Analysis of Media Independent Handover Assisted Mobility Management in Mobile Internet

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Abstract

The integration of available wireless access technology becomes an essential part of mobile communication. Interworking of wireless network promises the best quality of service and supports the cooperation of all the layers. In such heterogeneous background, mobility management and seamless service is still an important issue. Existing centralized approach lacks support its suitability in terms of dynamic mobility, scalability, reliability, seamless connectivity, etc. Hence a novel IEEE 802.21 media independent handover (MIH) assisted distributed Mobility Management (DMM) solution is proposed for handover optimization across heterogeneous (WiMAX, UMTS, WLAN etc.) environments based on PMIPv6 protocol. In DMM, the mobility anchors are distributed at an access network level in order to assist the fast exchange of signaling information during a handover operation in mobile internet. The vertical handover performance factors are compared with existing centralized mobility management (CMM) scheme in terms of packet loss, handover delay and throughput. Simulation result proves that the MIH assisted PMIPv6-DMM achieves seamless service by minimizing the handover delay, improves the network throughput for real time and non-real time applications.

Keywords

Vertical Handover, Mobility Management, Heterogeneous Network, IEEE 802.21 MIH, Mobile Internetworking, Proxy MIPv6, Quality of Service

1. Introduction

Existing wireless access technologies provides more proficient communication when compared to conventional wired networks. Nowadays the consumer demands to execute high speed data access with seamless connectivity to the best connected network at anytime and anywhere. These are one of the important challenges for improving the future generation wireless networks. Interworking of different wireless access technologies such as WiMAX, WLAN, UMTS etc. will aims to satisfy the user needs in terms of data rate, traffic class (Constant Bit Rate (CBR) and Variable Bit Rate (VBR)), resource utilization, ubiquitous access and seamless connectivity. In such heterogeneous environment, seamless mobility management is still a challenging task.

Seamless internetworking of heterogeneous network requires perfect cooperation among all the layers. With the attractive capability of multimode mobile terminals to seamlessly switch its connection across various wireless technologies is an effective way to optimize the customer requirements. Handover across heterogeneous networks have different characteristics in terms of security, data rate, bandwidth, priority of traffic class, quality of service (QoS) guarantee etc. Existing CMM scheme fails to support its suitability to handle the enormous amount of mobile internet data traffic locally with required QoS. This motivates DMM solution to manage mobility functions locally at the access network level in order to assist the fast exchange of signaling information during handover. In addition, the IEEE 802.21 MIH standard is also adopted in the proposed work for executing seamless
handover procedures across Inter-domain movement. The proposed MIH assisted DMM interworking architecture can efficiently utilize mobility anchors for intelligent handover operation based on PMIPv6 protocol. The remaining of this article is organized as follows. Section 2 summarizes the related works and discusses the need for DMM. Our proposed approach is presented in section 3. The implementation details are described in section 4, and finally conclude with the results and discussion.

2. Related Work

This section discusses several related studies for handover optimization in heterogeneous wireless environments. Numerous vertical handover schemes have been proposed, which are not sufficient enough to handle mobility functions locally. A comprehensive survey of different vertical handover decision algorithms for handover necessity estimation based on CMM scheme is discussed in [1]. Even though the existing CMM architecture provides global mobility, but the mobility contexts are anchored in a centralized manner and are not sufficient enough to provide the required QoS for mobile internet data traffic. The limitations of CMM are discussed in [2], and their extensive analysis are listed in Table 1. Hence the IETF working group [3] provides a distributed mobility solution for mobile nodes (MN) changes its point of attachment (PoA) across the inter-domain mobility.

### Table 1. Limitations of Existing CMM scheme.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CMM scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route optimization</td>
<td>Non optimal routing degrades the system performance.</td>
</tr>
<tr>
<td>Network architecture</td>
<td>Hierarchical and centralized</td>
</tr>
<tr>
<td>Scalability</td>
<td>Not scalable – CMM maintains and manages mobility signaling for all MN.</td>
</tr>
<tr>
<td>Dynamic mobility</td>
<td>Lack of dynamic mobility support</td>
</tr>
<tr>
<td>Reliability</td>
<td>Not reliable – Failure due to CMM</td>
</tr>
<tr>
<td>Security</td>
<td>Less secure with centralized scheme</td>
</tr>
<tr>
<td>Signaling overheads</td>
<td>Increases – all mobility signaling routed via centralized LMA anchor</td>
</tr>
<tr>
<td>Mobility range</td>
<td>Global</td>
</tr>
<tr>
<td>Resource utilization</td>
<td>Waste of network resource due to default mobility support for MN</td>
</tr>
</tbody>
</table>

The basic idea of DMM is to bring the mobility anchor at access level (near to the MN) in order to support the fast handover operation. Later [4] proposed motivation, challenges and possible DMM architectures at mobile core, access network and client level to prove the efficiency of the scheme. The host based MIPv6 DMM as discussed in [5, 6] and network based DMM solution in [7, 8] for heterogeneous background, in which the mobility functions are handled by the access router to assist fast handover procedure. The partial DMM and comparison of different mobility protocols are discussed in [9, 10]. Lots of efforts have been carried out by the IETF working group for DMM solution, but the implementation issue is still a challenging task. Therefore, the proposed work concentrates towards handover optimization by partially distributing the mobility anchors at an access level to support excellent QoS. Hence, in this paper, an MIH assisted PMIPv6-DMM is implemented for integrated WLAN / WiMAX networks to provide intelligent dynamic anchoring for seamless handover operation.

3. Proposed MIH assisted PMIPv6-DMM in WLAN/WiMAX Heterogeneous Architecture

DMM is a new approach for efficient mobility management in all IP flat architecture [11, 12] to cope mobile internet traffic locally. The MIH assisted PMIPv6-DMM is introduced in this section for efficient handover optimization across heterogeneous WLAN / WiMAX network. It is assumed that the MN initially resides in a WLAN network (home network) and moves towards WiMAX network due to poor support for real time traffic class and signal degradation in the serving network. The MN does not involve in mobility signaling during the handover process to candidate network. Since the DMM approach utilizes the existing PMIPv6 protocol and distributes the mobility functions at an access network level rather fully centralized. Thus the data plane purely consists of the mobility management access router (MMAR) and performs mobility function for the MN (IP prefix allocation and tunneling). The control plane consists of a centralized mobility management database (CMMD) for MN global binding management as shown in Fig. 1.

The MIH functionalities are installed in MN and WLAN, WiMAX PoA. The detailed MIH procedure for efficient handover optimization is discussed in [13, 14]. The MIH standard provides three important services for efficient handover process, namely media independent event service (MIES), media independent command service (MICS) and media independent information service (MIIS). It supports three important triggers based on the link quality, MIH_Link_Up, MIH_Link_Down, MIH_Link_Going_Down events. These triggers are sufficient enough to make intelligent handover across heterogeneous networks. The MIH procedures are combined with a DMM scheme to employ intelligent and seamless handover operation.

3.1. Registration with Home Network

At the initial phase, MN attached to MMAR1 (WLAN network) receives Link_Up event, if it is authorized for service (inquire in MIIS server), MMAR1 creates a local
binding cache entry (BCE) and reserves new home network IP prefix (HNP1) for the MN. It acts as a mobility anchor and provides proper routing information for the MN at access network level. The MMAR1 sends a proxy binding update (PBU) message to centralized CMMD in MN registration process using a MN-ID and HNP1 address. The CMMD receives the request and creates a global BCE for MN states (HNP1: MN-ID, MMAR1) and response to the proxy binding acknowledgement (PBA) message to indicate the successful registration. It also informs to MMAR1 that new mobility option of the MN. Later the MMAR1 unicast router advertisement (RA) message to MN for configuration of new IP addresses at MMAR1. The MN then communicates to the correspondent node (CN) voice or video application (CN1/CN2) with an IP prefix HNP1 anchored at MMAR1.

The MN initial registration delay \( \tau_{REG} \) at home network is associated with authentication, binding management and mobility detection time as given in equation (1). Where \( \tau_{AAA} \) is the authentication delay at home network and expressed as

\[
\tau_{REG} = \tau_{AAA} + \tau_{MN-BM} + \tau_{MD}
\]

(1)

\[
\tau_{AAA} = d_{MMAR1-MN} + 2d_{AAA}(t_{req},t_{res})
\]

(2)

The \( d_{MMAR1-MN} \) is the time taken for the MMAR1 to get MN-ID and \( d_{AAA}(t_{req},t_{res}) \) is the round trip time between MMAR and AAA server in the MN authentication process. The MN binding management delay \( \tau_{MN-BM} \) includes IP prefix allocation from DHCP server (\( \tau_{DHCP-IP} \)) and exchange of PBU / PBA messages (\( \tau_{MMAR1-PBU}, \tau_{CMMD-PBA} \)) between MMAR1 and CMMD as in equation (3). The mobility detection delay \( \tau_{MD} \) is completed when the MN receives RA (\( t_{RA} \)) from MMAR1 for configuring new IP prefix (\( t_{MN-CONF} \)).

\[
\tau_{MN-BM} = \tau_{DHCP-IP} + \tau_{MMAR1-PBU} + \tau_{CMMD-PBA}
\]

(3)

\[
\tau_{MD} = \tau_{RA} + \tau_{MN-CONF}
\]

(4)

\[
\tau_{REG} = d_{MMAR1-MN} + 2d_{AAA}(t_{req},t_{res}) + \tau_{DHCP-IP} + \tau_{MMAR1-PBU} + \tau_{CMMD-PBA} + \tau_{RA} + \tau_{MN-CONF}
\]

(5)

The End-to-End transmission delay \( \tau_{MN-CN1} \) for the data packets sent from MN (current serving WLAN network) to CN depends on many factors such as packet size, no. of hops (wireless and wired interface) etc.

### 3.2. Handover to Candidate WiMAX Network (MMAR2)

At a later time \( t \), the MN moves from MMAR1 to MMAR2 (WiMAX network) and perceives a Link_down event (handover initiation) at the current serving network. The MMAR2 detects the MN attachment and verifies the MN-ID to MIIS server for service authorization. If authorization is successful, it creates BCE, reserves new IP prefix (HNP2) and sends PBU to CMMD for new mobility options. The CMMD checks the BCE and recovers the MN previous mobility option at MMAR1 (HNP1: MN-ID, MMAR1) with PBA messages to MMAR2. The CMMD is used to retrieve and update the MN home address (HoA) and MMAR2 proxy care of address (PCoA). The MMAR2 updates the MN new state and send access binding update (ABU) to MMAR1 to establish a bidirectional tunnel to carry out ongoing session anchored at MMAR1 to CN1. The MMAR1 receives the request and sends an access binding acknowledgement (ABA) for successful tunnel establishment. After receiving the ABA from MMAR2, the MN waits for time to trigger handover i.e Link_Going_Down event (\( RSS_{WLAN} < RSS_{thr} \) & \( RSS_{WiMAX} > RSS_{thr} \)). If the Link_Going_Down event is triggered, the MN immediately executes handover to
WiMAX network and continues its ongoing session with CN1.

Finally, all the packets are tunneled from MN to CN1 with the old HNP1 address. The new IP prefix HNP2 is used for new session anchored at MMAR2 follows the regular routing process without tunneling mechanism. The detailed handover operation of MIH assisted PMIPv6-DMM is illustrated in Fig. 2. The vertical handover delay (VHO) from IEEE 802.11 to IEEE 802.16 for VoIP or video session is calculated by

$$\tau_{VHO}^{PMIPv6-DMM} = \tau_2 + \tau_{REG} + \tau_{MD}(d_{RA}, d_{MN-CONF})$$  \hspace{1cm} (6)$$

where $\tau_2$ is the layer 2 handover delay in detecting link up event at the candidate WiMAX network, $\tau_{REG}$ and $\tau_{MD}$ is the registration and mobility detection latency. The registration delay $\tau_{REG}$ at MMAR2 includes authentication phase $d_{MIIS-AAA}(t_{req}, t_{res})$, IP prefix allocation ($d_{DHCP-IP}$), binding management ($\tau_{MN-BM}$) and access tunnelling delay ($\tau_{tunnel}$) (only if the ongoing session is active) as represented in equation (7).

$$\tau_{REG} = d_{MMAR2-MN} + 2d_{MIIS-AAA}(t_{req}, t_{res}) + d_{DHCP-IP} + \tau_{MN-BM} + \tau_{tunnel}$$  \hspace{1cm} (7)$$

![Figure 2. Mobility management signalling flow based on MIH assisted PMIPv6-DMM.](image-url)
\[ \tau_{MN-BM} = \alpha d_{MMAR2-CMMD}(t_{MMAR2}^{PBUR} + \Delta_{BCE}) + \\
(\tau_{CMMD}^{PBAR} + \Delta_{BCE}) \]  
(8)

\[ \tau_{tunnel} = \beta d_{MMAR2-MMAR1}(t_{ABU}^{PBUR} + \Delta_{BCE}) + \\
(\tau_{MMAR1}^{ABAR} + \Delta_{BCE}) \]  
(9)

The \( d_{MH-AAA}(t_{req}, t_{res}) \) is the request and response time for MN authentication process in MIIS server and \( \Delta \) is the respective BCE update time. The BM and tunnelling delay depends on the exchange of signaling messages PBU / PBA and ABU /ABA between MMAR2 to CMMD and MMAR2 to MMAR1 with their respective distance \( a \) and \( \beta \). The final analytical expression for \( \tau_{P-DMM} \) is obtained by substituting equation (7), (8) and (9) in equation (6).

\[ \tau_{P-DMM}^{VHO} = \tau_{MB} + d_{MMAR2-MN} + 2d_{MHIS-AAA}(t_{req}, t_{res}) + \\
d_{DHCP-IP} + c_{CMMD}(t_{MMAR2}^{PBUR} + \Delta_{BCE}) + \\
(\tau_{CMMD}^{PBAR} + \Delta_{BCE}) + \beta d_{MMAR2-MMAR1}(t_{MMAR2}^{ABU} + \\
(\tau_{MMAR1}^{ABAR} + \Delta_{BCE}) + \tau_{MD}(d_{BA}, d_{MN-CONF}) \]  
(10)

\[ S_{VHO-Overhead} = Y_{w1}(S_{MN-MMAR2}(2t_{mess}, \Delta_{DHCP}) + \\
S_{MMAR2-CMMD}(\Delta_{PBUR}, \Delta_{PBA}) + \\
c_{tunnel} \cdot S_{MMAR2-MMAR1}(\Delta_{ABU}, \Delta_{ABA}) + \\
S_{MN-CN}(\Delta_{MN-RA}, \Delta_{CN}) \]  
(11)

The signaling overhead \( S_{VHO-Overhead} \) is the exchange of signaling message during handover process and it is defined in equation (11). The signaling message arrival rate at wireless interface is assumed as \( Y_{w1} \).

4. Simulation Results and Discussion

This section analyzes the evaluation of existing CMM and the proposed MIH assisted PMIPv6-DMM solution in integrated WLAN and WiMAX networks. The proposed heterogeneous architectures presented here to analyze the vertical handover performance in OPNET software.

The comparison results of integrated WLAN and WiMAX wireless network are analyzed from the following simulation results. Fig. 3 describes the vertical handover delay between IEEE 802.11 and IEEE 802.16 network based on CMM and MIH assisted PMIPv6-DMM schemes. It is noted that the vertical handover delay is larger (0.085) for CMM and a minimum (0.02) for DMM scheme. The reason is the mobility anchors are distributed at the access level, which are closer to the MN. Hence the time to exchange of signaling information during the handover process is less due to excellent route optimization in MIH assisted PMIPv6-DMM scheme and thus reduces MAC overheads when compared to CMM as in Fig. 4.

The routing information for the network convergence activity of PMIPv6 mobility protocols based on CMM and DMM schemes are shown in Fig. 5, in which DMM takes minimum time to compute the best route by providing maximum routing information when compared to CMM.

Handover delay and data packet loss are directly related, which in turn degrades the system performance. Larger packet dropped experiences service disruption, particularly for delay sensitive applications (VoIP). Higher the packet delay variation leads to congestion of data which in turn tends to lose some of the packets.
The proposed MIH assisted PMIPv6-DMM scheme provides fewer packets dropping ratio in both upward and downward flows. Since the mobility anchors are closer to MN leads to seamless handover execution due to MIH operation as shown in Fig. 6 and Fig. 7. The end-to-end ethernet delay for CMM and DMM are illustrated in Fig. 8. During the handover execution phase, the time taken for the data packets sent from WLAN to WiMAX network is quite large. This is because the MN receives bad signal strength when it is far away from the serving network. The main contribution of the delay depends on many factors such as handover latency, packet queuing at WiMAX network, mobility protocols, routing parameters etc.

Therefore the proposed DMM approach reduces the overall WiMAX delay as shown in Fig. 9 by providing an efficient route optimization path from source to destination. The received signal strength measurement and neighbor node
advertisement are fluctuating because of fading phenomenon. Therefore the mobile node must process these signals in addition to path loss associated with the distance achieves satisfied uplink and downlink SNR. The traffic now flows through WiMAX networks by balancing both the network load and improves the system throughput when compared to CMM as in Fig. 10. Table 2 summarizes the various performance factors of CMM and MIH assisted PMIPv6-DMM schemes. Tabulation results prove that the proposed DMM architecture provides best Qos by taking velocity of MN into account.

From the simulation results, it is proved that the proposed MIH assisted PMIPv6-DMM approaches highly support seamless connectivity across heterogeneous networks. Proper handover signaling achieves less handover delay, packets dropped ratio and retransmission attempts. Hence our proposed solution proves to be more efficient for both real time and non-real time Qos efficiency.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Existing CMM</th>
<th>MIH assisted PMIPv6-DMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handover Delay (sec)</td>
<td>0.085</td>
<td>0.020</td>
</tr>
<tr>
<td>Ethernet Delay (sec)</td>
<td>0.000024</td>
<td>0.000027</td>
</tr>
<tr>
<td>IP Network Converge Activity</td>
<td>0.080</td>
<td>0.060</td>
</tr>
<tr>
<td>RIVNG Traffic sent (bits/sec)</td>
<td>125</td>
<td>375</td>
</tr>
<tr>
<td>RIP Traffic sent (bits/sec)</td>
<td>1,200</td>
<td>1,700</td>
</tr>
<tr>
<td>RIP Traffic received (bits/sec)</td>
<td>850</td>
<td>1,300</td>
</tr>
<tr>
<td>WiMAX Delay (sec)</td>
<td>0.004</td>
<td>0.0035</td>
</tr>
<tr>
<td>WLAN Load (bits/sec)</td>
<td>80</td>
<td>210</td>
</tr>
<tr>
<td>WiMAX Throughput (bits/sec)</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>Uplink Packet Dropped (packets/sec)</td>
<td>3</td>
<td>0.025</td>
</tr>
<tr>
<td>Downlink Packet Dropped (packets/sec)</td>
<td>4.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Sub channel Tx. Power (dBm)</td>
<td>8 to -6</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Total Tx. Power (dBm)</td>
<td>26 to 13</td>
<td>24 to 26</td>
</tr>
<tr>
<td>Uplink SNR (dB)</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Downlink SNR (dB)</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>MAC Overheads (symbols)</td>
<td>98</td>
<td>95</td>
</tr>
</tbody>
</table>

5. Conclusion

Distributed mobility management (DMM) is a new approach for efficient mobility management in all IP flat architecture to cope mobile internet traffic locally. The MIH assisted PMIPv6-DMM approach is carried out and compared with existing CMM protocols in order to optimized handover procedures across Inter-domain environment. The proposed method proves to be energy efficient and more secure with number of mobility anchors and less vulnerable for the attackers. And also benefits the user with widespread coverage and high speed connectivity. The MIH assisted PMIPv6-DMM are analyzed in terms of packet dropped ratio, handover delay, end-to-end delay and throughput. The qualitative results suggest that the MIH assisted PMIPv6-DMM is fine applicable for delay sensitive and delay tolerant applications. Another feature of our approach is that it maintains seamless connectivity and outperforms the existing CMM protocols, which is really demanding for improving the next generation wireless networks. The future work aims to integrate more wireless network and analyze the users mobility simultaneously with different mobility protocols.
References


