Distributed Mobility Control for Mobile-Oriented Future Internet Environments

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Abstract — Ever-increasing demand of mobile Internet traffics makes mobile networks change from hierarchical architecture to flat architecture. Most of the current mobility protocols are based on a centralized mobility anchor, by which all the control and data traffics are processed. In the flat network architecture, however, the centralized mobility scheme has some limitations, which include unwanted traffic flowing into core network, service degradation by a point of failure, and increased operational costs, etc. In this paper, we propose the three distributed mobility control schemes for flat architecture of future mobile networks: Partially Distributed Mobility Control (PDMC), Data-driven Distributed Mobility Control (DDMC), and Signal-driven Distributed Mobility Control (SDMC). By numerical analysis, we compare the proposed distributed mobility schemes with the existing centralized mobility scheme using Proxy Mobile IPv6 (PMIP) in terms of binding update and packet delivery costs. From the results, it is shown that the three proposed distributed schemes give better performance than the existing centralized PMIP scheme, and the SDMC scheme provides the best performance among the three proposed distributed schemes.

Keywords—Future Internet; distributed mobility control; flat architecture; analysis

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 [1]. Such mobile-oriented trend inevitably tends to introduce a large amount of traffics into mobile Internet infrastructure.

The cellular system is a typical infrastructure for mobile Internet, as shown in the LTE/SAE of 3GPP. The cellular network was originally designed as hierarchical architecture to support circuit-based voice traffics. However, an ever-increasing demand of mobile Internet traffics has enforced non-hierarchical or flat structure on mobile networks, so as to provide data services more cost-effectively. Now, the flat architecture is regarded as a promising technology for future mobile networks [2–4].

Most of existing protocols for Internet mobility are based on the centralized approach, in which all the control and data traffics will be processed by a centralized mobility anchor, such as Home Agent (HA) of Mobile IP (MIP) [5] or Local Mobility Anchor (LMA) of Proxy Mobile IPv6 (PMIP) [6]. The centralized mobility anchor allows a mobile host to be reachable, when it is not connected to its home domain, by ensuring the forwarding of packets destined to or sent from the mobile host. In the flat architecture, however, such a centralized mobility scheme is vulnerable to some problems. First, the centralized anchor may induce unwanted traffic into the core network, which tends to give a big burden to mobile network operators in terms of operational costs. In addition, a single point of failure of the central anchor may affect overall data transmission and degradation of performance, which will increase the cost of network dimensioning and engineering.

To overcome the limitations of centralized management, the IETF has recently discussed the distributed mobility management [7, 8]. The distributed mobility management can be divided into the partially distributed approach, in which only the data plane is distributed, and the fully distributed approach where both data plane and control plane are distributed. In the centralized management, the routing path through a centralized anchor tends to be longer, which results in non-optimal routes and performance degradation, whereas the route optimization will be intrinsically supported in the distributed management. Moreover, the distributed mobility management can reduce unnecessary traffics, if the two end hosts communicate directly each other, not relying on a centralized anchor. This will also be helpful to reduce the handover delay. Moreover, the centralized approach is vulnerable to a single point of failure, whereas the distributed approach will mitigate such problem to a local network.

In this paper, we discuss the distributed mobility control in the flat architecture of future network, which is a part of research on Mobile Oriented Future Internet (MOFI) supported by Korean government [9]. Specifically, we propose the three distributed mobility control schemes for flat architecture of future mobile networks: Partially Distributed Mobility Control (PDMC), Data-driven Distributed Mobility Control (DDMC), and Signal-driven Distributed Mobility Control (SDMC). The PDMC scheme can be regarded as a partially distributed approach, whereas the DDMC and SDMC schemes correspond to the fully distributed schemes.

The remainder of this paper is organized as follows. Section 2 discusses the related works on distributed mobility control. In Section 3, we propose the three schemes for distributed mobility control. Section 4 compares the existing centralized PMIP scheme and the proposed distributed mobility schemes,
in terms of the binding update and packet delivery costs. Section 5 concludes this paper with future works.

II. APPROACHES FOR DISTRIBUTED MOBILITY CONTROL

In centralized mobility control, the information of binding between Home address (HoA) and Care of Address (CoA) is kept at a central mobility anchor (e.g., HA or LMA), and the data packets destined to mobile nodes are routed via this anchor. In other words, such the mobility control systems are centralized in both data plane and control plane. Most of current mobile networks, such as UMTS, CDMA networks, are based on such the centralized approach. However, such the centralized approach has several limitations, which include degradation of mobility performance, worse scalability, costly maintenance and operations of the network, and vulnerability of a single point of failure or attack. Moreover, network operators tend to have a big concern due to a large amount of unwanted traffic flowing into their core network [7, 8].

To address these problems of centralized management, the IETF recently began to discuss the distributed mobility control approaches. In the distributed mobility control, the mobility control functions are distributed to multiple locations in the network, so that a mobile node may be served by a nearby mobility agent. The distributed mobility control can be divided into the partially distributed approach, in which only data plane is distributed, and the fully distributed one where both data plane and control plane are distributed.

In the partially distributed approach, the control plane is separated from the data plane, and only data plane will be distributed for route optimization. First, a mobile node (MN) is connected to a mobility agent (MA). Then, the MA binds the location of MN with the control function. In a centralized approach, in which location query and query acknowledgement messages can be exchanged. Based on the obtained location information, the MA of CN can deliver the data packets directly to the MA of MN. Now, the data packet is forwarded to MN.

In the fully distributed architecture, both control plane and data plane are distributed, which can further be classified into the data-driven multicast/broadcast scheme and the peer-to-peer search scheme.

In the data-driven multicast/broadcast scheme, when a MN is attached to MA, no binding operation is performed. For data packets transmitted by CN, the MA of CN will deliver them all of the MAS by using multicast or broadcast in the domain. Then, the MA of MN will forward them to MN. This scheme does not use any binding process and searching (or query) procedure to find the MN. However, unnecessary data packets may be excessively generated in the domain, since the data packets will be delivered to all of MAS.

In the peer-to-peer search scheme, just before transmission of data packets, a searching process will be activated among MAS in the domain to find the location of MN. After network attachment, CN transmits a data packet to its MA. The MA of CN will find the location of MN by using an appropriate searching mechanism, such as the distributed hash table (DHT). Then, the MA of MN will respond to the MN of CN. Now, the MA of CN delivers the data packet to the MA of MN. The data packet will be forwarded to MN.

III. PROPOSED MOBILITY CONTROL SCHEMES

A. Overview

Based on the existing works, we now propose the three specific schemes for distributed mobility control schemes: Partially Distributed Mobility Control (PDMC), Data-driven Distributed Mobility Control (DDMC), and Signal-driven Distributed Mobility Control (SDMC). Table 1 summarizes the main features of the proposed distributed mobility control schemes and the existing centralized scheme such as PMIP.

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Mobility Architecture</th>
<th>Binding Update</th>
<th>Data delivery</th>
<th>Binding Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMIP</td>
<td>Centralized</td>
<td>Used</td>
<td>Data driven</td>
<td>Not used</td>
</tr>
<tr>
<td>PDMC</td>
<td>Partially Distributed</td>
<td>Used</td>
<td>Signal driven</td>
<td>Used (unicast)</td>
</tr>
<tr>
<td>DDMC</td>
<td>Fully Distributed</td>
<td>Not used</td>
<td>Data driven</td>
<td>Not used</td>
</tr>
<tr>
<td>SDMC</td>
<td>Fully Distributed</td>
<td>Not used</td>
<td>Signal driven</td>
<td>Used (multicast)</td>
</tr>
</tbody>
</table>

The existing PMIP can be regarded as a centralized architecture, in which MAG performs the Proxy Binding Update (PBU) operation with LMA, and the data packets are first delivered to LMA and then forwarded to MN, without using any search (or query) mechanism.

The proposed PDMC is a partially distributed architecture in which the control plane is separated from the data plane. The BU operation will be performed between Access Router (AR) and Locator Binding Server (LBS), as done in PMIP. In PMIP, MAG corresponds to AR of PDMC, and LMA does LBS of PDMC. In the packet delivery operation, however, AR of CN first finds the Locator (CoA) of MN, just before data delivery, by contacting with LBS. To do this, the AR of CN will transmit a newly defined Binding Query (BQ) message to LBS, and the LBS will respond with a Query ACK (QA) message to the AR. In this sense, this scheme is named ‘signal-driven’ scheme. After that, the AR of CN will deliver the data packet directly to the AR of MN, and further to MN.

The DDMC scheme is a fully distributed architecture, which is similar to the data-driven multicast/broadcast scheme described in Section 2. In this scheme, LBS is not used and the BU operation is not performed. The AR of CN will send a data packet to all of the ARs by multicast in the domain, without using the BQ operation. In this sense, this scheme is named ‘signal-driven’ scheme.

Finally, the proposed SDMC is also a fully distributed architecture, which is similar to the peer-to-peer search scheme described in Section 2. No binding update operation is performed. In the data packet delivery, the AR of CN will find the AR of MN by using sending a BQ message to all of the ARs by multicast. The AR of MN will respond with a BA message. After that, AR of CN will deliver the data packet directly to AR of MN, further to MN.
B. Partially Distributed Mobility Control (PDMC)

Fig. 1 shows the operation of PDMC. First, MN setups a connection with AR and obtains its HoA (step 1). AR sends a BU message to LBS to bind HoA and CoA of MN (step 2). On receiving the BU request, LBS will create the associated database entry, and send the BA to AR (step 3). Now, CN sends a data packet to MN (step 4). Then, AR sends a newly defined Binding Query (BQ) message to LBS to find the CoA of MN (step 5). On the reception of BQ, the LBS responds with a newly defined Query ACK (QA) message including the CoA of MN to AR of CN, after lookup of its database (step 6). Then, the AR of CN sends the data packet to AR of MN (step 7). Finally, the data packet is forwarded to MN (step 8).

C. Data-driven Distributed Mobility Control (DDMC)

Fig. 2 shows the operation of the DDMC. The MN setups a connection with the AR (step 1). When CN sends a data packet to MN (step 2), the corresponding AR sends the data packet to all the ARs in the domain by multicast or broadcast (step 3). On receiving the data packet from AR of CN, the AR of MN will respond with a response message to the AR of CN (step 4), which ensures that the further subsequent data packets of CN can be delivered to AR of MN by unicast, without relying on multicast transmission. Now, the AR of MN will deliver the data packet to MN (step 5).

D. Signal-driven Distributed Mobility Control (SDMC)

Fig. 3 shows the operation of SDMC. MN is attached to AR (step 1). When CN sends a data packet to MN (step 2), the AR of CN sends a BQ message all the ARs in the domain (step 3). Then, only the AR of MN will respond with a QA message to AR of CN (step 4). Now, the data packet will be delivered to AR of MN (step 5), and further to MN (step 6).

IV. PERFORMANCE ANALYSIS

To evaluate the performance of the proposed distributed mobility control schemes, we analyze the cost that consists of the binding update cost with LBS (or LMA of PMIP) and the data packet delivery cost from CN to MN. We compare the total costs of the existing PMIP scheme and the three proposed schemes: PDMC, DDMC, and SDMC.

A. Analysis Model

For simplicity, we assume that both of CN and MN are located within the same domain (i.e., both are mobile hosts). Although we only focus on analyzing the performance within a domain in order to simplify the analysis because there are various possible scenarios for inter-domain movement, we believe that this analysis could fully reflect the main features of each protocol. Let us consider a simplified network model, as illustrated in Fig. 4.

In addition, we define the parameters used for cost analysis in Table 2. The binding update cost and the packet delivery cost are denoted by $BUC$ and $PDC$ respectively. Then the total cost ($TC$) is represented as $TC = BUC + PDC$. 
TABLE II. PARAMETERS USED FOR COST ANALYSIS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{sa}$</td>
<td>Transmission cost of a packet between nodes $a$ and $b$</td>
</tr>
<tr>
<td>$P_i$</td>
<td>Processing cost of node $c$ for binding update or lookup, which depends on the number of active hosts</td>
</tr>
<tr>
<td>$T_{setup}$</td>
<td>Setup time of connection between MN and AR</td>
</tr>
<tr>
<td>$N_{AR}$</td>
<td>Number of active hosts per AR</td>
</tr>
<tr>
<td>$N_{AR}$</td>
<td>Number of ARs in the domain</td>
</tr>
<tr>
<td>$H_{BS}$</td>
<td>Hop count between nodes $a$ and $b$ in the network</td>
</tr>
<tr>
<td>$S_{control}$</td>
<td>Size of a control packet (in byte)</td>
</tr>
<tr>
<td>$S_{data}$</td>
<td>Size of a data packet (in byte)</td>
</tr>
<tr>
<td>$a$</td>
<td>Unit cost of binding update with LBS</td>
</tr>
<tr>
<td>$b$</td>
<td>Unit cost of lookup at LBS or AR</td>
</tr>
<tr>
<td>$\tau$</td>
<td>Unit transmission cost of a packet over the wired link</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Unit transmission cost of a packet over the wireless link</td>
</tr>
</tbody>
</table>

B. Cost Analysis

The binding update operations of PMIPv6 are performed as follows. When a MN enters a new MAG region, MN establishes a link with MAG and gets its HoA based on the MN identifier [3]. We assume that this operation takes roughly $T_{setup}$. After that, the MAG will perform the PMIPv6 Proxy Binding Update operations with LMA by exchanging the PBuU and PBuA control messages, and LMA will update its database. This operation takes $2T_{AR-LBS}$ and $P_{LBS}$, where $T_{AR-LBS} = \alpha \log (N_{AR} \times N_{Host/AR})$ and $P_{LBS} = \alpha \log (N_{AR} \times N_{Host/AR})$. It is assumed that the processing delay for binding update with LMA database ($P_{LBS}$) is proportional to the total number of active hosts in the domain ($N_{AR} \times N_{Host/AR}$) in the log scale by implementing the associated database using a tree-based data structure. Accordingly, the binding update cost of PMIPv6 can be represented as follows:

$$BUC_{PMIPv6} = T_{setup} + S_{control} \times 2T_{AR-LBS} + PLBS$$

$$= T_{setup} + S_{control} \times 2 \tau H_{AR-LBS} + \alpha \log (N_{AR} \times N_{Host/AR})$$.

In PMIPv6, the packet delivery cost of a data packet from CN to MN can be calculated as follows. First, a data packet of CN is delivered to LMA via MAG of CN, which is equal to $T_{CN-AR} + T_{AR-LBS}$. The LMA will look for CoA of MN with its database, which takes $P_{LBS} = \alpha \log (N_{AR} \times N_{Host/AR})$. Then, the data packet will be forwarded to MAG of MN over the PMIPv6 tunnel, and it is delivered from MAG to MN, which corresponds to $T_{AR-LBS} + T_{AR-MN}$. Then, the packet delivery cost of PMIPv6 is represented as follows.

$$PDC_{PMIPv6} = S_{data}(T_{CN-AR} + T_{AR-LBS}) + P_{LBS} + S_{data}(T_{AR-LBS} + |T_{AR-MN}|)$$

$$= S_{data} (k H_{CN-AR} + 2 \tau H_{AR-LBS} + \kappa H_{AR-MN}) + \beta \log (N_{AR} \times N_{Host/AR}).$$

So, we obtain the total cost of PMIPv6 as

$$TC_{PMIPv6} = BUC_{PMIPv6} + PDC_{PMIPv6}.$$  

After that, the AR of CN will deliver the data packet directly to the AR of MN, which corresponds to $S_{data} \times T_{AR-AR}$. Now, the AR of MN will forward the data packet to MN, which is equal to $S_{data} \times T_{AR-MN}$. Accordingly, the packet delivery cost of PMIPv6 can be represented as follows.

$$PDC_{PMIPv6} = S_{data} \times T_{CN-AR} + S_{control} \times 2T_{AR-LBS} + P_{LBS} + S_{data}(T_{AR-AR} + T_{AR-MN})$$

$$= S_{data} (k H_{CN-AR} + \tau H_{AR-AR} + \kappa H_{MN-AR})$$

$$+ S_{control} \times 2 \tau H_{AR-LBS} + \beta \log (N_{AR} \times N_{Host/AR}).$$

So, we obtain the total cost of PMIPv6 as

$$TC_{PMIPv6} = BUC_{PMIPv6} + PDC_{PMIPv6}.$$  

In DDMC, the binding update between AR and LBS will not be performed. Accordingly, the binding update cost of DDMC will simply be $BUC_{DDMC} = T_{setup}$. The binding update cost of DDMC is as follows.

$$PDC_{DDMC} = S_{data} \times T_{CN-AR} + S_{data} \times T_{AR-AR} \times N_{AR} + P_{AR}$$

$$+ S_{control} \times T_{AR-AR} + S_{data}(T_{AR-MN})$$

$$= S_{data} (k H_{CN-AR} + \tau H_{AR-AR} \times N_{AR} + \kappa H_{MN-AR})$$

$$+ S_{control} \times \tau H_{AR-LBS} + \beta \log (N_{Host/AR}).$$

So, we obtain the total cost of DDMC as

$$TC_{DDMC} = BUC_{DDMC} + PDC_{DDMC}.$$  

In SDMC, the packet delivery cost is not performed, and we only have $BUC_{SDMC} = BUC_{DDMC}$. However, the SDMC is a signal-driven distributed scheme. In the packet delivery, the CoA query operation is performed by AR of CN before transmission of data packet. After that, the data packets are delivered directly to MN. Thus, the packet delivery cost of SDMC can be calculated as follows. First, a data packet of CN is delivered to AR, which is equal to $S_{data} \times T_{CN-AR}$. Then, the AR sends the PBQ message to all of the ARs in the domain by multicast or broadcast, which corresponds to $S_{control} \times T_{AR-AR} \times N_{AR}$. Only the AR of MN will respond to AR of CN with the PQA message after lookup of its AR cache, which is equal to $P_{AR} + S_{control} \times T_{AR-AR}$. After that, the AR of CN can deliver the data packet directly to the MN via AR, which takes $S_{data} \times (T_{AR-AR} + T_{AR-MN})$. Accordingly, the packet delivery cost of SDMC can be represented as follows.

$$PDC_{SDMC} = S_{data} \times T_{CN-AR} + S_{control} \times T_{AR-AR} \times N_{AR} + P_{AR}$$

$$+ S_{control} \times T_{AR-AR} + S_{data}(T_{AR-MN})$$

$$= S_{data} (k H_{CN-AR} + \tau H_{AR-AR} + \kappa H_{MN-AR})$$

$$+ S_{control} \times \tau H_{AR-LBS} \times N_{AR} + \tau H_{AR-MN} + \beta \log (N_{Host/AR}).$$

So, we obtain the total cost of SDMC as

$$TC_{SDMC} = BUC_{SDMC} + PDC_{SDMC}.$$  

C. 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 PMIPv6 domain so as
to simplify the analysis. That is, the inter-domain issue is not considered. However, we believe that this analysis could fully reflect the main features of each mobility scheme.

For numerical analysis, we set the parameter values used for comparison based on [10], as shown in Table 3. In the table, $\gamma$ represents the hop count ratio of $H_{AR-AR}$ over $H_{AR-LBS}$.

**Table III. Parameter Values Used for Cost Analysis**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\kappa$</td>
<td>4</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>$\tau$</td>
<td>2</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$N_{Host/AR}$</td>
<td>100</td>
<td>10</td>
<td>1,000</td>
</tr>
<tr>
<td>$N_{AR}$</td>
<td>10</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>$H_{AR-LBS}$</td>
<td>10</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>$\gamma (=H_{AR-AR}/H_{AR-LBS})$</td>
<td>0.3</td>
<td>0</td>
<td>2.0</td>
</tr>
<tr>
<td>$T_{setup}$</td>
<td>500 (ms)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$S_{data}$</td>
<td>1024 (bytes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$S_{control}$</td>
<td>50 (bytes)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5 compares the total costs of the candidate schemes for different values of unit transmission cost over wireless or wired link. In Fig. 5(a), it is shown that the costs linearly increase for all the schemes, as the unit transmission cost of wireless link ($\kappa$) gets larger. The three proposed distributed schemes give better performance than the existing PMIP. In Fig. 5(b), we see that the performance gaps between the distributed schemes and the existing PMIP become larger, as the unit transmission cost of wired link ($\tau$) increases. All the distributed schemes provide a nearly same performance, but the SDMC scheme give slightly better performance, compared to DDMC and PDMC.

Fig. 6 describes the impacts of the number of hosts and ARs. In Fig. 7(a), we can see that the total costs of candidate schemes are nearly the same for different number of hosts per AR ($N_{Host/AR}$). This implies that $N_{Host/AR}$ does not give significant impact on the performance. However, from the analysis of $N_{Host/AR}$ in the domain, as shown in Fig. 7(b), we can see that the DDMC scheme depends severely on $N_{Host/AR}$. The SDMC is also dependent on $N_{Host/AR}$. However, the PDMC and PMIP are not affected by $N_{Host/AR}$ in the domain.

![Figure 5](image1.png)  
(a) Unit transmission cost over wireless link

![Figure 5](image2.png)  
(b) Unit transmission cost over wired link

Figure 5. Impact of transmission costs on total cost

![Figure 6](image3.png)  
(a) Number of hosts in AR

![Figure 6](image4.png)  
(b) Number of ARs in the PMIP domain

Figure 6. Impact of the number of hosts and ARs on total cost
traffics to the network. This is because the

noted that the

be more suitable than the other two distributed schemes. It is

Among the proposed dis

sented schemes give better performance than the existing PMIP scheme in the viewpoint of total cost. Among the proposed distributed schemes, the SDMC seems to be more suitable than the other two distributed schemes. It is noted that the PDMC gives better performance than the DDMC. This is because the DDMC tends to inject unnecessary data traffics to the network.

Fig. 7 compares the candidate schemes in terms of the hop counts between two nodes in the domain. In Fig. 8(a), we can see that the hop count between AR and LBS (H_{AR-LBS}) gives significant impacts on total costs for PMIP and PDMC. This is because the PMIP uses LMA for binding update and data delivery as well, and the PDMC uses LBS for binding update. On the other hand, in Fig. 8(b), $\gamma$ represents the ratio of hop counts, $H_{AR,AR}$ over $H_{AR,LBS}$, where $\gamma=0$ (i.e., $H_{AR,AR}=0$) implies that MN and CN are located in the same AR region. From the figure, we can see that the fully distributed schemes, DDMC and SDMC, gives the best performance among the candidate schemes, when $\gamma=0$. However, the associated total costs tend to increase, as $\gamma$ gets larger, since most of the operations of DDMC and SDMC are performed between ARs.

Throughout all the numerical results, it is shown that all the distributed mobility control schemes give better performance than the existing PMIP scheme in the viewpoint of total cost. Among the proposed distributed schemes, the SDMC seems to be more suitable than the other two distributed schemes. It is noted that the PDMC gives better performance than the DDMC. This is because the DDMC tends to inject unnecessary data traffics to the network.

V. CONCLUSIONS

In this paper, we present the distributed mobility control architecture that has recently been discussed in the IETF, and propose the three extensional schemes for distributed mobility control in the PMIP-based mobile networks: PDMC, DDMC, and SDMC.

By numerical analysis, the three proposed schemes are compared with the existing PMIP scheme in terms of the binding update and packet delivery costs. From the numerical results, it is shown that all the distributed mobility control schemes give better performance than the existing PMIP scheme in the viewpoint of total cost. Among the proposed distributed schemes, the SDMC seems to be more suitable than the other two distributed schemes. It is noted that the PDMC gives better performance than the DDMC. This is because the DDMC tends to inject unnecessary data traffics to the network.

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