I1: Wireless Networks
Chair: Zoubir Mammeri
Room: Concorde (11:00-12:30)

NEW MEASURES FOR MULTICAST GAIN AND THEIR APPLICATION TO IPTV DELIVERY IN WIMAX BASED ACCESS NETWORKS
Alireza Abdollahpouri (University of Hamburg); Bemd E. Wolfinger (University of Hamburg)

ADAC: ADAPTIVE COVERAGE COORDINATION SCHEME IN FEMTOCELL NETWORKS
Fadoua Mhiri (IME Université), Kaoutar Sethom (Sup’Com, Tunisia); Ridha Bousillegue (Sup’Com, Tunisia); Guy Pujolle (University of Pierre et Marie Curie)

DISTRIBUTED HANDOVER CONTROL IN LOCALIZED MOBILE LISIP NETWORKS
Moneeb Gohar (Kyungpook National University); Seok Joo Koo (Kyungpook National University)

ON INDOOR WIFI SIGNAL STATISTICAL PROPERTIES
Yacine Mezali (INRIA); Jacquel Philippe (INRIA)
Abstract—The Locator Identifier Separation Protocol (LISP) has been made as an identifier-locator separation scheme for scalable Internet routing. The identifier-locator separation is also helpful for mobility support. The issue of mobility is a serious challenge in LISP. However, the existing LISP-based handover schemes tend to induce larger handover latency and packet loss. To overcome this problem, we propose a network-based distributed handover control scheme, named LISP-DHC. In the proposed LISP-DHC scheme every access router has the functionality of LISP tunnel router. From numerical results, it is shown that the proposed scheme can give better performance than the existing LISP-based schemes in terms of handover latency.

Keywords-component; LISP, Mobility, Handover Control, Analysis

I. INTRODUCTION

With wide popularity of smart phones and various mobile/wireless access networks, the number of mobile Internet users has been rapidly increasing. It is reported that the number of mobile Internet users will be 1.6 billions in around 2014 and thus exceed the number of desktop users [1]. This mobile trend has caused a rapid growth of BGP routing table, as known as the routing scalability problem [2, 3].

To solve this problem the Locator Identifier Separation Protocol (LISP) has recently been made in IETF [4], which splits the current IP address space into endpoint identifier (EID) and routing locator (RLOC). An EID is not changed, which is used by end host to send and receive data packets. During communication between hosts, an Ingress Tunnel Router (ITR) prepends a new LISP header to the data packet of a source host, and an Egress TR (ETR) strips the LISP header prior to final delivery to the destination host.

One of the critical issues on LISP is how to manage the EID-RLOC mapping system. Several proposals have so far been proposed, such as LISP-MS [5], LISP-ALT [6], LISP-NERD [7], LISP-DHT [8], and LISP-CONS [9]. On the other hand, we note that all of these mapping schemes commonly make an assumption that EIDs can be aggregated within an edge network. However, the EID aggregation may not be achieved in mobile networks, since every mobile host will have its own distinctive and different EID from the other hosts in the same mobile network, as pointed out in [10].

II. RELATED WORKS

The existing schemes for LISP mobility control can be divided into host-based scheme and network-based schemes. To support the LISP mobility, the work in [11] proposed a host-based control scheme, in which it is assumed that a MN implements the light-weight TR functionality and it will act as ITR and/or ETR in mobile networks. In this architecture, a MS is used as an anchor point for MNs. That is, a MN will maintain the map cache and directly communicate with MS. However, this scheme is still subject to the triangle routing problem.

The work in [12] proposed an enhanced scheme for the host-based mobility control, which is denoted by LISP-MN in this paper. In this scheme, the main idea is the same with that in
[11]. However, it deploys a local mapping system (LMS) in the edge networks to solve the triangle routing problem.

On the other hand, the work in [13] proposed a network-based LISP mobility control, denoted by Seamless Mobility Support (SMOS) scheme. The main feature of LISP-SMOS is that the EID of MN represents a 128-bit identifier such as Host Identity Protocol (HIP) [14], rather than IP address. Each host uses an IP address of AR as its LLOC for network-based mobility control. The Border Router (BR) of a domain implements the TR functionality and it has its LMS to contain the EID-LLOC mapping information for MNs in the domain.

The work in [15] proposed a network-based LISP mobility control, denoted by LISP-PMIP scheme in this paper. The main feature of LISP-PMIP is that the Global Mobility Anchor Tunnel Point (GMATP) and Local Mobility Anchor Tunnel Point (LMATP) are introduced. GMATP has the functionality of TR, and also performs management of home EIDs and mobility-related signaling for foreign EIDs. In addition, it maintains bidirectional tunneling with GMATP to provide local mobility. A LMATP is responsible for detecting mobile node.

To describe the existing mobility schemes, we will first consider a generalized network model for LISP mobility control, as shown in Fig. 1. In the figure, there are a variety of fixed and mobile LISP networks. In the mobility perspective, we can consider the two types of mobility: 1) micro-mobility within the same mobile LISP network, and 2) macro-mobility across different domains.

In this paper, we will focus on only the micro-mobility control within a local mobile LISP domain, rather than the macro-mobility control across different mobile domains. For simplicity, we assume that both Correspondent Node (CN) and MN are located within the same mobile domain (i.e., both are mobile hosts), and also we will assume that MN moves from one AR to another AR within the same domain, as illustrated in Fig. 2.

Fig. 3 shows the handover operation of LISP-MN [12]. It is assumed that MN moves from ARold to ARnew region during data transmission with CN. Before handover, MN/TR with EID2:LLOC2 is communicating to CN with EID1:LLOC1. By handover to new AR region, the network attachment to new AR is performed. MN/TR shall configure a new LLOC3 address using DHCP or address auto-configuration scheme. Then, Map Register and Map Register Reply messages are exchanged between MN and LMS for binding update. After that, the Map Request/Reply messages are exchanged between CN and MN to update the modified LLOC3.

Fig. 4 shows the handover operation of LISP-MN [13]. It is assumed that MN moves from ARold to ARnew region during data transmission with CN. Before handover, MN/TR with EID2:LLOC2 is communicating to CN with EID1:LLOC1. By handover to new AR region, the network attachment is performed to new AR. LLOC3 of ARnew is used and MN does not need to configure the new LLOC. After that, the Map register and Map register reply messages are exchanged between AR and MN and also between AR and BR to update the modified LLOC3. After updating the local database, the BR broadcasts the Map update message in the domain.

Fig. 5 shows the handover operation of LISP-PMIP [15]. It is assumed that MN moves from LMATPold to LMATPnew region during data transmission with CN. Before handover, MN with EID2:LLOC2 is communicating to CN with EID1:LLOC1. By handover to new LMATP region, the network attachment is performed to new LMATP. LLOC3 of LMATPnew is used and MN does not need to configure the new LLOC. After that, the PBU and PBA messages are exchanged between LMATP and GMATP.
Data messages are exchanged between ARs in the proposed network. BR has the functionality of TR. LIS...plete. After that, ARnew will forward data packets to MN. This ELC is updated after Map request and Map reply messages are exchanged between ARs in the proposed scheme after handover of MN from old AR to new AR.

Table 1 gives an overview of existing centralized schemes and proposed distributed scheme.

<table>
<thead>
<tr>
<th>Schemes</th>
<th>Architecture</th>
<th>TR Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>LISP-MN</td>
<td>Centralized (host-based)</td>
<td>MN</td>
</tr>
<tr>
<td>LISP-SMOS</td>
<td>Centralized (network-based)</td>
<td>BR</td>
</tr>
<tr>
<td>LISP-PMIP</td>
<td>Centralized(network-based)</td>
<td>GMATP</td>
</tr>
<tr>
<td>LISP-DHC</td>
<td>Distributed (network-based)</td>
<td>AR</td>
</tr>
</tbody>
</table>

LISP-MN is a centralized host-based scheme, in which MN has the functionality of TR. LISP-SMOS is a centralized network-based scheme in which BR has the functionality of TR. LISP-PMIP is also a centralized network-based scheme in which GMATP has the functionality of TR. While LISP-DHC is a distributed network-based scheme, in which AR has the functionality of TR.

B. Handover Operation of LISP-DHC

The handover control is used to provide service continuity for ongoing sessions, especially in mobile environment. We note that some existing/future services require high-level handover performance (i.e. low packet loss/latency) and some additional considerations should be given to support seamless handover. In this context, LISP-DHC assumes the use of link-layer information such as Link-Up (LU), which is defined in the IEEE 802.21 MIH [16].

The handover latency is defined as the time interval from the time that MN loses L2 connection with old AR until the time that MN receives the first data packet from new AR.

We first consider the following handover scenario in which MN is communicating with CN, and it is moving from ARold to ARnew. During this process, it is assumed that the ARnew will get an LU trigger from the networks.

Fig. 6 shows the handover operation of LISP-DHC. We assume that CN and MN (in ARold) are communicating before handover. ARnew of MN performs network attachment with the newly attached MN, and the ARnew will update its ELC cache table for MN. After that, ARnew will exchange Map Request and Map Reply messages with ARold for handover control. The Map Reply message shall include the mapping information of EID1:LLOC1 for MN (EID2), which is recorded in the ELC of ARold. After exchanging of Map request and Map Reply messages between the ARold and ARnew, the bidirectional tunneling is established for data forwarding between ARold and ARnew. After establishing tunnel, ARold will forwards the data packets to ARnew, and then ARnew will forward data packets to MN.

Now, the ARnew of MN sends the Map Request message to the AR of CN for route optimization. On reception of the Map Request message, AR of CN will update its ELC table from EID2:LLOC2 to EID2:LLOC3. Then, AR of CN will send the Map Reply message to the ARnew of MN. On reception of the Map Reply message, the ARnew updates its ELC table by creating the EID1:LLOC1 entry.
IV. PERFORMANCE ANALYSIS

In order to evaluate the performance of proposed LISP-DHC scheme and existing schemes LISP-MN, LISP-SMOS and LISP-PMIP, we analyze the handover latency during handover.

A. Analysis Model

We consider a network environment with a single domain. The whole domain is served by a single BR/GMATP/LMS and each subnet is served by a single AR/LMATP as shown in Fig. 7.

![Figure 7. Network Model](image)

In the figure, the link between MN and AR are wireless links and the links between AR/LMATP and BR/GMATP/LMS, and AR/LMATP and AR/LMATP are wired links.

For analysis, we define the following notations in Table 2.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_i</td>
<td>Size of control packets</td>
</tr>
<tr>
<td>S_d</td>
<td>Size of data packets</td>
</tr>
<tr>
<td>B_w</td>
<td>Wired bandwidth</td>
</tr>
<tr>
<td>B_ar</td>
<td>Wireless bandwidth</td>
</tr>
<tr>
<td>L_w</td>
<td>Wireless link delay</td>
</tr>
<tr>
<td>L_md</td>
<td>Link switching delay</td>
</tr>
<tr>
<td>H_ab</td>
<td>Hop count between node a and b in the network</td>
</tr>
<tr>
<td>P_r</td>
<td>Routing lookup and Processing delay at node k</td>
</tr>
<tr>
<td>T_AC</td>
<td>Address configuration delay</td>
</tr>
<tr>
<td>T_MD</td>
<td>Movement detection delay</td>
</tr>
<tr>
<td>T_L2</td>
<td>Link switching delay</td>
</tr>
</tbody>
</table>

Let \( t(s) \) denote the transmission delay of a message of size \( s \) sent from ‘x’ to ‘y’ via the ‘wireless’ link. Then, \( t(s, H_{xy}) \) can be expressed as:

- For control packets: \( t(s, H_{xy}) = H_{xy} \times [(S_d/B_{ar}) + L_{wl}] + (H_{xy}+1) \times P_r \)
- For data packets: \( t(s, H_{xy}) = H_{xy} \times [(S_d/B_{ar}) + L_{wl}] + (H_{xy}+1) \times P_r \)

Let \( t(s, H_{xy}) \) denote the transmission delay of a message of size \( s \) sent from ‘x’ to ‘y’ via ‘wired’ link. \( H_{xy} \) denotes the number of wired link hops between node x and node y. Then, \( t(s, H_{xy}) \) can be expressed as:

- For control packets: \( t(s, H_{xy}) = H_{xy} \times [(S_d/B_{ar}) + L_{wl}] + (H_{xy}+1) \times P_r \)
- For data packets: \( t(s, H_{xy}) = H_{xy} \times [(S_d/B_{ar}) + L_{wl}] + (H_{xy}+1) \times P_r \)

B. Cost Analysis

In the analysis, we consider the handover latency (HOL) for the existing and proposed schemes.

1) LISP-MN

The HOL of LISP-MN can be composed of link switching delay (\( T_{L2} \)), Movement Detection Delay (\( T_{MD} \)), Address Configuration Delay (\( T_{AC} \)), Map Request and Map Reply messages exchanged between MN and LMS (\( 2T_{MN,LMS}(S_i) \)), Map Request and Map Reply messages between MN and CN (\( 2T_{MN,CN}(S_i) \)), delay of data between MN and AR (\( T_{CN,AR}(S_i) \)), delay of data between AR and ARnew (\( T_{AR,AR}(S_i) \)), and delay of data between ARnew and MN (\( T_{AR,AR}(S_i) \)).

HOL\(_{LISP-MN}\) = \( T_{L2} + T_{MD} + T_{AC} + 2T_{MN,LMS}(S_i) + 2T_{MN,CN}(S_i) + T_{CN,AR}(S_i) + T_{AR,AR}(S_i) + T_{AR,AR}(S_i) \)

(1)

2) LISP-SMOS

The HOL of LISP-SMOS can be composed of link switching delay (\( T_{L2} \)), Movement Detection Delay (\( T_{MD} \)), Map Request Request and Map Register Reply messages between MN and ARnew (\( 2T_{MN,AR}(S_i) \)), Map Request Request and Map Register Reply messages between ARnew and BR (\( 2T_{AR,BR}(S_i) \)), delay of update message broadcasted to all ARs in the domain from BR (\( T_{AR,BR}(S_i) \)), delay of data between ARnew and BR (\( T_{AR,BR}(S_i) \)), and delay of data between ARnew and MN (\( T_{AR,MN}(S_i) \)).

Then, we can derive the handover latency of LISP-SMOS as follows.

HOL\(_{LISP-SMOS}\) = \( T_{L2} + T_{MD} + 2T_{MN,AR}(S_i) + 2T_{AR,BR}(S_i) + T_{AR,BR}(S_i) + T_{AR,MN}(S_i) \)

(2)
3) **LISP-PMIP**

The HOL of LISP-PMIP can be composed of link switching delay \((T_{L2})\), Movement Detection Delay \((T_{MD})\), PBU and PBA messages between LMATPnew and GMATP \((2T_{LMATP,Gamatp}(S_1))\), delay of data between LMATPnew and GMATP \((T_{LMATP,Gamatp}(S_0))\), and delay of data between LMATPnew and MN \((T_{LMATP,MN}(S_0))\).

Then, we can derive the handover latency of LISP-PMIP as follows.

\[
\begin{align*}
\text{HOL}_{\text{LISP-PMIP}} &= T_{L2} + T_{MD} + 2T_{LMATP,Gamatp}(S_1) + T_{LMATP,Gamatp}(S_0) \\
&\quad + T_{LMATP,MN}(S_0) \\
&= T_{L2} + T_{MD} + 2\left(\frac{H_{LMATP,Gamatp}}{B_{AR}} \times \left(\frac{S_1}{B_m} + L_m\right) + H_{LMATP,Gamatp} + 1\right) \times P_1 \\
&\quad + \left(\frac{H_{LMATP,Gamatp}}{S_0} + L_m\right) \times \left(\frac{S_0}{B_m} + L_m\right) \\
&\quad + \left(H_{LMATP,Gamatp} + 1\right) \times S_0 + 2 \times \left(\frac{H_{AR,AR}}{B_{BR/G}} \times \left(\frac{S_1}{B_m} + L_m\right) + \left(H_{AR,AR} + 1\right) \times P_1 \right) \\
&\quad + \left(\frac{H_{AR,AR}}{S_0} + L_m\right) \times \left(\frac{S_0}{B_m} + L_m\right) \\
&\quad + \left(H_{AR,AR} + 1\right) \times S_0 + \left(H_{AR,AR} + 1\right) \times P_1 + \left(\frac{H_{AR,AR}}{B_{BR/G}} \times \left(\frac{S_1}{B_m} + L_m\right) + \left(H_{AR,AR} + 1\right) \times P_1 \right) \\
&\quad + \left(\frac{H_{AR,AR}}{S_0} + L_m\right) \times \left(\frac{S_0}{B_m} + L_m\right) \\
&\quad + \left(H_{AR,AR} + 1\right) \times S_0 + \left(H_{AR,AR} + 1\right) \times P_1 + \left(\frac{H_{AR,AR}}{B_{BR/G}} \times \left(\frac{S_1}{B_m} + L_m\right) + \left(H_{AR,AR} + 1\right) \times P_1 \right) \\
&\quad + \left(\frac{H_{AR,AR}}{S_0} + L_m\right) \times \left(\frac{S_0}{B_m} + L_m\right) \\
&\quad + \left(H_{AR,AR} + 1\right) \times S_0 + \left(H_{AR,AR} + 1\right) \times P_1. 
\end{align*}
\]

4) **LISP-DHC**

The HOL of LISP-DHC can be composed of link switching delay \((T_{L2})\), Movement Detection Delay \((T_{MD})\), Map Request and Map Reply messages between ARold and ARnew \((2T_{AR,AR}(S_1))\), delay of data between ARold and ARnew \((T_{AR,AR}(S_0))\), and delay of data between ARnew and MN \((T_{AR,MN}(S_0))\).

Then, we can derive the handover latency of LISP-DHC as follows.

\[
\begin{align*}
\text{HOL}_{\text{LISP-DHC}} &= T_{L2} + T_{MD} + 2T_{AR,AR}(S_1) + T_{AR,AR}(S_0) + T_{AR,MN}(S_0) \\
&= T_{L2} + T_{MD} + 2\left(\frac{H_{AR,AR}}{B_{BR/G}} \times \left(\frac{S_1}{B_m} + L_m\right) + \left(H_{AR,AR} + 1\right) \times P_1 \right) \\
&\quad + \left(\frac{H_{AR,AR}}{S_0} + L_m\right) \times \left(\frac{S_0}{B_m} + L_m\right) \\
&\quad + \left(H_{AR,AR} + 1\right) \times S_0 + \left(H_{AR,AR} + 1\right) \times P_1 + \left(\frac{H_{AR,AR}}{B_{BR/G}} \times \left(\frac{S_1}{B_m} + L_m\right) + \left(H_{AR,AR} + 1\right) \times P_1 \right) \\
&\quad + \left(\frac{H_{AR,AR}}{S_0} + L_m\right) \times \left(\frac{S_0}{B_m} + L_m\right) \\
&\quad + \left(H_{AR,AR} + 1\right) \times S_0 + \left(H_{AR,AR} + 1\right) \times P_1. 
\end{align*}
\]

C. Numerical Results

Based on the analytical equations for handover latency given so far, we compare the performance of the existing and proposed schemes. For the numerical analysis, we configure the default parameter values as those described in Table 3, by referring to [17]. In addition, we define \(Y\) as the ratio of \(H_{AR,AR}\) over \(H_{AR,BR/G,MAPTDLMS} (= H_{AR,AR}/H_{AR,BR/G,MAPTDLMS})\).

<table>
<thead>
<tr>
<th>Table 3. Default Parameter Values</th>
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<tbody>
<tr>
<td>Parameters</td>
</tr>
<tr>
<td>(T_{MD})</td>
</tr>
<tr>
<td>(T_{L2})</td>
</tr>
<tr>
<td>(B_{AR})</td>
</tr>
<tr>
<td>(B_{WR})</td>
</tr>
<tr>
<td>(L_{AR})</td>
</tr>
<tr>
<td>(L_w)</td>
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<tr>
<td>(S_c)</td>
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<tr>
<td>(S_{wL})</td>
</tr>
<tr>
<td>(H_{AR,AR})</td>
</tr>
<tr>
<td>(H_{AR,BR/G,MAPTDLMS})</td>
</tr>
<tr>
<td>(N_{AR})</td>
</tr>
<tr>
<td>(T_{AC})</td>
</tr>
<tr>
<td>(P_5)</td>
</tr>
</tbody>
</table>
the relative distance between ARs of CN and MN in the network. In the figure we can see that the host-based LISP-MN and the proposed network-based LISP-DHC scheme slightly depend on $\Upsilon$. This is because the optimized data path depends on $\Upsilon$. On the other hand, the network-based LISP-SMOS and LISP-PMIP schemes do not depend on $\Upsilon$, since MN sends the data packet directly to BR and GMATP, and then BR and GMATP will forward the data packet to AR of MN. From the figure, we can see that LISP-DHC gives the best performance among all the candidate schemes.

Figure 10. Impact of the hop count ratio of $H_{AR,AR}$ over $H_{AR,LMATP-BR/GMATP/LMS}$

Fig. 11 shows the handover latency for different $T_{AC}$. In the figure, we can see that the three network-based LISP-SMOS, LISP-PMIP and LISP-DHC schemes are not affected by $T_{AC}$. On the other hand, LISP-MN is affected by $T_{AC}$. This is because MN shall configure a new LLOC address in the LISP-MN. From the figure, we can see that LISP-DHC gives the best performance among all the candidate schemes.

Figure 11. Impact of $T_{AC}$ on handover latency

Fig. 12 shows the handover latency of each candidate scheme for different movement detection delay ($T_{MD}$). From the figure, it is shown that the existing host-based LISP-MN and proposed network-based LISP-DHC give much lower handover latency than LISP-SMOS and LISP-PMIP. This is mainly because the two network-based LISP-SMOS and LISP-PMIP schemes used centralized node for control and data packets. We can also see that LISP-DHC provides better performance than LISP-MN. This benefit comes from that LISP-DHC uses an optimized data path between CN and MN. From the figure, we can see that LISP-DHC gives the best performance among all the candidate schemes.

Figure 12. Impact of $T_{MD}$ on handover latency

Fig. 13 compares the handover latency of candidate schemes for different hop counts between AR or LMATP and BR or G-MATP ($H_{AR,LMATP-BR/GMATP/LMS}$). In the figure we can see that $H_{AR,LMATP-BR/GMATP/LMS}$ gives a significant impact on handover latency for the LISP-MN, LISP-SMOS and LISP-PMIP schemes. This is because LISP-SMOS and LISP-PMIP use a centralized node for control and data packets. On the other hand, LISP-MN uses a centralized node for only control packets. However, LISP-DHC do not depend on $H_{AR,LMATP-BR/GMATP/LMS}$. From the figure, it is shown that LISP-DHC gives the best performance among all the candidate schemes.

Figure 13. Impact of $H_{AR,LMATP-BR/GMATP/LMS}$ Delay on handover latency
V. CONCLUSION

In this paper, we proposed a network-based distributed mobility control scheme in mobile LISP network, named LISP-DHC. In LISP-DHC, every AR has the functionality of TR. For handover support, Map request and Map reply messages are exchanged between ARnew and ARold. After that, the tunnel is established for data forwarding from ARold to ARnew. Then, LLOC update operation should be performed between TR of CN and TR of MN so as to provide the route optimization.

By numerical analysis, the proposed scheme is compared with the existing centralized schemes, LISP-MN, LISP-SMOS, and LISP-PMIP, in terms of the handover latency. From the numerical results, we can see that the proposed LISP-DHC scheme is better than the existing schemes. This implies that the distributed mobility control is preferred to the centralized mobility control.

ACKNOWLEDGMENT

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