A Global Mobility Management Scheme for Reducing Overall Handover Latency in IP based VANETs

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Abstract:

In VANETs, Mobility Management is a challenging task because of the fast mobility of the vehicles and small coverage range of 802.11 Access Points (APs). This results in frequent handoffs as vehicles move across a series of adjacent access points. Due to which, the overall throughput reduces and hence results in the interruption of many established connections. Mobility in VANETs is supported by Mobile IPv6 (MIPv6). Greater latency, triangular routing and packet loss are some of the main issues in MIPv6. In this paper we have proposed a handover scheme based on HMIPv6 and FMIPv6 that will ultimately results in the reduction 802.11 handoff latency by eliminating the DAD process and address other related issues that arise when applied to vehicular network.

Keywords: *VANETs, mobility management, access points, mobile IP, HMIPv6, HNIPv6, Latency, DAD process RSSI value, CoA, nAR.*

1. Introduction

On the average, in United States of America there are more than 6 million car road accidents annually. More than 3 million people get injured due to car accidents, with more than 2 million of these injuries being permanent. According to the car accident statistics released by the United States Department of Transportation's (USDOT's) National Highway Traffic Safety Administration (NHTSA), there were almost 43,000 deaths in 2002 due to car accidents. While, half of the these highway accidents are mainly due to vehicles leaving the road or traveling unsafely through intersections. Also more than 40 hour are wasted on weekly basis of passengers in primary hours [2] [1].According to another statistics of USDOT, traffic car accidents that are due to congested highways cost over $75 billion due to lost worker productivity and over 8.4 billion gallons of fuel [3]. Due to these facts there is always a need for a safe and

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reliable system having safety applications that communicate through wireless network. With such a system vehicles will communicate with each other and with road side infrastructure. Such safety applications dramatically decrease the number of accidents. If an alarm massage is provided to drivers half a second before, then 60 percent of accidents are avoided [4]. Such mechanism also decreases the energy consumption, save precious time, increase human safety, avoid congestion and also increase productivity. For deployment such system, there is always needed a reliable and efficient network, which have high mobility, dynamic configuration, context awareness, infrastructure-less and fast changing topology. These Mobile Ad hoc Networks (MANETs) have some distinct features like limited range, limited bandwidth, low energy resources but more efficient and fast in data collection and forwarding. Actually MANET is an autonomous system of mobile nodes, build on ad hoc demands and work as wireless network, nodes moving from place to place in peer to peer fashion. MANET has no pre-define structure, no centralized administration, so any node may leave or enter the network. The self organizing nature of the ad hoc network comprises the nodes into arbitrary and temporary ad hoc topology. Any device can move independently in any direction and continually changing its links to other devices, data may be collected and forwarded and therefore each device working as a router. MANETs are also known as mobile mesh network. As MANETs are autonomous and self configuring networks of mobile nodes, these mobile nodes can be fixed on cars, ships or air planes etc.When MANETs are deployed for traffic monitoring and road safety applications, these MANETs term as VANETs (Vehicular Ad hoc Mobile Network). VANETs are a special case of MANETs that can communicate in either of the two ways, between vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). The main goal of such networks is to provide safety and comforts. But before constructing such networks certain issue must be addressed about its rapid changing topology, routing, content managements, security and quality of services.

To be very specific, two types of data are produced in VANETs. Delay sensitive and Delay tolerant. Delay sensitive data is collected by the safety related applications while delay tolerant data is collected by comfort applications. Delay sensitive data is about co-operative collision avoidance amongst cars, about warning massages like post crash and obstacle on road side and also information about the car condition like speed limit, engine statistics etc. Delay tolerant data is related to passenger comfort and traffic efficiency. This may include current traffic condition, weather condition, automatic payment for parking, toll collection, e-banner advertisement and business related. These service also known as value added service or user application data. The delay sensitive data must have some priority, due to the reason that, it needs quick assessment as compared to any other data. For value added services, VANETs needs seamless mobility management protocols. These protocols ensure continuous connection to real-time high speed data and multimedia applications with low latency and packet loss. The rest of the paper is organized as: Section 2 discuses the Structure of a typical VANET. Section 3 contains the background and related work to the topic. Section 4 discuses the standard IEEE 802.11 handover process and finally Section 5 contains the proposed system and the conclusion paragraph.

2. Structure of a Typical VANET

VANETs are advancement towards the Intelligent Transportation System (ITS), which provides communication to the nearby vehicles and between the vehicles and fixed infrastructure on road-side. Each vehicle work as a node, which is the part of ad hoc network, can receive and forwards massages to wireless network. Each node (vehicle) must have some basic devices for communication, these are communicating device for receiving and transmitting massages, a

Global Positioning System(GPS) for tracking its own location, devices for neighbor's position and nearby obstacles on road side (radars), a set of sensors which report crashes and other statistics (engine condition, tire condition, brake statistics, weather conditions etc), a pre-stored digital map and onboard computing device, which is responsible for all on board calculations. A typical VANET node is shown in figure 1.

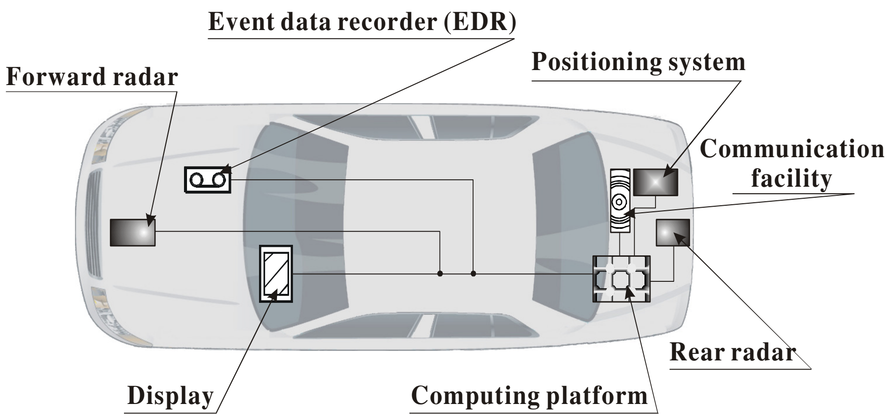

Fig. 1. The structural components of VANET node

3. Background

The main focus of the VANETs is to deploy a low cost, reliable and efficient communication network for transportation system. Two types of applications for VANETs are safety oriented and value added applications. The safety related application mainly concern with emergency warning massages, co-operative collision warning massages etc, while value added applications are mainly concerned with entertainment and mobile commerce [9]. In a vehicular environment, a mobile node (MN) moves with high rates of speed. The speed of a MN is very important factor that tells that how much time the MN stays in the communication range of a network and if the speed of the MN increases, the handover will result more frequently, which will certainly affect Quality of Service (QoS). So an optimized handover mechanism is always needed which maximize the use of short connectivity periods, support delay-sensitive applications and enhance throughput [8]. First time in 1999, U.S. FCC commission allocated 75Mz of Dedicated Short Range Communication (DSRC) [15] spectrum at 5.9 GHz to be used for V2V communications. The DSRC radio technology i.e. IEEE 802.11 is now standardized as IEEE 802.11p (WAVE). This standard provides wireless access in vehicular environment and support data rates of 6Mbps up to a maximum distance of 300m [16].

To address the issue of mobile communication with a continuous connection, without changing IP addresses, mobile IPv4 (MIPv4) was proposed in 2002 [17]. But due to some deficiencies such as the shortage of IP addresses and some security problems, mobile IPv6 (MIPv6) was proposed in 2004 [18]. But MIPv6 is very efficient for micro-mobility and inefficient for macro-mobility. To solve this problem, hierarchical mobile IPv6 (HMIPv6) was proposed in 2005. For network mobility, NEMO (network mobility) protocol was proposed to address the network mobility issues in 2005 while in 2006, fast MIPv6 was proposed for fast handover process.

A Group Handover Mechanism [5] is the simultaneous handover process of multiple terminals from the current base station to another base station. Resources are reallocated to guarantee QoS at different service levels. For reducing the handover call admission and drop rate, we use User Mobility Prediction technology, in a Group Handover mechanism. The main focus in a Group Handover Technology is on the design of mobility prediction and on the admission control strategy for the type of handover in sub-channel reallocation. Speed adaptive handover algorithm is also the main focus in such a case.

Cross-layer Mechanism (CLM) is there to make intelligent handover decisions and to optimize handover procedures in vehicular networks [6]. Cross-layer Mechanism uses the handover procedure of Fast Mobile IPv6 (FMIPv6). To be very specific, it uses the service of FMIPv6 named IEEE802.21 Media Independent Handover (MIH) service. CLM utilizes the 802.21 MIIS which has the L3 information of neighboring access networks. The service calculates a new information report for L2 and L3 neighbour access networks. By using this report and to address the issues of Radio Discovery and Candidate Access Routers (ARs), FMIPv6 takes the help of 802.21 MIIS.

Spatial Aware Forwarding Scheme (SIFT) protocol is a trajectory based routing protocol for VANET networks [7]. SIFT uses broadcast transmission instead of point to point transmission. SIFT only needs trajectory and the location of the last node which is use to forward a data packet from a source to a destination. So it does not require any neighbour's information a priori, since forwarding decisions are shifted from the transmitter to the receiver. The main focus of SIFT is to improve data delivery performance in large scale networks.

4. The Standard IEEE 802.11 Handover Process

Handover occur when one mobile node (MN) moves from one access point (AP) to another and changing its point of attachment. The process of handover is decomposed into following six phases: triggering, discovery, authentication, association, IP address acquisition, and home agent (HA) registration [8]. The first four phases related to the data link layer and called layer two (L2) while the last two phases done it the network layer and called layer three (L3) handover [9].

4.1 Triggering: The initial phase in the handover process of a mobile node is when a MN moves away from an access point (AP), the MN detects the received signal strength indication (RSSI) has dropped below a predefined threshold. When this trigger event occurs, the MN trying to discover other APs with better RSSI and then try to associate with the new AP with the best RSSI value. After triggering phase, the discovery phase has been started [8][9].

4.2 Discovery and Selection: In this phase, MN searches for a new AP by sending a probe massage or by listening to the beacons periodically broadcasted by nearby AP. IEEE 802.11 defines two types of scan modes: active scan and passive scan. In active scan, a MN sends a probe request massage on a channel, and then waits a period of time (MinChannelTime). If no response within MinChannelTime, the MN will continue to sends a probe massage on the next channel and wait for response from other APs. While in passive scanning, the MN does not send any probe massages, however, it sequentially listens to beacons on different channels. After listening to all the channels, the MN tries to associate an AP with the best signal strength.Actually the MN detects more than one APs in their communication range, then one of them is selected based on best RSSI value and therefore MN attaches itself with that AP[8][9].

4.3 Authentication: Access point uses this phase of authentication to find whether the MN is a legitimate node or malicious. Due to this process of authentication, the security of a network is ensured by authenticating the node. According to IEEE 802.11, two types of authentication modes are defined. The Shared authentication and Open System authentication [8][9].

4.4 Association: In this phase, a Mobile Node (MN) sends an association request to the new AP. The AP will send the response to this request. Also, if the MN switches from one AP to another AP, the association request will contain the information of the old AP [8] [9].

4.5 IP Address Acquisitions: When a MN moves from the premises of one AP to the area under control of another AP, the MN receives Router Advertisement (RA) messages from the new Access Router (nAR). Router Advertisement (RA) messages are periodically broadcasted by nAR or the MN sends Router Solicitation (RS) messages to nAR to obtain the RA messages. An RA message contains a prefix (FE80) and an interface identifier. From RA massage the MN generates the Care of address (CoA). After creating CoA, the DAD (duplicate address detection) procedure must be performed, which ensures the CoA is unique and is not in use by another MN in this premise. The DAD procedure takes a long time for completion, around 1000ms. This is the main reason that DAD process creates bottleneck for VANET handover [8] [9].

4.6 Home Agent (HA) Registration: When a MN obtains its CoA, the node informs it's Home Agent (HA) about the new CoA by sending a binding update message to the HA. The HA also sends a binding acknowledgement massages to the MN to complete the process [9].

The above process is effective but takes time in discovering new APs, creating new CoA and binding updates which causes latency [10]. To reduce this long IP handover latency, two schemes have been proposed based on IPv6. One of them is the Hierarchal MIPv6. The second is the Fast MIPv6.

The HMIPv6 handover reduces network registration time and hence results in fast Handover. Also attempts to reduce the address resolution delay. The HMIPv6 introduce a hierarchal network structure which minimize the registration time with HA [11]. Mobile Anchor Point (MAP) places by HA on edge of each network. MAPs are special agents. They divide the process of mobility into two types, local mobility and global mobility [12]. One MAP controls many APs at a given time. In local handover, the MN gets local CoA from nAR and also shares it locality with MAP. This makes possible local handover by MAP, with local CoA without informing the HA. This minimizes signaling traffic and latency as shown in figure 2.

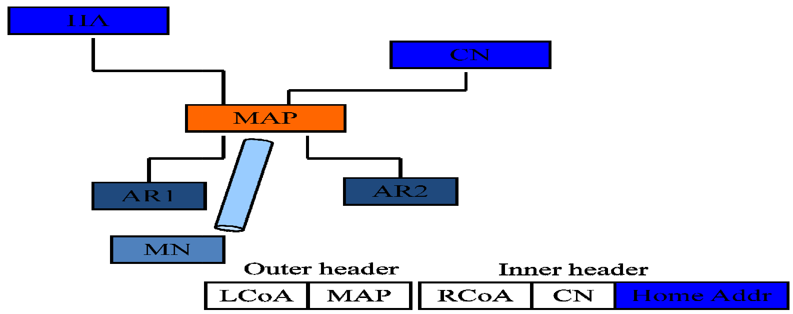

Fig.2 How MAP create tunnel for MN

In FMIPv6 Handover, the MN is responsible for taking decision of the handover process in IP-based network and updates the source router (SR). Now the SR sends request the nAR for assignment of CoA to the MN [13]. The CoA is assigned to the MN at the time when it is going to lose connection to the SR due to RSSI value [14]. The whole process is completed in three phases; initiation of handover, tunnel establishment and packets forwarding. Actually connection is established between the two routers for continuous communication of the MN while handover is in process. Fast handover reduces address resolution time by performing pre-configuration as shown in figure 3.

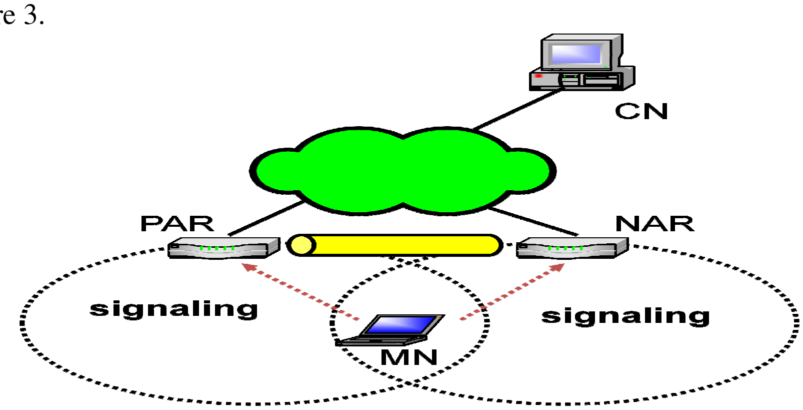

Fig.3 The FMIPv6

5. The Proposed System

We combine both of the mechanism i.e. FMIPv6 and HMIPv6 into a single scheme. In our proposed model, the handover process will started by the network rather than a MN. The router will continually advertise itself through which these routers know the mobility of MN towards its coverage. As this mobility detect by nAR, it sends massages to HA or MAP and MN and also generate CoA for MN. This address is based on its previous IP address with the prefix of the new visited network. The new CoA is pre-define in a range by an algorithm, the addresses assigned as CoAs are unique. A pool of addresses must be defined for this purpose. This reserved IPs is assigned to those users who came due to mobility in this network. These addresses are not used for ordinary users; these are only use for upcoming mobile users. In simple words the algorithm is bounded to produce a range of address (like IPv6). This algorithm also track the mobility of the MN in the neighbor network and then synchronize the network portion before actual handover take place while remaining portion of IP address can be generated automatically. So this algorithm eliminates the chances for IP conflict and the DAD (Duplicate Address Detection) process is completely eliminated. The DAD process increases the latency in HMIPv6 handover process but this technique eliminates the DAD process which minimizes the overall latency. All this procedure is done before actual handover has been started, so when the Signal Strength Indicator (SSI) of MN reaches below a certain threshold value, the MN just sends a simple massage for handover process. The HA/MAP and nAR have already calculate CoA in advance; hence communication with the MN will be now through its new CoA. The proposed mechanism completely eliminates the DAD process and also reduce the address resolution time and eliminates the binding update massages which dramatically reduces the overall handover latency in IP based VANETs.

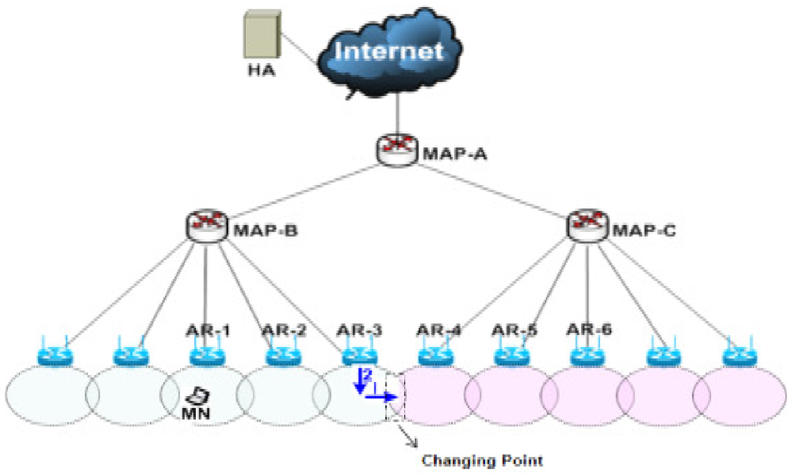

Fig.4 The proposed scheme based on FMIPv6 & HMIPv6.

6. Algorithm

The algorithm define the complete process of hand over which eliminate the DAD process.
Unq[MN, NAR, MAP, CoA, DAD]

I. Network (N/W) advertize itself for Mobile Nodes (MN_1 , MN_2 ,MN_3 ,MN_4,……MN_n)
N/W→[MN_1 , MN_2 ,MN_3 ,MN_4,……MN_n]

II. **IF** nAR detect the Mobile Node (nAR=→ MN_{new})
ELSE nAR sends Address to HA/MAP and generate CoA for MN
nAR→[HA/MAP] && [CoA→ MN_{new}]
END IF

III. **IF** Receive Signal Strength Indicator (RSSI) is below then certain Threshold (Ṫ), **THEN** Hand Over Message (MSG) send new MN
IF (RSSI<<Ṫ)
(MSG-→HA/MAP)
ELSE (continue)
END IF

IV. Create new Care of Address (CoA) = Previous IP + New IP

CoA == Pre IP + New IP

A pool of Address $\sum(x)$ is available for this purpose

$$\sum(\boldsymbol{x}) = \boldsymbol{x1} + \boldsymbol{x2} + \boldsymbol{x3} + \cdots + \boldsymbol{xn}$$

The mobile node (MN) sends a request for Handover from current network (low level RSSI) to new network (strong level RSSI), the mobile node send probe message to New Access Router.

IF MN_1 (MSG → nAR)

nAR == x_1 → MN_1

nAR == x_2 → MN_2

………..

nAR == x_n → MN_n

REPEAT (I = x_1 to x_n : $\boldsymbol{x1} + \boldsymbol{x2} + \boldsymbol{x3} + \cdots + \boldsymbol{xn} ==> \sum(\boldsymbol{x})$)

MN_{new} (MSG → nAR)

END REPEAT

END IF

7. Conclusion

The proposed scheme reduces latency in IP based VANETs, by eliminating the DAD. The proposed scheme is based on HMIPv6 and FMIPv6. This results in the enhancement of handover process in real time scenario like VANETs. The proposed system is more efficient by reducing the latency in the network. It ensures unique IP address allocation without DAD process and also minimizes the delay resulting due to binding update messages. The proposed scheme enhances the MIPv6 handover process by reducing the overall handover latency.

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