5. DYNAMIC MOBILITY MANAGEMENT SCHEME FOR INTER HANDOFF IN HWMNS

5.1 Introduction

This chapter proposes a Dynamic Mobility Management Scheme (DMMS) for inter domain handoff along with point forwarding in WMN. In Inter-Mobility Management (IMM) protocol, the overall network traffic caused by mobility and data forwarding is high particularly when mesh client’s mobility rate is higher than its service rate. The proposed DMMS solves this issue by the use of pointer forwarding. For mobility, the inter-domain mobility management scheme is proposed as shown in Fig. 5.1. To reduce signaling cost during location update, the pointer forwarding schemes for internet traffic are used. Simulation results show that the proposed mobility management scheme provides reduced packet drop and delay when compared to existing scheme.

![Block Diagram of Proposed Technique](image-url)
5.2 Inter-Mobility Management (IMM) Technique

In inter-domain handoff, repeated tunnels are removed in order to minimize the forwarding delay. The inter-domain handoff is executed when the changes the Access Router (AR) in different domain. In IMM, the location of moving MC is updated each time in the new AR and GW, which incurs more signaling overhead. To reduce this overall signaling overhead incurred in location updation, the concept of pointer forwarding scheme is developed.

5.3 Dynamic Mobility Management Scheme

The inter-domain mobility management is explained by the inter mobility management algorithm given below. This algorithm is triggered whenever the mesh clients enter into the new domain and change the point of attachment to new gateway.

At first, Mesh client broadcast a probe message and based on the response message, new AR is selected. New AR depends on the AR with the best signal strength. The client will send an association request message to the new AR. On receiving this request, the new AR sends an association confirmation message to the client. Once the client moves into a new domain, a short-term tunnel is formed between the old and the new gateway to transfer the data packets to the mesh client.

**Inter Mobility Management Algorithm**

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**Notations used**

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>Mesh Client</td>
</tr>
<tr>
<td>AR</td>
<td>Access Router</td>
</tr>
<tr>
<td>GW</td>
<td>Gateway</td>
</tr>
<tr>
<td>AR\text{new}</td>
<td>\text{new AR}</td>
</tr>
<tr>
<td>AR\text{old}</td>
<td>\text{old AR}</td>
</tr>
<tr>
<td>GW\text{new}</td>
<td>\text{new GW}</td>
</tr>
<tr>
<td>GW\text{old}</td>
<td>\text{old GW}</td>
</tr>
<tr>
<td>PR\text{M}</td>
<td>Probe message</td>
</tr>
</tbody>
</table>
RES\textsubscript{M} \quad Response message
sstr \quad Signal strength
ASS\_REQ \quad association request message
ASS\_CONF \quad association confirmation message
gw\_ip\_addr \quad IP address of GW\textsubscript{new}
ar\_mac\_ \quad MAC address of AR\textsubscript{new}
DIS\_ASS\_REQ \quad disassociation request message
TL \quad tunnel list

**Algorithm**

1. MC broadcasts \( PR\textsubscript{M} \)
2. MC collects \( PR\textsubscript{M} \) from all AR
3. For each AR\textsubscript{j}, \( j=1,2,... \)
4. \begin{itemize}
   \item If \( sstr = \max(sstr) \), then
   \item select AR\textsubscript{j} as AR\textsubscript{new}
\end{itemize}
   End if
   End for
5. MC transmits ASS\_REQ to AR\textsubscript{new}
6. If ASS\_REQ is received by AR\textsubscript{new}, then
   \begin{itemize}
   \item AR\textsubscript{new} send ASS\_CONF(ar\_mac\_, gw\_ip\_addr) to MC
   \end{itemize}
   End if
7. If ASS\_CONF is received by MC, then
   \begin{itemize}
   \item MC send DIS\_ASS\_REQ(gw\_ip\_addr) to GW\textsubscript{old}
   \end{itemize}
   End if
8. If DIS\_ASS\_REQ is received by GW\textsubscript{old}, then
   \begin{itemize}
   \item GW\textsubscript{old} creates a new entry <mc\_addr, gw\_ip\_addr> in its TL
   \end{itemize}
   End if
9. Temporary tunnel is established between GW\textsubscript{old} and GW\textsubscript{new}
10. Data packets are forwarded from GW\textsubscript{old} through GW\textsubscript{new} to MC
The above algorithm shows the process of inter domain mobility management in WMNs.

Fig. 5.2 Inter domain Mobility Management

Fig. 5.2 shows the process of inter domain mobility management in WMN. It consists of various data flows between the MC, New AR, New Gateway, Old Gateway and correspondent node (CN). In the initial flow, data packets are transmitted from CN to MC and MC to CN. In second flow, association request message is sent from MC to new AR. In third flow, association confirmation message is sent back from new AR to MC. In forth flow, disassociation request message is send from MC to old gateway. In fifth flow, a tunnel is established between the old and new gateways. In sixth flow, again data packets are exchanged between the MC and CN through the new gateway.

5.4 Pointer Forwarding (PF) Scheme

To reduce the overall network traffic incurred in location updation of IMM, the concept of pointer forwarding [73] scheme is developed. It uses a chain of pointers to locate the position of a moving mesh client. In this scheme, a forwarding pointer is set
between two neighboring MRs so that location update event need not be triggered. For each moving MC, location information is stored in the location database. The location information contains address of the Anchor Mesh Router (AMR) of the MC which forms the head of the forwarding chain. Data packets transmitted to the MC will be redirected to its current AMR which in turn forwards them to the MC through the chain of pointers. The length of the forwarding chain is bounded by an optimal threshold value which is determined dynamically based on mesh client’s mobility patterns.

The optimal threshold value is based on the service to mobility ratio (SMR) which is given by

\[
SMR = \frac{DAR}{MOR} \quad (5.1)
\]

Where DAR is the data arrival rate and MOR is the mobility ratio. Then the optimal threshold K is given by

\[
K = SMR \times 10 \quad (5.2)
\]

The data transmission for the Internet traffic session is explained by the static anchor algorithm.

**Static Anchor Algorithm for Internet Session**

In this algorithm, AMR of the given MC remains unchanged until the length of the forwarding chain exceeds the threshold K. When MC moves across two neighboring MRs, it re-associates from its old MR to new MR. When location update is over, the forwarding pointers are reset and the new MR is considered as the AMR of the MC.

**Static Anchor Algorithm**

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**Notations used**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>Mesh Router</td>
</tr>
<tr>
<td>MC</td>
<td>Mesh Client</td>
</tr>
<tr>
<td>FP</td>
<td>Forwarding Pointer</td>
</tr>
<tr>
<td>FPL</td>
<td>Length of the forwarding pointer</td>
</tr>
<tr>
<td>K</td>
<td>Threshold for FPL</td>
</tr>
</tbody>
</table>
Algorithm

1. MC transmits $ASS\_REQ$ to $AR_{new}$
2. If $ASS\_REQ$ is received by $AR_{new}$, then
   
   $AR_{new}$ send $ASS\_CONF(ar\_mac\_ , gw\_ip\_addr)$ to MC
   
   End if
3. If $ASS\_CONF$ is received by MC, then
4. If $FPL < K$, then
   
   $AMR = AR_{old}$
   
   Set FP between MC and AMR
   
   MC stores address of AMR
   
   else
   
   Location update is triggered
   
   Execute steps (7) and (8) of IMM
   
   Set $FPL = 0$
   
   $AMR = AR_{new}$
   
   End if
   
   End if
5. If GW receives data packets from CN
   
   GW lookup the AMR of MC
   
   GW forwards the data to AMR
   
   $AMR$ forwards the data to MC through the forwarding chain
   
   End if

Dynamic Anchor Algorithm for Internet Session

In the dynamic anchor scheme, the length of the forwarding chain of an MC will be reset based on the threshold value as well as the number of new internet sessions. That is, the forwarding chain length will be reset if it is greater than the optimal threshold or if there is a new internet or intranet session arrival. This dynamic scheme reduces the packet delivery cost but increases the location update overhead.
Dynamic Anchor Algorithm

Notations used

- **MR**: Mesh Router
- **MC**: Mesh Client
- **FP**: Forwarding Pointer
- **FPL**: Length of the forwarding pointer
- **K**: Threshold for FPL
- **NoIS**: Number of new Internet Sessions

Algorithm

1. MC transmits **ASS_REQ** to **AR_{new}**
2. If **ASS_REQ** is received by **AR_{new}**, then
   - **AR_{new}** send **ASS_CONF(ar_mac_, gw_ip_addr)** to **MC**
   End if
3. If **ASS_CONF** is received by **MC**, then
4. If **FPL < K OR NoIS = 0**
   - **AMR = AR_{old}**
   - Set FP between **MC** and **AMR**
   - **MC** stores address of **AMR**
   else if **FPL > K OR NoIS > 0**
     - Location update is triggered
     - Execute steps (7) to (8) of IMM
     - Set **FPL = 0**
     - **AMR = AR_{new}**
   End if
   End if
5. If **GW** receives data packets from **CN**
   - **GW** lookup the **AMR** of **MC**
GW forwards the data to AMR
AMR forwards the data to MC through the forwarding chain
End if

5.5 Simulation Results

This section presents the simulation settings of parameters and analysis of simulation results.

5.5.1 Simulation Settings and Parameters

The proposed Dynamic Mobility Management Scheme for Inter Handoff (DMMS) is simulated using Network Simulator-2 (NS-2) and it is compared with the Inter-Mobility Management (IMM) [12] scheme. The simulation parameters are represented in Table 5.1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of mesh clients in each gateway</td>
<td>4, 6, 8, 10 and 12</td>
</tr>
<tr>
<td>Size of the network</td>
<td>1250 X 1250m</td>
</tr>
<tr>
<td>MAC protocol</td>
<td>IEEE 802.11</td>
</tr>
<tr>
<td>Transmission Range</td>
<td>250m</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>50 sec</td>
</tr>
<tr>
<td>Traffic Source</td>
<td>Constant Bit Rate</td>
</tr>
<tr>
<td>Transmission Rate</td>
<td>100Kb</td>
</tr>
<tr>
<td>Packet Size</td>
<td>512 Bytes</td>
</tr>
<tr>
<td>Propagation</td>
<td>TwoRayGround</td>
</tr>
<tr>
<td>Antenna</td>
<td>OmniAntenna</td>
</tr>
</tbody>
</table>

Table 5.1 Simulation parameters

5.5.2 Analysis of Simulation Results

The simulation topology is shown in Fig. 5.3 (screen shot). In this figure, there are 3 mesh gateways connected to an Internet Server. Each gateway consists of set of mesh
clients are routers. The number of mesh clients in the network is varied as 4, 6, 8, 10 and 12. Two handoff scenarios are considered in our experiments. In scenario-1, mesh clients moves from GW1 to GW3. In this scenario-2, mesh clients move from GW3 to GW1. The metrics end-to-end delay, packet delivery ratio, average packet drop and throughput are measured.

Fig. 5.3 Simulation Topology (screen shot)

Two handoff scenarios are considered in our experiments.

**Scenario-1**

In scenario-1, mesh clients moves from GW1 to GW3. The corresponding results viz. end-to-end delay, packet delivery ratio, packet drop and throughput are given in Table 5.2
Table 5.2 Results for Varying Mesh Clients (Scenario-1)

<table>
<thead>
<tr>
<th>Node Count</th>
<th>Delay DMMS</th>
<th>Delay IMM</th>
<th>Delivery Ratio DMMS</th>
<th>Delivery Ratio IMM</th>
<th>Drop DMMS</th>
<th>Drop IMM</th>
<th>Throughput DMMS</th>
<th>Throughput IMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.047617</td>
<td>11.21214</td>
<td>0.997816</td>
<td>0.403947</td>
<td>26</td>
<td>7111</td>
<td>10963</td>
<td>4872</td>
</tr>
<tr>
<td>6</td>
<td>0.610514</td>
<td>10.18627</td>
<td>0.979157</td>
<td>0.433629</td>
<td>251</td>
<td>6873</td>
<td>10758</td>
<td>5230</td>
</tr>
<tr>
<td>8</td>
<td>1.501791</td>
<td>10.33918</td>
<td>0.936197</td>
<td>0.42227</td>
<td>717</td>
<td>7014</td>
<td>10286</td>
<td>5093</td>
</tr>
<tr>
<td>10</td>
<td>2.395444</td>
<td>11.20223</td>
<td>0.884591</td>
<td>0.356189</td>
<td>1408</td>
<td>7777</td>
<td>9719</td>
<td>4296</td>
</tr>
<tr>
<td>12</td>
<td>1.742408</td>
<td>10.69826</td>
<td>0.913352</td>
<td>0.368543</td>
<td>954</td>
<td>7857</td>
<td>10035</td>
<td>4445</td>
</tr>
</tbody>
</table>

$ Dynamic Mobility Management Scheme for Inter Handoff (DMMS)

# Inter-Mobility Management (IMM)

Fig. 5.4 Delay for Varying Mesh Clients (Scenario-1)

Fig. 5.4 shows the end-to-end delay for both the techniques. It represents the total time taken to transmit the data from multicast source to the receivers. The use of pointer forwarding in DMMS reduces the delay by 88%, when compared to the IMM technique.
The results of packet delivery ratio are presented in Fig. 5.5. The use of pointer forwarding and multicast tree construction increases the delivery ratio of DMMS up to 58% when compared to IMM.

The results of average packet drop occurred for both the techniques are presented in Fig. 5.6. When the number of mesh clients becomes more, the overload increases, leading to the increase in packet drop. The use of pointer forwarding and load balanced multicast tree construction reduces the packet drop of DMMS upto 90% when compared to IMM.
The results of throughput obtained for both the techniques are presented in Fig. 5.7. It represents the amount of data received by each receiver in terms of Mb/sec. The use of pointer forwarding and load balanced multicast routing increases the throughput of DMMS by 54%, when compared to IMM.

The percentage wise improvement of DMMS over IMM is presented in Table 5.3.

Table 5.3 Percentage Improvement of DMMS over IMM for Scenario-1.

<table>
<thead>
<tr>
<th>Node Count</th>
<th>Delay (%)</th>
<th>Delivery Ratio (%)</th>
<th>Drop (%)</th>
<th>Throughput (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>99.57</td>
<td>59.51</td>
<td>99.63</td>
<td>55.55</td>
</tr>
<tr>
<td>6</td>
<td>94.00</td>
<td>55.71</td>
<td>96.34</td>
<td>51.38</td>
</tr>
<tr>
<td>8</td>
<td>85.47</td>
<td>54.89</td>
<td>89.77</td>
<td>50.48</td>
</tr>
<tr>
<td>10</td>
<td>78.61</td>
<td>59.73</td>
<td>81.89</td>
<td>55.79</td>
</tr>
<tr>
<td>12</td>
<td>83.71</td>
<td>59.64</td>
<td>87.85</td>
<td>55.70</td>
</tr>
</tbody>
</table>

Scenario-2

In this scenario-2, mesh clients move from GW3 to GW1. The corresponding results viz. delay, packet delivery ratio, packet drop and throughput are given in Table 5.2.
Table 5.4 Results for Varying Nodes (Scenario-2)

<table>
<thead>
<tr>
<th>Node Count</th>
<th>Delay</th>
<th>Delivery Ratio</th>
<th>Drop</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DMMS</td>
<td>IMM</td>
<td>DMMS</td>
<td>IMM</td>
</tr>
<tr>
<td>4</td>
<td>0.915573</td>
<td>4.610241</td>
<td>0.979612</td>
<td>0.521398</td>
</tr>
<tr>
<td>6</td>
<td>0.161262</td>
<td>4.985061</td>
<td>0.99645</td>
<td>0.430761</td>
</tr>
<tr>
<td>8</td>
<td>1.014193</td>
<td>7.6577</td>
<td>0.938655</td>
<td>0.276958</td>
</tr>
<tr>
<td>10</td>
<td>2.529947</td>
<td>8.377059</td>
<td>0.824247</td>
<td>0.23846</td>
</tr>
<tr>
<td>12</td>
<td>5.278803</td>
<td>8.963393</td>
<td>0.671066</td>
<td>0.258456</td>
</tr>
</tbody>
</table>

Fig. 5.8 Delay for Varying Mesh clients (Scenario-2)

Fig. 5.8 shows the end-to-end delay for both the techniques. It represents the total time taken to transmit the data from multicast source to the receivers. The use of pointer forwarding in DMMS reduces the delay by 75% when compared to the IMM technique.
The results of packet delivery ratio are presented in Fig. 5.9. The use of pointer forwarding and multicast tree construction increases the delivery ratio of DMMS up to 61% when compared to IMM.

The results of average packet drop occurred for both the techniques are presented in Fig. 5.10. When the number of mesh clients becomes more, the overload increases, leading to the increase in packet drop. The use of pointer forwarding and load balanced multicast tree construction reduces the packet drop of DMMS up to 64% when compared to IMM.
Fig. 5.11 Nodes Vs Throughput for Varying Mesh clients (Scenario-2)

The results of throughput obtained for both the techniques are presented in Fig. 5.11. It represents the amount of data received by each receiver in terms of Mb/sec. The use of pointer forwarding and load balanced multicast routing increases the throughput of DMMS by 81%, when compared to IMM.

The percentage wise improvement of DMMS over IMM is presented in Table 5.5.

Table 5.5 Percentage Improvement of DMMS over IMM for Scenario-2

<table>
<thead>
<tr>
<th>Node Count</th>
<th>Delay (%)</th>
<th>Delivery Ratio (%)</th>
<th>Drop (%)</th>
<th>Throughput (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>80.14</td>
<td>46.77</td>
<td>90.51</td>
<td>74.07</td>
</tr>
<tr>
<td>6</td>
<td>96.76</td>
<td>56.77</td>
<td>98.46</td>
<td>78.94</td>
</tr>
<tr>
<td>8</td>
<td>86.75</td>
<td>70.49</td>
<td>72.57</td>
<td>85.62</td>
</tr>
<tr>
<td>10</td>
<td>69.79</td>
<td>71.06</td>
<td>47.59</td>
<td>85.90</td>
</tr>
<tr>
<td>12</td>
<td>41.10</td>
<td>61.48</td>
<td>8.46</td>
<td>81.24</td>
</tr>
</tbody>
</table>
5.6 Summary

In this chapter, a Dynamic Mobility Management Scheme (DMMS) for inter-domain handoff in HWMNs is proposed. For mobility management, the inter-domain mobility management scheme is used. Further, pointer forwarding scheme for internet traffic is used to reduce signaling overhead and also the excess traffic on the network. The proposed DMMS is compared with the IMM technique. Simulation results demonstrate that DMMS has reduced the delay by 88%, improved packet delivery ratio by 58%, reduced packet drop by 90% and increased throughput by 54%, when compared with IMM in scenario-1. Similarly, it has reduced the delay by 75%, improved packet delivery ratio by 61%, reduced packet drop by 64% and increased throughput by 81% when compared with IMM in scenario-2.