CHAPTER 5

AVOIDING DATA LOSS USING N-PMIPv6 AND SIMULTANEOUS BINDING

When a mobile user is traveling through a vehicle like a car or train the expectation is to maintain constant Internet connection without connection break-ups and data loss. This vehicular Internet connectivity is enabled by establishing connectivity to nearby networks. N-PMIPv6 Novell Architecture enables seamless and efficient integration of mobile networks. Users moving through vehicles access Internet through the mobile networks. It requires more bandwidth if the user access multimedia data such as audio, video, graphics and animation. As per the literature by X.Perez and Hartenstein (2002), accessing such high volume of data through wireless networks may degrade the quality of data due to the packet loss. The quality of audio and video may get affected due to serious data loss in mobile networks. A solution to avoid the data loss issue, by integrating simultaneous binding and N-PMIPv6 is proposed in this chapter. The proposal is called as SBNPMIPv6 (Simultaneous Binding in NEMO enabled Proxy MIPv6) and it is implemented using NS2 simulation tool to test.

5.1 PROXY MOBILE IPv6

PMIPv6 is a protocol devised by IETF to support mobility for a large network (Gundavelli et al. 2008). This protocol makes use of Mobile Access Gateway (MAG) which is pointed by Ignacio et al. (2010). MAG role is similar to access router, by providing connectivity to the Mobile Terminals (MT) present in its range. Chin-Chen et al. (2009) highlights that this protocol makes use of a
specific node called as Localized Mobility Anchor (LMA). LMA acts as a proxy and takes care of several MAG’s within its coverage area. Figure 5.1 illustrates PMIPv6 concept.

When a MT reaches a new mobile network, it requests a CoA to the MAG. MAG allocates the corresponding prefix to the MT. Ignacio (2010) points that, the MAG will register the information about the new MT along with its allocated prefix in the form of a table. LMA acts as a proxy and takes up the role of informing the latest CoA of the MT to the respective HA. After CoA binding, a tunnel is established between the LMA and the HA. Consider that the MT starts moving and reaches a new MAG in Figure 5.1. The new CoA allocated by MAG2 is updated only in LMA table, and details regarding this localized mobility are not informed to the HA. This is because MAG acts as proxy and takes the responsibility of tracking and updating the location of the mobile node to the central authority. When the MT moves to different LMA, it has to be updated to the respective HA. This protocol is considered as an existing mechanism to control mobility of terminals in a large network. LMA maintains a table (Table 5.1) to keep track of the each mobile node and its connectivity details through the address prefix.
Table 5.1 LMA Mobile Node Address Table

<table>
<thead>
<tr>
<th>Node</th>
<th>Prefix</th>
<th>Access Router</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN1</td>
<td>Prefix1::/64</td>
<td>MAG1</td>
</tr>
<tr>
<td>MN2</td>
<td>Prefix2::/64</td>
<td>MAG1</td>
</tr>
<tr>
<td>MN3</td>
<td>Prefix3::/64</td>
<td>MAG2</td>
</tr>
</tbody>
</table>

5.2 SIMULTANEOUS BINDING

Perkins (2002) shows that the Simultaneous Binding mechanism is an extension of FMIPv6. This technique minimizes the packet loss to MN. As per Patrick et al. (2000) literature, the traffic of the MN is forwarded to its current location and the next expected location. In vehicular networks, the terminals are in continual movement and thus it is complicated to track the location of the terminals in the specified period. Under many circumstances the MT moves to a new location and receives a new CoA while the packets are still delivered to the PAR. This problem is due to the binding delay of the new CoA to the HA (Karim and Hesham 2005). A simple solution for the above problem is to bi-cast or n-cast the data packets for a short period from Old Access Router (OAR) to one or more future locations before the node reaches it.

Figure 5.2 Simultaneous Binding Flow
The sequence diagram (Figure 5.2) illustrates the concept of simultaneous binding using three gateways and one mobile node. Consider a situation where the data transmission takes place between the MT and the CN. It is assumed that the MT moves out of the coverage area of MAG1 and reaches the range of MAG2. In normal conditions, the packets are still transmitted to MAG1 due to the lack of knowledge about the location change of MT. However in case of simultaneous binding, the packets are transmitted to the present and near future locations with a life time, which is discussed by Perkins (2002). This lifetime restricts the time taken for agent advertisement, registration and reply. According to this concept, if the handoff is initiated or detected, then the packets are forwarded to the current MAG and to the expected future locations. Unlike other techniques which demands more information to be processed at each components such as the address, location and other details of the user, this technique requires the storage of less bandwidth table information. Xavier et al. (2002) observed that, when the network tries to reduce the latency, fast handoff and HMIPv6 are plentiful. Simultaneous binding protocol performs well by avoiding the packet loss.

5.3 N-PMIPv6 (NEMO enabled PMIPv6)

In this approach, network mobility is integrated with the usage of MAG and LMA (Ignacio et al. 2009). In N-PMIPv6, users can obtain connectivity either from fixed locations or mobile platforms (e.g., Vehicles) and get uninterrupted data transmission. N-PMIPv6 structure exhibits two outstanding characteristics. Firstly, N-PMIPv6 is totally network based therefore no mobility support is required in the terminals. This means that the mobility of terminals within the network is transparent. Secondly, the handoff performance is improved, both in terms of latency and signaling overhead.
NEMO basic support protocol requires MR to manage their mobility, which is not required in N-PMIPv6. N-PMIPv6 makes use of LMA and MAG to manage the mobility of the entire network. Hence MR need not manage the individual MT. The LMA adds the new binding cache entry associating the id of MT with prefix. LMA table also contains details regarding the MAG to which the MT is being attached. The MAG acts as a proxy for the mobile node; hence only one control message is sent to the LMA. The disadvantage of this approach is the nested tunneling that in turn leads to packet loss. This packet loss degrades the quality of multimedia data that are transmitted.

Though this architecture provides connectivity for the vehicular networks, there is a security issue regarding the authentication of CoA given by MAG to LMA table. Providing the optimized route to the vehicular networks is another significant challenge for this N-PMIPv6 architecture. The main drawbacks are,

- Nested tunnels while delivering packets to the mobile nodes.
- The packet loss, which degrades the performance especially in multimedia data transmission.
- Mobile access gateways are not authenticated by LMA.

5.4 INTEGRATION OF SIMULTANEOUS BINDING and N-PMIPv6 (SBNPMIPv6)

The proposed architecture integrates N-PMIPv6 protocol with simultaneous binding. N-PMIPv6 uses MAG and LMA to provide seamless connectivity while simultaneous binding eliminates packet loss during mobility of terminals by n-casting the data packets to multiple access routers. The SBNPMIPv6 architecture is shown in Figure 5.3. Considering that there is an
ongoing data transmission between the CN and the MT, data packets from CN are first transmitted to the HA of the MT. The packets are then transmitted from HA to corresponding LMA through the bi-directional tunnel. The concept of simultaneous binding is integrated during the transmission of packets from the LMA to the MT. Hence the nodes that are under constant motion are identified to apply simultaneous binding.

LMA transmits the packets to the current MAG and the future MAG’s within its coverage. These data packets are sent with a short life time. The life time of the packets at the MT is watched by maintaining a table, to restrict the duplicate deliveries of packets. This approach makes sure that packet loss to the MT is prevented. This is because even if the MT reaches a near MAG, packets are delivered since the packets are n-casted by LMA to all MAGs. Only the MAG which contains the MT within its range accepts the packets while the remaining MAGs discard the packets. Duplication of the packet is being avoided by the usage of the life time. Each and every packet is sent along with its life span. In case the packet is not delivered to the destined node within the given life time, the packet gets discarded. Thus, packet loss as well as packet duplication is being eliminated in this approach. The problem of packet loss in N-PMIPv6 is eliminated that makes receipt of superior quality video and audio files.

Figure 5.3 Integration of Simultaneous Binding and N-PMIPv6
The Table 5.2 is a sample table maintained at LMA and acts as a root for all the data transfer. The parameters in the table are node ID, IPv6 prefix of the node, access router and the m-flag. The m-flag is used to ensure that the MN is constantly moving. This information inside the table is maintained at the LMA, and it is constantly updated with the necessary information. The information is shared by the trusted node or MAG. MAG plays a vital role in filling up the above table. If a mobile node comes under the MAG, it sends its IPv6 address to the LMA without the usage of bandwidth from the node.

**Table 5.2 LMA Table**

<table>
<thead>
<tr>
<th>ID</th>
<th>PREFIX</th>
<th>AR</th>
<th>M-FLAG</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN1</td>
<td>Pref1::/64</td>
<td>MAG1</td>
<td>No</td>
</tr>
<tr>
<td>mMAG1</td>
<td>Pref2::/64</td>
<td>MAG1</td>
<td>No</td>
</tr>
<tr>
<td>MN3</td>
<td>Pref3::/64</td>
<td>MAG3</td>
<td>No</td>
</tr>
<tr>
<td>MN2</td>
<td>Pref4::/64</td>
<td>mMAG1</td>
<td>Yes</td>
</tr>
</tbody>
</table>

If the node is constantly moving in the vehicle at some speed, the m-flag is set as true else as false. Using m-flag the mobility of the node can be judged.

**Table 5.3 MN Table**

<table>
<thead>
<tr>
<th>PACKET ID</th>
<th>LIFE TIME (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>34S</td>
</tr>
<tr>
<td>P2</td>
<td>20S</td>
</tr>
<tr>
<td>P3</td>
<td>10S</td>
</tr>
</tbody>
</table>
The Table 5.3 is maintained at the mobile node itself so that it can avoid the duplicate packets. When the mobile node is between the two MAGs it may get many duplicate packets, and it makes the node congested. The parameters packet id and lifetime are helps the mobile node in rejecting the duplicate packets.

When the CN needs to send packets to MN2, the packets first reach the LMA. Then the LMA refers the table which contains the details of the entire network such as IP address, access routers, terminals etc. By verifying the table, the LMA reads the current location of the MT and the Access Point (AP). According to the simultaneous binding technique, the packets are sent to the previous, current and the next AP or AR. In Figure 5.3, MN2 is situated under MAG2 and therefore the packets are sent to MAG1, MAG2 and MAG3. The packets reach all the three AP’s at the same time, so that the MN2 can be reached. As MN2 is situated in MAG2, it receives the packet and the other AP’s such as MAG1 and MAG3 discards the packets.

If the MN2 moves fast and it comes under MAG3, here the MAG3 receives the packets and other AP’s such as MAG1 and MAG2 discards the packets. In some cases, it is possible that the MN2 to visit the previous AP which also reachable. Rarely, the MN2 can be situated in both AP’s. The MT may receive the duplicate packets because MAG2 and MAG3 send packets to the MN2. The MT will maintain the table which contains the packet id and lifetime. In this case, the MN2 should discard the duplicate packets by verifying its life span and packet id with the previously received packets. Hence the duplicate packets will be discarded from the node. The congestion may occur in the mobile node due to duplicate and negative acknowledgements. Even congestion can be avoided by adding additional columns for ACK and N-ACK as additional fields. Hence the table may contain the packet id, lifetime, N-ACK and ACK. This table must be maintained at the mobile node itself in order to avoid the congestion and duplicate packets.
packets at the MT. The entries in the table are made when the new packet arrives, and the entries are deleted as soon as the life time of the packet expires. So that, the mobile node maintains only small information in the table else it will be an overhead for the MT. Mobile nodes can easily maintain its own table without disturbing its performance and other factors.

The simultaneous binding protocol by maintaining the table (with required parameters) within the mobile node will increase the efficiency of data transfer. Also, no packet loss will occur, and any type of data can be transferred. The SBNPMIPv6 system enhances the performance of Internet access in the vehicular network.

1. The system guarantees continuous data transmission without packet loss using the concept of simultaneous binding.
2. Packet duplication is avoided by the maintenance of a separate MN table consisting of the packet ID and its life time.
3. Handoff latency is significantly reduced by the usage of N-PMIPv6 by LMA that acts as localized HA and performs packet reception on behalf of the MT.
4. The SBNPMIPv6 consumes only minor bandwidth and hence the traffic is significantly reduced.
5. The time taken for reverse tunneling in the SBNPMIPv6 protocol is extremely low when compared to PMIPv6.
5.5 RESULT AND ANALYSIS

The packet loss, bandwidth, congestion, latency and reverse tunneling are the parameters used to analyze the performance of the protocols. After every simulation, trace file (with .tr extension) is generated by the simulator. It is assumed that a video of 5000 packets is transferred through both the systems. On comparing the trace files of PMIPv6 and the SBNPMIPv6 system, it is obvious that the SBNPMIPv6 is better than the PMIPv6.

5.5.1 Packet Loss

The number of packets dropped is counted from the trace files of the PMIPv6 and SBNPMIPv6. The values from the trace file are plotted in the graph (Figure 5.4). In graph, the ‘x’ axis refers the simulation time and the ‘y’ axis refers the number of lost packets. The Table 5.4 shows the packet loss comparison of the PMIPv6 and SBNPMIPv6.

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Total Packets transferred</th>
<th>Packets Lost</th>
<th>Packet loss percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMIPv6</td>
<td>5000</td>
<td>534</td>
<td>10.6</td>
</tr>
<tr>
<td>SBNPMIPv6</td>
<td>5000</td>
<td>175</td>
<td>3.5</td>
</tr>
</tbody>
</table>
5.5.2 Bandwidth

The bandwidth is the overall capacity of channels in the network. The bandwidth utilization for single data transfer through the network is considered for plotting the graph. During the data transfer some packets are dropped. Those packets are sent again by the source on receiving negative acknowledgement. These additional packets are also taken into consideration.
As mentioned in Figure 5.5, the NEMO uses maximum of 31 MB, whereas SBNPMIPv6 uses maximum of 15 MB. In graph, the ‘x’ axis refers the simulation time and ‘y’ axis refers the bandwidth. Hence SBNPMIPv6 bandwidth consumption is less which means the remaining bandwidth can be used for other purposes. The traffic is also considerably reduced due to lower bandwidth consumption.

5.5.3 Congestion at Each Node

Congestion of packets denotes the overcrowding of the packets at the nodes. The number of packets handled at each node is taken for plotting the graph (Figure 5.6), which proves that the congestion in SBNPMIPv6 is tremendously less. In graph, the ‘x’ axis refers the node count and ‘y’ axis refers the number of packets.
Hence the SBNPMIPv6 protocol can handle more number of users in its network than the PMIPv6 and also can manage all the data transfers efficiently.

5.5.4 Reverse Tunneling

In vehicular network, the user moves frequently. When some node wants to send packets to the user who is constantly moving, the home network sends the packets to the AP which is nearer to the user. The packets may be transferred when the user moves from one AP to other. At this situation, the packets from the previous access point are redirected back to the HN. The HN redirects the packets to the new access point, which is nearer to the user. This is called reverse tunneling. Reverse tunneling occupies more bandwidth and causes more packets loss and so on. In the new system, the occurrence of reverse tunneling is avoided. So there will be little packet loss and uses less bandwidth; hence it performs well for even multimedia data transfers. The graph below (Figure 5.7) shows the difference between the two systems. For example, user
moves at some certain high speed inside the vehicle, it has to travel across many access points. If more packet loss happens, the quality of data will be reduced.

![Reverse Tunneling Graph Comparison](image)

**Figure 5.7 Reverse Tunneling Graph Comparison**

The same parameter is shown in bar graph (Figure 5.8) below along with the latency comparison. Reverse tunneling will increase the latency which reduces the performance so the latency should be very low. The PMIPv6 takes 10 seconds, whereas SBNPMIPv6 takes only 4 seconds of latency for packet delivery.
SBNPMIPv6 concentrates on enhancing the performance of mobile networks while the users requesting multimedia data by avoiding the data loss. Applying simultaneous binding protocol in N-PMIPv6 architecture leads to better performance of NEMO. The SBNPMIPv6 and the PMIPv6 protocols were tested in simulated environment by transferring 5000 packets of data. PMIPv6 lost 534 packets which is of approximately 10% of the total data, whereas SBNPMIPv6 lost just 175 packets. The lower packet loss leads to better performance of the protocol. The trace file of the simulation shows that SBNPMIPv6 protocol occupies only 15 MB of the total bandwidth of the network, where the remaining can be used for any other purpose. The congestion graph on the node is derived from the trace file of PMIPv6 and SBNPMIPv6 protocol. On comparing both the protocols it is evident that SBNPMIPv6 has very less congestion. The reverse tunneling is totally avoided in SBNPMIPv6 protocol. These credits over SBNPMIPv6 enhance the performance of the network while the user is in request of multimedia data.
5.6 SUMMARY

The SBNPMIPv6 method improves the performance of the mobile network by concentrating multiple factors on PMIPv6 environment. The packet loss is enormously decreased which leads to the better quality of multimedia data flow to the users. The bandwidth used efficiently and the congestion at the node level is also decreased. The reverse tunneling problem is completely avoided in SBNPMIPv6 method.

There are several issues faced in the real world implementation of network mobility, especially nested networks and their consequences. The next chapter discusses one of the problems of nested network called pinball route problem and proposes a solution to eliminate the same.