CHAPTER 4

AMST BASED ALGORITHM FOR LOAD STABILIZATION: METHODOLOGY

4.1 Introduction

To reduce the packet loss and handover delay IEEE 802.16 standard has described two layered mobility management [59, 115-119]. When a Mobile station moves between the Access Service Networks (ASN) and Base Stations in End to End WiMAX Communication network then to minimize the handoff latency ASN connected mobility is adopted by the MS. But this process will increase the load heavily on ASN Gateway. Hence to reduce the load from gateway, relocation of gateway for connected gateway will be required. The standards only describe the procedures of the gateway relocation but they do not describe that when should gateway relocation be performed and how many number of Mobile Stations should be relocated. This problem is left for the researchers and service providers. In this chapter we will propose an algorithm based on average mobile stay time (AMST) in which a decision will be taken for the number of mobile stations to be relocated and to determine the appropriate time for the gateway relocation so that the load and handover delay can be reduced from ASN gateway.

The WiMAX Architecture standardizes only two layers i.e, MAC (media Access Control) Layer and PHY (Physical Layer), thus higher layers will be required to fabricate the complete system. WiMAX Forum had proposed a communication network architecture which is also known as End to End WiMAX Network Architecture [120, 121] and it is shown in Figure 16.
The main constituents of this architecture are CSN (Connectivity Service Network), ASN (Access Service Network), BS (Base Stations) and MS (Mobile Stations). There may be one or more ASN Gateways and BSs in an ASN and the main task of the ASN is to facilitate WiMAX subscribers with wireless radio access. IP (internet Protocol) communication services are provided by the CSN and these are connected with ASNs. WiMAX Forum has chosen MIP (Mobile IP) [122] to maintain IP Mobility. The location of the MS’s HA (Home Agent) is in the CSN and MS’s HNSP (Home Network Service Provider) is responsible to operate that. The location of FA (Foreign Agent) is in ASN gateway and its functionality is also supported by ASN gateway.

ASN mobility and CSN mobility are the two types of mobility management methods which are described by the WiMAX Forum for End to End WiMAX Network Architecture. Some procedures will be required when an MS moves between BSs and ASNs and it does not change the Communication Reference Point C3, and those procedures are referred by ASN connected mobility management. Mobile IP is adopted by the CSN connected mobility management to construct new C3 between latest ASN gateway and CSN. Both kind of mobility are shown in Figure 17. Now let us assume that
an MS wants to establish a connection to WiMAX Communication Network and needs to access some web server also known as Correspondent Node (CN), thus in beginning a connection will establish between MS, BS-1, ASN Gateway-1, CSN and CN. We will name it as Data Flow 1 in Figure 17.

![Figure 17 ASN connected and CSN connected Mobility in WiMAX](image_url)

In this scenario there can be two types of handover, one is intra ASN handover and other is inter ASN handover. Intra ASN handover means when there is a movement of an MS between BSs within ASN, and Inter ASN handover means when MS moves from one ASN to another ASN. Now suppose MS does an inter ASN handover and it does not prefer CSN connected mobility then Mobile IP will not be utilized and a data channel will establish between ASN gateway-1 and ASN gateway-2. ASN gateway-1 will be referred as connected ASN gateway and ASN gateway-2 will be referred as serving ASN gateway. Now a new connection will establish between MS, BS-2, ASN gateway-2, ASN
gateway-1, CSN and CN. We represent this connection as Data Flow 2. Thus the Original Channel in C3 is still maintained between ASN gateway-1 and CSN. Hence, Handover Latency could be reduced by adopting this method but end to end delay might be longer. Now consider that many MSs got connected with ASN gateway-1 then load on this gateway would become very heavy and thus at some point ASN gateway Relocation must be performed by the system. ASN gateway relocation means that some of the MSs require performing the CSN connected mobility thus creating a new connection (Data Flow 3) between MS, BS-2, FA of ASN Gateway 2, HA of CSN to CN. A new data channel will establish between ASN gateway-2 and CSN in new C3 and thus ASN gateway-1 will not serve the MS. The old Data Channel between ASN gateway-1 and CSN in C3 is now removed. Thus Data Flow 2 is considered as ASN connected mobility and Data Flow 3 is considered as CSN connected mobility.

Consider a scenario in which MS performs CSN connected mobility during every inter ASN handover in which MS moves from ASN-1 to ASN-2 and the movement of MS is for a short period of time means the MS moves from ASN-1 to ASN-2 and stays in ASN-2 for a very short period and comes back to ASN-1 and stays there for a longer duration. In this scenario MS performs CSN connected mobility twice but it stills attached with ASN gateway-1 in the end. Thus the communication channel created between ASN gateway-2 and CSN is utilized by MS for a very short duration and if it performs ASN connected mobility the communication channel between ASN gateway-1 and CSN is always utilized. Thus performing ASN connected mobility is better in this scenario because in ASN connected mobility the handover delay and overhead is less than the CSN connected mobility. Now if the ASN connected mobility handover is performed by the MS than it remains connected to the older gateway and thus the number of MSs will not reduce and the load on the older gateway keeps on increasing. In this condition gateway relocation must be performed by the system. Thus the main problem is that when to perform the gateway relocation by the system as WiMAX standard only defines the methods of gateway relocation and a decision should be taken that which MS should perform gateway relocation and how many number of MSs should be relocated. Another problem is that which type of mobility should be preferred ASN or CSN connected mobility whenever an MS performs the inter ASN handover.

For above said problems we will propose an AMST based algorithm in this chapter to choose appropriate mobility scheme and to decide when should gateway relocation be
performed and which MS will perform it and how many number of MSs be relocated to reduce the load and handover latency from ASN gateway.

4.2 Background Work

The basic outline of WiMAX architecture and its technology has been presented by the authors of [123, 124]. Various optimization methods for ASN connected mobility and the implementation of mobility management in WiMAX has been discussed in [125]. They also discussed how the delay caused by handover is reduced by extending the data path from old ASN gateway to new ASN gateway. To maintain rapid and efficient handoff in WiMAX, the authors of [126] suggest a cross layer handoff and fast intra network protocol. A seamless IP mobility Scheme is presented by the authors of [127] and evaluations were made for the flat WiMAX architecture. Hierarchical MIP and two layered mobility management adopted by WiMAX are similar [128]. To localize the signal traffic of MIP and to minimize the handoff latency, multiple levels of FA hierarchy is maintained in HMIP. A design for dynamically HMIP scheme was presented by the authors of [119] and it is for mobile IP networks. In this design every MS determine the hierarchy of Foreign Agents dynamically based on call to mobility ratio. When a threshold is achieved then the registration of MIP is executed and thus the signaling load due to MIP can be minimized appreciably. ASN gateways acts as the foreign agents in WiMAX network due to the presence of two layered mobility management an MS can get serviced by two ASN gateways at most. The ASN gateway in WiMAX is very similar to Serving Radio Network Controller (SRNC) in Universal Mobile Telecommunication Systems (UMTS) and the authors of [129] have proposed the SRNC relocation to reduce the load. SRNC relocation is performed immediately if an MS no longer remains connected with BS under SRNC and relocation is executed by the new SRNC. Whereas in the case of WiMAX, MS only executes the ASN connected mobility if that MS connects to BS which lies in another ASN. This happens due to the fact that if ASN Connected and CSN connected mobility are executed by MS simultaneously then the time taken for handover procedure becomes very large. Load control and load balancing techniques have been presented for mobile IP in [130, 131]. But the load of serving and connected ASN gateway will be affected if we use the techniques proposed in [130, 131] in WiMAX. Sometimes during inter ASN handover the MSs need to execute the CSN connected mobility and ASN connected mobility together but this will cause high packet
loss and a large time will be taken for handover due to which the quality of service is degraded. To provide an excellent quality of service to subscribers the traffic in the network should be managed and Admission Control is a kind of technique used for network traffic management. Admission Control techniques are quite complex in wireless and mobile communication networks as MSs keep on changing their location from one network to the other network. If the resources in the target network are not at par or not well managed then link of MS possibly be dropped. A higher priority is given to the handover MS to use network resources due to the fact that an ongoing link is more essential than providing a new link to a new MS entering in the network. Different type of Admission Control algorithms has been proposed in [28, 132-134]. Authors of [135] have presented two types of gateway relocation techniques for WiMAX. One is predictive algorithm and another one is non-predictive algorithm and these algorithms make a decision regarding the feasible time for gateway relocation and they also determine that how many of MSs connected should be relocated. In these algorithms load of connected MSs is only considered and depending on that load the gateway relocation is executed. If the load on ASN gateway due to serving MSs is high but load due to connected MSs is low then those algorithms will not perform gateway relocation. Moreover these algorithms just decide that how many numbers of connected MSs should perform relocation and does not decide regarding which connected MSs should perform relocation and that may cause unnecessary gateway relocations.

4.3 AMST Based Algorithm

4.3.1 Selection of Mobility

In AMST based algorithm ASN gateway will register the arrival time of a serving MS and it also registers the departure time of the serving MS. Sample mobile stay time is calculated by the ASN gateway with the help of the arrival and departure times it already registered. AMST for an MS is adjusted by the ASN gateway whenever it receives a fresh sample mobile stay time. Generally AMST is recorded as a weighted average by ASN gateway and it uses new sample mobile stay time to manipulate the average slowly. Thus new AMST can be calculated as follows:

\[ T_q = (1 - \mu) \times S_q + \mu \times T_{q-1} \]
In above expression $T_q$ is the new AMST, $T_{q-1}$ is the old AMST, $S_q$ is the new Sample Mobile Stay Time and $0 \leq \mu < 1$. Let us assume that a WiMAX Communication Network have $A_1, A_2, \ldots, A_m$ ASN gateways and $MS_1, MS_2, \ldots, MS_n$ number of mobile stations. Let $T(x, y)$ is the current AMST for $MS_y$ which is maintained in ASN gateway $A_x$ and AMST threshold $H_x$ for each $A_x$ ($x = 1, 2 \ldots m$) is defined as:

$$H_x = \delta \times \left| T_{\max}^x - T_{\min}^x \right| + T_{\min}^x$$

Where $T_{\min}^x = \min \{T(x, y) \mid y = 1, 2 \ldots n\}, T_{\max}^x = \max \{T(x, y) \mid y = 1, 2 \ldots n\}$

and $\delta$ is a constant weighing factor ($0 \leq \delta < 1$).

Now if Mobile Station $MS_y$ performs inter ASN handover from $A_y$ to $A_x$ then ASN gateway $A_x$ checks whether $MS_y$’s AMST $T(x, y)$ is larger than $H_x$ or not. If it’s larger than $H_x$ than ASN gateway $A_x$ will perform CSN connected mobility for mobile station $MS_y$ else it will perform ASN connected mobility. It is quite difficult to select the value of weighing factor $\delta$. ASN gateway $A_x$ will always perform CSN connected mobility for $MS_y$ if the value of $H_x$ is close to $T_{\min}^x$ which means $\delta = 0$. Such kind of condition will waste the bandwidth and resources of the ASN gateway network. If the value of $\delta = 1$ i.e $H_x = T_{\max}^x$ then the load on ASN gateway will increase significantly as in this condition MSs will always perform the ASN connected mobility. In this thesis we recommend the value of $\delta$ as 70.

Let us assume a WiMAX network with four MSs, $MS_1, MS_2, MS_3$ and $MS_4$ and two ASN Gateways $A_1$ and $A_2$ as shown in Figure 18 and the current AMSTs are shown in Table 4.
An Example for selection of suitable mobility in WiMAX

![Diagram of WiMAX network showing MSs and ASNs.]

**Figure 18** An Example for selection of suitable mobility in WiMAX

<table>
<thead>
<tr>
<th>$T(x, y)$</th>
<th>$MS_1$</th>
<th>$MS_2$</th>
<th>$MS_3$</th>
<th>$MS_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_y$</td>
<td>95</td>
<td>70</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>$A_x$</td>
<td>5</td>
<td>35</td>
<td>80</td>
<td>95</td>
</tr>
</tbody>
</table>

We apply the value of $\delta = 0.70$ and $H_y$ and $H_x$ are calculated as follows:

$$H_y = \delta \times |T_{max}^y - T_{min}^y| + T_{min}^y = 0.70 \times |95 - 10| + 10 = 69.5$$

$$H_x = \delta \times |T_{max}^x - T_{min}^x| + T_{min}^x = 0.70 \times |95 - 5| + 5 = 68$$

The AMST $T(x, y)$ of $MS_2$ at $ASN_x$ is 35 which is smaller than $H_x$. When $MS_2$ performs handover from $ASN_y$ to $ASN_x$ it will make use of the ASN connected Mobility and remains connected at $ASN_y$. Whereas the AMST $T(x, y)$ of $MS_3$ is 80 which is greater than $H_y$ and thus it will use CSN connected mobility when it performs handover from $ASN_y$ to...
ASN_y and gets connected with ASN_x. Now if we apply the value of $\delta = 0.95$ and 0.20 than $H_x$ is recalculated as follows:

$$(\delta = 0.95) \; H_x = \delta \times |T_{\text{max}}^x - T_{\text{min}}^x| + T_{\text{min}}^x = 0.95 \times |95 - 5| + 5 = 90.5$$

$$(\delta = 0.20) \; H_x = \delta \times |T_{\text{max}}^x - T_{\text{min}}^x| + T_{\text{min}}^x = 0.20 \times |95 - 5| + 5 = 23$$

If we make $\delta = 0.95$ than the $H_x$ becomes close to $T_{\text{max}}^x$ and when MS_2 and MS_3 make a shift from ASN_y to ASN_x than both the MSs will perform ASN connected mobility.

Whereas when we make $\delta = 0.20$, $H_x$ becomes close to $T_{\text{min}}^x$ and thus the AMST of both the MS is greater than the $H_x$ and whenever they performs the handover they will choose CSN connected mobility and change their connected ASN Gateway from $A_y$ to $A_x$.

### 4.3.2 Selection of Mobile Station

Let us assume a WiMAX Communication Network as depicted in Figure 19 with nine mobile stations $MS_1, MS_2 \ldots MS_9$ and three ASN gateways $A_1, A_2$ and $A_3$ in which $A_1$ provides service to the $MS_1, MS_2, MS_3$, $A_2$ provides service to $MS_4, MS_5, MS_6$ and $A_3$ to $MS_7, MS_8$, and $MS_9$. Also $MS_3, MS_8$, and $MS_9$ are connected MSs of the ASN gateway $A_2$.

Now the latest AMSTs $T(x, y), x = 1, 2, 3$ and $y = 1, 2 \ldots 9$ are as follows:

$$T(x, y) = \begin{bmatrix} 20 & 70 & 90 & 15 & 20 & 10 & 5 & 15 & 20 \\ 60 & 15 & 15 & 80 & 85 & 90 & 60 & 30 & 35 \\ 30 & 10 & 5 & 15 & 15 & 10 & 20 & 10 & 70 \end{bmatrix}$$
Consider that the load on $A_2$ is too high and thus system needs the relocation of ASN gateway to release that load from $A_2$. Now here comes the problem that which MSs among $MS_3$, $MS_8$, and $MS_9$ should perform the gateway relocation as they are connected with ASN gateway $A_2$. Thus to solve this problem we will consider the proportion of time $PS_y$ which can be defined as the ratio of AMST in serving gateway to the AMST in connected gateway for each mobile station connected with ASN gateway. Thus $PS_y$ for a mobile station $MS_y$ which is connected in $A_e$, and served by $A_f$ can be given as follows:

$$PS_y = \frac{T(f, y)}{T(e, y)}$$

Where $T(f, y)$ is AMST of mobile station $MS_y$ in serving gateway and $T(e, y)$ is AMST of $MS_y$ in connected gateway. By this expression we can calculate the proportion values of each MS which are connected with ASN gateway i.e. for $MS_3$, $MS_8$, and $MS_9$ as follows:

$$PS_3 = \frac{T(1,3)}{T(2,3)} = \frac{90}{15} = 6$$

Figure 19 WiMAX Network using three ASN Gateways
From the obtained proportional values we can conclude that MS₃ will stay in serving gateway for a large duration of time as its $PS₃ = 6$ whereas the $PS₈ = 0.34$ which shows that $MS₈$ will stay in servicing gateway for a smaller period of time and it will come back to its connected gateway. Thus the priority should be given to $MS₃$ to perform relocation of gateway. Hence $PS₃$ is considered as criterion to select that which MS should execute the gateway relocation.

Another problem is the selection of an appropriate time to execute gateway relocation which is very essential to reduce the load from the ASN gateway and to avoid frequent gateway relocation. To deal with this problem we will define the load for the ASN gateway based on [28, 135] and modify that accordingly. We will apply RED (Random early Detection) [136] for marking and dropping of the packets and the measurement will be defined on the basis of drop rate. If the load on the ASN gateway grows rapidly we will mark the packets randomly like that in RED so that those marked packets and some new arrived packets can be dropped if the queue becomes full. We will evaluate the drop rate at every interval $v$ as follows:

$$d_v = \frac{m_v}{r_v}$$

where $d_v$ is the drop rate ($0 \leq d_v < 1$), $m_v$ is the marked packets which are dropped in interval $v$ and $r_v$ is the total packets received in interval $v$. Hence we can evaluate the load on an ASN gateway for a time $t$ as a weighted moving average of $d_v$ ($v = t, t-1, t-2 \ldots t-(z-1)$) as follows:

$$L_t = \frac{\sum_{v=t-(z-1)}^{t} w_v d_v}{\sum_{v=t-(z-1)}^{t} w_v}$$
where $w_v$ is weighting factor for $d_v$ and $w_i > w_{i-1} > \ldots w_{i-(z-1)}$. The load $L_t$ will fall in interval [0, 1] and is measured by the newest drop rates. Load of an ASN Gateway may also get affected by the older drop rates. $L_t$ makes ASN Gateways capable to know the current load states. Hence a constraint $z$ is defined for $L_t$ which is a record for maximum number of latest drop rate and it should be taken in account to calculate $L_t$.

Even though the drop rates of every 6 interval is recorded by the ASN Gateway but to calculate $L_t$ for 6\textsuperscript{th} interval only 5 records have been used. First interval’s record is not considered because the $z$ of the ASN gateway is taken as 5. Like this the current load conditions can be represented more accurately by $L_t$.

\begin{table}[h]
\centering
\begin{tabular}{c|c|c|c|c|c|c|c}
\hline
\textbf{Z=5} & & & & & & & \\
\hline
\textbf{t} & 0 & 1 & 2 & 3 & 4 & 5 & 6 \\
\hline
\textbf{$d_v$} & 0 & 0.02 & 0.06 & 0.09 & 0.14 & 0.19 & 0.25 \\
\hline
\textbf{$w_v$} & $-$ & $-$ & $-$ & $2^1$ & $2^2$ & $2^3$ & $2^4$ & $2^5$ \\
\hline
\end{tabular}
\end{table}

\[ L_6 = \frac{2^5 \times 0.25 + 2^4 \times 0.19 + 2^3 \times 0.14 + 2^2 \times 0.09 + 2^1 \times 0.02}{2^5 + 2^4 + 2^3 + 2^2 + 2^1} = 0.209 \]

\textbf{Figure 20 Lt Calculation example}

ASN gateway defines four conditions of the load depending on the three thresholds $L_L$, $L_M$, and $L_H$ ($0 < L_L < L_M < L_H < 1$) and performs the following operations depending on these conditions.

- **Condition 1**: If the load on the ASN gateway is low i.e. $0 \leq L_t < L_L$ then in this condition no relocation will be performed.
- **Condition 2**: If the Load on the ASN gateway is medium i.e. $L_L \leq L_t < L_M$ then in this condition the ASN gateway can handle the traffic generated by MSs easily
but it chooses the mobile station $MS_y$ whose $PS_y \geq P_{th}$ to perform gateway relocation among the connected MSs where $P_{th}$ is a threshold provided.

- **Condition 3:** If the load on ASN gateway is heavy i.e. $L_M \leq L_t < L_H$ then in this condition also ASN gateway still chooses the mobile station $MS_y$ whose $PS_y > P_{th}$ to perform gateway relocation among connected MSs. And if the load on ASN gateway keeps on increasing (i.e. $L_t < L_{t-1}$) then the gateway will instruct all MSs to perform CSN connected mobility (C3 Mobility) when they moves to another ASN gateway.

- **Condition 4:** If the load on the gateway is very heavy i.e $L_H \leq L_t < I$ then in this condition it is very difficult ASN gateway to handle the traffic generated by the MSs and ASN gateway will ask all the connected MSs to perform the CSN connected mobility (C3 Mobility) and thus all connected MSs get relocated to lower the load on the ASN gateway.

### 4.4 AMST Based Algorithm

- **Step A:** Judge the ASN Gateway Loading at every detection interval
- Compare $L_t$ and $L_H$
  - If $L_t < L_H$, Then
    - Compare $L_t$ and $L_M$
      - If $L_t < L_M$, Then
        - Perform **Step C**
      - Else,
        - Compare $L_t$ and $L_{t-1}$
          - If $L_t < L_{t-1}$, Then
            - Perform **Step E**
          - Else,
            - Use CSN connected mobility
            - Perform Relocation for anchor MS with $PS_y > P_{th}$
            - Perform **Step A**
      - Else,
        - Use CSN connected mobility
        - Number of Relocation MSs ($m=1$)
- **Step B:** Perform Relocation of MS in Descending order according to $PS_y$
- Compare $L_t$ and $L_M$
- If $L_t < L_M$, Then
  - **Step C:** Compare $L_t$ and $L_L$
  - If $L_t < L_L$, Then,
    - **Step D:** Use ASN connected mobility
    - Go to **Step A**
  - Else,
    - **Step E:** Perform Relocation for connected MS with $PS_y > P_{th}$
    - Go to **Step D**
- Else,
  - The Number of Relocation MSs ($m = m \times 2$)
  - If $m > \text{MAX}(\text{maximum number of MS for one relocation})$, $m = \text{MAX}$
  - Go to **Step B**

Let us consider a scenario of WiMAX network in which there are three ASN Gateways $A_1, A_2$, and $A_3$ and six MSs $MS_1, MS_2, ..., MS_6$ which is shown in Figure 21. The AMSTs $T(x, y)$ and $PS_y$ at interval $t$ in which $MS_4$ moves from $A_2$ to $A_3$ are shown in Table 5.
Figure 21 Relocation Strategy based on Four Conditions

<table>
<thead>
<tr>
<th>Interval $t$</th>
<th>$MS_2$</th>
<th>$MS_2$</th>
<th>$MS_3$</th>
<th>$MS_4$</th>
<th>$MS_5$</th>
<th>$MS_6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T(x, y)$</td>
<td>$A_1$</td>
<td>80</td>
<td>90</td>
<td>20</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>$A_2$</td>
<td>10</td>
<td>15</td>
<td>70</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$A_3$</td>
<td>30</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>$PS_y$</td>
<td>8</td>
<td>6</td>
<td>--</td>
<td>--</td>
<td>0.5</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Even though the network system has same state, at next interval there will be different results if the load state of the connected ASN Gateway is different. After go through each conditions of load as aforementioned with AMSTs as mentioned in Table 5 and movement at interval $t$, we will find the outcomes of WiMAX network system.

Let us consider that at interval $t$ the load on ASN Gateway $A_2$ is at condition 1 which is $0 \leq L_t < L_L$, then no relocation will be performed when $MS_y$ moves from $A_2$ to $A_3$ and ASN
Connected mobility will be selected. After performing the operation of condition 1 at interval $t$, system conditions at interval $t+1$ are shown in Figure 22.

<table>
<thead>
<tr>
<th>Interval $t+1$</th>
<th>MS$_1$</th>
<th>MS$_2$</th>
<th>MS$_3$</th>
<th>MS$_4$</th>
<th>MS$_5$</th>
<th>MS$_6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_1$</td>
<td>80</td>
<td>90</td>
<td>20</td>
<td>40</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>$A_2$</td>
<td>10</td>
<td>15</td>
<td>70</td>
<td>40</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>$A_3$</td>
<td>30</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>$PS_y$</td>
<td>8</td>
<td>6</td>
<td>--</td>
<td>1</td>
<td>0.5</td>
<td>0.67</td>
</tr>
</tbody>
</table>

**Figure 22 Condition of system after condition 1 operation at interval $t+1$**

Now considering that at interval $t$ the load on ASN Gateway $A_2$ is at condition 2 which is $L_L \leq L_t < L_M$ then ASN Gateway $A_2$ will select the MSs whose $PS_y \geq P_{th}$ to perform the relocation among connected MSs with it i.e. $MS_1$, $MS_2$, $MS_3$ and $MS_6$. $MS_1$ and $MS_2$ have $PS_y \geq P_{th}$ and thus at interval $t$ they will be relocated to ASN Gateway $A_1$ and $MS_4$ will use ASN connected mobility to perform handover from $A_2$ to $A_3$. After performing the operation of condition 2 at interval $t$, system conditions at interval $t+1$ are shown in Figure 23.
Now considering that at interval $t$ the load on ASN Gateway $A_2$ is at condition 3 which is $L_M \leq L_t < L_H$ which is almost similar to condition 2, then ASN Gateway $A_2$ will select the MSs whose $PS_y \geq P_{th}$ to perform the relocation among connected MSs with it i.e. $MS_1$, $MS_2$, $MS_3$, and $MS_6$. $MS_1$ and $MS_2$ have $PS_y \geq P_{th}$ and thus at interval $t$ they will be relocated to ASN Gateway $A_1$. $MS_4$ will use CSN connected mobility to perform handover from $A_2$ to $A_3$ as in this condition the load on ASN Gateway is increasing. After performing the operation of condition 3 at interval $t$, system conditions at interval $t+1$ are shown in Figure 24.

![Figure 23](image-url)
Now considering that at interval $t$ the load on ASN Gateway $A_2$ is at condition 4 which is $L_H \leq L_t < I$ then ASN Gateway $A_2$ will select the MSs to perform the relocation among connected MSs with it i.e. $MS_1$, $MS_2$, $MS_5$, and $MS_6$ and the priority for relocation is according to $PS_i$ i.e. $MS_1 > MS_2 > MS_6 > MS_5$. Relocation of MS will start at 1, thus $MS_1$ will be relocated at interval $t$. In this condition CSN connected Mobility will be used by $MS_4$ to perform relocation from $A_2$ to $A_3$. After performing the operation of condition 4 at interval $t$, system conditions at interval $t+1$ are shown in Figure 25.
Now let us suppose that at interval \( t+1 \), still the load of ASN Gateway \( A_2 \) is at condition 4 then the priority for relocation at this interval will be as \( MS_2 > MS_6 > MS_5 \) and the relocation will get doubled i.e. 2. Hence at interval \( t+1 \) two MSs will be relocated i.e. \( MS_2 \) and \( MS_6 \). After performing the operation of condition 4 at interval \( t+1 \), system conditions at interval \( t+2 \) are shown in Figure 26.
Figure 26 Condition of system after condition 4 operation at interval t+2