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T. Melia, Ed.  
Alcatel-Lucent  
S. Gundavelli, Ed.  
Cisco  
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Logical Interface Support for multi-mode IP Hosts  
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Abstract

A Logical Interface is a software semantic internal to the host operating system. This semantic is available in all popular operating systems and is used in various protocol implementations. The Logical Interface support is required on the mobile node operating in a Proxy Mobile IPv6 domain, for leveraging various network-based mobility management features such as inter-technology handoffs, multihoming and flow mobility support. This document explains the operational details of Logical Interface construct and the specifics on how the link-layer implementations hide the physical interfaces from the IP stack and from the network nodes on the attached access networks. Furthermore, this document identifies the applicability of this approach to various link-layer technologies and analyzes the issues around it when used in context with various mobility management features.

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## 1. Introduction

Proxy Mobile IPv6 [RFC5213] is a network-based mobility protocol. Some of the key goals of the protocol include support for multihoming, inter-technology handoffs and flow mobility support. The base protocol features specified in [RFC5213] and [RFC5844] allow the mobile node to attach to the network using multiple interfaces (simultaneously or sequentially), or to perform handoff between different interfaces of the mobile node. However, for supporting these features, the mobile node is required to be activated with specific software configuration that allows the mobile node to either perform inter-technology handoffs between different interfaces, attach to the network using multiple interfaces, or perform flow movement from one access technology to another. This document analyzes from the mobile node's perspective a specific approach that allows the mobile node to leverage these mobility features. Specifically, it explores the use of the Logical Interface support, a semantic available on most operating systems.

A Logical Interface is a construct internal to the operating system. It is an approach where a logical link-layer implementation hides a variety of physical interfaces from the IP stack. This semantic has been used on a variety of operating systems to implement applications such as Mobile IP clients [RFC6275] and IPsec VPN clients [RFC4301].

In the context of an access infrastructure providing network network-based mobility management services across a variety of access technologies, as provided by a Proxy Mobile IPv6 domain [RFC5213], a logical interface can be used to afford inter-technology handover, multihoming, and/or flow mobility without requiring from the mobile node IP stack specific support to that effect.

The rest of the document provides a functional description of a Logical Interface on the mobile node and the interworking between a mobile node using logical interface and network elements in the Proxy Mobile IPv6 domain when supporting the aforementioned mobility management features. It also analyzes the issues involved with this approach and characterizes the contexts in which such usage is appropriate.

## 2. Terminology

All the mobility related terms used in this document are to be interpreted as defined in Proxy Mobile IPv6 specifications, [RFC5213] and [RFC5844]. In addition, this document introduces the following terms:

PIF (Physical Interface) - a network interface card attached to an an host providing network connectivity (e.g. an Ethernet card, a WLAN card, an LTE interface).

LIF (Logical Interface) - It is a virtual interface in the IP stack. It appears just as any other physical interface, provides similar semantics with respect to packet transmit and receive functions to the upper layers in the IP stack. However, it is only logical construct and is not a representation of an instance of any physical hardware.

Sub-If (Sub Interface) - a physical interface that is part of a logical interface construct. For example, a logical interface may have been created abstracting two physical interfaces, LTE and WLAN. These physical interfaces, LTE and WLAN are referred to as sub-interfaces of that logical interface. In some cases, a sub-interface can also be another logical interface, such as an IPsec tunnel interface.

### 3. Hiding Link-layer Technologies - Approaches and Applicability

There are several techniques/mechanisms that allow hiding access technology changes or movement from host IP layer. This section classifies these existing techniques into a set of generic approaches, according to their most representative characteristics. Later sections of this document analyze the applicability of these solution approaches for supporting features such as, inter-technology handovers and IP flow mobility support for a mobile node in a Proxy Mobile IPv6 domain [RFC5213].

#### 3.1. Link-layer Abstraction - Approaches

The following generic mechanisms can hide access technology changes from host IP layer:

- o Link-layer Support - Certain link-layer technologies are able to hide physical media changes from the upper layers. For example, IEEE 802.11 is able to seamlessly change between IEEE 802.11a/b/g physical layers. Also, an 802.11 STA can move between different Access Points within the same domain without the IP stack being aware of the movement. In this case, the IEEE 802.11 MAC layer takes care of the mobility, making the media change invisible to the upper layers. Another example is IEEE 802.3, that supports changing the rate from 10Mbps to 100Mbps and to 1000Mbps. Another example is the situation in the 3GPP Evolved Packet System[TS23401] where a UE can perform inter-access handovers between three different access technologies (2G GERAN, 3G UTRAN, and 4G E-UTRAN) that are invisible to the IP layer at the UE.
- o A logical interface denotes a mechanism that that logically group/bond several physical interfaces so they appear to the IP layer as a single interface (see Figure 1). Depending on the type of access technologies, it might be possible to use more than one physical interface at a time -- such that the node is simultaneously attached via different access technologies -- or just to perform handovers across a variety of physical interfaces. Controlling the way the different access technologies are used (simultaneous, sequential attachment, etc) is not trivial and requires additional intelligence and/or configuration within the logical interface implementation. The configuration is typically handled via a connection manager, and based on a combination of user preferences on one hand, and operator preferences such as those provisioned by the Access Network Discovery and Selection Function (ANDSF) [TS23402] on the other hand.

### 3.2. Applicability Statement

We now focus on the applicability of the above solutions against the following requirements:

- o multi technology support
- o sequential vs. simultaneous access

#### 3.2.1. Link layer support

Link layer mobility support applies to cases when the same link layer technology is used and mobility can be fully handled at that layer. One example is the case where several 802.11 access points are deployed in the same subnet with a common IP layer configuration (DHCP server, default router, etc.). In this case the handover across access points need not to be hidden to the IP layer since the IP layer configuration remains the same after a handover. This type of scenario is applicable to cases when the different points of attachment (i.e. access points) belong to the same network domain, e.g. Enterprise, hotspots from same operator, etc.

Since this type of link layer technology does not typically allow for simultaneous attachment to different access networks of the same technology, the logical interface would not be used to provide simultaneous access for purposes of multihoming or flow mobility. Instead, the logical interface can be used to provide inter-access technology handover between this type of link layer technology and another link layer technology, e.g., between IEEE 802.11 and IEEE 802.16.

#### 3.2.2. Logical Interface

The use of a logical interface allows the mobile node to provide a single interface perspective to the IP layer and its upper layers (transport and application). Doing so allows to hide inter-access technology handovers or application flow handovers across different physical interfaces.

The logical interface may support simultaneous attachment, in addition to sequential attachment. It requires additional support at the node and the network in order to benefit from simultaneous attachment. For example special mechanisms are required to enable addressing a particular interface from the network (e.g. for flow mobility). In particular extensions to PMIPv6 are required in order to enable the network (i.e., the MAG and LMA) to deal with logical interface, instead to IP interfaces as current RFC5213 does. RFC5213 assumes that each physical interface capable of attaching to a MAG is

an IP interface, while the logical interface solution groups several physical interfaces under the same IP logical interface.

It is therefore clear that the Logical Interface approach satisfies the multi technology and the sequential vs: simultaneous access support.

#### 4. Technology Use cases

3GPP has defined the Evolved Packet System (EPS) for heterogeneous wireless access. A mobile device equipped with 3GPP and non-3GPP wireless technologies can simultaneously or sequentially connect any of the available devices and receive IP services through any of them. This document focuses on employing a logical interface for simultaneous and sequential use of a variety of access technologies.

As mentioned in the previous sections the Logical Interface construct is able to hide to the IP layer the specifics of each technology in the context of network based mobility (e.g. in multi-access technology networks based on PMIPv6). The LIF concept can be used with at least the following technologies: 3GPP access technologies (3G, LTE), IEEE 802.16 access technology, and IEEE 802.11 access technology.

In some UE implementations the wireless connection setup is based on creation of a PPP interface between the IP layer and the wireless modem that is configured with the IPCP and IPv6CP protocol [RFC5072]. In this case the PPP interface does not have any L2 address assigned. In some other implementations the wireless modem is presented to the IP layer as a virtual Ethernet interface.



## 5. Logical Interface Functional Details

This section identifies the functional details of a logical interface and provides some implementation considerations.

On most operating systems, a network interface is associated with a physical device that offers the services for transmitting and receiving IP packets from the network. In some configurations, a network interface can also be implemented as a logical interface which does not have the inherent capability to transmit, or receive packets on a physical medium, but relies on other physical interfaces for such services. Example of such configuration is an IP tunnel interface.

An overview of a logical interface is shown in Figure 1. The logical interface allows heterogeneous attachment while making changes in the underlying media transparent to the IP stack. Simultaneous and sequential network attachment procedures are therefore possible, enabling inter-technology and flow mobility scenarios.

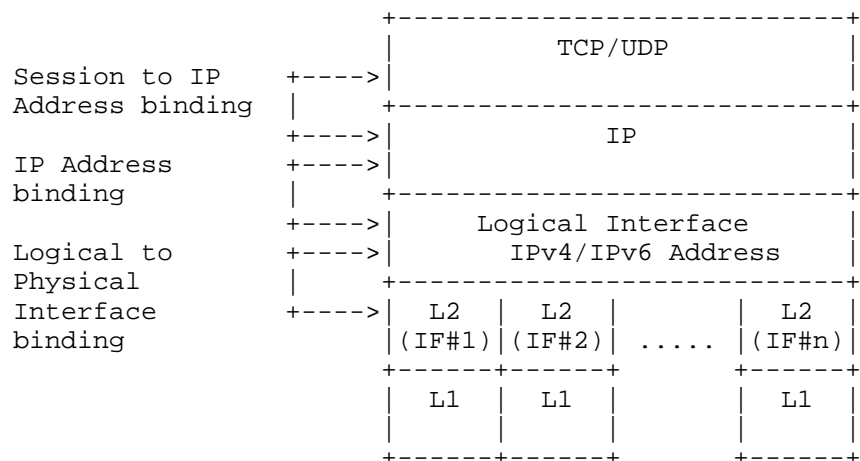


Figure 1: General overview of logical interface

From the perspective of the IP stack and the applications, a Logical interface is just another interface. In fact, the logical interface is only visible to the IP and upper layers when enabled. A host does not see any operational difference between a Logical and a physical interface. As with physical interfaces, a Logical interface is represented as a software object to which IP address configuration is bound. However, the Logical interface has some special properties which are essential for enabling inter-technology handover and flow-mobility features. Following are those properties:

1. The logical interface has a relation to a set of physical interfaces (sub-interfaces) on the host that it is abstracting. These sub-interfaces can be attached or detached from the Logical Interface at any time. The sub-interfaces attached to a Logical interface are not visible to the IP and upper layers.
2. The logical interface may be attached to multiple access technologies.
3. The Transmit/Receive functions of the logical interface are mapped to the Transmit/Receive services exposed by the sub-interfaces. This mapping is dynamic and any change is not visible to the upper layers of the IP stack.
4. The logical interface maintains IP flow information for each of its sub-interfaces. A conceptual data structure is maintained for this purpose. The host may populate this information based on tracking each of the sub-interface for the active flows.

#### 5.1. Configuration of a Logical Interface

A host may be statically configured with the logical interface configuration, or an application such as a connection manager on the host may dynamically create it. Furthermore, the set of sub-interfaces that are part of a logical interface construct may be a fixed set, or may be kept dynamic, with the sub-interfaces getting added or deleted as needed. The specific details related to these configuration aspects are implementation specific and are outside the scope of this document.

The IP layer should be configured with a default router reachable via the logical interface. The default router can be internal to the logical interface, i.e., it is a logical router that in turns decide which physical interface is to be used to transmit packets.

#### 5.2. Logical Interface Forwarding Conceptual Data Structures

The logical interface maintains the list of sub-interfaces that are part of the logical interface. This conceptual data structure is called as the LIF Table. The logical interface also maintains the list of flows associated with a given sub-interface and this conceptual data structure is called as the PIF Table. Both of these data structures have to be associated with a logical interface, and are depicted in Figure 2

LIF TABLE		FLOW table	
PIF_ID	FLOW RoutingPolicies	FLOW ID	Physical_Intf_Id
	Link Status		
PIF_ID	FLOW RoutingPolicies	FLOW_ID	Physical_Intf_Id
	Link Status		
....	....	....	....

Figure 2

The LIF table maintains the mapping between the LIF and each PIF associated to the LIF (refer to property #3, Figure 1). For each PIF entry the table should store the associated Routing Policies, and the Link Status of the PIF (e.g. active, not active). The method by which the Routing Policies are configured on the host is out of scope for this document.

The FLOW table allows the logical interface to properly route each IP flow over the right interface. The logical interface can identify the flows arriving on its sub-interfaces and associate them to those sub-interfaces. This approach is similar to reflective QoS performed by the IP routers. For locally generated traffic (e.g. unicast flows), the logical interface should perform interface selection based on the Flow Routing Policies. In case traffic of an existing flow is suddenly received from the network on a different sub-interface than the one locally stored, the logical interface should interpret the event as an explicit flow mobility trigger from the network and it should update the PIF\_ID parameter in the FLOW table. Similarly, locally generated events from the sub-interfaces, or configuration updates to the local policy rules can cause updates to the table and hence trigger flow mobility.

6. Logical Interface Use-cases in Proxy Mobile IPv6

This section explains how the Logical interface support on the mobile node can be used for enabling some of the Proxy Mobile IPv6 protocol features.

6.1. Multihoming Support

A mobile node with multiple interfaces can attach simultaneously to the Proxy Mobile IPv6 domain. If the host is configured to use Logical interface over the physical interfaces through which it is attached, following are the related considerations.

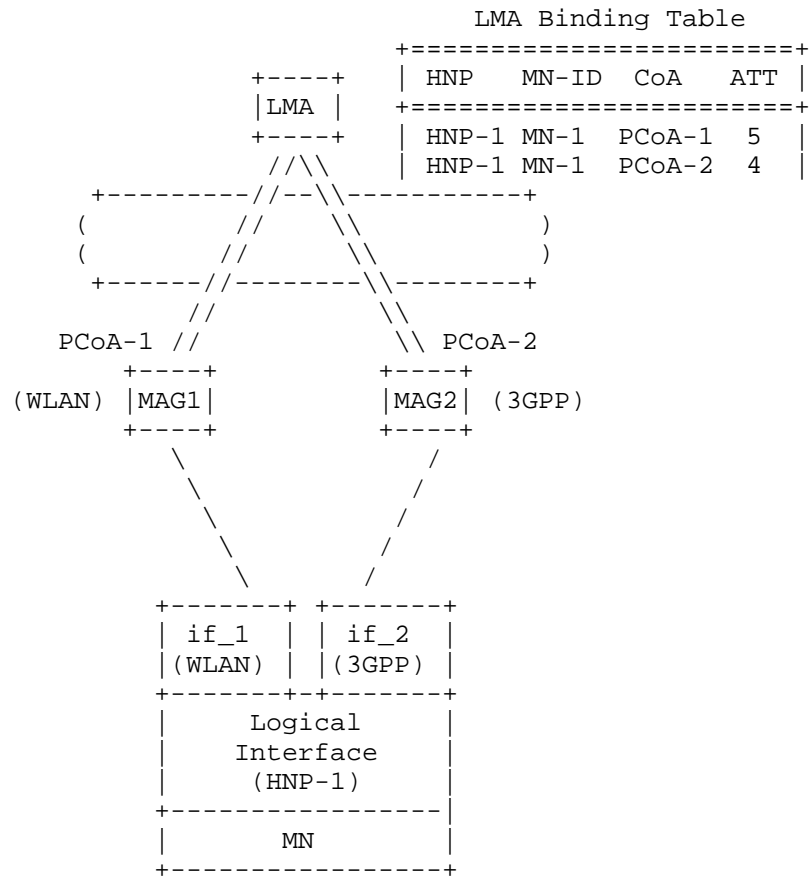


Figure 3: Multihoming Support

6.2. Inter-Technology Handoff Support

The Proxy Mobile IPv6 protocol enables a mobile node with multiple network interfaces to move between access technologies, but still retaining the same address configuration on its attached interface. The protocol enables a mobile node to achieve address continuity during handoffs. If the host is configured to use Logical interface over the physical interface through which it is attached, following are the related considerations.

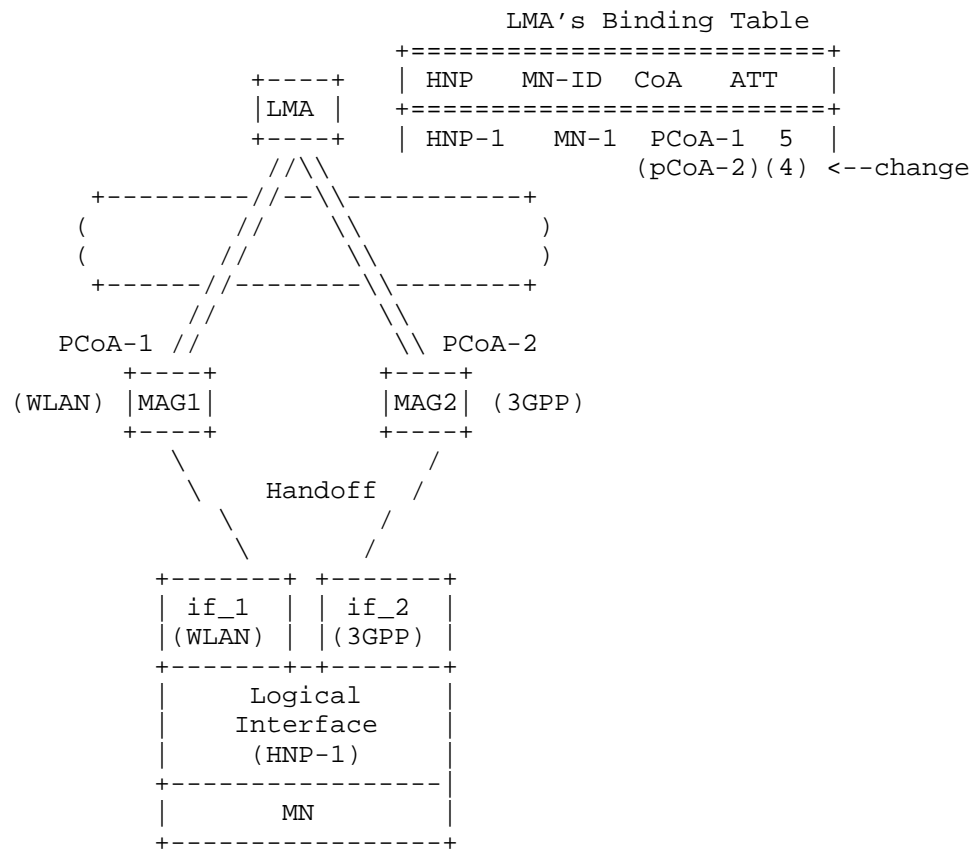


Figure 4: Inter-Technology Handoff Support

- o When the mobile node performs an handoff between if\_1 and if\_2, the change will not be visible to the applications of the mobile node.

- o The protocol signaling between the network elements will ensure the local mobility anchor will switch the forwarding for the advertised prefix set from MAG1 to MAG2.

### 6.3. Flow Mobility Support

For supporting flow mobility support, there is a need to support vertical handoff scenarios such as transferring a subset of prefix(es) (hence the flows associated to it/them) from one interface to another. The mobile node can support this scenario by using the Logical interface support. This scenario is similar to the Inter-technology handoff scenario defined in Section 6.2, only a subset of the prefixes are moved between interfaces.

Additionally, IP flow mobility in general initiates when the LMA decides to move a particular flow from its default path to a different one. The LMA can decide on which is the best MAG that should be used to forward a particular flow when the flow is initiated e.g. based on application policy profiles) and/or during the lifetime of the flow upon receiving a network-based or a mobile-based trigger.

## 7. IANA Considerations

This specification does not require any IANA Actions.

## 8. Security Considerations

This specification explains the operational details of Logical interface on an IP host. The Logical Interface implementation on the host is not visible to the network and does not require any special security considerations.



## 9. Authors

This document reflects contributions from the following authors (listed in alphabetical order):

Carlos Jesus Bernardos Cano

cjbc@it.uc3m.es

Antonio De la Oliva

aoliva@it.uc3m.es

Yong-Geun Hong

yonggeun.hong@gmail.com

Kent Leung

kleung@cisco.com

Tran Minh Trung

trungtm2909@gmail.com

Hidetoshi Yokota

yokota@kddilabs.jp

Juan Carlos Zuniga

JuanCarlos.Zuniga@InterDigital.com

Julien Laganier

jlaganier@JUNIPER.NET

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Authors' Addresses

Telemaco Melia (editor)  
Alcatel-Lucent  
Route de Villejust  
Nozay 91620  
France

Email: telemaco.melia@alcatel-lucent.com

Sri Gundavelli (editor)  
Cisco  
170 West Tasman Drive  
San Jose, CA 95134  
USA

Email: sgundave@cisco.com

