

# Distributed Mobility Control Schemes in the HIP-based Mobile Networks

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**Abstract**— The Host Identity Protocol (HIP) has been proposed as an identifier-locator (ID-LOC) separation scheme, in which the 128-bit Host Identity Tag (HIT) is used as an ID and the IP address of the host is used as a LOC. In HIP, the mobility control operations are performed based on a centralized Rendezvous Server (RVS) that acts as a mobility anchor for mobile nodes, in which all the HIP control messages are passed through the RVS server. However, this centralized mobility scheme has some limitation, such as the service degradation by a point of failure and the overhead of centralized anchor. In this paper, we propose the two schemes for distributed mobility management (DMM): HIP-DMM-Push and HIP-DMM-Pull. From the numerical analysis, it is shown that the proposed DMM schemes can provide better performance than the existing centralized scheme, and that the pull-based distributed control scheme (HIP-DMM-Pull) provides the best performance among the candidate mobility schemes in terms of the processing overhead at the central RVS server and the HIP connection setup delays.

**Keyword**—HIP, Rendezvous Server, Distributed management

## I. INTRODUCTION

WITH emergence of new types of wireless/mobile networks and wide popularity of smart phones, the number of mobile Internet users has been rapidly increasing. This mobile trend has caused a rapid growth of BGP routing table, as known as the routing scalability problem. [1].

To solve this problem the Host Identity Protocol (HIP) has been proposed in IETF [2], which splits the current IP address space into Host Identity (HI) and routing locator (IP address). An HI is encoded to Host Identity Tag (HIT) and both HI and HIT are not changed. If an end host wants to communicate to another, it finds out other host's IPv4 address using the HIT of the other host. In HIP, the centralized Rendezvous Server (RVS) has the responsibility of this search process [3]. In the centralized scheme, all binding and first Initiate message (I1)

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are processed by a central RVS. However, the centralized scheme is vulnerable to several problems [4]. First, a single point of failure of central RVS may affect severe degradation of overall system performance and also the increased cost of network engineering. In addition, the centralized RVS has the risk of overhead by increasing of host that is stored in the RVS's HIT-IPv4 mapping table.

In this paper, we proposed the two distributed mobility management schemes in HIP-based mobile networks. The proposed schemes can be used to effectively provide the mobility support in HIP-based wireless/mobile HIP networks, compared to the existing centralized control schemes. This paper is organized as follows. Section II describes the existing centralized schemes for HIP mobility control. In Section III, we propose the two distributed mobility control schemes. Section IV compares the existing and proposed schemes in terms of the HIP connection setup delays, and the processing overhead at the central RVS server. Section V concludes this paper.

## II. EXISTING HIP SCHEME

In the existing scheme for HIP mobility control, all HIT-IPv4 mapping entries are stored at centralized RVS. Figure 1 shows the operation of existing HIP data transmission.

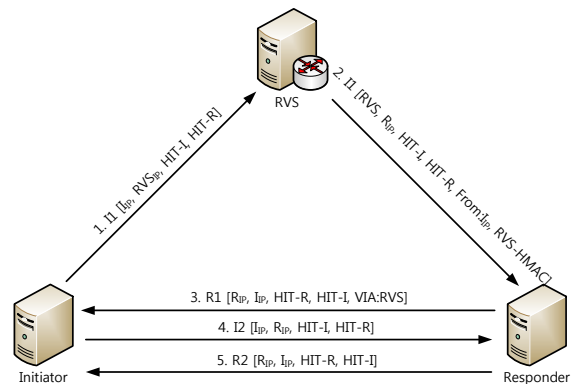


Fig. 1. Existing HIP data transmission

If Initiator wants to communicate with Responder, it sends the I1 message that contains the IP address of Initiator, IP address of RVS, HIT of Initiator, and HIT of Responder to centralized RVS, as described in Step 1. Next, RVS will search

the HIT-IPv4 mapping table. Then, RVS will forward I1 message that adds the RVS-HMAC for authentication to Responder (Step 2). On reception of I1 message, Responder responds with a R1 message that contains the IP address of Responder, IP address of Initiator, HIT of Initiator, and VIA:RVS for authentication (Step 3). After that, Initiator and Responder exchange the I2 message and R2 message (Step 4, 5). Now, communication between Initiator and Responder is possible, because Initiator knows the IP address of Responder.

In this paper, we will focus on only the inter-domain mobility control within a HIP-based mobile network, rather than the intra-domain mobility control.

Figure 2 describe the existing HIP data transmission schemes in the inter-domain case. First, Responder sends the Binding Update message to RVS for adding the HIT-IPv4 entry of Responder. Then, RVS responds with Binding ACK message to Responder. In this stage, if Initiator wants to communicate with Responder, it sends the I1 message to centralized RVS through Access Router (AR) and Gateway (GW) of Initiator. Then, centralized RVS will search the HIT-IPv4 table and forward to IP address of Responder through GW and AR of Responder. On reception of I1 message, Responder responds with R2 message to Initiator directly. After that, Initiator and Responder exchange the I2 message and R2 message through each AR and GW of Initiator and Responder.

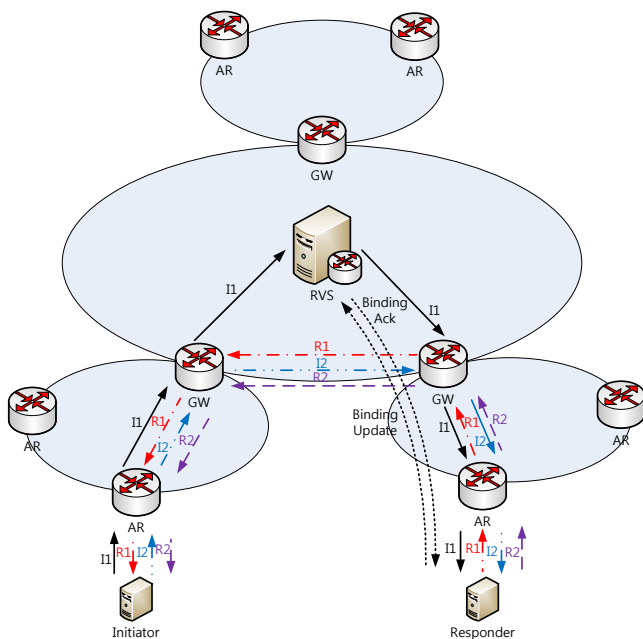


Fig. 2. Existing HIP schemes

### III. PROPOSED DMM SCHEMES

#### A. Overview

In the proposed schemes, each GW has the Distributed Rendezvous Server (D-RVS) functionality, and stores the information on HIT and IPv4 for hosts.

Each of the proposed schemes updates the HIT-IPv4 table in the different way. In HIP-DMM-Push, if initiator is attached to a domain, the GW of Initiator sends the Binding Update message

that contains the HIT and IP address of Initiator to the other D-RVS by multicast. On reception of this Binding Update message, each D-RVS updates their HIT-IPv4 table and then responds with Binding ACK message. This is called the ‘push’ operation, which is similar to the legacy routing protocol (e. g., OSPF) mechanism.

In HIP-DMM-Pull, on the other hand, each Binding Update message of Responder is completed by the D-RVS of Initiator, and only the D-RVS of Responder updates the binding entry. After that, if Initiator wants to communicate with Responder, the GW of Initiator sends the I1 message that is the first message of mapping query to the other GW through multicast for HIT-IPv4 mapping entry. Then, only the GW of Responder responds with R1 message that contains the IP address of Responder. From this R1 message, the D-RVS of Initiator can update the Responder’s information in the HIT-IPv4 table.

The existing HIP scheme is a centralized scheme, in which all Binding Update and Mapping Query messages are processed by centralized RVS.

The proposed HIP-DMM-Push scheme is a distributed scheme, in which each GW performs the RVS functionality. In this scheme, the Binding Update with RVS is not performed. Instead, each D-RVS will send its Binding Update message to other D-RVS by multicast, when a new Responder is attached to the network. From this process, this scheme does not need to query for HIT-IPv4 mapping to other D-RVS, because the D-RVS already knows the associated information.

The proposed HIP-DMM-Pull scheme is also a distributed scheme with GW acting as RVS. The Binding Update is processed at D-RVS of the host. Then, each D-RVS sends an I1 message to other D-RVS to find the IP address of host.

#### B. HIP-Push

Figure 3 show the HIP-DMM-Push operations.

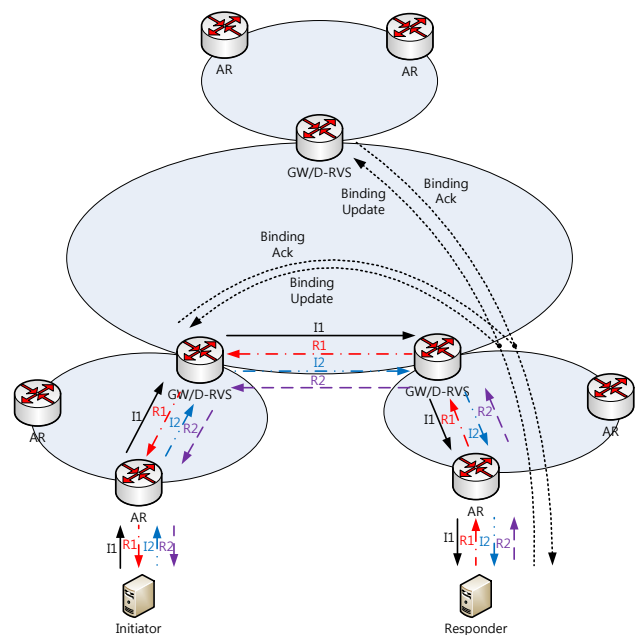


Fig. 3. HIP-DMM-Push operations

In the figure, when Responder is attached to a new domain, its HIT will be bound to its AR and GW/D-RVS. Then, GW of Responder will send (or push) the Binding Update message that contain the HIT and IP address of Responder to other GW/D-RVS by multicast. Every GW/D-RVS will update its HIT-IPv4 address, based on the Binding Update received from the GW/D-RVS of Responder. When Initiator wants to communicate with Responder, Initiator sends the I1 message to GW/D-RVS of Initiator. Then GW/D-RVS looks up the HIT-IPv4 table to find the IP address of Responder. If the IP address is found, GW/D-RVS forwards the I1 message to GW/D-RVS of Responder. Then, I1 message is forwarded to Responder. On reception of I1 message, Responder sends the R1 message to Initiator through GW/D-RVS of Responder and GW/D-RVS of Initiator. Next, Initiator sends the I2 message to Responder and receives the R2 message from Responder in the same way. Now, Initiator can send the data message to Responder directly.

C. HIP-Pull

Figure 4 shows the HIP-DMM-Pull operations.

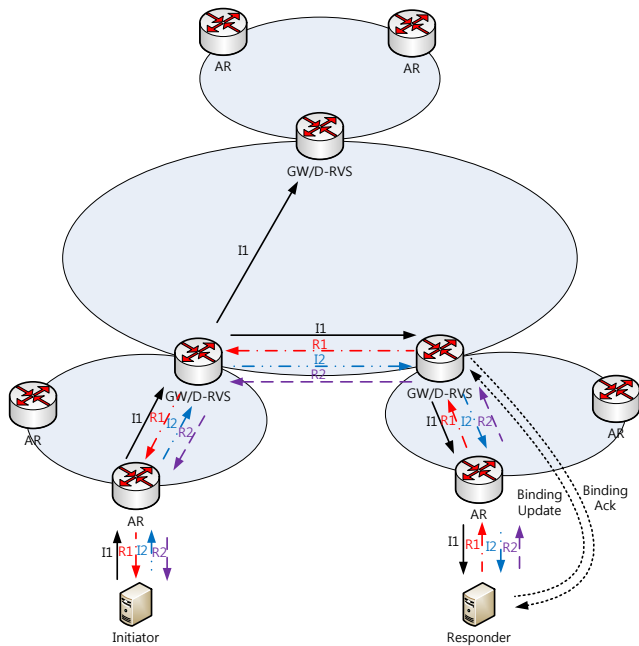


Fig. 4. HIP-DMM-Pull operations

In the figure, when Responder enters a domain, it is connected to AR and the Binding Update is processed at the GW/D-RVS of Responder. Now, the Initiator sends the I1 message to the GW/D-RVS of Initiator. Then, GW/D-RVS forwards the I1 message to other GW/D-RVS to find the IP address of Responder. Then, only the GW/D-RVS of Responder will forward the I1 message to Responder, the other GW/D-RVS will discard this message. On reception of I1 message, Responder sends the R1 message to Initiator through GW/D-RVS of Responder and GW/D-RVS of Initiator. Next, Initiator sends the I2 message to Responder and receives the R2 message from Responder in the same way. Now, Initiator can send the data message to Responder directly.

IV. PERFORMANCE ANALYSIS

To evaluate the performance of the proposed mobility schemes, we analyze the delay of the total transmission of first data and the overhead of GW/D-RVS. We compare the total transmission delay cost and the number of HIT-IPv4 table entry of GW/D-RVS for the existing scheme (HIP) and the proposed schemes (HIP-DMM-Push, HIP-DMM-Pull).

A. Analysis Model

Initiator and Responder are located within the different domain (i.e., Initiator is a mobile host and Responder is a static host), as illustrated below in the Figure 5.

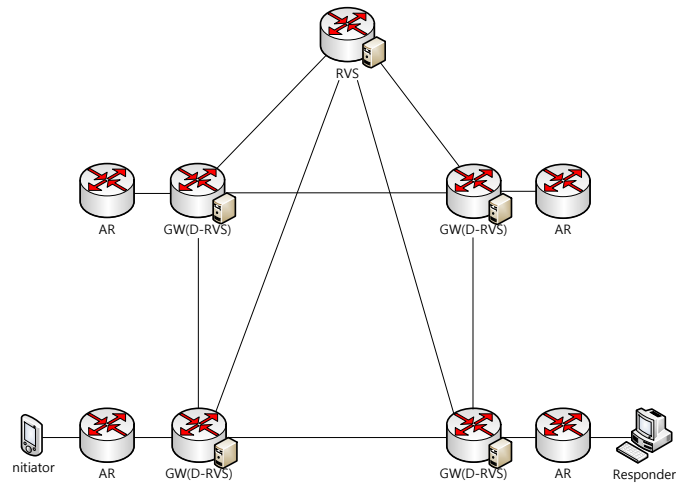


Fig. 5. Network model for numerical analysis

The binding update delay and the data delivery delay are denoted by BUD and DDD, respectively. Then the total delay (TD) is represented as  $TD=BUD+DDD$ . Then, for the processed signal at each D-RVS, we calculate the Signal Overhead (SO) that is sum of processed signal when Binding Overhead (BO) and Query Overhead (QO) process is performed.

B. Delay and Overhead Analysis

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

TABLE I  
PARAMETERS USED FOR DELAY AND OVERHEAD ANALYSIS

Parameter	Description
$T_{setup}$	Node setup and HIT encoding delay
$S_b$	Size of a 'b' packet
$N_{GW}$	Number of GW in the Network
$H_{a-b}$	Hop count between node a and b in the network
$\gamma (H_{GW-GW}/H_{GW-RVS})$	Ratio of $H_{GW-GW}$ over $H_{GW-RVS}$
$P_c$	Processing cost of node c for binding update or lookup

## 1) HIP

If the Responder enters a network, the HIT encoding process begins. We assume that this operation takes roughly  $T_{\text{setup}}$ . Then, Responder sends the Binding Update message to centralized RVS through GW and AR of Responder and receives the Binding Ack message. This operation takes  $2S_{\text{control}} \times \{H_{\text{AR-GW}} + H_{\text{GW-RVS}} + (H_{\text{host-AR}}/2)\}$ . On reception of Binding Update message, the centralized RVS updates their HIT-IPv4 table. This operation takes  $P_{\text{RVS}}$ . We assumed that the processing cost of RVS is proportional to the total number of active hosts in the domain ( $N_{\text{AR}} \times N_{\text{Host/AR}}$ ) in the log scale by using a tree-based data structure to implement the database. Accordingly, the binding update delay of HIP can be represented as follows.

$$\text{BUD}_{\text{HIP}} = T_{\text{setup}} + 2S_{\text{control}} \times \{H_{\text{AR-GW}} + H_{\text{GW-RVS}} + (H_{\text{host-AR}}/2)\} + \log_2(N_{\text{host}}N_{\text{RVS}}) \quad (1)$$

In HIP, the data delivery delay for Initiator to Responder can be calculated as follows. First, Initiator sends the I1 message to centralized RVS through AR and GW of Initiator. Then, centralized RVS will look for the IP address of HIT of Responder in the HIT-IPv4 table, which takes  $\log_2(N_{\text{host}}N_{\text{RVS}})$ . After that, RVS will forward the I1 message to Responder through AR and GW of Responder. This operation takes  $2S_{\text{I1}} \times (H_{\text{host-AR}} + H_{\text{AR-GW}} + H_{\text{GW-RVS}})$ . After that, Initiator and Responder exchange R1, I2, and R2 message through AR and GW of Initiator and Responder. Then, the first data packet will be forwarded from Initiator to Responder in the same way. This operation takes  $(S_{\text{R1}} + S_{\text{I2}} + S_{\text{R2}} + S_{\text{data}}) \times (H_{\text{host-AR}} + H_{\text{AR-GW}} + H_{\text{GW-GW}} + H_{\text{GW-AR}} + H_{\text{AR-host}})$ . Thus, the data delivery delay of HIP can be represented as follows.

$$\text{DDD}_{\text{HIP}} = 2S_{\text{I1}}(H_{\text{host-AR}} + H_{\text{AR-GW}} + H_{\text{GW-RVS}}) + (S_{\text{R1}} + S_{\text{I2}} + S_{\text{R2}} + S_{\text{data}}) \times (2H_{\text{host-AR}} + 2H_{\text{AR-GW}} + H_{\text{GW-GW}}) + \log_2(N_{\text{host}}N_{\text{RVS}}) \quad (2)$$

So, we obtain the total delay of HIP as

$$\text{TD}_{\text{HIP}} = \text{BUD}_{\text{HIP}} + \text{DDD}_{\text{HIP}}$$

Now, to analyze the overhead of RVS, we will calculate the number of signals processed by RVS. For simplicity, we assume that the hosts are equally distributed in each domain. When hosts enter the network, they send a Binding Update message to the centralized RVS to update the HIT-IP address mapping entry. From this operation, the number of processed signal of RVS is  $N_{\text{Host}}$ . Then, if  $N_{\text{Host}}$  want to communicate with other hosts, they sends an I1 message to the other host through RVS. From this operation, the RVS shall process  $N_{\text{Host}}$ . From BO and QO, we can calculate the SO of HIP.

$$\text{SO}_{\text{HIP}} = \text{BO}_{\text{HIP}} + \text{QO}_{\text{HIP}} = 2N_{\text{Host}}$$

## 2) HIP-DMM-Push

If the Responder enters a network, HIT encoding process begins. We assume that this operation takes roughly  $T_{\text{setup}}$ . Then, Responder sends the Binding Update message to D-RVS of Responder and D-RVS will forward the Binding Update message to other D-RVS by multicast. This operation takes  $2S_{\text{control}} \times \{H_{\text{AR-GW}} + H_{\text{GW-GW}} + (H_{\text{host-AR}}/2)\}$ . On reception of Binding Update message, each D-RVS updates their HIT-IPv4 table. This operation takes  $\log_2(N_{\text{host}})$ , since each D-RVS has all host's mapping information from forwarded Binding Updated message. Accordingly, the binding update delay of HIP-DMM-Push can be represented as follows.

$$\text{BUD}_{\text{HIP-DMM-Push}} = T_{\text{setup}} + 2S_{\text{control}} \times \{H_{\text{AR-GW}} + (H_{\text{host-AR}}/2) + H_{\text{GW-GW}}\} + \log_2(N_{\text{host}}) \quad (3)$$

In the HIP-DMM-Push, the data delivery delay for Initiator to Responder can be calculated as follows. First, Initiator sends the I1 message to D-RVS of Initiator through AR and GW of Initiator. Then, D-RVS will look for the IP address of HIT of Responder in their HIT-IPv4 table, which takes  $\log_2(N_{\text{host}})$ . After that, D-RVS of Initiator will forward the I1 message to Responder through GW/D-RVS and AR of Responder. On reception of I1 message, Responder sends the R1 message to Initiator directly. Then Initiator and Responder exchange the I2 and R2 message in the same way. This operation takes  $(S_{\text{I1}} + S_{\text{R1}} + S_{\text{I2}} + S_{\text{R2}} + S_{\text{data}}) \times (2H_{\text{host-AR}} + 2H_{\text{AR-GW}} + H_{\text{GW-GW}})$ . Thus, the data delivery delay of HIP-DMM-Push can be represented as follows.

$$\text{DDD}_{\text{HIP-DMM-Push}} = (S_{\text{I1}} + S_{\text{R1}} + S_{\text{I2}} + S_{\text{R2}} + S_{\text{data}}) \times (2H_{\text{host-AR}} + 2H_{\text{AR-GW}} + H_{\text{GW-GW}}) + \log_2(N_{\text{host}}) \quad (4)$$

So we obtain the total delay of HIP-DMM-Push as

$$\text{TD}_{\text{HIP-DMM-Push}} = \text{BUD}_{\text{HIP-DMM-Push}} + \text{DDD}_{\text{HIP-DMM-Push}}$$

Now, we will calculate the number of signals processed by one D-RVS. When hosts enter the network, they send a Binding Update message to D-RVS that located at same domain to update the HIT-IP address mapping entry. In this case, the number of processed signal of one D-RVS is  $N_{\text{Host}}/N_{\text{GW}}$ . Then, each D-RVS forward the I1 message of host to other D-RVS by multicast. In this case, the number of processed signal of one D-RVS is  $N_{\text{Host}} - N_{\text{Host}}/N_{\text{GW}}$ . From these operations, BO of HIP-DMM-Push is  $N_{\text{Host}}$ . After that, if  $N_{\text{Host}}$  want to communicate with other hosts, they sends a I1 message to D-RVS of same domain. Since each D-RVS knows the location of other host, the I1 message is passed directly. From this operation, QO of HIP-DMM-Push is  $N_{\text{Host}}/N_{\text{GW}}$ . From BO and QO, we can calculate the SO of HIP-DMM-Push.

$$\text{SO}_{\text{HIP-DMM-Push}} = \text{BO}_{\text{HIP-DMM-Push}} + \text{QO}_{\text{HIP-DMM-Push}} = N_{\text{Host}} + (N_{\text{Host}}/N_{\text{D-RVS}})$$

### 3) HIP-DMM-Pull

The Binding Update operations are performed as follows. When responder enters a network, HIT encoding process starts. We assume that this operation takes roughly  $T_{\text{setup}}$ . Then Responder sends the Binding Update message to D-RVS of Responder. This operation takes  $2S_{\text{control}} \times \{H_{\text{AR-GW}} + (H_{\text{host-AR}}/2)\}$ . At that time, the D-RVS of Responder updates their HIT-IPv4 mapping table. This operation takes  $\log_2(N_{\text{host}}/N_{\text{D-RVS}})$ , since each D-RVS stored only HIT-IPv4 mapping information of host that belongs to D-RVS's domain. Accordingly, the binding update delay of HIP-DMM-Pull can be represented as follows.

$$\text{BUD}_{\text{HIP-DMM-Pull}} = T_{\text{setup}} + 2S_{\text{control}} \times \{H_{\text{AR-GW}} + (H_{\text{host-AR}}/2)\} + \log_2(N_{\text{host}}/N_{\text{D-RVS}}) \quad (5)$$

In the HIP-DMM-Pull, the data delivery delay for Initiator to Responder can be calculated as follows. First, Initiator sends the I1 message to D-RVS of Initiator through AR and GW of Initiator. Then, D-RVS of Initiator forward the I1 message to other D-RVS by multicast. This operation takes  $S_{I1}(H_{\text{host-AR}} + H_{\text{AR-GW}})$ . After that, each D-RVS look for the IP address of HIT of Responder in their HIT-IPv4 table, which takes  $\log_2(N_{\text{host}}/N_{\text{D-RVS}})$ . If D-RVS find out that entry, then it will forward the I1 message to Responder through AR of Responder, and other D-RVSs discard the I1 message. This operation takes  $S_{I1}(H_{\text{host-AR}} + H_{\text{AR-GW}} + H_{\text{GW-GW}})$ . On reception of I1 message, Responder sends the R1 message to Initiator directly. Then, Initiator and Responder exchange the I2, R1, and I2 message, and next, Initiator sends the data packet to Responder directly. This operation takes  $(S_{R1} + S_{I2} + S_{R2} + S_{\text{data}}) \times (2H_{\text{host-AR}} + 2H_{\text{AR-GW}} + H_{\text{GW-GW}})$ . Thus, the data delivery delay of HIP-DMM-Pull can be reprinted as follows.

$$\text{DDD}_{\text{HIP-DMM-Pull}} = S_{I1}(2H_{\text{host-AR}} + 2H_{\text{AR-GW}} + H_{\text{GW-GW}}) + (S_{R1} + S_{I2} + S_{R2} + S_{\text{data}}) \times (2H_{\text{host-AR}} + 2H_{\text{AR-GW}} + H_{\text{GW-GW}}) + \log_2(N_{\text{host}}/N_{\text{D-RVS}}) \quad (6)$$

So, we obtain

$$\text{TD}_{\text{HIP-DMM-Pull}} = \text{BUD}_{\text{HIP-DMM-Pull}} + \text{DDD}_{\text{HIP-DMM-Pull}}$$

Now, we will calculate the number of signal processed by one D-RVS. When hosts enter the network, they send a Binding Update message to D-RVS that located at same domain to update the HIT-IP address mapping entry. From this operation, the BO is  $N_{\text{Host}}/N_{\text{D-RVS}}$ . Then, if  $N_{\text{Host}}$  want to communicate with other hosts, they sends a I1 message to D-RVS of same domain. In this case, processed signal of each D-RVS is  $N_{\text{Host}}/N_{\text{D-RVS}}$ . After each D-RVS receive the I1 message, they forward this message to other D-RVS by multicast. This process is takes  $N_{\text{Host}} - N_{\text{Host}}/N_{\text{D-RVS}}$ . From this operation, the QO is  $N_{\text{Host}}$ . So we can calculate the SO of HIP-DMM-Pull.

$$\text{SO}_{\text{HIP-DMM-Pull}} = \text{BO}_{\text{HIP-DMM-Pull}} + \text{QO}_{\text{HIP-DMM-Pull}} = (N_{\text{Host}}/N_{\text{D-RVS}}) + N_{\text{Host}}$$

### C. Numerical Results

Based on the cost analysis given in the previous section, we now compare the numerical results. For numerical analysis, we set the parameter values, as shown in Table 2, which are partly obtained from the results given in [5].

TABLE II  
PARAMETER VALUES USED FOR DELAY AND OVERHEAD ANALYSIS

Parameter	Default	Minimum	Maximum
$T_{\text{setup}}$		100	
$S_{I1}, S_{R1}, S_{I2}, S_{R2}$		1	
$S_{\text{control}}, S_{\text{data}}$		1	
$N_{\text{D-RVS}}$	4	1	256
$N_{\text{host}}$	400	100	8000
$H_{\text{host-AR}}$		1	
$H_{\text{AR-GW}}$		1	
$H_{\text{GW-GW}}$		3	
$H_{\text{GW-RVS}}$		10	
$\gamma$	0.3	0.1	1.5

Figure 6 shows the impact of hop count ratio GW-GW over GW-RVS on total transmission delay. From the figure, we can see that the distributed mobility control schemes have lower total transmission delay until the ratio is equal to 0.8 and the HIP-DMM-Pull scheme shows the lower delay than HIP-DMM-Push. When the ratio is higher than 1.2, delay of distributed mobility control schemes are higher than existing HIP scheme. However, it is not a critical weakness. In general network, average distance between centralized server and gateway is farther than the distance between two gateways. So we are focus on the value that is lower than 1. In this general situation, we are sure that two distributed mobility control schemes can show the better performance than existing HIP scheme.

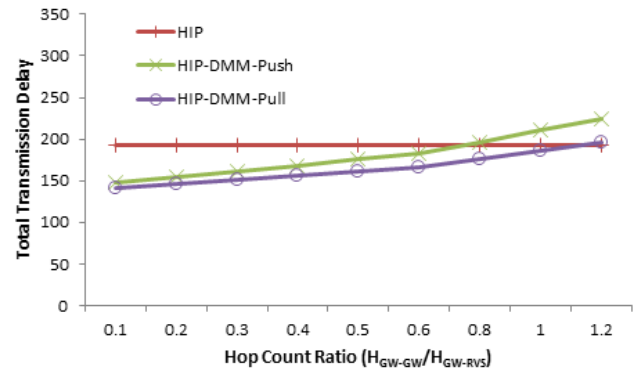


Fig. 6. Impact of hop count ratio on total delay

Figure 7 and 8 show the impact of number of host and D-RVS on total transmission delay. From this figure, we can see that the two distributed mobility schemes show lower total transmission delay than existing HIP scheme. In HIP-DMM-Push, although each D-RVS has the same entry with RVS of existing HIP, there



is no query operation to get the Responder's IP address. So, this scheme can perform with low delay. In HIP-DMM-Pull, the I1 message's route is shorter than that of existing HIP. In addition, this scheme's HIT-IPv4 table has less entry than existing HIP scheme and HIP-DMM-Push. From these reasons, we can see that the two distributed mobility control schemes shows better performance than existing scheme and the HIP-DMM-Pull has the best performance.

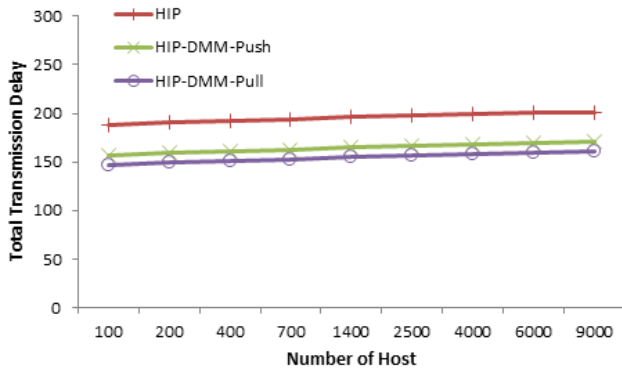


Fig. 7. Impact of number of host on total delay

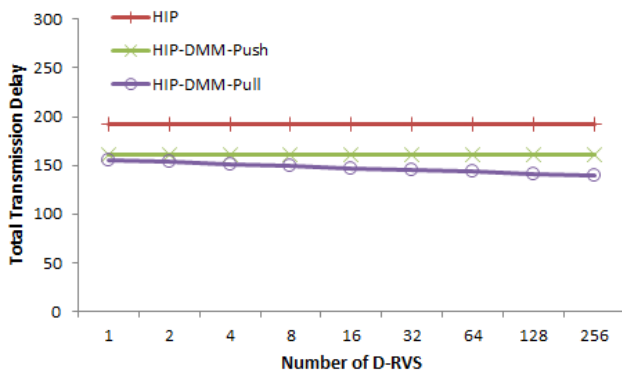


Fig. 8. Impact of number of D-RVS on total delay

Figure 9 and 10 show the impact of number of host and D-RVS. In HIP-DMM-Push, HIT-IPv4 table update of D-RVS is completed at binding update operation. So, the entry number of two schemes (HIP and HIP-DMM-Push) are the same. From this reason, the existing scheme and HIP-DMM-Push show the same performance. However, in HIP-DMM-Pull, each D-RVS has the MIP-IPv4 mapping entry of hos that is located in domain of GW. Accordingly, HIP-DMM-Pull has the best performance.

Figure 11 and 12 show the impact of number of host and D-RVS on processed signal in each D-RVS. From this figure, we can see that the proposed schemes shows better performance. In HIP, all Binding Update message and I1 message is processed at centralized RVS. However, in HIP-DMM-Push, only all Binding Update message is processed at D-RVS and each I1 message is processed at each D-RVS that located in same domain. In HIP-DMM-Pull, only all I1 message is processed at D-RVS and each Binding Update message is processed at each D-RVS that located in same domain. So, the two proposed schemes shows lower number of processed signal than existing HIP scheme.

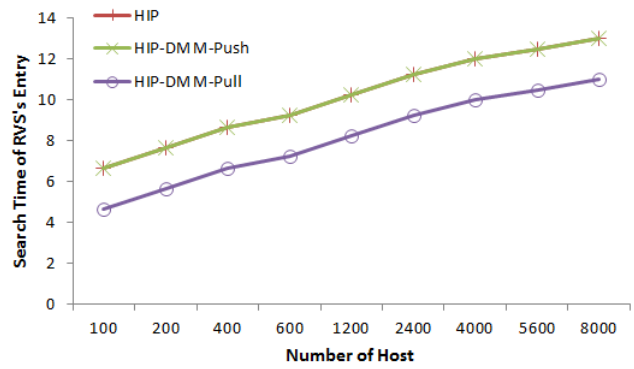


Fig. 9. Impact of number of host on search time of RVS

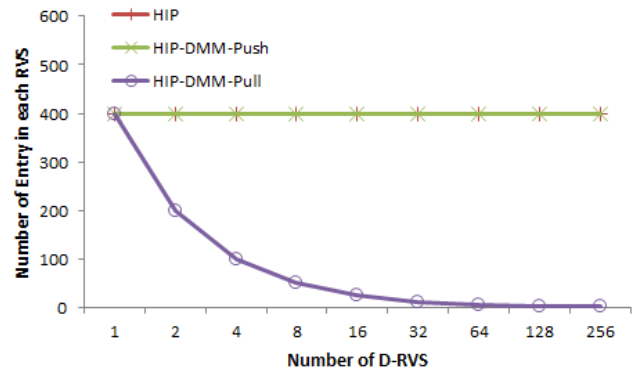


Fig. 10. Impact of number of D-RVS on performance

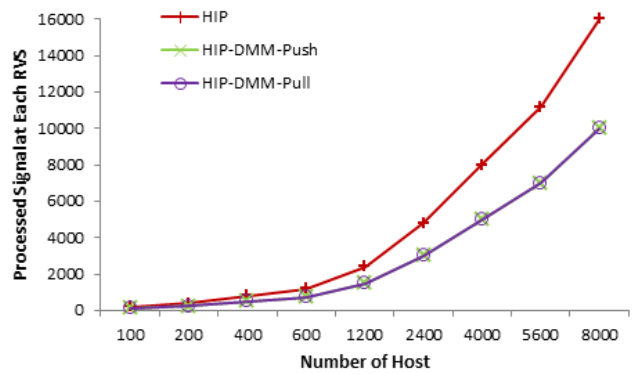


Fig. 11. Comparison of processed signal at each D-RVS

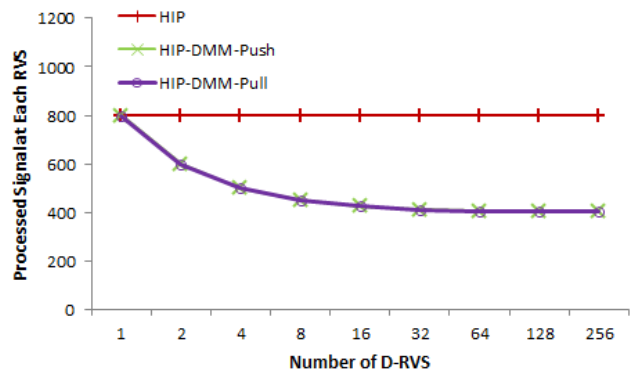


Fig. 12. Impact on the processed signal at each D-RVS

Figure 13 shows the impact of number of D-RVS in terms of generated signals in the network. In HIP, each host sends a Binding Update message and the I1 message to the centralized RVS. So, there is no affected by D-RVS. However, in HIP-DMM-Push, if host enters the network, it sends a Binding Update message to D-RVS that located in the same domain. On reception of Binding Update message, D-RVS forwards the message to other D-RVS and receives Binding ACK message from each D-RVS. From this operation, in Binding Update operation, the signals are generated by twice number of D-RVS. In HIP-DMM-Pull, if host want to communicate with Responder, it sends the I1 message to D-RVS that located in the same domain. Then, D-RVS forwards this message to other D-RVS. On reception of I1 message, D-RVS that is located in same domain with Responder responds with R1 message. From this operation, in Binding Query operation, the signals are generated by the number of D-RVS. Because of this, existing HIP scheme shows best performance.

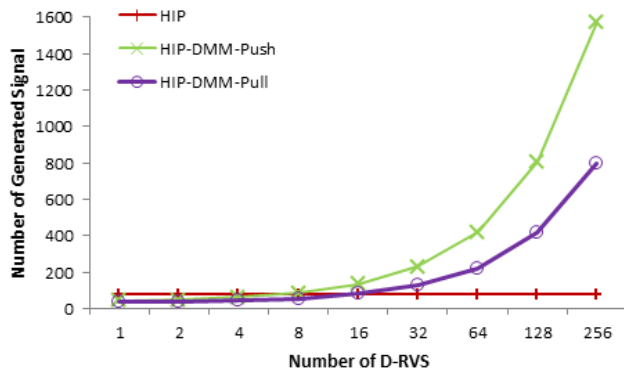


Fig. 13. Impact on the number of generated signal

V. CONCLUSIONS

In this paper, we propose the two schemes for distributed mobility management (DMM): HIP-DMM-Push and HIP-DMM-Pull. By numerical analysis, we compare the existing centralized RVS scheme and the two proposed distributed schemes, in terms of processing overhead at the central RVS server, and the HIP connection setup delays.

From the numerical results, on total transmission delay and processed signal at each RVS, we can see that the distributed mobility control scheme is better than the existing centralized RVS scheme. In particular, HIP-DMM-Pull scheme gives the best performance among all schemes. This is because HIP-DMM-Pull scheme's D-RVS has less HIT-IPv4 mapping entry than HIP-DMM-Push and Existing-HIP scheme.

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