



Mobility Management in Vehicular Networks

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Abstract— *Mobility Management is an upcoming research domain for vehicular communication and smart transport related applications. One of the designs metric in mobility management in vehicles is a continuous communication between two or more mobile vehicle nodes. This requirement is more severe when the network type is vehicular. The present study provides a state of the art analysis of various mobility management protocols for vehicular networks, based on handoff latency and signaling cost. The study also provides detailed signaling of each mobility management protocol for handoff in vehicular networks.*

Keywords— *MIPv6; FMIPv6; HMIPv6; PMIPv6; NEMO BS; Handover Latency; Signaling Cost.*

I. INTRODUCTION

Now-a-days users are more mobile because of wireless technology and so mobility is one of an important issue in the networking scenarios. One of the goals of mobility management is to identify the location of the vehicle and the soft handoff. [5]. To manage handoff more efficiently in a vehicular environment, a good mechanism of detection and localization is needed. Handoff is a change of access point due to client's displacement. Solutions for V2I Mobility Management are based on Mobile IPv6 for interoperability.

A Handoff is a movement of a MN [Mobile Node] from one to other similar or dissimilar technology by keeping the connection active and seamless throughout. Handoff technique must ensure minimum signal overhead, small handoff latency and a small packet loss.

Handoff latency is defined as the time gap in which a MN cannot send or receive any packets during handoff over the network. It consists of L2 (Data Link Layer) and L3 (Network Layer) related handoff latencies [12]. IP Layer handoff latency includes vehicle movement detection latency; addresses configuration latency and Binding update procedure. Signaling Cost is the total number of packets exchanged between a MN and a home agent over the network (HA) [12].

Fig.1. illustrate V2I Mobility Management Schemes. If signaling is send or received by mobile host then it is host mobility, but if mobile network dynamically changes its PoA to the internet, then it is a Network Mobility.

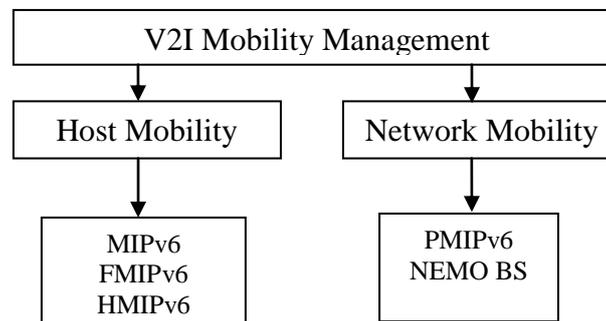


Fig 1: Basic Scheme of Mobility Management

MIPv6: When the mobile vehicular node travel to a different subnet, home IPv6 address is changed. An efficient mobility solution for this situation at network layer (L3) is required. The main limitation of MIPv6 is comparatively long handoff delay, high packet losses and high signaling overhead means MIPv6 is not scalable means with increasing number of vehicular nodes, signaling overhead increases dramatically. Due to these limitations, extensions of MIPv6 were proposed like FMIPv6 (Fast Handover for mobile IPv6) and HMIPv6 (Hierarchical mobile IPv6). Benefit of FMIPv6 is the reduction in the packet loss and handoff latency compared to MIPv6. HMIPv6 is better than MIPv6, since it reduces signaling overhead. Due to large handoff latency and packet loss, MIPv6 is not suitable for V2I communication for real-time services and due to heavy signaling overhead, caused by fast moving vehicles, MIPv6 is not Scalable for V2I communication [2].

FMIPv6: FMIPv6 brought a concept of Previous Access Router (PAR) and New Access Router (NAR) protocols. The mobile node like vehicle prepares for the handoff before it actually takes place [6].

HMIPv6: To improve performance of MIPv6 in terms of handoff speed, Mobility Anchor Point (MAP) is introduced. It is a router visited by the mobile node. It works like a local Home Agent for a vehicular node [7].

PMIPv6: PMIPv6 is a network based mobility management that is, the responsibility of handling mobility lies with the network devices and not mobile node. PMIPv6 partners are Local Mobility Anchor (LMA) and Mobile Access Gateway (MAG) [8].

NEMO BS: This Protocol used for mobility management is seamless to the mobile network nodes (MNNs) inside the vehicular area network. In this MNs are not directly connected to the infrastructure but are connected to Mobile Router (MR) placed on top of vehicle which handles mobility [17].

The paper is organized as follows: Section II gives literature survey of mobility management protocols in Vehicular Networks. Section III represents detailed signaling of Host mobility and Network mobility solution for Vehicular Networks in Network layer. Section IV gives analysis of each protocol with respect to handoff latency and signaling cost. In Section V, analysis results are shown. Comparisons of all protocols based on various parameters are tabulated in section VI. Finally, Section VII gives conclusion.

II. LITERATURE SURVEY

In [1], author has done a comprehensive survey on mobility management for vehicular networks.

In [2], author has broadly divided the mobility management into two types V2V and V2I communication. In this, NEMO BS protocol supports network mobility in vehicular communication.

In [10], authors have performed study to assess the most appropriate approach for the functional specification and the implementation, especially with respect to the implementation for the project's field trial by comparing MIPv6, FMIPv6 and HMIPv6 for handover latency. The authors concluded that when MIPv6 is compared with HMIPv6 or FMIPv6, HMIPv6 and FMIPv6 assures an equal or better performance, referring to handoff latency, than basic MIPv6 for most of the cases.

In [12], framework for IPv6-based mobility management protocols (i.e., MIPv6, HMIPv6, FMIPv6 and F-HMIPv6) is explained and analyzed. In terms of signaling cost and handoff latency, these protocols are compared and evaluated. In the paper, the effect of various parameters related to mobility was studied.

III. DETAILED SIGNALING

A) Mobile IPv6 (MIPv6) [5], [12]

MIPv6 is used for mobility management at the IP layer and allows a mobile node like vehicle to remain reachable even though it moves its moves within the IP environment. MN identification is done by its HoA, when it is a foreign network; MN is associated with a care-of address (CoA). Fig. 2 illustrates message sequence for MIPv6.

- Exchanging message RS/RA through NAR, is a Router Discovery procedure.
- Exchanging of Neighbor Solicitation/ Advertisement (NS/NA) messages is a DAD procedure to identify the uniqueness of CoA.
- Binding update to the home agent (HA) by MN is done by exchanging messages: binding update (BU) and binding acknowledgment (BAck).

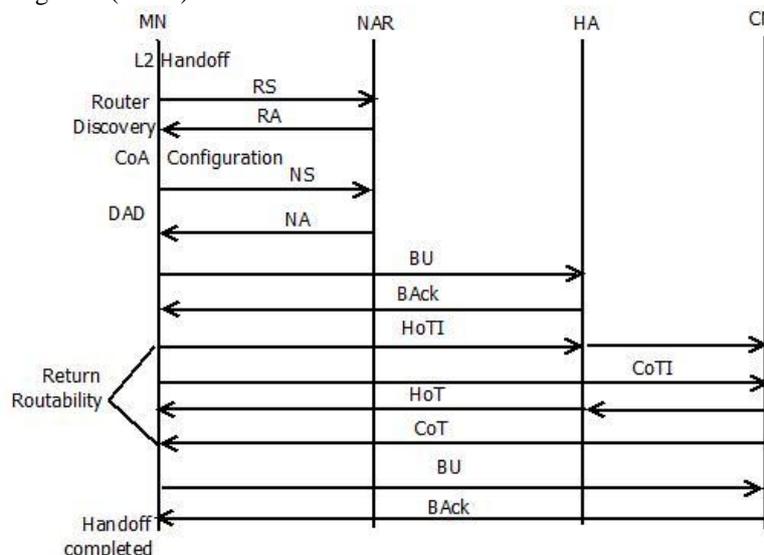


Fig. 2. Signaling messages sequence in MIPv6

- BU is performed to correspondent nodes (CN) for route optimization. To ensure BU message is authentic, Return Routability (RR) procedure must be performed.

B) Fast Handover for Mobile IPv6 (FMIPv6) [6], [12]

If MN receives FBBack message on the previous link before connecting to the new link, it is in the Predictive mode of Fast Handover. The Fig.3 illustrates message sequence for FMIPv6.

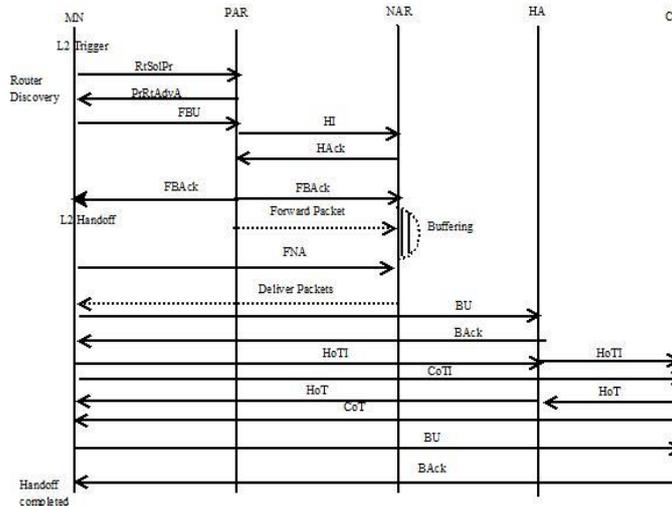


Fig.3. Signaling messages sequence in FMIPv6

- Movement Detection toward NAR (New Access Router) by MN is done by exchanging Router Solicitation for Proxy (RtSolPr) and messages with previous access router (PAR) is done by Proxy Router Advertisement (PrRtAdv).
- Fast Binding Update (FBU) message is then send to PAR by MN to associate previous CoA (PCoA) with NCoA.
- To prevent routing failure Handover Initiate (HI) and Handover Acknowledgment (HAck) message are exchange, between PAR and NAR.

C] Hierarchical Mobile IPv6 (HMIPv6) [7], [12]

MIPv6 signals overhead and the latency issues are handle by HMIPv6 using a special node called Mobility Anchor Point (MAP). The MAP works like HA in the visited network and it will restrict the amount of MIPv6 signaling outside its domain and reduce the amount of delay. HMIPv6 operates in two scenarios: Intra-MAP domain and Inter-MAP domain. Intra-MAP handoff happens when Mobile Node moves within a MAP domain and Inter-MAP handoff takes place, when MN moves between two different MAP's.

Sequence of messages used in HMIPv6-Intra MAP Domain is shown in Fig. 4.a.

- Temporary IP addresses like a regional care-of address (RCoA) on the MAP's subnet and an on-link care-of address (LCoA) which corresponds to the current location of the Mobile Node is configured in a MAP's domain.

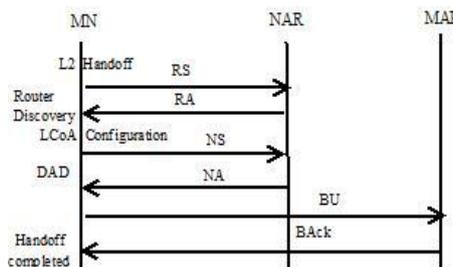


Fig. 4.a. Signaling messages sequence HMIPv6-Intra MAP Domain

MIPv6 is used for Inter-MAP Domain. Sequence of messages used in HMIPv6-Inter MAP Domain is shown in Fig. 4.b.

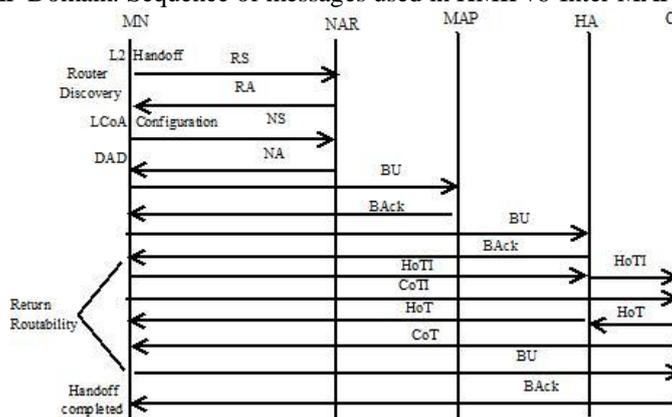


Fig. 4.b. Signaling messages sequence in HMIPv6-Inter MAP Domain

- When an Mobile Node cross a new MAP's domain , BU messages are required to be send by the Mobile Node to its HA/CNs.

D] Proxy Mobile IPv6 (PMIPv6) [8], [12]

PMIPv6 is used to support mobility using the AAA Server, LMA, and MAG. The AAA Server (Authentication, Authorization, and Accounting) is used to manage the Mobile Node's authentication and maintain Mobile Node's profile. Reachability to MN's address while the MN moves around within a PMIPv6 domain, is the main function of LMA. LMA consists of a Binding Cache Entry (BCE) for currently registered Mobile Node. The MAG (Mobile Access Gateway) is a function on an Access Router (AR), responsible for tracking the Mobile Node's movements to and from the access link. Sequence of messages used in PMIPv6 is shown in Fig.5.

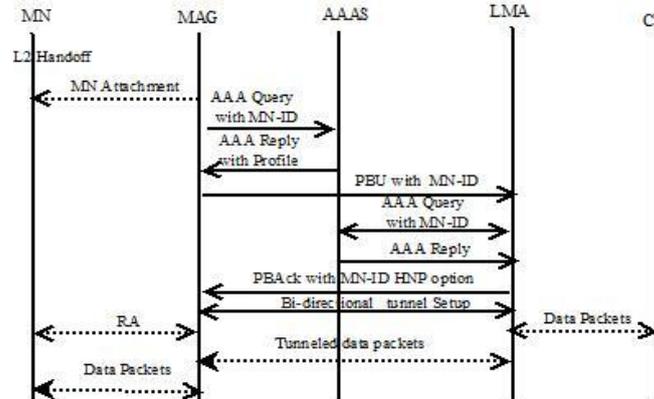


Fig. 5. Signaling messages sequence in PMIPv6

- The authentication is performed using MN's identity (MN-ID), when MN connects to an access network via MAG.
- After authentication is valid, the MAG can obtain the MN's-Profile which contains MN-ID, LMA address from policy store (like, Authentication, Authorization and Accounting Server).
- MAG sends a Proxy Binding Update (PBU) message to the MNs-LMA for the Mobile Node.
- After LMA receives PBU message, it checks the policy store to confirm that the sender is valid to send the PBU message. If the sender is a valid MAG, the LMA accepts the PBU message.
- Then LMA sends a PBAck message including MN's-HNP option to MAG. The MAG then sends RA message to the Mobile Node with its MN-HNP
- A tunnel is established between the LMA and MAG, after which all traffic sent from the MN gets routed to its LMA through the tunnel.

E] NEMO BS Protocol [17]

NEMO BS was designed, to minimize the change to existing architecture and to maintain backward compatibility which was based on MIPv6. Sequence of messages used in NEMO BS is shown in Fig.6.

- In NEMO BS, when a foreign MNNs (Mobile Network Nodes) visit to the mobile network using MIPv6, the MNN receive a subnet prefix called Mobile Network Prefix (MNP) which is advertised by the MR.
- After receiving MNP, Mobile Network Nodes (MNN) established a new CoA based on MNP.
- Binding Update (BU) message is send by MNN to its Home Agent (HA), which then reverses back to MNN.
- Acquires a CoA from the visiting network and binding cache is then updated.
- A path between mobile router and home agent is established, after the Binding Procedure.
- The packets from HA to MR is then forwarded to MNNs. As a result, packets cannot be tunneled to the MR correctly.

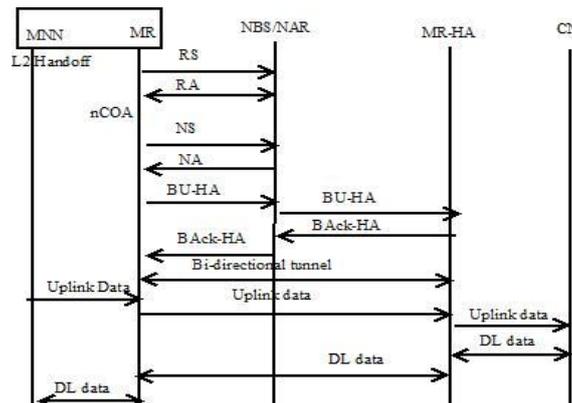


Fig. 6. Signaling messages sequence in NEMO BS

IV. ANALYSIS

Following notations are considered for analysis from [14] [16].

Table 1: Notation

<i>HL</i>	Length of Handover Latency
<i>SC</i>	Total signaling cost for handover
<i>C(L2)</i>	Layer 2 handover latency/cost
<i>C(MD)</i>	Movement Detection latency/cost
<i>C(DAD)</i>	Duplicate Address Detection latency/cost
<i>C(FNA)</i>	Latency/cost in sending FNA message to NAR
<i>C(BU)</i>	Binding Update latency/cost for HA/CN
<i>C(BU-MAP)</i>	Binding Update latency/cost for MAP/NMAP
<i>C(MAG-LMA)</i>	Latency/cost between MAG and LMA
<i>p</i>	Latency or cost of packet delivery between MN and Access Router (PAR/NAR/MAP/MAG/LMA)
<i>q</i>	Latency or cost of packet delivery between Intermediate Routers (PAR-NAR/MAG, LMA)
<i>a</i>	Latency or cost of packet delivery between MN and HA
<i>b</i>	Latency or cost of packet delivery between HA and CN
<i>c</i>	Latency or cost of packet delivery between MN and CN

Table 2: Analysis of Mobility Management Protocols

Protocols	Handoff Latency	Signaling Cost
MIPv6	$C(L2)+4p+(4a+2b+4c)$	$C(L2)+4p+(4a+2b+4c)$
FMIPv6	$C(L2) + p$	$C(L2)+5p+2q+(4a+2b+4c)$
HMIP-INTRA	$C(L2)+6p$	$C(L2)+6p$
HMIP-INTER	$C(L2)+6p+(4a+2b+4c)$	$C(L2)+6p+(4a+2b+4c)$
PMIPv6	$C(L2)+p+6q$	$C(L2)+p+6q$
NEMO BS	$C(L2) + 4p + 2a$	$C(L2)+4p+2a$

V. ANALYSIS RESULTS

Table 3 is based on values used in [16].

Table 3: Numerical Analysis Values

<i>C(L2)</i>	<i>p</i>	<i>q</i>	<i>a</i>	<i>b</i>	<i>c</i>
20ms	6ms	2ms	5ms	8ms	3ms

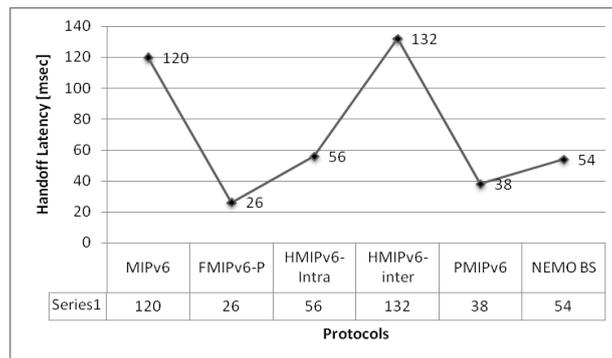


Fig. 7. Numerical Result for Handoff Latency

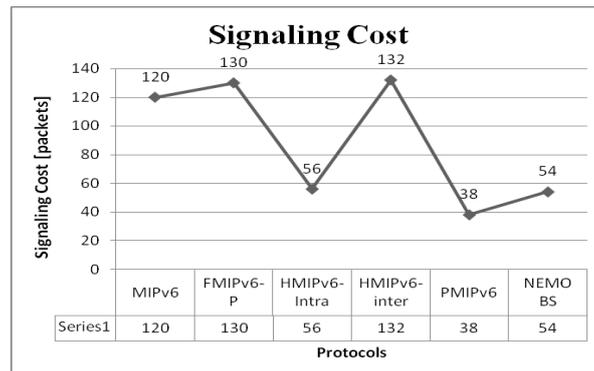


Fig. 8. Numerical Result for Signaling Cost

VI. COMPARISON

Table 4: Comparative Study of Mobility Management Protocols

Parameters Protocols		Movement detection	Duplicate address detection (DAD)	Return Routability	MN Modification
MIPv6		Required (performed by RS/RA)	Performed at every subnet movement	Required	Required
FMIPv6				Required	
HMIPv6	Intra			Not Required	
	Inter			Required	
PMIPv6		Not required (performed by layer 2)	Performed only one time (at initial movement into the domain)	Not Required	Not Required
NEMO BS		Required (performed by RS/RA)	Performed at every subnet movement	Not Required	

VII. CONCLUSION

Future vehicular networks are quickly evolving towards all-IP networks and most of the hand-held devices will be Internet enabled. Therefore, with the explosive growth of mobile devices on the Internet, the IP mobility management technology issue will arise.

- L2 information should be utilized to reduce handoff latency. Among the protocols considered, FMIPv6-Predictive mode follows this. Thus they result in reduced handoff latency as compared to others.
- Buffering Management should be implemented to avoid packet loss. Thus, FMIPv6 provide buffering at NAR which reduces packet loss during Layer2 handoff.
- DAD process comprises of a considerable amount of handoff latency. MIPv6 and HMIPv6 show poor performance as compared to others as they need to perform DAD process after L2 handoff.
- Observation shows that due to reduced handoff, NEMO BS is more efficient for vehicular networks, when compared with MIPv6.
- When compared NEMO BS with PMIPv6 protocol, it is found that allowing MN to be free from any handoff signaling, considerably reduces handoff latency. This is provided by PMIPv6 protocol.
- Thus, in mobility management for vehicular network, PMIPv6 based protocol is a better option compared to the NEMO BS.

REFERENCES

- [1] Kun Zhu, Dusit Niyato, Ping Wang, Ekram Hossain and Dong In Kim, "Mobility and Handoff Management in Vehicular Networks: A Survey", in Wiley Inter- Science in 2009.
- [2] Muhammad Naveed Dilber, "V2I Mobility Management in Vehicular Networks", International Journal of Advances in Science and Technology (IJAST).
- [3] Marc Bechler, Lars Wolf, "Mobility Management for Vehicular Ad Hoc Networks", in proceeding of IEEE vehicular technology, 2005.
- [4] Richa Sharma and Jyoteesh Malhotra, "A Survey on Mobility Management Techiques in Vehicular Ad-hoc Network", International Conference on Communication, Computing and Systems (ICCCS), 2014.
- [5] D. Johnson, C. Perkins, and J. Arkko, "Mobility Support in IPv6", IETF RFC 3775, June 2004.
- [6] R. Koodli, "Fast Handovers for Mobile IPv6", IETF RFC 4068, July 2005.
- [7] H. Soliman, C. Castelluccia, K. ElMalki, and L. Bellier, "Hierarchical Mobile IPv6 Mobility Management (HMIPv6)", IETF RFC 4140, August 2005.
- [8] S. Gundavelli, K. Leung, V. Devarapalli, K. Chowdhury, and B. Patil, "Proxy Mobile IPv6", IETF RFC 5213, August 2008.
- [9] H. Yokota, K. Chowdhury, R. Koodli, B. Patil, and F. Xia, "Fast Handovers for Proxy Mobile IPv6", IETF RFC 5949, September 2010.
- [10] Ian F. Akyildiz, Jiang Xie, and Shantidev Mohanty, "A Survey of Mobility Management In Next-Generation All-IP-Based Wireless Systems", IEEE Wireless Communications, August 2004.
- [11] X. Perez-Costa, M. Torrent-Moreno, and H. Hartenstein, "A Performance Comparison of Mobile IPv6, Hierarchical Mobile IPv6, Fast Handovers for Mobile IPv6 and their Combination", ACM SIGMOBILE Mobile Computing and Communications Review, vol. 7, no. 4, pp. 5–19, October 2004.
- [12] C. Makaya and S. Pierre, "An Analytical Framework for Performance Evaluation of IPv6-Based mobility Management Protocols", IEEE Transactions on Wireless Communications, vol. 7, no. 3, pp. 972–983, March 2008.

- [13] Xavier Pérez Costa, Ralf Schmitz, Hannes Hartenstein, Marco Liebsch, "A MIPv6, FMIPv6 and HMIPv6 handover latency study: analytical approach", Information Society Technologies Mobile and Wireless Telecommunications Summit, vol. 6, pp. 100-105, 2002.
- [14] Jong-Hyouk Lee, Jean-Marie Bonnin, Ilsun You, Tai-Myoung Chung, "Comparative Handover Performance Analysis of IPv6 Mobility Management Protocols", IEEE Transactions On Industrial Electronics, 2012.
- [15] Ibrahim Al-Surmi, Mohamed Othman, Borhanuddin Mohd Ali, "Mobility management for IP-based next generation mobile networks: Review, challenge and perspective", ELSEVIER Journal of Network and Computer Applications 35, 2012.
- [16] Nguyen Van Hanh, Soonghwan Ro, Jungkwan Ryu, "Simplified fast handover in mobile IPv6 networks", ELSEVIER Computer Communications 31, 2008.
- [17] Zhenxia Zhang, Azzedine Boukerche, Richard W. Pazzi, "A Novel Network Mobility Management Scheme for Vehicular Networks", IEEE Globecom, 2010.