Handoff Schemes for Vehicular Ad-Hoc Networks: A Survey

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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. However, 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 of the steps involved in a VANET handoff process along with handoff classification and reviews of some related studies which reduces the handoff latency.

Keywords— VANET; handoff; network mobility; mobile router;

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 [1]. 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 [2]. 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. 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.)[3][4] and (2) Internet connectivity related (such as web browsing, entertainment and mobile commerce etc.)[5].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 [6].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 [7].

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 [8].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.

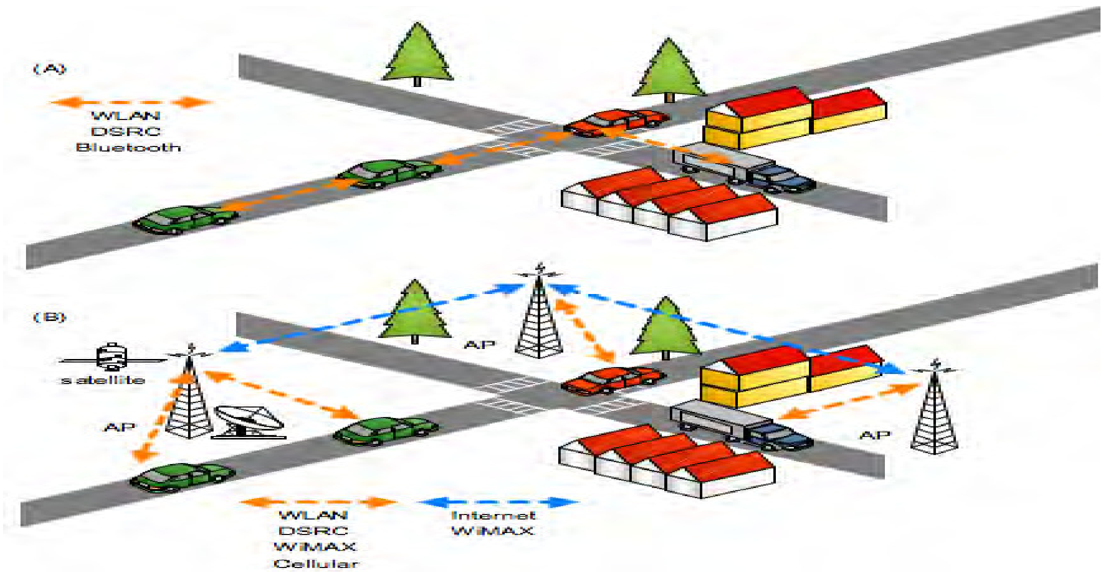

Fig.1 Two types of communication modes of VANET: (a) V2V communication (b) V2I communication

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 [9]. 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 includes the procedure of VANET handoff process. Section III includes survey of the related studies, Section IV concludes the paper.

II. 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.

A. *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.

B. *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:

- Network discovery
- Handoff triggering and decision
- Handoff 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.

III. 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.

1). Vehicular fast handoff scheme

In this paper, new developed wireless network technique, termed WiMAX Mobile Multihop Relay (MMR)[11], provides a good communication framework for a VANET formed from vehicles on high-speed freeways. According to study [12] 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.2 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.

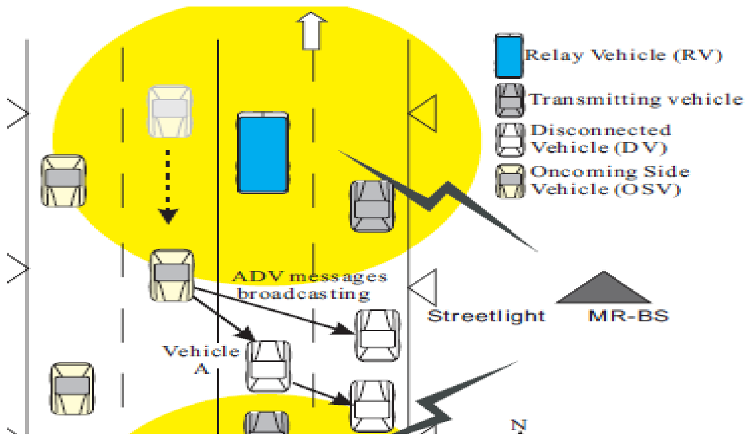

Fig.2 Architecture of VFHS (adapted from [12])

2). Two antenna approach

In this paper [13], proposed that each vehicle is equipped with two wireless LAN interface cards. Each interface card is equipped with one antenna (see Fig. 3). 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.

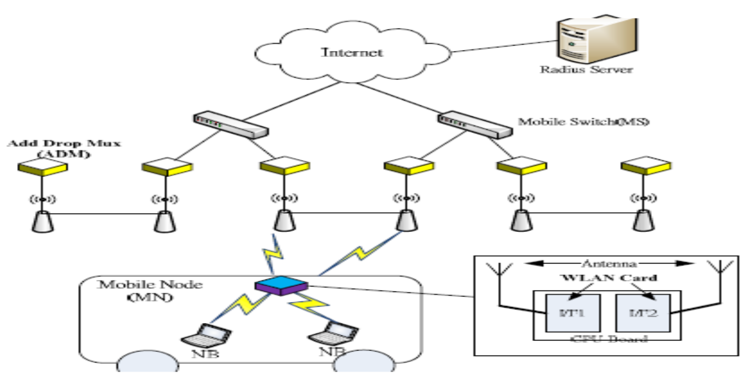

Fig. 3 Two-antenna approach (adapted from [13])

3). Fast authentication

In this paper [14], handoff latency is reduced by authentication. Their method is to request authenticated data from the neighboring base station in this AAA server is used before performing the handoff process.

4). IP passing

In this paper [16], 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 [17]. 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 pre-registration (see Fig.4). However, if the entering vehicle does not get IP from vehicle, it acquires its IP address using the normal DHCP procedures.

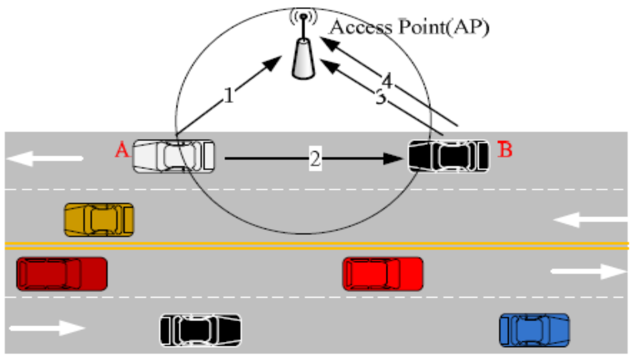

Fig.4 IP Passing (adapted from [17])

5). Network mobility protocol

In this paper [15], 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.

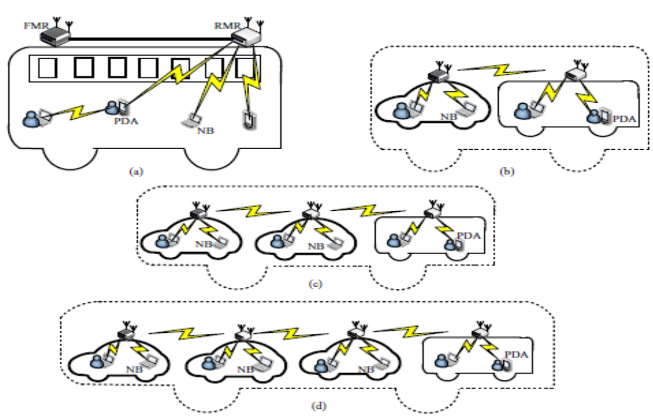

Fig. 5 Network mobility scenario: (a) NEMO on a real Bus (b) NEMO on a Virtual Bus with two vehicles (c) NEMO on a Virtual Bus with three vehicles (d) NEMO on a Virtual Bus with more than three vehicles

IV. 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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