with multiple active interfaces 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. There are two kinds of scanning methods defined in the standard: active and passive [10]. In the passive mode, the mobile unit only listens to the hello messages. In the active mode, apart from listening to hello messages, the station sends additional station actively probes for the APs.

2. Handoff Triggering and Decision: This is the phase where the decision regarding "when" to perform handoff is made. In this phase, the target wireless access network is selected based on multiple criteria.

3. Handoff Execution: This is the last phase of the handoff process where the actual transfer of the current session to the new access network takes place. This requires the current network to transfer routing and other contextual information related to the MS to the newly selected access network as quickly as possible.

IV. REVIEW OF RELATED STUDIES

This section reviews some related to the problem. These studies show how to handoff latency is reduced by using the scheme. Handoff latency reduced because of that packet delay and packet loss also reduces.

4.1 VEHICULAR FAST HANDOFF SCHEME

In this paper, new developed wireless network technique, termed WiMAX Mobile Multihop Relay (MMR), provides a good communication framework for a VANET formed from vehicles on high-speed freeways. According to study public transportation buses are good candidates to serve as relay nodes, called relay vehicles (RV). An RV is a large vehicle that can provide the capability of relay and mobile management of the MMR WiMAX network to its neighboring vehicles. Oncoming Side Vehicle (OSV): An OSV is a small vehicle driving on the oncoming direction, and has no packets to transmit. The neighboring vehicles first send the data packets to RV, and then RV send these packets to the internet. Fig.4 Shows architecture of VFHS. Broken vehicles (BV) utilize the information broadcasted by OSV. An OSV is designed to collect the physical information of RV by receiving RV's network advertisement. The main idea behind VFHS is that the OSV uses a predefined set of channel frequencies to broadcast network topology message (NTM) to BVs. In NTM, when the unconnected vehicle enters the transmission range of the RV in front, it can learn which channel to listen to. From this, the handover latency could be reduced.

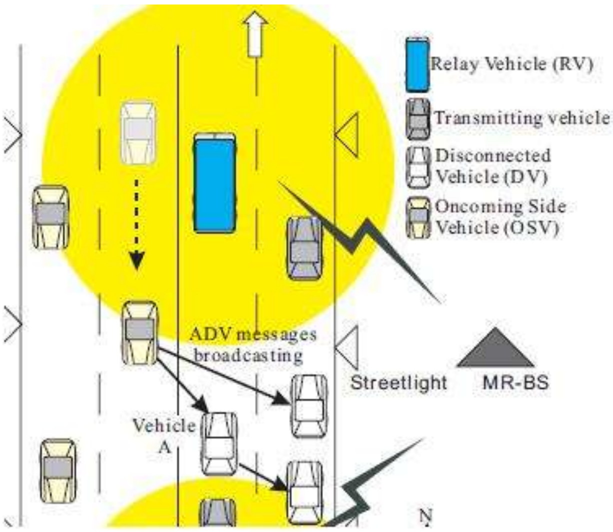

Fig.4 Architecture of VFHS

4.2 Two Antenna Approach

In this paper, proposed that each vehicle is equipped with two wireless LAN interface cards. Each interface card is equipped with one antenna (see Fig. 5). These, two antennas cooperate with each other: one antenna is used to transmit and receive data and the other antenna is used to scan channels to search the new base station. After measuring the signal strength by vehicle, it determines to switch to a new base station that will perform registration and authentication. When registration is completed, it uses the other antenna to transmit and receive data packets. On the other hand, the original antenna is not stopped immediately; instead, it only receives data. After a defined time period, the original antenna is replaced by the new antenna completely. In this way two antennas continually cooperate. By this, a smoother handoff can be achieved with less packet losses and handoff time is also reduced.

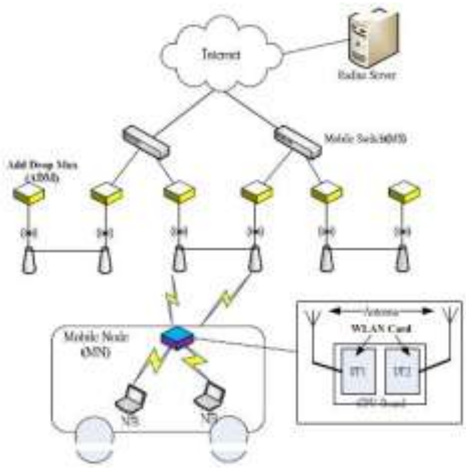

Fig. 5 Two-Antenna Approach

4.3 Fast Authentication

In this paper, handoff latency is reduced by authentication. Their method is to request authenticated data from the neighbouring base station in this AAA server is used before performing the handoff process.

4.4 IP Passing

In this paper, proposed a scheme called IP passing. When a vehicle is leaving the communication region of its serving base station (BS) and is moving to the boundary of the target

BS's communication region, it gets IP from the DHCP procedure which takes time. In IP passing concept it gets new IP from the inbound vehicles by IP exchange or from the outbound vehicles by IP passing and it can assist the vehicle behind of it to perform preregistration (see Fig.6). However, if the entering vehicle does not get IP from vehicle, it acquires its IP address using the normal DHCP procedures.

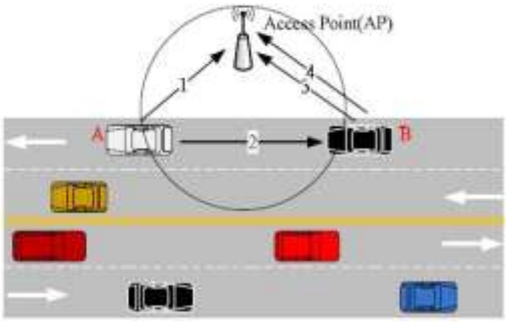

Fig.6 IP Passing

4.5 Network Mobility Protocol

In this paper, proposed a scheme in which NEMO and multi-hop relay concept is combined. NEMO uses the MR to communicate with base station. In real bus two MRs is equipped with a bus, called rear MR and front MR. MRs connects the Internet using WiMAX and all mobile host in a bus connects MRs using Wi-Fi. All devices in a bus can connect the MRs using one-hop connection or multi-hop connection. The front MR is responsible for performing pre-handoff for the rear MR, which provides real connection. Instead of considering a real-bus, in this paper extend their idea to a group of vehicles, which form a virtual-bus. In virtual bus first vehicle in the group acts as the front MR, and the last vehicle of the group acts as the rear MR. from this scheme handoff latency is reduced.

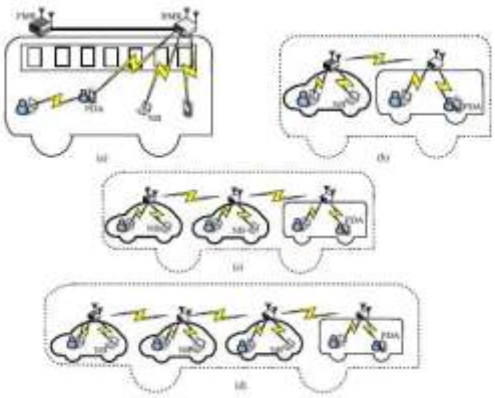

Fig. 7 Network mobility scenario: (a) NEMO on a real Bus (b) NEMO on a Virtual Bus with two vehicles (c) NEMO on a Virtual Bus with three vehicles (d) NEMO on a Virtual Bus with more than three vehicles

V. CONCLUSIONS

In this paper, we review the necessary procedures involved in a VANET handoff process. We also review the fast handoff schemes proposed to improve the different procedures involved in the handoff process. Till now, not much work has been done on the fast handoff for VANET. How to combine the different handoff approaches and reduce handoff latency remains an open research issue and needs more.

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