Optimized Fast Handover using TBU Scheme for PMIPv6 Based Network Mobility

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Abstract  
The Internet Engineering Task Force proposed a host-based mobility management protocol, called Mobile IPv6 for mobile nodes to maintain continuous service when they move to a foreign network but causes long disruptions during handover. Hence a new scheme is proposed based on PMIPv6 and EfNEMO to mitigate packet loss, signaling problem and handover latency. This scheme ensures that the MN maintains the same Home Network Prefix in the localized domain and the current location of the MN is stored in Home agent and pre-registration of MN location is performed. This work is being carried out using the Network Simulation tool OMNeT++ 4.0.

Keywords: Mobile Nodes, Home Network Prefix, Enhanced Fast Nemo

INTRODUCTION  
Motivation  
Internet Protocol version 4 (IPv4) was introduced in 1981. The growth of interconnected computers has lead to the depletion of IPv4 and a new version of addressing system called IPv6 was developed. The main difference between IPv4 and IPv6 lies in the addressing format. IPv4 uses 32 bits addresses, but in contrast, IPv6 uses 128-bits as the length of the IP address. The demand for being connected to the network always has led to challenges in developing next generation wireless networks that provide seamless connectivity when an MN undergoes handover. This connection transfer is called a handover and is shown in Fig. 1.

During the handover, there is a period of time that the MN is unable to send or receive any data packet and all packets destined to the MN are lost. This IP mobility management is handled by the introduction of multiple Mobile Management protocols such as Mobile IPv6 (MIPv6) and its extensions within the control of the Internet Engineering Task Force (IETF) [1][2]. Currently, the protocols are either host-based mobility management protocol or Network-based Localized Mobility Management Protocol (NETLMM).

NETLMM shown in Fig. 2 is more convenient for deployment by operators for the reasons: Support for unmodified MN since no software modification is required, Efficient use of wireless resources by not requiring for tunneling and extra overheads over wireless links and Reduction in handover-related signaling volume and thereby reducing battery usage.

Figure 1: Host based Mobility Management Protocol

Figure 2: Network based mobility management handover process

The paper is organized as follows: Section II illustrates Existing techniques. Section III presents the proposed method. Section IV gives the proposed algorithm and performance analysis. Result of the proposed method is discussed in Section V. Real time application of the proposed method is presented in section VI. Section VII concludes.
EXISTING TECHNIQUES

MIPv6
Shyama Sinan et al [3] present an overview of the handover process in MIPv6. Here each node in MIPv6 has a home network and an IPv6 home address assigned to MN within the network prefix of the home network. The MN’s IPv6 home address does not change regardless of where MN is. The MN acquires a Care of Address (CoA) when it moves away from the home network. The MIPv6 protocol shown in Fig. 3 requires registration of CoA with the home agent thereby giving the home agent the current point of attachment to the mobile node [4]. The correspondent node maintains a mapping of the home address and the care of address of the mobile node. The mobile node updates the mapping to the correspondent node by sending binding update messages whenever it receives packets from the home agent. But MIPv6 suffers from significant overhead in increased delay, packet loss and signaling cost when the MN changes the point of attachment to the network frequently and is not acceptable to the real-time applications like VoIP. This has lead to the development of the faster protocols like FMIPv6 and their enhancements.

![Figure 3: Handover process of a MIPv6 node](image)

fNEMO (fNEMO with MIPv6)
Yvette E. et al [5] discussed a scheme for reducing packet loss in MIPv6 fast handover. Fast handovers for Mobile IP protocol proposed by the Mobile IP working group of the IETF specify the enhancements to Mobile IPv6 that enable a mobile node (MN) to connect to a new point of attachement more rapidly [6]. fNEMO works as a combination of NEMO BS and MIPv6. Here the mobility movement is performed for a single MN at a time. In Fast NEMO (NEMO) shown in Fig 4, the handover process is triggered by the previous MAG (PMAG), A Fast Binding Update (FBU) is sent from PMAG to new MAG (NMAG). The FBU message contains the New Care of Address (NCoA) to which the MN wishes to move. At the NMAG, the Duplicate Address Detection (DAD) process is performed and the mobility is rejected as invalid if the profile of a Mobile Node(MN) does not support mobility process. Otherwise the mobility is considered to be valid and the location of the Mobile Node is registered in the Home Agent (HA). During the handover process the location of the Mobile Node (MN) is unknown and the packets are lost during the movement. The protocol aims to reduce service degradation by minimizing the time during which an MN is unable to send or receive IP packets But this protocol suffers from the disadvantage of packet loss since the concept of MR could not be incorporated here. With the emergence of real-time traffic, it is necessary to ensure IP connectivity and rapid handovers to avoid unnecessary latencies. Disadvantages in FMIPv6 includes possibility that an MN may fail, either inadvertently or purposely, to undergo handover to the NMAG. This can cause the NMAG to waste its memory containing the buffered packets, and in the worst case, could create resource exhaustion concerns. Hence implementations must limit the size of the buffer as a local policy configuration that may consider parameters such as the average handover delay, expected size of packets, and so on. FMIPv6 protocol provides a mechanism that reduces a packet loss and improves handover latency [7]. Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. There are numerous reasons why packet loss occurs: Insufficient bandwidth, network connection problems, hardware failure, routing problems, router configuration and others. Hence, packets will be lost if the MN is not attached to the NMAG at the time of packet transmission.

![Figure 4: Handover Process in fNEMO](image)

NEMO BS
Ignacio Sotoet al [8] considered a NEMO-Enabled Localized Mobility Support for Internet Access in Automotive Scenarios. Here attachment points are available both in fixed locations (airports) and mobile locations (vehicle). Users require continuous connectivity to the network while moving from one access point to another. Since users spend only a short period of time in vehicle they require continuous connectivity with the fixed access point as well. This requirement is addressed by an integration solution. Thus the
protocol used to provide transparent access to internet is NEMO BS [9][10]. For this purpose special devices called Mobile Routers located in vehicle handle the communication with the fixed infrastructure and provide access to users devices using short range radio technology. Here a set of Mobile Network Nodes (MNN) as shown in Fig 5 are connected to the Mobile Router (MR), which performs signaling on behalf of all the MNs. During handover process the Mobile Router along with its network moves from one access point to another access point. Since Route Optimization protocols were not standardized in NEMO BS an integrated solution that combined NEMO BS and MIPv6 was required. Since NEMO resides in home network when it is not moving the mobile network address is configured based on this home network called Mobile Node Prefix (MNP)[10]. While NEMO is away from its home network packets are still addressed through the home agent. Additionally, while NEMO is away from home the MR acquires an address from the visiting network called Care of Address (CoA). This protocol lacks the ability to standardize route optimization protocols. Hence integrated solution is required to achieve further improvement in performance [12].

**PROPOSED METHOD**

The objective of the proposed system is to achieve fast handover by extending the basic handover process of PMIPv6 and EfNEMO protocol. The handover process should be followed in order to reserve the connectivity when a mobile router moves from one subnet to another subnet. The mobility is performed by the mobile router in vehicular networks to which a set of mobile nodes are connected. The handover process consists of Layer2 (L2) and Layer3 (L3) handover. In the proposed method, the mobile router exchanges the binding update and binding acknowledgement messages on behalf of mobile node with the LMA. A scheme named Tentative binding update (TBU) that pre-registers the NCOA is incorporated. The mobile router sends Fast Binding Update (FBU) along with TBU before the Layer2 handover to the PMAG as shown in Fig. 6.

![Figure 5: NEMO BS Representation](image)

![Figure 6: EfNEMO Representation](image)

![Figure 7: PMIPv6 Handover process](image)

**ALGORITHM OF PROPOSED METHOD**

1. The MR initiates TBU scheme from a Layer2 trigger.
2. The MR sends the FBU message encapsulating TBU message to the PMAG.
3. When the PMAG receives the FBU message it creates a HI message encapsulating TBU message.
4. The NMAG verifies NCOA and acknowledges to PMAG.
5. The NMAG sends a TBU to the LMA.
6. Upon receiving this request, the LMA assigns a prefix to the MR.
7. The LMA receives the TBU message and verifies the authentication information. If the TBU message is verified, a prefix with Tentative MAG field is added in the binding cache entry is stored.
8. Then the LMA sends the TBA including the prefix assigned to the MR to the NMAG.
9. Whenever the MR moves, NMAG updates the MR location in the LMA and advertises the same prefix to the MR.

RESULTS DISCUSSED
The implementation of network mobility has been carried out using OMNET++ 4.0 simulation tool. The network mobility of MIPv6 shown in Fig. 8 shows the movement from home agent to foreign agent. The simulation parameters are given in Table 1.

The corresponding Care of Address gets registered in the Binding Cache Entry of the Home Agent. This process consists of a single MN undergoing handover process and the corresponding HoA and CoA gets registered. EfNEMO is implemented consisting of a set of MNs undergoing handover process. The proposed system where PMIPv6 is combined TBU is developed and graphical representation of the Handover Latency, Packet Delivery Ratio are plotted.

![Diagram](image)

**Figure 8: Network Mobility of MIPv6 with 3AR**

<table>
<thead>
<tr>
<th>Table 1: Simulation Parameters for Handover process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Total_MN</td>
</tr>
<tr>
<td>Total_CN</td>
</tr>
<tr>
<td>neighbourDiscovery. minIntervalBetweenRAs</td>
</tr>
<tr>
<td>neighbourDiscovery. maxIntervalBetweenRAs</td>
</tr>
<tr>
<td>*<em>. MN</em>. **._mgmt. accessPointAddress</td>
</tr>
<tr>
<td>*<em>. MN</em>. mobilityType</td>
</tr>
<tr>
<td>*<em>. MN</em>. mobility. updateInterval</td>
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<tr>
<td>*<em>. MN</em>. pingApp[0]. destAddr</td>
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<td>[Config One]</td>
</tr>
</tbody>
</table>

**Graph for Handover Latency**
The Handover procedure is composed of several sub-processes and the delay associated with them. The total handover is calculated as shown in equation (1).

$$T_{HO} = T_{MD} + T_{HR} + T_{RD} + T_{CR}$$  \hspace{1cm} (1)

Where $T_{HO}$ = Total Handover, $T_{MD}$ = Movement Detection, $T_{HR}$ = Home Registration, $T_{RD}$ = Return Routability.

The movement detection ($T_{MD}$) is further composed of the following sub-components as shown in equation (2).

$$T_{MD} = T_{L2} + T_{RD} + T_{DAD}$$  \hspace{1cm} (2)

Where $T_{L2}$ = Layer 2 (L2) Handover, $T_{RD}$ = Router Discovery, $T_{DAD}$ = Duplicate Address Detection Delay.

The overall handover is a sum of the handover latency incurred by L2 handoff process ($T_{L2}$) and L3 process. The handover delay incurred by this protocol mainly depends on the speed with which the MN is able to detect its movement and discover a new access router. This delay is represented by $T_{RD}$ and is dependent on the RA interval, the value of which is determined using a uniform distribution function over a minimum and maximum value, whereas the other delay components are more or less constant and they depend on the quality and reliability of the wireless link. For this reason a minimum RA interval value of 0.03 seconds and a maximum RA interval value of 0.07 seconds have been altered for various runs of the simulation as shown in Table 2.

<table>
<thead>
<tr>
<th>Test Cases</th>
<th>Minimum RA interval (in seconds)</th>
<th>Maximum RA interval (in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Test 2</td>
<td>0.05</td>
<td>1.5</td>
</tr>
<tr>
<td>Test 3</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Handover Components</th>
<th>MIPv6 with EfNEMO</th>
<th>PMIPv6 with EfNEMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Detection</td>
<td>2.06374</td>
<td>0.34316</td>
</tr>
<tr>
<td>Home Reg</td>
<td>1.93871</td>
<td>0.654</td>
</tr>
<tr>
<td>Return Routability</td>
<td>1.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Total Handover</td>
<td>5.012</td>
<td>1.004</td>
</tr>
</tbody>
</table>

The graphical representation of the total handover based on the L2 and L3 trigger is shown in Fig. 9. The latency components taken into consideration and the handover time in seconds are taken as X axis and Y axis respectively. The simulation of the existing system indicated by the blue color in the graph depicts the mobility of the MN carried out by varying the RA intervals in the range 0.03 to 1 (minimum RA value) and 0.07 to 3 (maximum RA value) as shown in Table 2. The mobility of the MN considered is Linear motion mobility. Since NEMO BS support was lacking in the existing system the individual binding updates and acknowledgments consumed significant time resulting in increased handover latency which is evident from the graph.
The graphical representation of the packet loss involved based on the L2 and L3 trigger is shown in Fig. 10. The parameters taken into consideration and the time in seconds during which the packet loss occurs are taken as x axis and Y axis respectively. The existing system indicated by the blue color line shows that the packets lost during the time between the de registration of the MN and the time the MN attaches itself to the new access point is high. The proposed system represented as the red color line in the graph shows the packet loss rate has reduced by half by pre-registering the HoA in the BCE and BU list and utilizing the NEMO BS principle. The results of packet loss in each latency component is recorded and shown in the Table 4.

**APPLICATIONS**

Network Mobility carries the entire network of IP devices that is connected to the internet. By incorporating the NEMO BS protocol the entire network experiences seamless connectivity without having to change its address during the handover process. Internet access in automotive scenarios is a relevant case because people in modern cities spend much time in transportation and vehicles. Similarly in Automobiles the wireless equipment provides a shared access point to all the users. A special device called a mobile router (MR) is defined to extend the mobile node (MN) by adding the capability of routing between its point of attachment and a subnet that moves with the MR. This environment is constructed for travelers in a moving car.

**CONCLUSION**

The various mobility management protocols have been discussed. The combination of PMIPv6 and TBU has been proposed to improve the handover latency and reduce packet loss. The proposed PMIPv6 structure has also been implemented and the results are discussed. The performance parameters such as handover latency and packet loss prove that the proposed method outperforms EfNEMO. Performance of the proposed system in real time applications needs to be analyzed in future.

**REFERENCES**


