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Kyoungjae Sun
Younghan Kim
Soongsil University
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Use case analysis for supporting flow mobility in DMM
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Abstract

Distributed Mobility Management (DMM) allows network traffic to distribute among multiple mobility anchors which have mobility functions to solve the existing problems in current centralized mobility protocols. There are many DMM approaches extending network-based mobility protocols (e.g. Proxy Mobile IPv6).

In Proxy Mobile IPv6 (PMIPv6), they allow a mobile node to connect to PMIPv6 domain through different physical interfaces. In this reason, flow mobility that enables movement between physical interfaces of mobile node is proposed.

In this document, we present some use cases to support flow mobility in DMM domain and analyze some problems. These use cases are based on scenarios of flow mobility in PMIPv6. In these scenarios, a multi-interface mobile node connects to different distributed mobility access points and move specific flows from one interface to another. These use cases have common issues which will be analyzed in detail.

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[1. Introduction](#)

Distributed Mobility Management aims at overcoming limitations of centralized mobility protocol, such as a single point failure, scalability and non-optimal routing. In [I-D.ietf-dmm-best-practices-gap-analysis], they distribute existing mobility functions to access network, and show practices to use existing protocols (e.g. MIP, PMIP).

When mobile node can use multiple interfaces and connect to network simultaneously or sequentially, flow mobility allows a mobile node

to move specific traffic flows by using network status or policy. In NETEXT WG, [[I-D.ietf-netext-pmipv6-flowmob](#)] explains about PMIPv6 based flow mobility and proposes some scenarios for supporting that.

In this document, we consider PMIPv6 based flow mobility with DMM architecture. [[I-D.seite-dmm-dma](#)] mentions about multi-interface support for network based DMM but not in detail. This document refers DMM architecture and message flows from [[I-D.bernardos-dmm-distributed-anchoring](#)] and [[I-D.seite-dmm-dma](#)]. For supporting flow mobility in DMM, we consider two approaches; fully and partially distributed approaches. From analyzing these use cases, it would incline that multi-interface mobile node can connect to different distributed anchors and move traffic flows between physical interfaces.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC-2119](#) [[RFC2119](#)].

The following terms used in this document are defined in the Proxy Mobile IPv6 [[RFC5213](#)]:

Proxy Binding Update (PBU)

Proxy Binding Acknowledgement (PBA)

The following terms are defined in the Proxy Mobile IPv6 Extensions to Support Flow Mobility [[I-D.ietf-netext-pmipv6-flowmob](#)]:

FMI (Flow Mobility Initiate)

FMA (Flow Mobility Acknowledgement)

FMC (Flow Mobility Cache)

The following terms are defined and used in this document:

Distributed-Mobile Access Gateway (D-MAG): It provides an IP prefix to each attached mobile node. D-MAG is the topological anchor point of mobile node's prefix. It performs regular IPv6 routing for connecting mobile node directly and when mobile node moves and attaches to another D-MAG, similar to LMA in [[RFC5213](#)], it tracks the mobile node location and performs mobility routing to forward packets via D-MAG where mobile node is attached.

Centralized Database (CDB): It is a centralized entity proposed in the partially distributed mobility approach. CDB can store location information of mobile nodes in the DMM domain. When a mobile node attaches to the D-MAG, D-MAG firstly request to the CDB whether information of mobile node is existing. If there is information of previous location of mobile node, D-MAG perform the mobility routing between a mobile node and previous D-MAG.

3. Use case scenario in fully DMM architecture

In the fully distributed approach, as shown in figure 1, each distributed mobility anchor has functions of MAG and LMA. Distributed mobility anchors called Distributed Mobile Access Gateway (D-MAG) support same or different access technologies so that different physical interfaces of mobile node can access to D-MAG simultaneously or sequentially. When a mobile node attaches to network, the D-MAG may assign prefix and support regular IPv6 routing. When the mobile node moves to another D-MAG, previous D-MAG may perform as a mobility anchor like LMA which exchanges signaling messages (e.g. PBU/PBA) and supports mobility routing(e.g. Tunnel).

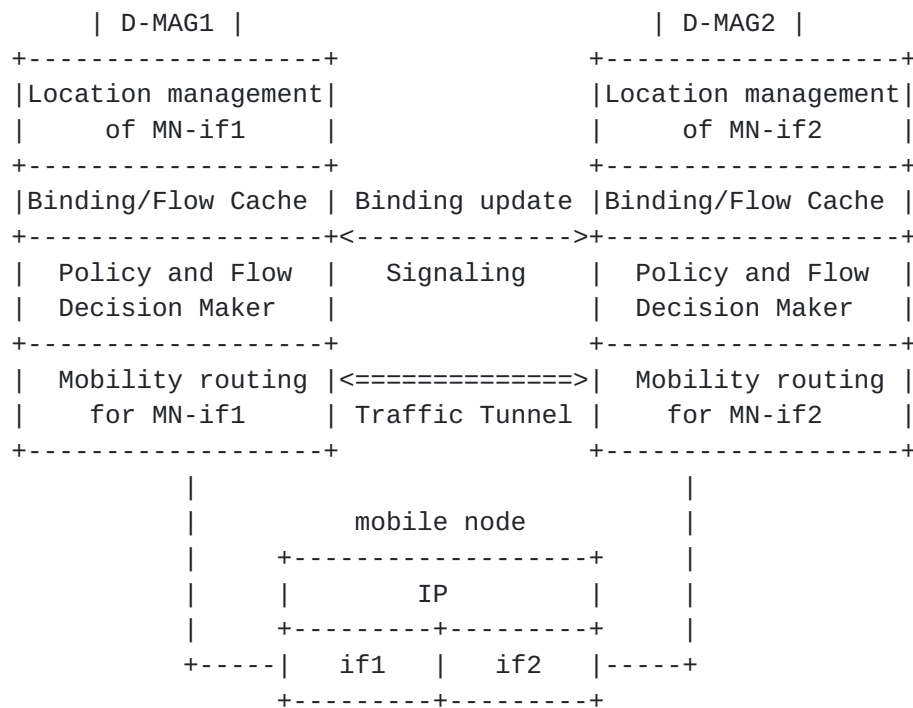


Figure 1 <Flow mobility scenario in the fully distributed architecture>

In [[I-D.ietf-netext-logical-interface-support](#)], logical interface is defined that allows the mobile node to move different traffic flows to different physical interfaces regardless of the assigned prefixes on those interfaces. By using the logical interface, mobile node can accept incoming packets which is addressed to another interface of mobile node. Flow mobility cache which is separated from the binding cache is defined [[I-D.ietf-netext-pmipv6-flowmob](#)] to contain all registered flow information. This specification uses the format of flow binding list defined in [[RFC6089](#)]. Similarly to [[I-D.ietf-netext-pmipv6-flowmob](#)], we assume that mobile node have logical interface and D-MAG includes flow cache entry. There are three use cases to support flow mobility in DMM.

3.1. Use case 1

The first possible use case, as shown in Figure 2, assumes that multiple interfaces attach to DMM network sequentially and movement of flow starts from the activation of secondary interface of mobile node. In this case, basic operation may follow normal PMIPv6 protocol as follows:

- o When a mobile node initially attaches to the D-MAG1 using the physical interface if1, the D-MAG1 should assign prefix pref1 and support regular IPv6 routing. In this time, no mobility function is used. Mobile node may communicate with one or more corresponding nodes after receiving pref1 from D-MAG1. However, D-MAG1 SHOULD know the information of all flows used by if1 of mobile node. D-MAG1 already has binding cache entry and flow cache entry so it can update its own entries. TS option in the IPv6 header of packet can be used to update flow cache entry.
- o During the time, mobile node connects to D-MAG1 through the if1, it could enable another interface if2 to attach to D-MAG2. Upon D-MAG2 receives information (discussed about this operation later.), the D-MAG2 may send a PBU message to the D-MAG1 to request mobility routing. In the PBU message, it SHOULD include the mobile node identifier and the address of D-MAG1. It may also include the request for supporting flow mobility because the D-MAG1 does not observe that the mobile node connects to the D-MAG2 by using the another interface.
- o When the D-MAG1 receives the PBU message, the D-MAG1 SHOULD make a tunnel first with the D-MAG2 and determine what flows will move to the D-MAG2. Decision method or policy for flow mobility is out of scope of this document. After decision, the D-MAG1 updates its binding cache entry and flow cache entry for moving flow. Finally, the D-MAG1 sends a PBA message to the D-MAG2 and forwards moving flows to the D-MAG2 via tunnel. In the PBA message, additional contents, such as Flow Identification option

[[RFC6089](#)] or the service type of flow, are needed to provide the

flow information. After receiving the PBA message, the D-MAG2 updates its routing table and delivers packets received from the D-MAG1 to if2. Independently, the D-MAG2 also SHOULD assign a new prefix to if2 for normal IPv6 routing because all D-MAGs have location management and address allocation function in DMM.

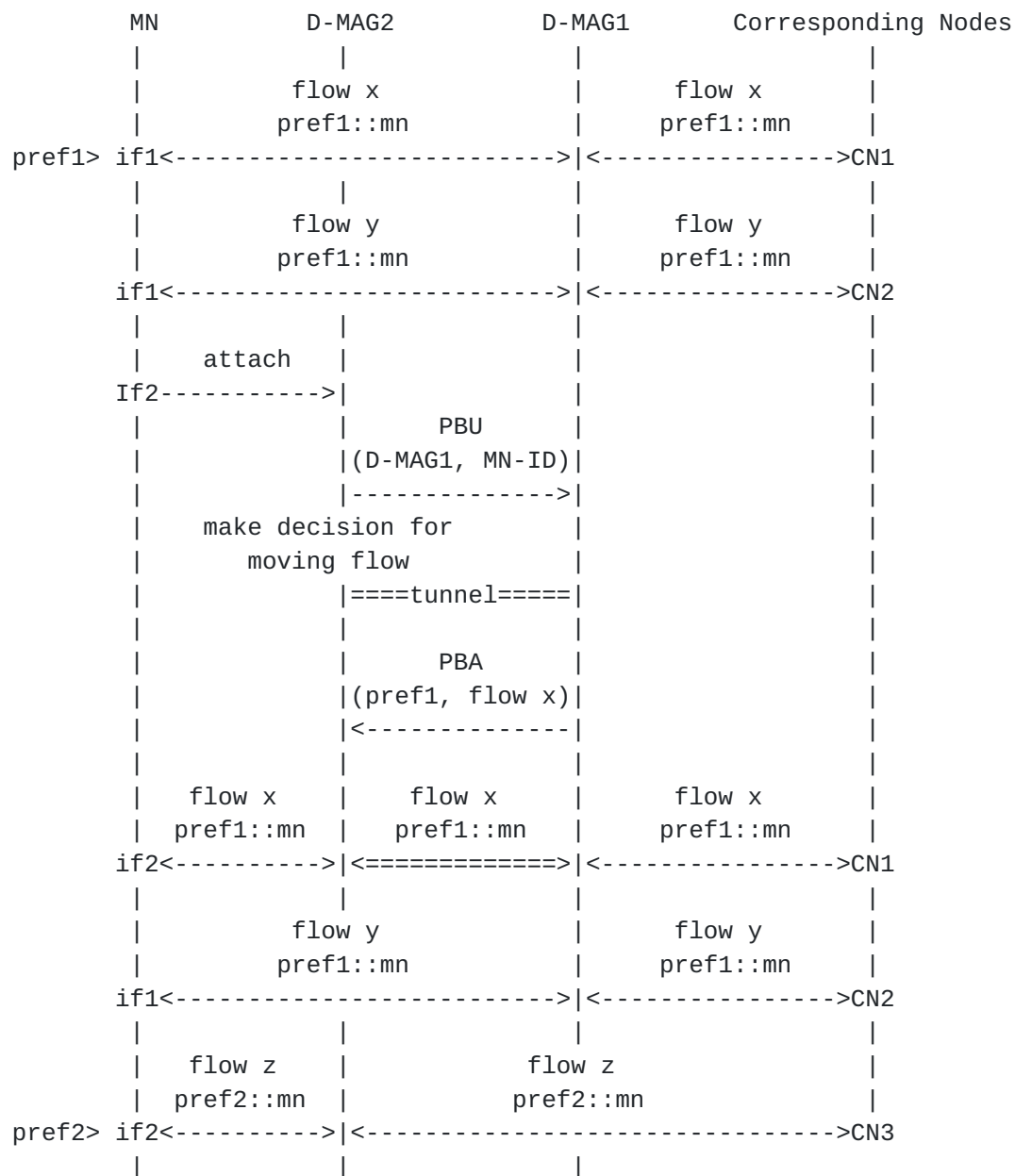


Figure 2 <Use case 1 operation>

3.2. Use case 2

The second possible case, as shown in Figure 3, assumes that multiple interfaces attach to network simultaneously. Each interface has been assigned prefixes from the different D-MAGs. When several

flows are already existed through both interfaces, basic operation will be as follows:

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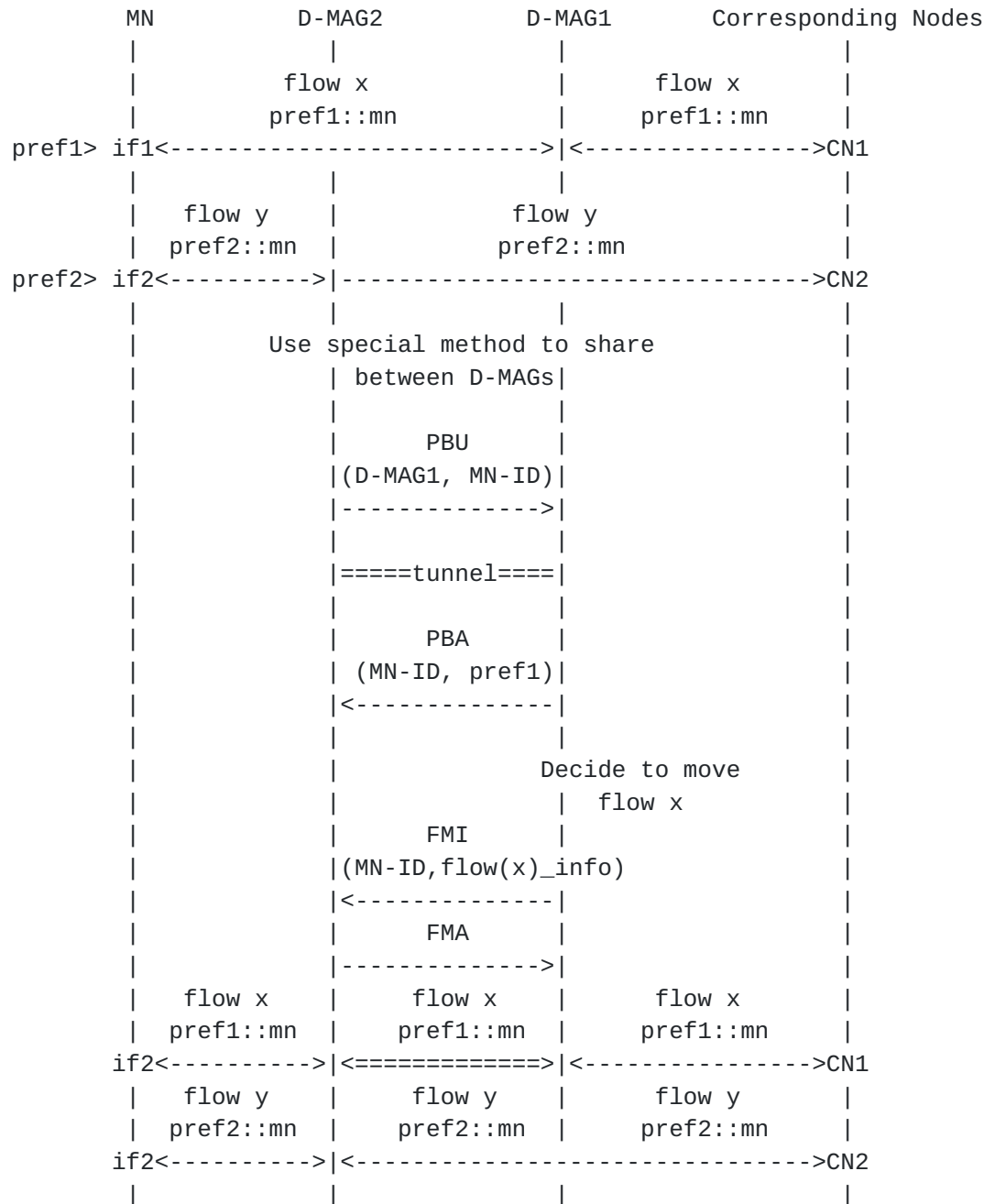


Figure 3 <Use case 2 operation>

- o When the mobile node attaches to the different D-MAGs through multiple interfaces, each interface has been assigned different prefixes and managed separately. In this figure, if1 and if2 are connecting to the D-MAG1, D-MAG2 and using the pref1, the pref2, respectively. To support flow mobility, a special method in which both D-MAGs share information of mobile nodes attached to network, activated flows, and network policy.

- o In the certain time, when the network decides to move a specific flow, flow x in this figure, first both D-MAGs exchange PBU/PBA messages to bind prefix of mobile node's interface. However, in this case, the PBU/PBA messages are only for binding prefix. So D-MAG1 just updates binding cache entry but no traffic path is changed. To do this, the modification of PBU/PBA or functions of D-MAG may be needed. After exchanging signaling messages, tunnel is setup between the D-MAG1 and the D-MAG2, but no traffic flow moves through this interface yet.
- o Considering move a specific flow from the D-MAG1 to the D-MAG2, the D-MAG1 SHOULD send a request message for the D-MAG2 because the flow information is only stored in the D-MAG1. Since the D-MAG1 cannot send a PBA message which has not been triggered in response to a received PBU message, new signaling messages are defined to cover this case. In [I-D.ietf-netext-pmipv6-flowmob-06], they defined a new signaling message, FMI/FMA message, which contains the MN-Identifier, the Flow Identification Mobility option information, and the type of flow mobility operation (add flow). Adjusting the scenario of this document in the DMM, the D-MAG2 may receive the FMI message from the D-MAG1, update the flow cache entry, and send a FMA message to reply. Finally, the flow will move to if2 via the D-MAG2 using mobility routing.

3.3. Use case 3

The last possible case, as shown in Figure 4, the multi interfaces of mobile node attach to network sequentially and flows are moved with a prefix granularity. It means that the flows are moved by moving prefixes among the different D-MAGs the mobile node is attached to. This use case also extends one scenario of [I-D.ietf-netext-pmipv6-flowmob]. In this case, mobile node obtains a combination of prefix(es) in use and a new prefix(es). Basic operation will be as follows:

- o As shown in Figure 4, initially the mobile node connects to the D-MAG1 using if1 but if2 is not activated yet. When mobile node adds traffic flows which use a different service, each flow are assigned the different sets of prefixes. Since that, the D-MAG1 can perform mobility routing only for specific flow when D-MAG2 requests. After the mobile node turns on if2 and attaches to the D-MAG2, the D-MAG2 sends a PBU message to the D-MAG1 and the D-MAG1 determines what flow should be moved (using network policy, etc.). Since the flow moves with a finer granularity, the operation may complete from the D-MAG1 by making a tunnel and sending a PBA message included the prefix of selected flow (flow x in figure 4.).



Figure 4 <Use case 2 operation>

3.4. Use case analysis

Since these use cases attempt to extend simply existing flow mobility scheme of centralized mobility protocols to the distributed architecture, there are several limitations and unclear points. In the PMIPv6, LMA which is a centralized anchor could manage all network entities and also all MAGs know location and address of LMA. Therefore, the MAGs can send the PBU packets immediately after detecting the access of the mobile node. However, in the distributed architecture, the D-MAGs have all functions of LMA and MAG in PMIPv6 and manage their network separately. For this reason, a method used to exchange information among D-MAGs is required.

One possible solution is that a new signaling message between D-MAGs and they share the address or policy. Another solution is that mobile node sends a trigger message to request flow mobility. In this case, the trigger message may include the address of D-MAG which will send packets to another the D-MAG, flow information or another additional function. The trigger message may be defined on the Layer 3, and also be defined on the Layer 2. In previous works, the Handoff Indicator (HI) for fast handover can be used to trigger message for flow mobility. However, the trigger message from mobile node is not appropriate for network-based mobility because a mobile node makes signaling messages.

4. Use case scenario in partially DMM architecture

In the partially distributed DMM architecture, as shown figure 5, a Centralized Database(CDB) gathers information of all users in the domain (e.g., IP address, traffic flows, etc.), so each D-MAG can access to the database and get information when a mobile node attach to. In [[I-D.seite-dmm-dma](#)], they already proposed a centralized database to share information between distributed access routers. Since centralized database performs only for sharing information, no data traffic from mobile node forwards to this database.

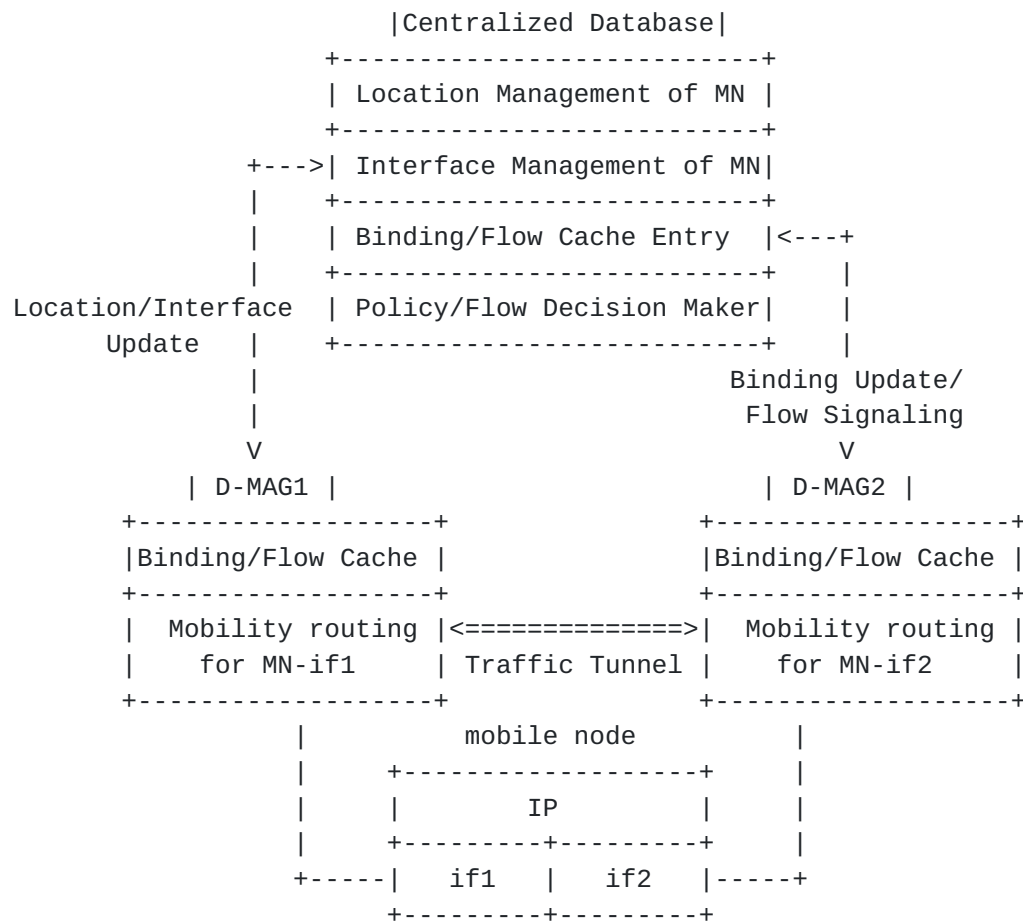


Figure 5 <Flow mobility scenario in the partially distributed architecture>

For the implementation of distributed and dynamic mobility management solution, it could be considered to separate control and data plane. In that case, besides centralized management functions, the CDB also has policies of network management policies and route decisions, so it can make decision and trigger to move the specific flows. Actually it is not fully distributed architecture but data can be distributed and forwarded without signaling messages between D-MAGs. [[Paper-Chan](#)] and several researches are proposed

control/data separation schemes based on PMIPv6.

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4.1. Use case 4

Possible use case in the partially distributed mobility approach is shown in figure 6. When mobile node attaches to the network, D-MAG should updates information of identifier (e.g. MAG, IP address) as well as interface (e.g. Access technology type). Basic operation will be as follows:

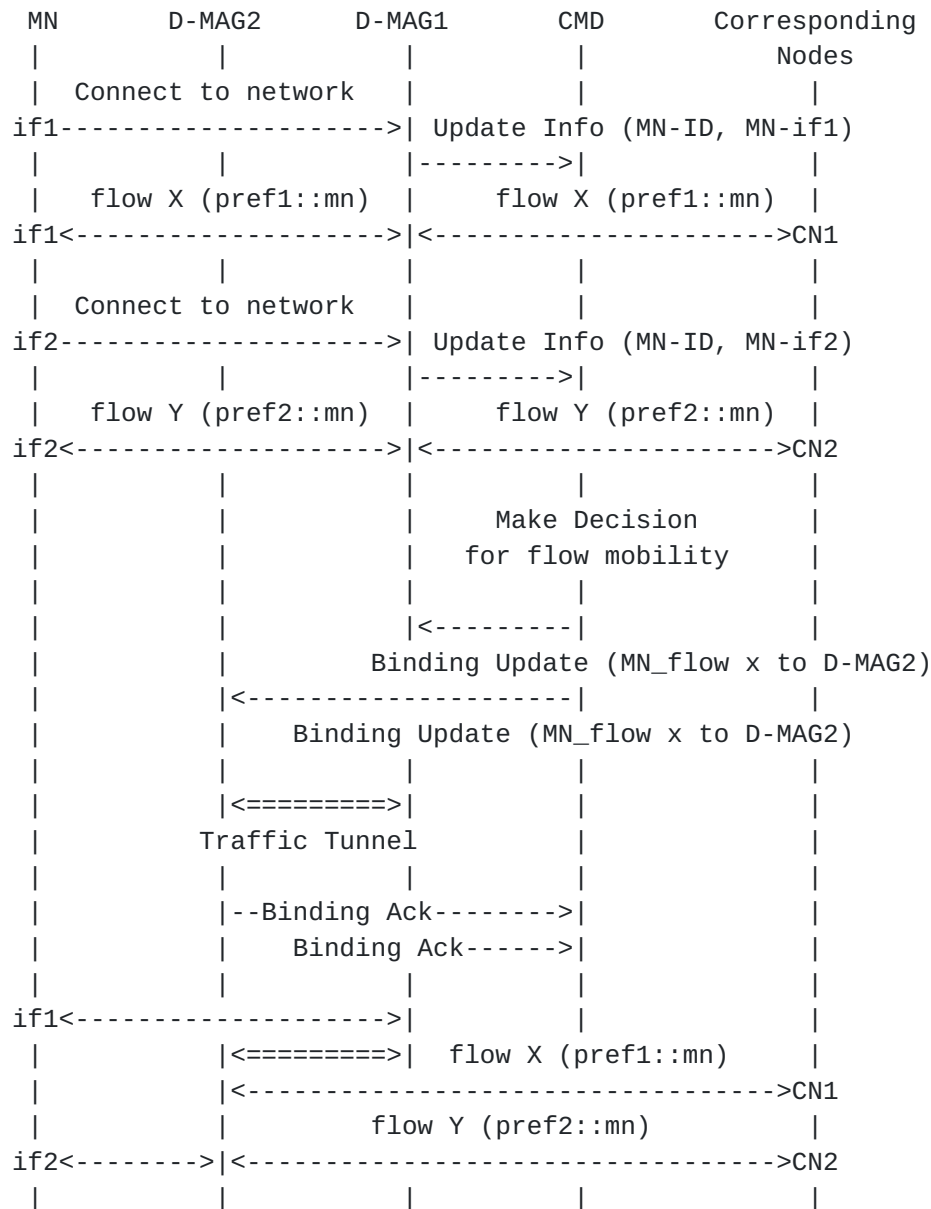


Figure 6 <Use case operation>

- o When the mobile node attaches to the different D-MAGs through multiple interfaces, simultaneously or sequentially, each interface may be assigned different prefixes by each connected D-MAG. After making a connection between mobile node and D-MAG, Each D-MAG should send update message to the CDB. Since the CDB may have a database for mobile nodes in the domain as well as interface of each mobile node, it can inform to the D-MAG whether connected mobile node were making connection before.
- o For flow mobility decision based on policy, the CDB may determine to move specific flow by using location and flow information in the database. If the CDB decide to move flow X to if2, it may send Binding Update messages to both D-MAG1 and D-MAG2. When both D-MAGs receive Binding Update message, they may modify their binding cache/flow cache entry and make traffic tunnel between each other. After receiving Binding Ack message from D-MAGs, the CDB may update its database.

4.2. Use case 5

In particular, Software-Defined Networking (SDN) has been proposed from [[Paper-SDN](#)] to simplify routing entities in the network. In that architecture, the centralized control function knows network topology, so when a device attaches to the network and sends data, the control function catches the packets, makes a path and pushes flow rules to routing entities (e.g. switch, router) via specific interface (e.g. OpenFlow). Routing entities in that network just forward packets by the rules from the centralized control function. Although the SDN is not fully distributed architecture, it can achieve several requirements of DMM. SDN-based mobility management is expected to be a promising approach which will support mobility management for only moving user and session connectivity continuity for mobile users without the waste of network resources (e.g. tunneling). Moreover, by using SDN concept, we can adjust network policies easily for users and specific flows.

5. Considering Multicast Routing

In [[RFC 7333](#)], they described that DMM should enable multicast solutions to avoid network inefficiency. In PMIPv6 multicast routing, the MAG perform as MLD proxy which maintains information of subscribers, aggregates MLD report and make multicast tunnel with multicast router. In DMM, similar with PMIPv6, D-MAG may perform MLD proxy function to deliver multicast traffic. Considering flow mobility, unicast traffic should be forwarded by using tunnel between D-MAGs but multicast traffic can be delivered directly through current D-MAG. To do that, however, there should be enhance functionality to perform MLD proxy in D-MAG and extension of protocol similar with PMIPv6 multicast method.

6. IP address type consideration

In [[dmm-on-demand-mobility](#)], they described IP address types that depend on IP session continuity and IP address reachability, including Fixed, Sustained, and Nomadic IP addresses. For each address type, an application can request the appropriate IP address type that supports a mobility management mechanism. In the existing flow method mobility scheme, the IP address assigned to the mobile node is assumed Fixed/Sustained IP address which guarantee IP session continuity. In other words, the IP address is assigned by the network regardless of characteristics of application. However, in consideration of the type of IP address, a particular type of IP address is requested by specific application and this address may not provide session continuity. For example, such application that has the Nomadic IP address may be used through one of interface of the mobile node and, at the same time, such application that has the Fixed IP address may be used through other interface of the mobile node. In this case, access networks that are connected to each interface of mobile node should determine the possibility of supporting flow mobility in consideration of the IP address type of the specific flow. If the IP address type requested by the application is the Nomadic IP address which does not support IP session continuity, the distributed anchor in the access network does not need to consider mobility support for that flow at all. On the other hand, if the IP address type requested by the application needs to be provide IP session continuity, such as fixed/sustained address, the anchor should determine for the flow mobility support through the mobility anchor. To determine flow mobility support based on the IP address type, the mechanism which makes decision for flow mobility according to flow information and address type is required.

7. Security Considerations

TBD

8. IANA Considerations

This document makes no request of IANA.

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[10](#). Acknowledgments

Authors' Addresses

Kyoungjae Sun
Soongsil University
369, Sangdo-ro, Dongjak-gu,
Seoul 156-743, Korea

Email: gomjae@dcn.ssu.ac.kr

Younghan Kim
Soongsil University
369, Sangdo-ro, Dongjak-gu,
Seoul 156-743, Korea

Email: younghak@ssu.ac.kr