A Survey on Mobility Management Techiques in Vehicular Ad-hoc Network

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***Abstract*—It came to the light of the world that last few years have brought a boom in the wireless communication. Continuous progresses in this field have opened new research field in computer networking aimed at enhancing data network connectivity to environment where the wired networks are not that practical. Due to importance of related applications vehicular networks are attracting most of the researchers and its mobility management is a challenging task due to small coverage range of 802.11 Access Point (AP) and fast mobility of the vehicles. Still now these traditional mobility management techniques cannot meet the requirement of vehicular networks and performance degrades. This article presents a comprehensive survey on mobility management solutions in vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communication protocols in vehicular ad hoc network (VANET). Analysis is done on the critical issues over which the future vehicular applications should be deployed. The existing mobility management schemes are also reviewed. At the last, several open issues in mobility management for vehicular networks are outlined.**

Keywords: V2I Communication, V2V Communication, Handoff and Location Management, Research Issues

I. INTRODUCTION

VANET is an intelligent vehicular Ad-hoc network which uses WiMAX IEEE 802.16 and WiFi IEEE 802.11for efficient communication between vehicles with varying mobility. VANET is a type of Mobile ad-hoc network which provides communication among vehicles and vehicles and fixed equipments nearby usually these are called as roadside equipments. The key difference between MANET and VANET is as VANET as special mobility pattern and rapidly changing topology. [2] We cannot implement existing routing protocols of MANET in VANET. VANET are widely used to support the growing number of wireless products which can be used in vehicles. VANET is a special type of mobile ad-hoc network which is divided into V2I and V2V networks. To introduce this many researchers has introduced Media Access Control protocols to improve VANET working. Evaluated from cellular networks, mobility management in VANET has seems to be a tough issue to support seamless communication. Mobility management has two types of management, one is handoff management and other is location management. Handoff management helps to regulate the active connections between mobile nodes when they change its point of attachment. Location management functions to continuously update and track the current location of mobile nodes. Different types of wireless standards used: 802.11 (WLAN), 802.13 (WiMax), 802.15 1 (Bluetooth), 802.15 4 (Gigbee). [1] Due to various architectural differences between V2I and V2V communications, their mobility management patterns are designed differently. V2I communication is designed based on the internet mobility management protocols due to interoperability and compatibility reasons (e.g., mobile IPv6). [3] [7] For mobility management in V2V communication, it mainly emphasis on route discovery, maintenance and recovery. The rest of paper is organized as follows. Next section gives the brief introduction of the mobility management in VANET. In section III an exhaustive related work has been presented for various different mobility management techniques. Section IV provides the open issues and future scope before the paper is finally concluded in section V.

II. MOBILITY MANAGEMENT IN VEHICULAR NETWORKS

In this section ITS (intelligent transport system) of VANET is described and V2I and V2V communication scenarios are discussed.

A. ITS

VANET is a very critical part of ITS i.e., intelligent transport system. ITS provides the user various innovative and resourceful services for different modes of transportation. V2V and V2I communication in VANET is implemented on ITS. Various systems of ITS:

1. Vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication.
2. Advanced Transportation Management System (ATMS). e.g., traffic management centre.
3. Advanced Public System Transportation (APTS). e.g., electronic fare payment.
4. Advanced Traveler Information System (ATIS) e.g., parking information.

B. Mobility Management for V2V Communication

In this section discussion is done on the various problems arise in different mobility management for V2V communication. Mobility in VANET is managed through route discovery, maintenance and its recovery. [2]

1) Topology management

Two types of schemes belong to this topology management. In proactive scheme its sends signaling messages periodically to know the scenario of which type of topology. In reactive scheme it only on demand

obtain the topology information. As the main problem which arises in VANET is its large topology. This problem is resolved by using cluster based topology control in which vehicles are grouped together into multiple clusters. Also for interconnection communication COIN network was proposed [9]. Also a prediction based topology was proposed [4].

2) Location management

Due to large latency and overhead ad hoc routing protocols are unable to apply on VANET. Various geographical routing protocols are used to solve this issue like greedy perimeter stateless routing (GPSR), geographical routing algorithm (GRA). Further flooding based approach and rendezvous based approach is used in location management in VANET which gives rise to region based location service management protocol (RLSMP) which support both scalability and locality awareness [10]. In 2002 mobile internet protocol version 4 (MIPv4) was introduced to achieve seamless handover because of problems like IP addresses, weak security, routing problems in 2004 mobile internet protocol version 6 (MIPv6). It removes all the drawbacks of MIPv4. Either for further efficiency improvement hierarchical mobile internet protocol (HMIv6) was produced in 2005 [7]. This HMIv6 has produced a new concept known as Mobility Anchor Point (MAP) which easily manages user location. MAP provides macro mobility and micro mobility management techniques for location management. Also HAWAII [8], Proxy MIPv6 (PMIPv6) [10], Cellular IP [7] was further introduced.

3) Handoff management

Handoff management is needed for successful communication of vehicles. So in VANET special rerouting is done to construct a new path from sender to destination. As packet loss and packet delay are the two basic problems in handoff. Somehow this problem is solved by introducing WIMAX Mobile Multi hop Relay MMR [5]. This technique provides good communication even when vehicles are on high speed freeways.

C. Mobility Management for V2I Communication

1) Host mobility management

Researchers until have given many solutions for host specific mobility in VANET. As in link layer when mobile node moves specifically between the accesses points in a common subnet, this mobility are handled by link layer protocols e.g., WLAN. Also Fast DLMAP-IE was introduced to reduce downlink traffic reception during handoff process. Some research work has been done on the various host specific standard mobility and handover management schemes in VANET listed below in tabular form.

TABLE I COMPARISON OF VARIOUS MOBILITY MANAGEMENT TECHNIQUES

	MIPv6	FMIPv6	FHMIPv6	IFHMIPv6	SCTP	SIP
Route Optimization Support	Yes	Yes	No	No	Yes	Yes
Protocol Layer	L3	L3	L3	L3	L4	L4
Cross Layer Information Required	No	Yes	Yes	Yes	No	No
Handover Latency	High	Low	Low	Low	High	High
Overhead	High	High	Low	Low	Low	High

2) Network mobility management

NEMO (network mobility) was introduced in 2005 for network mobility problems [11]. As base station is not directly accessed by all users, as mobile host can only be accessed by using mobile routers (MR). Mobile router has its own home address. When the MR moves to a foreign access router it requires Care Of Address (COA) from the visited network. When it get its COA it sends the update message to it's HA (Home Address). Then HA of the MR forward this message to all data packets. The network mobility solutions like NEMO leads to reduced handoff, scalability, reduced complexity.

III. RELATED WORK

Considering the importance of mobility management in VANET researchers have suggested various techniques for mobility management as mentioned below:

Hayong Oh, Joon Yoo, Chang-kwon Kim and Sang hyun Ahn [13] in 2009 suggested a handover scheme to support multimedia services in VANET as well as in Vehicular Intelligent Transportation System. It uses FMIPv6 which reduces MIPv6 handover latency by using handover prediction, but it fails to manage sudden direction change of vehicles. It reduces handover latency using DAD (Duplicate Address Detection) process which helps to limit IP configuration delay. This model compares the handover delay of proposed scheme with FMIPv6 by using parameters like mobile position in AR and handover latency. This leads to robust handover by preventing original COA.

Ravi Shankar Shukla, Neeraj Tyagi [11] in September 2013 suggested a network mobility approach in VANET. In this model the movement of vehicles from one network to other is described. Every vehicle is equipped with MR, which is connected with AR. This model proposes that handover taking place at MR1 can also use MR2 for internet connectivity until handover is completed. This model supports seamless mobility of vehicles connected to mobile network across heterogeneous network in VANET by no service disruption during handover process between different ISPs using AR and MR.

Muhammad Nawaz Khan, Ishtiaq Wahid, Gulzar Mehmood [5] in 2012 proposed a handover scheme based on HMIPv6 and FMIPv6 for fast mobility of the vehicles and small coverage range of 802.11 Access Point (APs). In 802.11 Access Point due to fast mobility frequent handoff takes place, as a result throughput reduces. Mobility in VANET supports MIPv6 which leads to issues like packet loss, triangular routing and greater latency. So handover scheme based on FMIPv6 and HMIPv6 reduces handover latency by eliminating the DAD (Duplicate Address Detection) process. Also it minimizes the delay resulting due to binding update messages by ensuring unique IP address allocation.

Jong-Tae Park, Seung-Man Chun, Jun-Hyuk Choi and Seung-Mu Lee [12] in 2012 suggested SMMP. Simple Mobility Management Protocol (SMMP) provides global seamless handover in both homogenous and heterogeneous network. MMIPv6 is not used here but Session Initiation Protocol (SIP) is used here. It uses the concept of location management for mobility management by transmission of packets by bi-directional tunnel between mobile hosts. SMMP is compared with HMIPv6 and MIPv6 by using parameters like Pear signal ratio, Packet loss, Handover delay which concludes SMMP provides globally seamless IP handover.

S. Cespedes, X. Serman Shen [7] in 2010 suggested a scheme for seamless internet access in urban Vehicular Scenarios by using Hybrid HIP-PMIPv6. The proposed scheme is compared with NEMO, MIP and HIP. Analysis is done on the mobility handover delay and packets dropped which results to give better results on using Hybrid HIP-PMIPv6.

Dae Won Lee, Yoon-Ho Kim and Hwa Min Lee [14] in 2014 proposed a scheme which focuses on network mobility management to provide reliable communication within the vehicle even in highway scenario. This proposed mobility management scheme provides robustness of frequent path disruption caused by frequent vehicle mobility this leads to reducing handoff latency, minimizing packet loss during transition and reducing the signaling overhead by base unit and provides transparency to corresponding host.

Rodolfo I. Menguette, Luiz F. Bitten Court and Edmundo R.M. Mdeir [16] in 2012 proposed A Seamless Flow Mobility Management Architecture to provide good quality of service for vehicular applications with network based mobility management. Using NS3 simulator on different scenarios is tested to analyze the behavior of this architecture. The proposed architecture deals with different network interfaces at the same time to provide maximum network throughput, to decrease the handover time and to satisfy maximum number of packet loss and latency for each class of vehicular network application.

Jerome Harri, Christian Bonnet [4] in 2007 suggested a location aware framework called Kinetic Graph by using ad hoc protocols to implement reactive mobility management. Frameworks are suggested to kinetic graph which are beneficial for location awareness.

D. Rajini Girinath, S. Selvin [15] in 2010 suggested a cluster based routing algorithm named as Location based Multipath Flooding for hybrid mobility model to regulate the vehicular traffic. This algorithm helps to transmit real time updated information and maintain long link duration using NS2 simulator. The combination of clustering and routing patterns does influence the performance of VANET mobility.

Various authors have covered various mobility management techniques and their issues in the survey as listed above. Table given below summarizes these issues.

TABLE II MOBILITY MANAGEMENT ISSUES

Paper Name	Issues Covered	Remarks
Mobility and Handoff Management in VANET[2009]	Various host and network mobility solutions	Solution to mobility issues is to use NEMO to provide IP mobility support and various host specific protocols to be employed in more realistic scenarios.
An efficient Hybrid HIP-PMIPv6 scheme for seamless internet access in urban vehicular scenario[2010]	Interworking HIP-PMIPv6 scheme.	Mobility issues need improvement. Author suggests the need of Proxy Mobile IPv6 (PMIP) and further extensions.
Seamless quality driven multi hop data delivery scheme for video streaming in urban VANET scenario.[2011]	Multi hop PMIPv6 for VANET	For multi hop authentication problem in PMIPv6 author propose EM3A, a authentication scheme that guarantees authenticity of both MN and RN.
IP mobility management for VANET: challenges and solutions [2011]	Evaluation of NEMO RO solutions of VANET.	Due to handover delays and packet drops various mobility issues arises. Use of PMIPv6, NEMO protocols can be beneficial.
Global mobility and handover management for heterogeneous network in VANET[2013]	Network mobility among vehicles	For highways issues author suggest more and more access routers (AR) through which MR are connected, which helps MR1 to use MR2 services when handover takes place
Different mobility and handover management techniques in VANET[2013]	Comparison among SIGMA, MMIPv6, SMMP, EAR-HMIPv6 with MMIPv6.	Author suggests that recent mobility schemes to be evaluated in more realistic scenarios as mostly use NS2-network simulators.

IV. Open Issues and Future Scope

Lot of work has been reported in the related work section number III related to mobility management and handover techniques in VANET. Based on this related work various open issues have been extracted.

In Ad hoc routing various limitations which leads to degrading handoff performance with increasing number of hops, for which authors have given the solutions but they are unable to resolve. Traditional mobility model are not suitable for performance evaluation as they assume a random direction and speed selection. Major advancements still have to be taken in the field of providing security. Mobility management has also problem of data access and address configuration. All requests to compete for same limited bandwidth and time constraint are other challenges. Also miss of data upload leads to data staleness. Merging of dedicated VANET technologies like RAN (e.g, WiMAX) and 802.11p are still to be done, which is a challenge. Proper balancing of high priority safety info and users demands for infotainment applications are still the challenges to be resolved.

Future scope comprises an improved evaluation of various recent techniques like MMIPv6, SMMP, HMIPv6 and many more in more realistic vehicular scenarios. Still now accurate mobility patterns, network models and network performance which are the parameters on which evaluation relies are not available yet. There is a need of improving old technologies by keeping in mind large number of vehicles, frequently changing topologies, highway scenarios and high speed of vehicles. Mobility management issues are increasing rapidly so to resolve these issues there is a lot of scope in this area. Researchers have done a lot of work. Some of the issues have been solved built still there are many unsolved issues.

V. Conclusion

VANET is a critical part of ITS, so it has attracted significant research interest as the requirement of mobility management techniques are increasing. In this paper a comprehensive survey of mobility management techniques for VANET have been presented. The mobility management solutions for vehicular networks based on V2I or V2V communication have also been described. Some of the existing work for V2V and V2I mobility management has also been reviewed. Some light have also been thrown on several open research issues. Types of mobility management like handoff management and location management have also been outlined. In this paper various issues like security, performance evaluation, data access, address configuration, broadcast and routing issues, collision warning have been also presented. It is hoped that the survey done in this paper will prove to be beneficial to researchers working in the area of mobility management and its issues in VANET.

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