

Analysis of the usage of a logical interface in PMIPv6

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Abstract— A logical interface is used to hide the change of network interface from the upper host IP layer and it also can be used for a multiple interfaces mobile node in PMIPv6 domain. In a MN point of view, the link-layer identifier of a logical interface can use same link-layer identifier of physical interface or a totally different link-layer identifier from them of physical interface. And in a LMA point of view, a LMA may acknowledge each physical interface or only a logical interface of a mobile node when a multiple interfaces mobile node utilizes a logical interface. If a LMA assigns multiple home network prefixes to a multiple interfaces mobile node with a logical interface, a logical interface has various usages of the multiple home network prefixes. As following general PMIPv6 operations described in RFC 5213, all multiple home network prefixes are shown to host IP layer. Also, the logical interface hides the existence of multiple home network prefixes and shows only one home network prefix to host IP layer. In this paper, we analyse various usages of a logical interface in a viewpoint of link-layer identifier and multiple home network prefixes and give some guidelines to implement.

Keywords— PMIPv6, logical interface, link-layer identifier, home network prefix

I. INTRODUCTION

Proxy Mobile IPv6 (PMIPv6) is a network based IP mobility support protocol, which does not require any modifications to mobile nodes [1]. PMIPv6 makes it possible to support mobility for IPv6 nodes without an involvement of mobile nodes. That is, on behalf of mobile nodes, a mobile access gateway (MAG) in the network performs the signalling for mobility management with a local mobility anchor (LMA).

Due to the simultaneous usage of multiple interfaces in a mobile node and the change of network interfaces, IETF netext (Network-based Mobility Extensions) working group has studied the hiding access technology changes from host IP layer [2]. Link layer implementation such as "logical interface" can hide the actually used physical interfaces and the change of physical interfaces from the IP layer. Many operating systems offer support to the usage of logical interface over multiple physical interfaces without any big efforts. In another IETF internet draft, operations details of the

logical interface are explained and it identifies the applicability of the usage of logical interface [3].

PMIPv6 specifications allow mobile nodes to connect PMIPv6 domain through multiple network interfaces for simultaneous access and a LMA may allocate more than one home network prefix for a given interface of the mobile node. In basic PMIPv6 specification, the multiple home network prefixes that the LMA allocates to a mobile node are shown totally to the host IP stack of the mobile node. Also, if a mobile node utilizes a logical interface to hide the change of network interfaces, we can extend the usage of a logical interface to hide the multiplicity of home network prefixes. So we can categorize the usage of a logical interface as two cases. First, as following general PMIPv6 operations described in RFC 5213, all multiple home network prefixes are shown to host IP layer. Second, for some reasons such as the session continuity, only one home network prefix is shown to the host IP stack of the mobile node even though the LMA allocates multiple home network prefixes. In second case, the logical interface does some necessary jobs to hide the existence of multiple interfaces and also the existence of multiple home network prefixes. And the logical interface does some necessary jobs when network interfaces are changed and/or home network prefixes are changed.

Although the primary purpose of a logical interface is to hide the access technology changes from host IP layer in a mobile node, the usage of a logical interface can influence the acknowledgement of interfaces of a mobile node in a LMA point of view. If a multiple interfaces mobile node utilizes a logical interface, we can consider both cases; a LMA may acknowledge each physical interface of a multiple interfaces mobile node; a LMA may acknowledge only a logical interface of a multiple interfaces mobile node. And when we design/implement a logical interface in a multiple interface mobile node of PMIPv6, we can use same link-layer identifier of physical interface for the link-layer identifier of the logical interface and totally different link-layer identifier from them of physical interface.

In this paper, we analyse the usage of the logical interface in a multiple interfaces mobile node in PMIPv6 domain in a viewpoint of link-layer identifier and the allocation of multiple home network prefixes to a mobile node. The rest of this paper is organized as follows: In section 2, we describe basic Multihoming support in PMIPv6 and its usage on the logical interface. In section 3, we describe various scenarios of the usage of the logical interface in a viewpoint of link-layer identifier and multiple home network prefixes and, in section 4, give some guidelines to design/implement a logical interface in PMIPv6 based on the analysis. Finally, we conclude in section 5.

II. MULTIHOMING SUPPORT ON A LOGICAL INTERFACE IN PMIPv6

PMIPv6 defines basic operations for registration, deregistration, and tunnel management to provide mobility for a mobile node in PMIPv6 domain. But, it does not define protocol operations for supporting seamless handover for a mobile node with multiple network interfaces based on different access technologies (inter-technology handoff) [4]. And it also has problems from a lengthy handover latency and packet loss during a handover [5]. While PMIPv6 itself supports handover across interfaces and between access types, there are several issues with effectively performing inter-technology handoff such as formatting of interface identifier, usage of the same address on multiple interfaces, limitations of interfaces, access selection, detection handovers, and predictive handovers [6].

In PMIPv6 specification, to provide multihoming support, it describes three key aspects as following.

- o When a mobile node connects to a PMIPv6 domain through multiple interfaces for simultaneous access, the LMA must allocate a mobility session for each of the attached interfaces.
- o The LMA may allocate more than one home network prefix for a given interface of the mobile node.
- o The LMA must allow for a handoff between two different interfaces of a mobile node. In such a scenario, all the home network prefixes associated with one interface (part of one mobility session) will be associated with a different interface of the mobile node.

Even though a logical interface is adopted in a multiple interface mobile node in PMIPv6 domain, the above three aspects also should be applied.

For the regarding of first aspect, if a logical interface is used in a multiple interfaces mobile node, even though multiple interfaces are used, the host IP stack of the mobile node only acknowledges the logical interface. But in a LMA point of view, LMA can acknowledge each physical interface or only a logical interface. Section 3.A and section 3.B

describe these scenarios. If a LMA acknowledges each physical interface, the LMA allocates mobility sessions for each interface and each mobility session for the each physical interface is generated. But, if a LMA acknowledges only a logical interface, the LMA allocates a mobility session for the logical interface of the mobile node and one mobility session for the logical interface is generated.

For the regarding of second aspect, in basic PMIPv6 specification, if a LMA allocates multiple home network prefixes to a multiple interfaces mobile node, these multiple home network prefixes are totally shown to the host IP stack of the mobile node. This is also effective when a logical interface is used. But, due to the usage of a logical interface in a mobile node in PMIPv6 domain, we can extend the allocation method of multiple home network prefixes to a mobile node. As same as the role of a logical interface to hide the change of multiple interfaces, the logical interface can hide the existence and the change of multiple home network prefixes. In section 3.C, section 3.D, we describe more detail.

For the regarding of third aspect, if a LMA acknowledges only a logical interface, this description is no longer effective because only one logical interface is shown to the LMA and the LMA assumes that the mobile node has one interface even though it has multiple interfaces. But, the PMIPv6 specification should be extended to consider a handoff between two different physical interfaces of a mobile node with a logical interface.

III. ANALYSIS OF THE USAGE OF LOGICAL INTERFACE

A. Scenario 1 – LMA acknowledges physical interface of a MN

The first scenario of the usage of a logical interface is same as described in IETF internet draft of "Proxy Mobile IPv6 Extensions to Support Flow Mobility [7]." The role of a logical interface is only to hide the existence of multiple network interfaces and the change of network interfaces for inter-technology handoff and flow mobility in a mobile node point of view. So, the logical interface is transparent to the LMA. The LMA acknowledges each physical interfaces and it generates each mobility sessions for each physical interface.

Figure 1 shows this case. As shown in Figure 1, if the mobile node uses two physical interfaces *if_1* and *if_2*, these two different physical interfaces are referred as different link-layer identifier (LL-ID) *xxx*, *yyy*. As a result of proxy binding update, two different mobility sessions of two physical interfaces are generated.

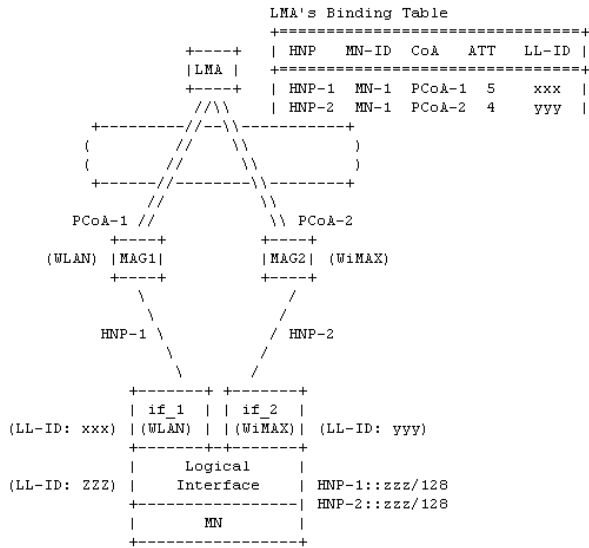


Figure 1. LMA acknowledges each physical interface of a MN

B. Scenario 2 – LMA acknowledges a logical interface of a MN

The second scenario of the usage of a logical interface is same as described in an IETF internet draft of "Logical Interface Support for multi-mode IP Hosts [3]." The role of a logical interface is to hide the existence of multiple network interfaces and the change of network interfaces for inter-technology handoff and flow mobility in a mobile node point of view. Also, in a LMA point of view, the LMA acknowledges only a logical interface and it generates mobility sessions for the logical interface.

Figure 2 shows this case. As shown in Figure 2, the mobile node uses two physical interfaces if_1 and if_2 and these two different physical interfaces are referred as LL-ID zzz, zzz. The LL-ID zzz of logical interfaces is same as the LL-ID of the physical interface and it is used in a LMA's binding table. As a result of proxy binding update, mobility sessions of the logical interface are generated.

C. Scenario 3 –All home network prefixes are shown to IP host stack

The third scenario of the usage of a logical interface is same as described in IETF internet draft of "Logical Interface Support for multi-mode IP Hosts [3]" and "Proxy Mobile IPv6 Extensions to Support Flow Mobility [7]." The role of a logical interface is only to hide the existence of multiple network interfaces and the change of network interfaces. The home network prefixes that a LMA allocates to a multiple interface mobile node are totally shown to host IP stack of the mobile node. The logical interface simply bypasses the home network prefixes between host IP stack and physical interfaces.

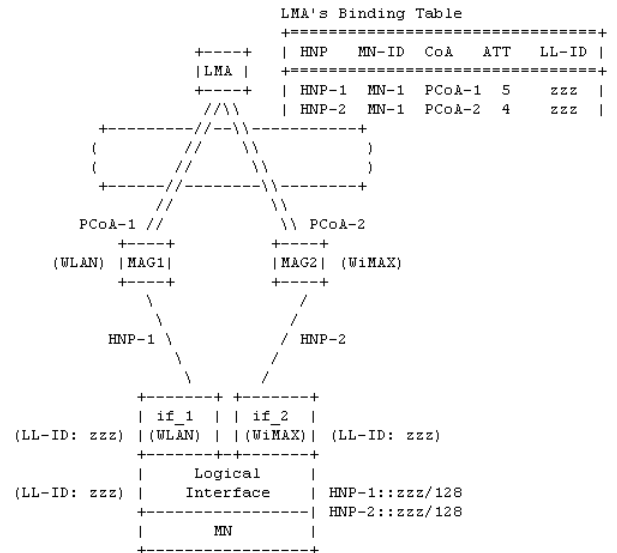


Figure 2. LMA acknowledges a logical interface of a MN

Figure 3 shows this case. As shown in Figure 3, if the LMA allocates two home network prefixes HNP-1, HNP-2 to the mobile node, these two home network prefixes are shown to IP host stack of the mobile node. As a result of receiving multiple home network prefixes in IP host stack, two different IPv6 addresses HNP-1::zzz/128 and HNP-2::zzz/128 can be generated.

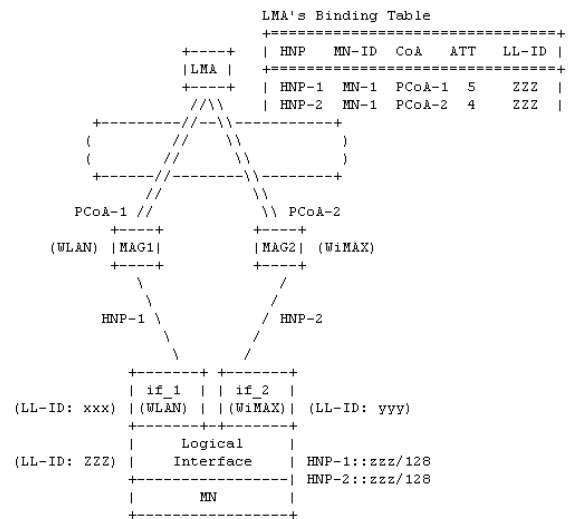


Figure 3. All HNPs are shown to IP host stack

D. Scenario 4 –Only one home network prefix is shown to IP host stack

In above scenario 3, basic PMIPv6 operations can be applied even though a logical interface is used. Multihoming support and inter-technology handoff support is provided without any modification of PMIPv6 operations but for flow mobility, it needs method to transfer a subset of multiple home network prefixes.

In scenario 3, one application that uses one specific home network prefix cannot utilize the multiplicity of home network prefixes. For on-going session continuity, applications cannot change their home network prefix during packet sending/receiving. Even though a logical interface supports the inter-technology handoff between different network interfaces, applications should use same home network prefix before/after handoff.

But, if a logical interface supports the change of network interface and also the change of home network prefix, applications can utilize the multiplicity of home network prefixes. As a same manner of the handling of network interface, only one home network prefix is shown to host IP stack of the mobile node. And the logical interface manages the relationship between multiple home network prefixes and the home network prefix that is shown to host IP stack and dynamically update them. In this case, only one logical interface and one home network prefix is shown to host IP stack of the mobile node.

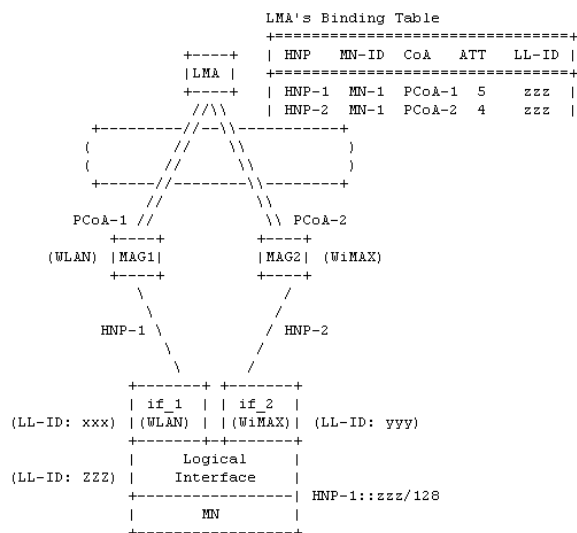


Figure 4. Only one HNP is shown to IP host stack

Figure 4 shows this case. As shown in Figure 4, if the LMA allocates two home network prefixes HNP-1, HNP-2 to the mobile node, only one home network prefix is shown to IP host stack of the mobile node. As a result of receiving single home network prefix in IP host stack, one IPv6 addresses HNP-1::zzz/128 can be generated.

IV. GUIDELINES OF DESIGN/IMPLEMENTATION OF LOGICAL INTERFACE IN PMIPv6

A. The relationship of link-layer identifier between logical interface and physical interface

One of the simplest ways to implement logical interface is to set the same link-layer identifier such as MAC address for both logical interface and physical interfaces. To do that, the devices should allow source address spoofing or allow

changing link-layer identifier and the link-layer identifier format of access type should be similar.

The figure 2 shows this case in which the logical interface and physical interfaces use the same link-layer identifier (LL-ID) zzz. As shown in figure 2, the link-layer identifier of logical interface is delivered to a LMA and the LMA acknowledges a logical interface a MN.

In figure 2, if we assume that the physical interface 1 (if_1) and physical interface 2 (if_2) are associated with Access Point 1 (AP1) which is connected to MAG1 and Access Point 2 (AP2) which is connected to MAG2 respectively, both AP1 and AP2 recognize the same link-layer identifier zzz from the MN's attachments. The AP1 and AP2 can forward any packet sending from corresponding nodes to the logical interface or vice versa without any problem.

In this case, to find a nearby router the MN send Router Solicitation (RS) message via both if_1 and if_2. The MN can receive Router Acknowledgement (RA) message from both of these two interfaces. In case that the MN wants to send a unicast packet but does not know the neighbour's link-layer addresses, it will perform address resolution by sending Neighbour Solicitation (NS) message through both if_1 and if_2. On receiving NS message, the corresponding nodes will send back Neighbour Acknowledgement (NA) message back to the MN through the path that it receives NS from. Thus the logical interface at the MN may receive NA message through both if_1 and if_2. The same for the inverse direction, the corresponding nodes node may sends NS message to the MN through both direction. On receiving the NS message the logical interface at the MN will send NA reply message through the interface that it receives NS from. Sometime, the logical interface may also send unsolicited Neighbour Advertisement message via all enabled physical interfaces in order to propagate new information quickly.

On the other hand, many wireless devices do not allow source address spoofing or do not allow changing link-layer identifier. In addition, different access devices may use different link-layer identifier format. In these cases, it is very difficult to use same link-layer identifier between logical interface and physical interfaces. In this case, the logical interface must use totally different link-layer identifier from those of physical interfaces or it can only use the same link-layer identifier with one of the physical interfaces. Scenario 1 and figure 1 are included in this case. As shown in figure 1, the logical interface uses a different link-layer identifier zzz with comparing link-layer identifier xxx and yyy of each physical interface.

But, in the view point of implementation, this case can cause several problems:

In figure 1, if we assume that the physical interface 1 (if_1) and physical interface 2 (if_2) are associated with Access

Point 1 (AP1) which is connected to MAG1 and Access Point 2 (AP2) which is connected to MAG2 respectively, each AP1 and AP2 recognize each link-layer identifier of physical interface from the MN's attachments. In this case, the logical interface cannot send packet to corresponding nodes via AP1 and AP2 since AP1 and AP2 can recognize the associated link-layer identifier xxx and yyy of if_1 and if_2 only. It may send packet to corresponding nodes only if the AP1 and AP2 is placed in promiscuous mode. For example, if AP1 and AP2 is WLAN Access Point, AP1 and AP2 only recognize the link-layer identifier xxx of if_1 and yyy of if_2 respectively. If layer 2 frames come from the logical interface uses link-layer identifier zzz, the WLAN AP1 and AP2 cannot process these frame and discard them because only link-layer identifier xxx of if_1 and yyy of if_2 is associated with WLAN AP1 and AP2.

The corresponding node cannot send the packet to the MN via AP1 and AP2 because the global IP address is assigned to logical interface only. When the corresponding node sends NS message, the NA message will be sent by logical interface with link-layer identifier zzz, thus the NA message cannot be delivered through AP1 and AP2, which understands only each link-layer identifier of if_1 and if_2.

In this case, to find a nearby router the MN also send RS message via both if_1 and if_2. The MN can receive RA messages from both of these two interfaces. In case that the MN wants to send a unicast packet but does not know the neighbour's link-layer addresses, it will perform address resolution by sending NS messages through both if_1 and if_2. On receiving NS message, the corresponding node will send back NA message back to the MN through the path that it receives NS from. However, it is different with the first implementation method that the corresponding node cannot send NA message to MN through each AP1 and AP2 since the AP1 and AP2 may understand and accept only the NA message that carries the link-layer identifier of the if_1 and if_2. In case of the inverse direction, the corresponding node may send NS message to the MN through both direction. On receiving the NS message the logical interface at the MN will send NA reply message through the interface that it receives NS from. However the NA reply message sent via AP1 and AP2 may not be forwarded to the corresponding node.

If we want to implement the logical interface which is transparent from some specific access technologies (e.g., WLAN Access Point processes only layer 2 frame that the link-layer identifier is associated with itself), one of the possible approach is swapping the link-layer identifier of layer 2 frame between logical interface and physical interfaces. Some specific access technologies may need the real(original) link-layer identifier of physical interfaces and it is difficult to modify layer 2 Access Point to process the layer 2 frame that the link-layer identifier is not associated with itself.

B. The usage of multiple home network prefix on logical interface

As shown in Scenario 3, when multiple home network prefix are used, the basic feature of PMIPv6 is showing all of these multiple home network prefixes to IP layer. But if we want to fully utilize the multiplicity of home network prefix and dynamically change the home network prefix without session continuity, we need different approach. To consider Scenario 4, only one home network prefix is shown to IP host stack even though multiple home network prefix are used, we must extend the function of logical interface. If we utilize logical interface, it can hide the change of network interface from the host IP layer. If the logical interface supports the change of network interface and also the change of home network prefix, some typical application may fully utilize the multiplicity of home network prefix without the problem of session continuity. To hide the change of home network prefix, we can use the similar approach of NAT (Network Address Translation), where a public IP address is translated into multiple private IP address. In this approach, even though multiple home network prefix are allocated to a logical interface, the logical interface bypass only one typical home network prefix to IP layer and maintain the relationship between the one typical home network prefix and multiple home network prefixes.

V. CONCLUSIONS

Up to now, most studies related to multiple interfaces are focusing on finding best one interface among multiple interfaces. Recently, there have been activities of simultaneous utilization of multiple interfaces in IETF relevant working groups. But, to simultaneously use multiple interfaces, there are many problems to use existing communication protocols.

Basic PMIPv6 supports the usage of multiple interfaces of a mobile node and it aims to provide the support of the usage of multiple interfaces, but it is not efficient scheme. When a mobile node wants to simultaneous access to PMIPv6 domain during inter-handoff with multiple interfaces, basic PMIPv6 has a couple of problems. A logical interface is used to hide the interface change and it can be used to support inter-technology handoff and flow mobility. In this paper, we focus on describing the various usages of a logical interface in a multiple interface mobile node in a view point of link-layer identifier and multiple home network prefix in PMIPv6 domain and give some guidelines to implement of a logical interface for PMIPv6.

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