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Day 3 : February 21 (Tuesday)

Time 13:00 ~ 14:30

Session A5: Wireless Communication Technology V

Room : Ruby

Chair : Dr. Aymen Belghith, Université de Rennes, France

A5-01 Blind Equalization and Characteristic Function Based Robust Modulation Recognition

Qinghua Shi

0419

University of Electro-Communications, Japan

A5-02 An Improved Scheme Based on Physical-layer Network Coding

LIU Qin-yong*, PENG Hua**

0531

National Digital Switching System Engineering Technology Center, China.

A5-03 Intensity Reflection Coefficient based Min-Sum Decoding for Low Density Parity Check Codes

Md. Mosthur Rahman FARAZI¹, Mohammad Rakibul ISLAM², Khondaker Sultan MAHMOOD³, Md. Farhan Tasnim OSMAN⁴

0399

Islamic University of Technology, Bangladesh

A5-04 A GTS Allocation Scheme for Emergency Data Transmission in Cluster-Tree WSNs

Hyeopgeon Lee*, Kyoung-hwa Lee**, Yongtae Shin*

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Soongsil University, Korea

A5-05 MIMO-OFDM Scheme Based on Permutation Spreading

Sherif Moussa^{1,2}, Adel Omar Dahmane¹, Claude D'Amours³ and Habib Hamam⁴

0220

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Session B5: NGN & Future Network I

Room : Emerald

Chair : Dr. Vladislav Pyattaev, OJSC "GIPROSVYAZ" North-West Branch, Russia

B5-01 Enhanced Mobility Control in Mobile LISP Networks

Moneeb Gohar, Ji In Kim, Seok Joo Koh

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Kyungpook National University, Korea

B5-02 VSCCN: CCN with a Very Simple Control Plane

Insang Choi, Byungjoon Lee, Hongseok Jeon, Hoyoung Song, and Youhyeon Jeong

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ETRI(Electronics and Telecommunications Research Institute), KOREA

B5-03 IPv6 Rapid Deployment in Taiwan Academic Network (TANet)

Po-Kang CHEN, Chia-Wen LU, Quincy WU

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National Chi Nan University, Taiwan

B5-04 A Closer Look at Content-Centric Internet Research Projects

H.S. JEON ^a, I.S. CHOI ^b, B.J. LEE ^b, and H.Y. SONG ^b

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^a KAIST(Korea Advanced Institute of Science and Technology), Korea, ^b ETRI(Electronics and Telecommunications Research Institute), Korea

B5-05 Concept Statements for Russian Telecom Development till 2015

Vladimir BONDARIK

0203

OJSC "GIPROSVYAZ", Russia.

Time 14:30 ~ 15:00

Coffee Break

Enhanced Mobility Control in Mobile LISP Networks

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Abstract— The Locator Identifier Separation Protocol (LISP) has been made for scalable Internet routing. In LISP, the mobility control is a host-based scheme in which each mobile node implements the LISP Tunnel Router functionality, and it is also a centralized approach using Map Server (MS) as a mobility anchor for mobile nodes. However, such a centralized scheme has some limitations in terms of scalability and performance. As the number of mobile nodes increases, the control overhead of MS gets larger, since the aggregation of EIDs for mobile nodes cannot be achieved in mobile networks. Moreover, the centralized scheme is subject to services degradation by single point of failure, and increased operational costs. In this paper, we propose the two network-based distributed mobility control schemes for localized mobile LISP networks, LISP-PMIP-Push and LISP-PMIP-Pull, which are designed by referring to the Proxy Mobile IP (PMIP). From the numerical analysis, it is shown that the proposed distributed mobility schemes can give better performance than the existing centralized scheme, and that the pull-based distributed control scheme (LISP-PMIP-Pull) provides the best performance among the candidate mobility schemes, in terms of the binding update and data delivery costs.

Keywords- LISP, Mobile Networks, Network-based, Distributed mobility control

I. INTRODUCTION

Most of the current Internet mobility schemes are based on a centralized anchor, as shown in the Home Agent (HA) of Mobile IP (MIP) [1], the Mobility Anchor Point (MAP) of Hierarchical MIP [2], and the Local Mobility Anchor (LMA) of Proxy MIP [3]. In the centralized scheme, all control and data packets are processed by a central mobility anchor. This anchor allows a mobile node (MN) to be reachable, when it is away from its home domain, by ensuring the forwarding of data packets destined to or sent from MN. However, the centralized scheme is vulnerable to several problems. First, the centralized mobility anchor tends to induce unwanted control/data traffic into core networks, which may give a big burden to network operator due to large operational costs. In addition, a single point of failure of central node may affect severe degradation of overall system performance and also the increased cost of network engineering.

The IETF has recently discussed the distributed mobility management to overcome limitations of the centralized approach, in which data and control planes are distributed [4]. The centralized mobility control has non-optimal routes and performance degradation, whereas the distributed mobility

control has optimal routes, because the route optimization is intrinsically supported. Moreover, the centralized approach is vulnerable to a single point of failure, whereas the distributed approach will mitigate such problem to a local network.

The Locator Identifier Separation Protocol (LISP) has recently been made in IETF [5], 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 [6], LISP-ALT [7], LISP-NERD [8], LISP-DHT [9], and LISP-CONS [10]. 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 [11].

To address the LISP mobility control, the host-based schemes were proposed [12, 13], in which each mobile host implements the TR functionality. In addition, the works in [14, 15] proposed the network-based schemes, in which a router implements the TR functionality. However, we note that all of the existing LISP mobility schemes are based on a centralized approach by using the LISP Map Server (MS) as a mobility anchor for mobile hosts. However, such a centralized scheme has some limitations in terms of scalability and performance. As the number of MNs increases, the control overhead of MS gets larger, since the EIDs of MNs may not be aggregated in mobile networks. Moreover, the centralized scheme is subject to services degradation by a single point of failure, and increased operational costs.

In this paper, we propose two network-based distributed mobility control schemes for localized mobile LISP networks. The proposed distributed control schemes can be used to effectively provide the mobility support in wireless/mobile LISP networks, compared to the existing centralized control schemes.

The rest of this paper is organized as follows. In Section 2, we review the existing centralized schemes for LISP mobility

control. In Section 3, we propose the two network-based distributed mobility control schemes. Section 4 analyzes and compares the existing and proposed schemes in terms of the binding update and data delivery costs. Section 5 concludes this paper.

II. EXISTING LISP MOBILITY SCHEMES

The existing schemes for LISP mobility control can be divided into host-based schemes and network-based schemes. In the host-based scheme [12, 13], each MN implements the TR functionality and the mobility control operations in a local mobile network are similar to those of Hierarchical MIP (HMIP) [2]. In this paper, we thus name the existing host-based LISP mobility scheme as LISP-HMIP. It is noted that MAP of HMIP is equal to Local Map Server (LMS) of LISP-HMIP, and Regional CoA and Local CoA of HMIP correspond to RLOC and Local LOC (LLOC) of LISP-HMIP, respectively. On the other hand, in the network-based scheme [14, 15], each access router (AR) implements the TR functionality and the mobility control operations in a local mobile network are similar to those of Proxy MIP (PMIP) [3]. We thus name the existing network-based LISP mobility scheme as LISP-PMIP in this paper. It is noted that Mobile Access Gateway (MAG) and LMA of PMIP correspond to TR/AR and LMS of LISP-PMIP, and Proxy CoA of PMIP is equal to LLOC of LISP-PMIP.

In this paper, we will focus on only the intra-domain localized mobility control within a local mobile LISP domain, rather than the inter-domain mobility control across different mobile domains, since there are various possible scenarios for inter-domain communication. For simplicity, we assume that both CN and MN are located within the same mobile domain (i.e., both are mobile hosts).

Figure 1 describes the operations of LISP-HMIP in a localized mobile LISP network. MN is attached to a new AR, as described in Step 1. MN configures its LLOC, since MN shall perform the TR functionality. Then, MN will send a Map Register message to LMS. This LMS may be configured on the gateway (or border router) of mobile domain (Step 2). LMS responds with a Map Register Reply message to MN (Step 3). Now, a CN wants to send a data packet to MN. CN will first send a Map Request to LMS to find the LLOC of MN (Step 4). LMS will respond to CN with a Map Reply message after lookup of its database (Step 5). Now, CN sends the data packet to MN (Step 6, 7, 8).

Figure 2 describes the LISP-PMIP operations. MN is attached to AR (Step 1). LLOC configuration is not required for MN, since AR performs the TR functionality. AR/TR of MN sends a Map Register to LMS to bind EID-LLOC of MN (Step 2). In response to Map Register, LMS send a Map Register Reply to AR/TR of MN (Step 3). Now, CN sends a data packet to MN (Step 4). AR/TR of CN will first send a Map Request to LMS to find the LLOC of MN (Step 5). LMS will respond with a Map Reply to AR/TR of CN, after lookup of its database (Step 6). Based on this Map Reply message, AR/TR of CN sends the data packet to AR/TR of MN (Step 7). Finally, the data packet is forwarded to MN (Step 8).

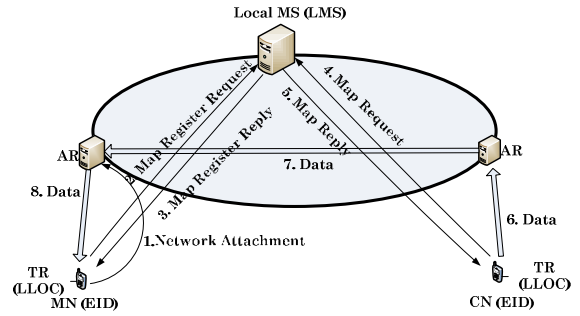


Figure 1. Host-based LISP-HMIP operations

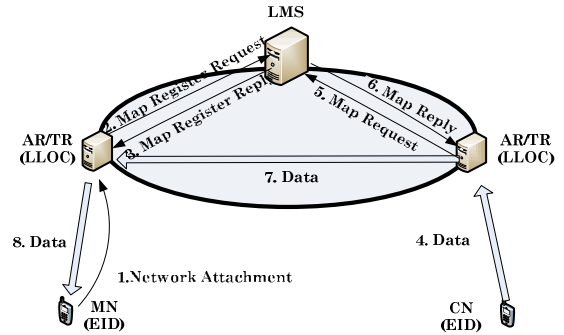


Figure 2. Network-based LISP-PMIP operations

III. PROPOSED DISTRIBUTED MOBILITY CONTROL SCHEMES

In this section, we describe the proposed distributed mobility control schemes: LISP-PMIP-Push and LISP-PMIP-Pull.

A. Overview

In the proposed network-based mobility control model, each AR implements the TR functionality, and it will maintain an EID-LLOC Cache (ELC) for remote hosts. This ELC is used by TR to deliver data packets to remote hosts in the mobile network.

The ELC is updated in the different way, as per the proposed scheme. In LISP-PMIP-Push, to update the ELC, each TR will send the list of its attached EIDs to all the other TRs within the mobile domain, when a new MN is attached to. For this purpose, a new message of ‘EID update’ needs to be defined. This is called the ‘push’ operation, which is similar to the legacy routing protocol (e. g., OSPF) mechanism. Based on the EID update messages from the other TRs, each TR will maintain its ELC cache so as to keep the EID-LLOC mappings for all MNs in the mobile network. In LISP-PMIP-Pull, on the other hand, each TR will query the LLOC of MN by sending a Map Request message to all the other TRs, which is called the ‘pull’ operation. Only the TR that is attached to MN will respond with a Map Reply message. Based on this Map Reply, each TR will maintain the EID-LLOC for MN into ELC cache.

LISP-HMIP is a centralized scheme, in which MN performs the EID-LLOC binding update with LMS by using the Map Register message, while the Map Request message is used for

binding query operation. TR functionality is implemented at MN.

LISP-PMIP is also a centralized scheme, in which AR implements the TR functionality and performs the EID-LLOC binding update with LMS by using Map Register message. In the binding query operation, AR of CN sends a Map Request to LMS to find the LLOC of MN.

LISP-PMIP-Push is a distributed scheme, in which each AR performs the TR functionality. In this scheme, the Map Register with LMS is not performed for binding update. Instead, Each TR will send its EID update (list of EIDs) messages to all the other TRs in the mobile domain by multicast, when a new MN is attached to. The binding query (Map Request) operation is not used. CN can send the data packet directly to MN, based on the EID update information.

LISP-PMIP-Pull is also a distributed scheme with AR acting as TR. The binding update is not performed. For binding query, each TR sends a Map Request to all the other TRs to find the LLOC of MN.

B. LISP-PMIP-Push

Figure 3 shows the LISP-PMIP-Push operations. When MN enters a new AR region, its EID will be bound to its AR/TR (Step 1). Then, AR/TR of MN will send (or push) the EID list (an EID update message) to all the other ARs/TRs in the domain by multicast. Every AR/TR will update its ELC (for all active hosts in the mobile domain), based on the EID update message received from AR/TR of MN (Step 2). When CN sends a data packet to MN, the AR/TR of CN looks up its ELC to find the LLOC of MN (Step 3). If the LLOC is found, AR/TR of CN sends the data packet to AR/TR of MN (Step 4). Finally, the data packet is forwarded to MN (Step 5).

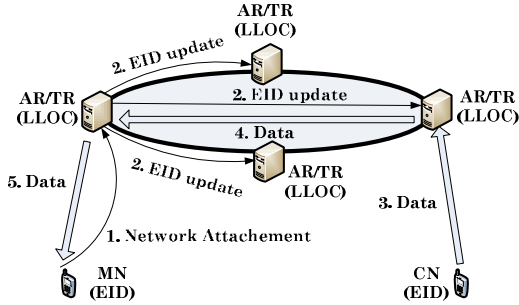


Figure 3. Distributed LISP-PMIP-Push operations

C. LISP-PMIP-Pull

Figure 4 shows the LISP-PMIP-Pull operations. When MN enters a new network, it is connected to AR/TR, and the EID-LLOC binding is performed (Step 1). Now, CN sends a data packet to MN (Step 2). Then, AR/TR of CN sends a Map Request by multicast to all the other ARs/TRs in the domain to find the LLOC of MN (Step 3). Then, only the AR/TR of MN will respond with a Map Reply message to AR/TR of CN (Step 4). AR/TR of CN will update its ELC and send the data packet to AR/TR of MN (Step 5). Finally, the data packet is forwarded to MN (Step 6).

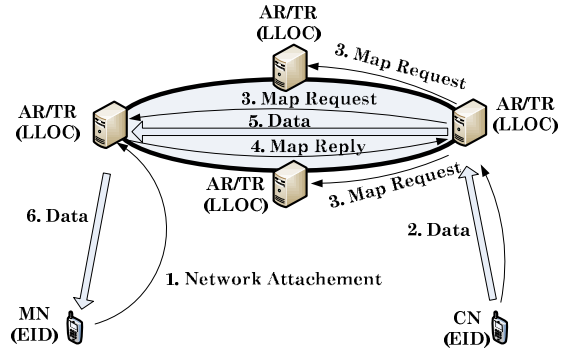


Figure 4. Distributed LISP-PMIP-Pull operations

IV. PERFORMANCE ANALYSIS

To evaluate the performance of the proposed mobility schemes, we analyze the costs of the binding update with MS and the data delivery from CN to MN with binding query. We compare the binding update and data delivery costs for the existing schemes (LISP-HMIP, LISP-PMIP) and the proposed schemes (LISP-PMIP-Push, LISP-PMIP-Pull).

A. Analysis Model

For simplicity, we assume that both CN and MN are located within the same mobile LISP domain (i.e., both are mobile hosts), as illustrated below in the Fig. 5.

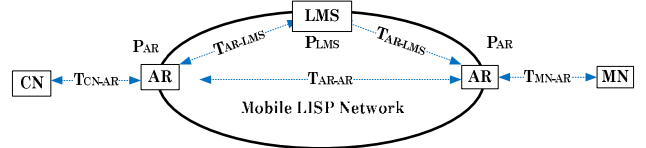


Figure 5. Network Model for numerical analysis

We define the parameters used for the analysis in Table 1.

The binding update cost and the data delivery cost are denoted by BUC and DDC , respectively. Then the total cost (TC) is represented as $TC=BUC+DDC$.

B. Cost Analysis

1) LISP-HMIP

The binding update operations are performed as follows. When MN enters a new AR, it configures LLOC by using the DHCP or IP address auto-configuration. We assume that this operation takes roughly T_{AC} . After that, AR of MN will perform the Map Register operation with LMS by exchanging Map Register and Map Register Reply messages, and LMS will update the database. This operation takes $2T_{MN-LMS}$ and P_{LMS} , where $T_{MN-LMS} = \kappa H_{MN-AR} + \tau H_{AR-LMS}$ and $P_{LMS} = \alpha \log(N_{AR} \times N_{Host/AR})$. It is assumed that the processing cost for binding update with LMS (P_{LMS}) is proportional to the total number of active hosts in the domain ($N_{AR} \times N_{Host/AR}$) in the log scale by using a tree-based data structure to implement the database. Accordingly, the binding update cost of LISP-HMIP can be represented as follows.

$$\begin{aligned}
BUC_{LISP-HMIP} &= T_{AC} + S_{Control} \times 2 T_{MN-LMS} + P_{LMS} \\
&= T_{AC} + S_{Control} \times 2 (\kappa H_{MN-AR} + \tau H_{AR-LMS}) \\
&\quad + \alpha \log(N_{AR} \times N_{Host/AR}) \quad (1)
\end{aligned}$$

In LISP-HMIP, the data delivery cost from CN to MN can be calculated as follows. First, CN will send a Map Request message to LMS to find the LLOC of MN. Then, LMS will look for the LLOC of MN in its database, which takes $P_{LMS} = \beta \log(N_{AR} \times N_{Host/AR})$. After that, LMS will respond with the Map Reply message to CN via AR. So, the cost of control message transmission is equal to $2T_{CN-AR} + 2T_{AR-LMS}$. Then, the data packet will be forwarded directly from CN to MN, which takes $T_{CN-AR} + T_{AR-AR} + T_{MN-AR}$. Thus, the data delivery cost of LISP-HMIP can be represented as follows.

$$\begin{aligned}
DDC_{LISP-HMIP} &= S_{Data} \times (T_{CN-AR} + T_{AR-AR} + T_{MN-AR}) \\
&\quad + S_{Control} \times (2T_{CN-AR} + 2T_{AR-LMS}) + P_{LMS} \\
&= S_{Data} \times (\kappa H_{CN-AR} + \tau H_{AR-AR} + \kappa H_{MN-AR}) \\
&\quad + S_{Control} \times (2\kappa H_{CN-AR} + 2\tau H_{AR-LMS}) \\
&\quad + \beta \log(N_{AR} \times N_{Host/AR}). \quad (2)
\end{aligned}$$

So, we obtain the total cost of LISP-HMIP as

$$TC_{LISP-HMIP} = BUC_{LISP-HMIP} + DDC_{LISP-HMIP}$$

TABLE 1. PARAMETERS USED FOR COST ANALYSIS

Parameter	Description
T_{a-b}	Transmission cost of a packet between nodes a and b
P_c	Processing cost of node c for binding update or lookup
$N_{Host/AR}$	Number of active hosts per AR
N_{AR}	Number of AR in the LISP domain
H_{a-b}	Hop count between nodes a and b in the network
$S_{control}$	Size of a control packet (in byte)
S_{data}	Size of a data packet (in byte)
α	Unit cost of binding update with LMS
β	Unit cost of lookup for MN at LMS or TR
τ	Unit transmission cost of a packet per a wired link (hop)
κ	Unit transmission cost of a packet per a wireless link (hop)
$\gamma (= H_{AR-AR} / H_{AR-LMS})$	Ratio of H_{AR-AR} over H_{AR-LMS}
T_{AC}	Address configuration delay

2) LISP-PMIP

For binding update, AR/TR of MN performs the Map Register operation with LMS by exchanging the Map Register and Map Register Reply messages, and LMS will update its database. This operation takes $2T_{AR-LMS}$ and P_{LMS} , where $T_{AR-LMS} = \tau H_{AR-LMS}$ and $P_{LMS} = \alpha \log(N_{AR} \times N_{Host/AR})$. Thus, the binding update cost of LISP-PMIP can be represented as follows.

$$BUC_{LISP-PMIP} = S_{Control} \times 2T_{AR-LMS} + P_{LMS}$$

$$= S_{Control} \times 2 \tau H_{AR-LMS} + \alpha \log(N_{AR} \times N_{Host/AR}) \quad (3)$$

In LISP-PMIP, the data delivery cost of data packet from CN to MN can be calculated as follows. First, a data packet of CN is delivered to AR/TR of CN, which is equal to T_{CN-AR} . Then, AR/TR of CN will send a Map Request message. LMS will look for the LLOC of MN in its database. After that, LMS will send a Map Reply message to AR/TR of CN, This operation takes $2T_{AR-LMS}$ and P_{LMS} , where $T_{AR-LMS} = \tau H_{AR-LMS}$ and $P_{LMS} = \beta \log(N_{AR} \times N_{Host/AR})$. Then, the data packet will be forwarded directly to MN from AR/TR of CN, which takes $T_{AR-AR} + T_{MN-AR}$. Then, the data delivery cost of LISP-PMIP is represented as follows.

$$\begin{aligned}
DDC_{LISP-PMIP} &= S_{Data} \times (T_{CN-AR} + T_{AR-AR} + T_{MN-AR}) \\
&\quad + S_{Control} \times 2T_{AR-LMS} + P_{LMS} \\
&= S_{Data} \times (\kappa H_{CN-AR} + \tau H_{AR-AR} + \kappa H_{MN-AR}) \\
&\quad + S_{Control} \times 2 \tau H_{AR-LMS} + \beta \log(N_{AR} \times N_{Host/AR}) \quad (4)
\end{aligned}$$

So, we obtain the total cost of LISP-PMIP as

$$TC_{LISP-PMIP} = BUC_{LISP-PMIP} + DDC_{LISP-PMIP}$$

3) LISP-PMIP-PUSH

In LISP-PMIP-Push, no Map Register is performed between AR/TR and LMS. Instead, each AR/TR sends its EID update message to all the other ARs/TRs by multicast in the domain. Accordingly, the binding update cost of LISP-PMIP-Push will be

$$\begin{aligned}
BUC_{LISP-PMIP-Push} &= S_{control} \times N_{AR} \times (T_{AR-AR} + P_{AR}) \\
&= S_{control} \times N_{AR} \times (\tau H_{AR-AR} + \beta \log(N_{Host/AR})) \quad (5)
\end{aligned}$$

In LISP-PMIP-Push, the data delivery cost from CN to MN can be calculated as follows. First, a data packet of CN is delivered to AR/TR of CN, which is equal to T_{CN-AR} . AR/TR of CN will look for LLOC of MN in its ELC, which takes $P_{AR} = \beta \log(N_{Host/AR})$. Then, the data packet will be forwarded directly to AR/TR of MN from AR/TR of CN, which takes $T_{AR-AR} + T_{MN-AR}$. Accordingly, the data delivery cost of LISP-PMIP-Push is represented as follows.

$$\begin{aligned}
DDC_{LISP-PMIP-Push} &= S_{Data} \times (T_{CN-AR} + T_{AR-AR} + T_{MN-AR}) + P_{AR} \\
&= S_{Data} \times (\kappa H_{CN-AR} + \tau H_{AR-AR} + \kappa H_{MN-AR}) \\
&\quad + \beta \log(N_{Host/AR}) \quad (6)
\end{aligned}$$

So, we obtain

$$TC_{LISP-PMIP-Push} = BUC_{LISP-PMIP-Push} + DDC_{LISP-PMIP-Push}$$

4) LISP-PMIP-PULL

In LISP-PMIP-Pull, no Map Register is performed between AR/TR and LMS. Thus, we obtain

$$BUC_{LISP-PMIP-Pull} = 0 \quad (7)$$

In data delivery, the binding query operation is performed by AR/TR of CN, before transmission of data packet to MN. After that, the data packets are delivered directly to MN. Thus, the data delivery cost of LISP-PMIP-Pull can be calculated as follows. First, a data packet of CN is delivered to AR/TR of CN, which is equal to T_{CN-AR} . Then, AR/TR of CN sends a Map Request message to all the ARs/TRs in the domain by

multicast, which corresponds to $T_{AR-AR} \times N_{AR}$. Only the AR/TR of MN will respond to the AR/TR of CN with a Map Reply message, after lookup of its EID list, which is equal to $P_{AR} + T_{AR-AR}$. After that, AR/TR of CN can deliver the data packets directly to MN via AR/TR, which takes $T_{AR-AR} + T_{MN-AR}$. Accordingly, the data delivery cost of LISP-PMIP-Pull, can be represented as follows.

$$\begin{aligned} DDC_{LISP-PMIP-Pull} &= S_{Data} \times (T_{CN-AR} + T_{AR-AR} + T_{MN-AR}) \\ &\quad + S_{Control} \times T_{AR-AR} \times (N_{AR} + 1) + P_{AR} \\ &= S_{Data} \times (\kappa H_{CN-AR} + \tau H_{AR-AR} + \kappa H_{MN-AR}) \\ &\quad + S_{Control} \times \tau H_{AR-AR} \times (N_{AR} + 1) \\ &\quad + \beta \log(N_{Host/AR}) \end{aligned} \quad (8)$$

So, we obtain

$$TC_{LISP-PMIP-Pull} = BUC_{LISP-PMIP-Pull} + DDC_{LISP-PMIP-Pull}$$

D. Numerical Results

Based on the cost analysis given in the previous section, we now compare the numerical results. In the analysis, we assume that both CN and MN are within the same LISP domain so as to simplify the analysis. For numerical analysis, we set the parameter values, as shown in Table 2, which are partly obtained from the results given in [16].

Figure 6 compares the total cost of candidate schemes for different transmission cost over wireless link (κ). In the figure, it is shown that the total cost linearly increases for all the schemes, as the unit transmission cost of wireless link (κ) gets larger. It is shown that the network-based schemes (LISP-PMIP, LISP-PMIP-Push, and LISP-PMIP-Pull) give better performance than the host-based LISP-HMIP scheme. This is because, in the network-based scheme, AR performs the binding update and query operation and thus the use of wireless network resources can be reduced, compared to the host-based scheme. LISP-PMIP-Push gives the similar performance with LISP-PMIP. It is noted that the pull-based distributed scheme (LISP-PMIP-Pull) gives the best performance among all the candidate schemes. This is because, in LISP-PMIP-Pull scheme, the binding update (Map Register or EID binding update) is not performed used, which is very helpful to reduce the total cost.

TABLE 2. PARAMETER VALUE USED FOR COST ANALYSIS

Parameter	Default	Minimum	Maximum
κ	2	1	10
α	3	1	46
$N_{Host/AR}$	100	100	1,000
N_{AR}	10	10	100
H_{AR-LMS}	10	1	46
H_{MN-AR}, H_{CN-AR}	1		
S_{data}	1024 (bytes)		
$S_{control}$	50 (bytes)		
τ	1		
β	2		
γ	0.3		
T_{AC}	150 ms		

Figure 7 shows the impacts of binding update cost on total cost. From the figure, we can see that the total costs are not nearly affected by the unit binding update cost (α) for LISP-

HMIP, LISP-PMIP and LISP-PMIP-Pull. However, LISP-PMIP-Push is severely affected by α . This is because AR/TR will send the EID update message to all the ARs/TRs in the domain by multicast

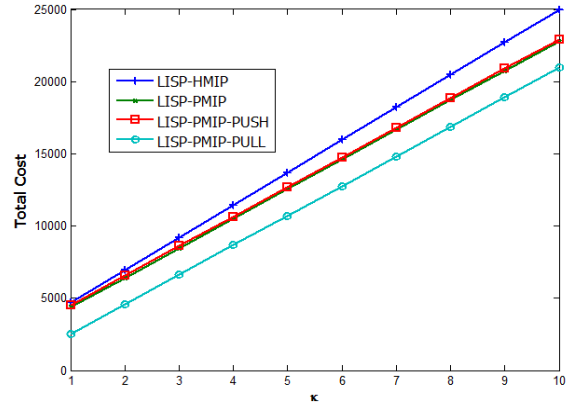


Figure 6. Impact of unit transmission cost over wireless link on total cost

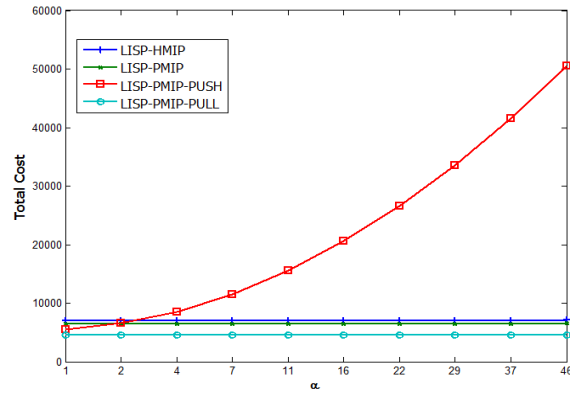


Figure 7. Impact of the binding update cost on total cost

Figure 8 shows the impact of the number of hosts per AR ($N_{Host/AR}$) on total cost. In the figure, we can see that only the LISP-PMIP-Push scheme is affected by the number of host per AR, since the EID update message is multicast to all the ARs/TRs. This implies that $N_{Host/AR}$ will not give any significant impact the on performance of LISP-HMIP, LISP-PMIP-Pull, and LISP-PMIP.

Figure 9 shows the impact of the number of AR in the domain (N_{AR}). Only the LISP-PMIP-Pull scheme slightly depends on N_{AR} , since the Map Request for binding query is multicast to all ARs. Nevertheless, LISP-PMIP-Pull gives the best performance until N_{AR} reaches about 100.

Figure 10 compares total costs of candidate schemes for different hop counts between AR and LMS (H_{AR-LMS}). In the figure, we can see that H_{AR-LMS} gives significant impacts on total cost for LISP-HMIP and LISP-PMIP. This is because LISP-HMIP and LISP-PMIP are the centralized scheme, which use LMS for the Map Register operations. It is noted that LISP-PMIP-Pull gives the best performance among all the schemes.

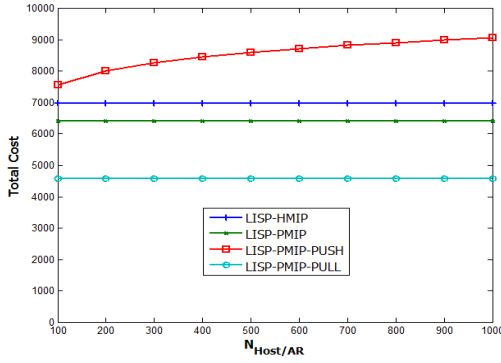


Figure 8. Impact of Number of hosts in AR on total cost

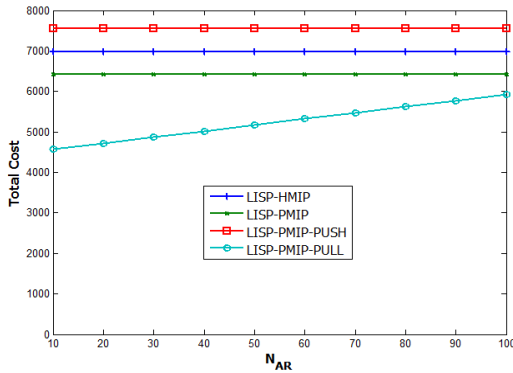


Figure 9. Impact of the number of AR's in the LISP domain on total cost

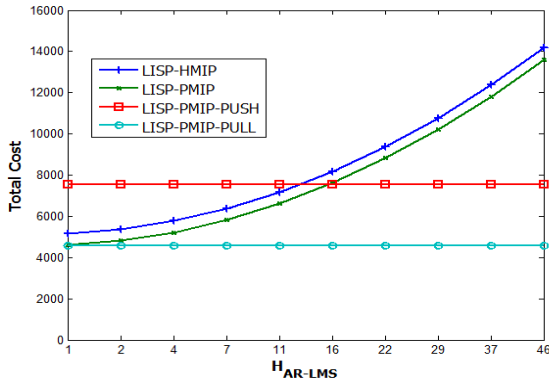


Figure 10. Impact of hop counts between AR and LMS on total cost

V. CONCLUSION

In this paper, we proposed the two network-based distributed mobility control schemes in mobile LISP network: LISP-PMIP-Push and LISP-PMIP-Pull. By numerical analysis, the two proposed schemes are compared with the existing centralized schemes, LISP-HMIP and LISP-PMIP, in terms of the binding update and data delivery costs.

From the numerical results, we can see that the network-based scheme is better than the host-based scheme, and that

the distributed mobility control is preferred to the centralized mobility control. In particular, it is noted that the proposed pull-based distributed mobility scheme, LISP-PMIP-Pull, gives the best performance among all the candidate schemes. However, the push-based distributed mobility scheme, LISP-PMIP-Push, rather gives worse performance than the existing centralized schemes, LISP-HMIP and LISP-PMIP, in a certain network condition. This is because LISP-PMIP-Push depends on multicast transmission of EID update messages to all the ARs in the domain, whenever a new MN is connected to the AR, which tends to induce performance degradation in the binding update cost.

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