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이동 LISP망에서 네트워크 기반 이동성 제어 기법

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요 약

기존 Locator-Identifier Separation Protocol(LISP) 기반 이동성 제어 기법에서는 각 이동 단말이 Tunnel Router(TR)의 기능을 가진다. 하지만, 이러한 단말 기반 이동성 제어에서는 핸드오버 지연이 길어진다. 본 논문에서는 네트워크에 기반한 이동성 제어 방식을 제안한다. 기존의 단말 기반 이동성 방식과 달리 제안하는 네트워크 기반의 방식은 두 가지 특징을 가진다: 1) 각 TR은 이동 단말이 접속한 Access Router(AR)에 구현된다. 2) 핸드오버를 지원하기 위해 Routing Locator(RLOC) 갱신 동작은 Ingress TR(ITR) 과 Egress TR(ETR) 사이에서 수행된다. 수치 분석 및 비교를 통해 기존의 방식에 비해 제안하는 방식이 핸드오버 지연을 크게 줄일 수 있음을 확인하였다.

키워드 : LISP, 이동성, 네트워크 기반, 핸드오버, 성능분석

Network-based Mobility Control in Mobile LISP Networks

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ABSTRACT

This paper proposes a network-based mobility control scheme in wireless/mobile networks, which is based on the Locator-Identifier Separation Protocol (LISP). Compared to the existing LISP mobility scheme, the proposed scheme is featured by the following two points: 1) each LISP Tunnel Router (TR) is implemented at the first-hop access router that mobile nodes are attached to, and 2) for handover support, the LISP Routing Locator (RLOC) update operation is performed between Ingress TR and Egress TR. By numerical analysis, it is shown that the proposed scheme can reduce the handover latency much more than the other candidate schemes.

Keywords : LISP, Mobility, Network-based, Handover, Performance Analysis

1. Introduction

The Locator-Identifier Separation Protocol (LISP) [1] was proposed for routing scalability by separating IP addresses into Endpoint Identifiers (EIDs) and Routing Locators (RLOCs). For mobility support, a host-based scheme for mobile LISP [2] is being discussed, in which the Tunnel Router (TR) is located at a mobile node (MN). However, such the host-based mobile LISP scheme tends to give large signaling overhead and handover latency, as seen in the comparison of Mobile IP (MIP) [3] and Proxy MIP (PMIP) [4].

In this paper, we propose a network-based mobility scheme to support seamless handover in mobile LISP networks. Compared to the existing LISP mobility scheme, the proposed scheme is featured by 1) each TR is implemented at the access router that mobile nodes are attached to; and 2) for handover support, the RLOC update operation is performed between Ingress TR (ITR) and Egress TR (ETR).

This paper is organized as follows. Section 2 describes the proposed LISP-based mobility control. In Section 3 and 4, we analyze and compare the proposed scheme with the other candidate schemes in terms of handover latency. Section 5 concludes this paper.

2. Proposed LISP-based Mobility Control

2.1 Network Model

(Fig. 1) shows a network model for LISP-based mobility control, in which Correspondent Node (CN) and

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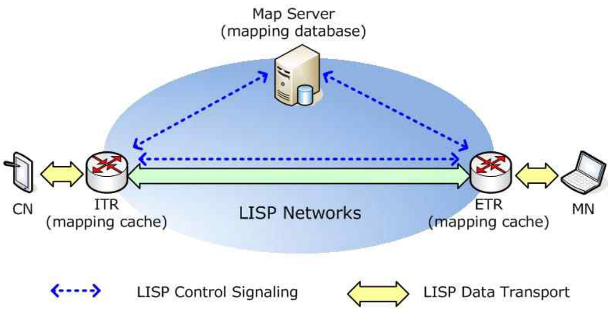


(Fig. 1) Network model for LISP-based mobility control

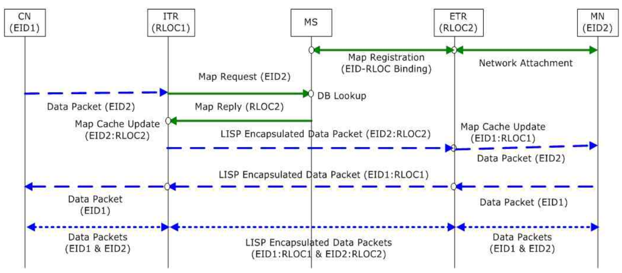
MN are located in the same domain. For EID-RLOC mapping services, the Map Server (MS) is employed to manage the EID-RLOC mapping for all MNs in the domain [5].

In addition, the proposed mobility scheme assumes that each TR is co-located with the first-hop access router (AR) that MNs are attached to. Each TR also has its local mapping cache, which contains the EID-RLOC mapping that has been obtained by the Map Query operation with MS. This mapping cache will be referred to by TR in the data forwarding to a remote node.

2.2 Map Registration and Map Query

When a MN enters a new TR area, it will establish the network connection with the concerned AR/TR. In this process, MN shall bind its EID to its TR, by which a TR can identify the list of EIDs of its attached MNs. Then, TR performs Map Registration (for EID-RLOC binding) by sending a Map Register message to MS.

The Map Query operation for data transport can be illustrated in (Fig. 2), in which CN (EID1) sends data packets to MN (EID2).



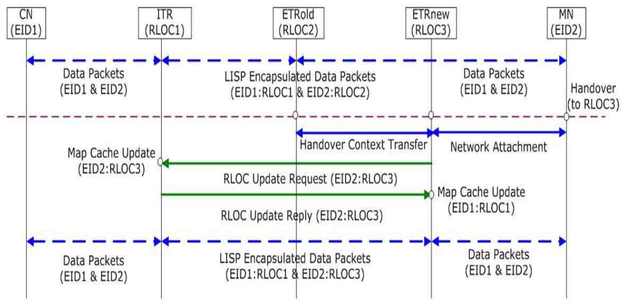
(Fig. 2) Data transport with Map Query

In the figure, CN sends an initial data packet to MN via its attached ITR (RLOC1). ITR will first look up its Map Cache to find the RLOC of MN; if yes, it can deliver the data packet to the identified RLOC2, which is not shown in the figure; otherwise, ITR shall perform the MAP Query operation by sending a Map Request to MS. On reception of the Map Request, MS responds with a Map Reply to ITR after DB lookup. Based on the received Map Reply message, ITR will update its Map Cache by creating the entry with EID2 and RLOC2.

Now, ITR sends the data packet to ETR (RLOC2). On reception of the data packet from ITR, ETR will update its Map Cache by creating an entry with EID1:RLOC1. This is done to deliver the data packets from MN to CN. Then, ETR forwards the original data packet to MN. Since then, MN and CN can exchange data packets based on the established Map Caches of ITR and ETR.

2.3 RLOC Update for Handover Support

For handover support, the two messages are defined: 1) RLOC Update Request from ETR of MN to ITR of CN, and 2) RLOC Update Reply as a response to RLOC Update Request. Then, the RLOC Update operations for handover control are performed as shown in (Fig. 3).



(Fig. 3) Handover control with RLOC Update

With an L2 trigger such as Link-Up, MN is attached to ETRnew. We assume that the L2 trigger contains the information of ETRold, which is delivered from MN to ETRnew. For context transfer, ETRnew asks ETRold about the information of MN (*e. g.*, EID and RLOC of CN). Then, ETRnew sends an RLOC Update Request to ITR of CN. ITR of CN updates its Map Cache from EID2:RLOC2 to EID2:RLOC3, and send an RLOC Update Reply to ETRnew. ETRnew updates its Map Cache with EID1:RLOC1. The data path between MN and CN is changed to MN ⇔ RLOC1 ⇔ RLOC3 ⇔ CN.

3. Analysis of Handover Latency

Let us consider the following handover schemes.

- *LISP-MN-MIP*: This scheme is based on the work in [2], in which TRs are implemented into MNs. Mobile IPv6 [3] is employed to support mobility. For handover support, MN shall perform the MIPv6 *Route Optimization* with CN.
- *LISP-AR-PMIP*: This scheme employs Proxy MIPv6 [4], in which TRs are implemented at PMIP Mobile

Access Gateways (MAGs). It is assumed that HA is co-located with PMIP Local Mobility Anchor (LMA). To support the handover of MN, MAG (acting as TR) shall perform the *Proxy Binding Update* operation with LMA/HA.

- *LISP-AR-RU*: This is a purely proposed scheme, in which TRs are implemented at ARs. For handover of MN, its new ETR shall perform the *RLOC Update* (RU) operation with ITR of CN. To do this, a handover context transfer is required between old ETR and new ETR.

In the analysis, we assume that CN and MN are located within a single mobile network domain. In the mobility control operations, we will ignore the security issues.

Let us denote T_{MD} by the movement detection delay in the link layer, and T_{AC} by IP address (RLOC) configuration delay such as DHCP or IPv6 address auto-configuration. In addition, we define T_{a-b} as the transmission delay of a packet between two nodes, *a* and *b*. It is assumed that all the node processing delays are relatively small and thus negligible.

In the *LISP-MN-MIP* scheme, the handover latency ($HO_{LISP-MN-MIP}$) consists of the following components: 1) movement detection of MN in the new AR region, which is T_{MD}; 2) RLOC (i.e., IP address) configuration of MN, which is equal to T_{AC}; 3) MIPv6 *Route Optimization* between MN and CN, which is $2(T_{MN-AR}+T_{AR-AR}+T_{CN-AR})$; 4) data transmission from CN to MN after handover, which is $T_{CN-AR}+T_{AR-AR}+T_{MN-AR}$. Accordingly, $HO_{LISP-MN-MIP}$ can be represented as

$$T_{MD}+T_{AC}+3(T_{CN-AR}+T_{AR-AR}+T_{MN-AR}).$$

In the *LISP-AR-PMIP* scheme, the handover control will be performed between MAG of MN and LMA. Thus, its handover latency ($HO_{LISP-AR-PMIP}$) consists of the following components: 1) movement detection of MN, T_{MD}; 2) MN-HoA acquisition of MAG from Policy Server (PS), which is $2T_{MAG-PS}$; 3) Proxy BU operation between MAG and LMA/HA, which is $2T_{MAG-LMA}$; 4) data transmission from CN to MN via LMA/HA, which is equal to $T_{CN-MAG}+T_{MAG-LMA}+T_{LMA-MAG}+T_{MAG-MN}$. Therefore, $HO_{LISP-AR-PMIP}$ can be represented as

$$T_{MD}+2T_{MAG-PS}+T_{CN-MAG}+4T_{MAG-LMA}+T_{MAG-MN}.$$

In the proposed *LISP-AR-RU* scheme, the handover latency ($HO_{LISP-AR-RU}$) consists of the following components: 1) movement detection of MN, T_{MD}; 2) handover context transfer between old ETR and new ETR, which is $2T_{oETR-nETR}$; 3) *RLOC Update* between new ETR of MN and ITR of CN, which is equal to $2T_{ITR-ETR}$; 4) data transmission from CN to MN, $T_{CN-ITR}+T_{ITR-ETR}+T_{ETR-MN}$. Thus, $HO_{LISP-AR-RU}$ can be represented as

$$T_{MD}+2T_{oETR-nETR}+3T_{ITR-ETR}+T_{CN-ITR}+T_{ETR-MN}.$$

For analysis, we further assume that the distances from AR to CN and MN are equal, and that T_{MAG-PS} is approximately equal to T_{AR-LMA} in *LISP-AR-PMIP*.

In the notations, by using UE and AR instead of CN/MN and TR/MAG, the handover latency of each candidate scheme can be summarized as follows:

$$HO_{LISP-MN-MIP} = T_{MD}+T_{AC}+3(2T_{UE-AR}+T_{AR-AR}) \quad (1)$$
$$HO_{LISP-AR-PMIP} = T_{MD}+2T_{UE-AR}+6T_{AR-LMA} \quad (2)$$
$$HO_{LISP-AR-RU} = T_{MD}+2(T_{oAR-nAR}+T_{UE-AR})+3T_{AR-AR} \quad (3)$$

4. Numerical Results

For numerical analysis, the default values of delay components are set as follows: T_{MD}=10ms, T_{AC}=150ms, T_{UE-AR}=10ms, T_{AR-LMA}=20ms, and T_{AR-AR}=28ms, $T_{oAR-nAR}$=3ms, which are the same or similar to those given in [6]. Among these parameter values, T_{MD}, T_{AC}, T_{AR-AR} and T_{UE-AR} may depend on a variety of network conditions. Thus, we need to compare the handover latency for different values of those parameters.

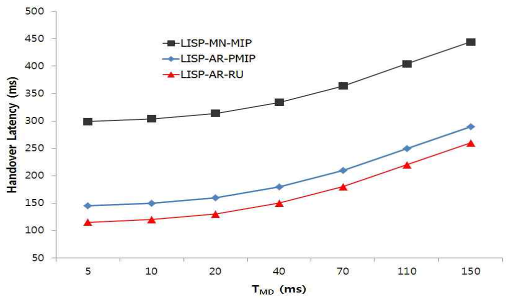
(Fig. 4) shows the handover latency of each candidate scheme for different movement detection delay (T_{MD}). From the figure, it is shown that the network-based schemes (LISP-AR-PMIP and LISP-AR-RU) give much lower handover latency than the host-based scheme (LISP-MN-MIP). The performance gap gets larger, as TMD increases. This is mainly because the host-based LISP-MN scheme needs the RLOC (IP address) configuration in the new AR region, differently from LISP-AR schemes. We can also see that LISP-AR-RU provides slightly better performance than LISP-AR-PMIP. This benefit comes from that LISP-AR-RU uses a more optimized data path between CN and MN than LISP-AR-PMIP.

(Fig. 5) shows the handover latency for different T_{AC}. In the figure, we can see that the two LISP-AR schemes are not affected by T_{AC}, and that the gaps of performance between LISP-AR and LISP-MN increase, as T_{AC} gets larger.

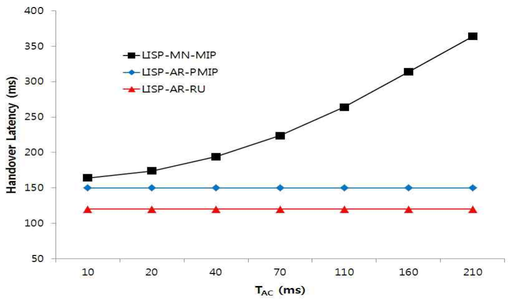
(Fig. 6) shows the handover latency for different T_{AR-AR}, which depends on the relative distance between ARs of CN and MN in the network. For simple analysis, we assume that $T_{AR-AR} = \sqrt{2}\ T_{AR-LMA} \cong 1.414\ T_{AR-LMA}$.

From the figure, we can see that the two network-based schemes give better performance than the host-based scheme and that the LISP-AR-RU gives lower handover latency than LISP-AR-PMIP for a larger T_{AR-AR} value.

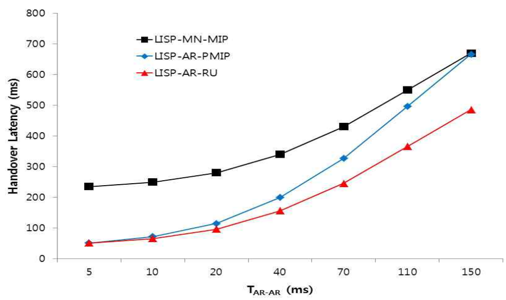
(Fig. 7) shows compares the performance for different T_{UE-AR}, in order to see the impact of wireless network condition. From the figure, we can see that the proposed LISP-AR-RU scheme gives the best performance among all of the candidate schemes.



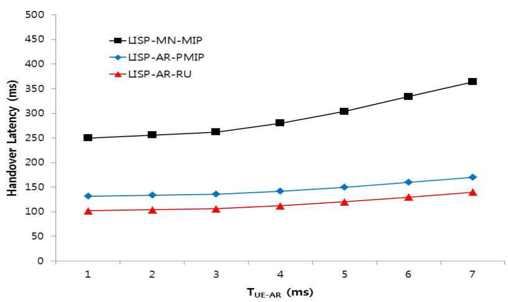
(Fig. 4) Handover latency for different T_{MD}



(Fig. 5) Handover latency for different T_{AC}



(Fig. 6) Handover latency for different T_{AR-AR}



(Fig. 7) Handover latency for different T_{UE-AR}

5. Conclusions

This paper proposed a network-based mobility control scheme in mobile LISP networks. From the performance analysis for three candidate schemes, it is suggested: 1) each LISP Tunnel Router should be located with the first-hop 'access router' of mobile nodes, rather than the mobile node, and 2) for handover support, the RLOC update operation should be performed between Ingress TR and Egress TR to provide the route optimization.

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