

# A Network Mobility Management Architecture for IPv4 and IPv6 Environments

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**Abstract.** The current design of Network Mobility(NEMO) basic protocols doesn't provide the compatibility between networks of different versions. However, we need the scheme supporting seamless mobility between IPv4 and IPv6 networks because the coexistence between the two networks is expected in future internet. So, in this paper, we propose a new architecture for the network mobility through a Tunnel Agent(TA) managing NEMO Tunnels when a Mobile Router(MR) moves from IPv6 to IPv4 networks.

## 1 Introduction

The transition technology between IPv4 and IPv6 is essential to deploy IPv6 successfully. And several standards about the transition technology like dual stack of stationary hosts, tunneling, and translator already were fixed in IETF NGTrans WG(Network Generation Transition Working Group). However, the protocol supporting the mobility like Mobile IPv6[1] and NEMO[2] does not guarantee session connectivity of nodes or mobile network nodes(MNN)[2] in the case of moving to IPv4 networks. Therefore, this paper proposes the scheme which can guarantee session connectivity by keeping a NEMO Tunnel through a Tunnel Agent(TA) when a mobile network including a Mobile Router(MR) moves to an IPv4 network. This paper is organized as follows. Section 2 introduces some related works. In section 3, we describe the operation of the TA and the MR. Then we show the result of performance evaluations in section 4. Finally, we conclude in section 5.

## 2 Related Works

The simplest mechanism for the transition between Mobile IPv4[3] and Mobile IPv6 is the dual stack structure[4]. But, when a terminal moves to other links, it needs to send a signal to the Home Agent(HA) of IPv4 and IPv6 networks to keep connectivity. Doors mechanism[5] suggests the method using a 'Doors Router' between IPv4 and IPv6 networks. In this mechanism, when an MR roams to an IPv4 network,

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an MNN carries tunneled packets of IPv4-IPv6-IPv6 to the HA. Then tunnel overhead increases additionally.

### 3 Proposed Architecture

In this paper, we focus on the proposal of an architecture which supports the NEMO basic protocol in an IPv6 network while moving to an IPv4 network. Figure 1(a) shows a new Tunnel Agent Information(TAI) option and a “V” flag in a Home Agent Address Discovery(HAAD) Request/Reply[3] messages that we proposed. These fields support the MR in the IPv6 network to discover a TA’s IPv4/IPv6 address, which is assumed to be known by a HA. If an MR moves to the IPv4 network, and wants to maintain session from the TA, it sets the “V” flag and sends the HAAD Request message by Anycast address. Then, the HA knows the tunnel end point address and responds the HAAD Reply message that includes the TAI option with the “V” flag to the MR. At this time, the TAI option must include the TA’s IPv4/IPv6 address necessarily, and MR must store this information. If the MR detects its movement in the IPv4 network, then the MR sends a BU message with the “V” flag to the HA in order to register the information. Figure 1(b) shows BU and BA message format having the “V” flag.

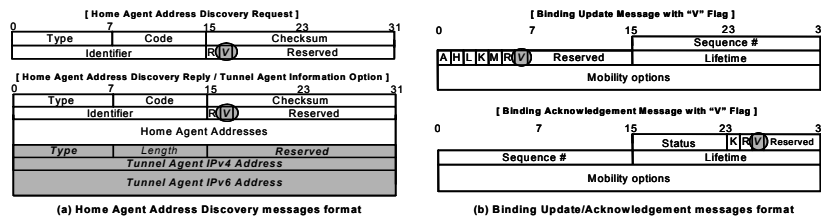


Fig. 1. New messages format

Figure 2 shows the process of home registration. In this paper, when the MR moves to the IPv4 it sends the BU message to the HA, its source address is decided by a tunnel end point’s IPv6 address which is known by the MR already. And the MR sends the encapsulated IPv4 header to the TA. At this time, an IPv4 protocol number in the BU header field must be 41 to inform that it is an IPv6 packet, source address is an MR’s IPv4 CoA, and destination address is a TA’s IPv4 address. After the TA receives the BU message, it decapsulates the IPv4 header and forward it to the HA. And the HA receives the BU from the TA and registers the MR’s CoA moving to the IPv4 network. This time, as the source address of the BU message is a TA’s IPv6 source address, the HA makes the MR’s IPv6 CoA address to the TA’s IPv6 address and updates the binding cache. HA sends all packets in the direction of the MR in IPv4 network to the TA. The reason is that CoA which is mapped to MR’s home address in binding cache has the TA’s IPv6 address.

In the network infrastructure, the TA is proposed to be implemented in the Border Router between IPv6 and IPv4 networks with a dual stack IPv4/IPv6 including several functionalities such as address translation, encapsulation, decapsulation, and tunnel cache to support the mobility between these two networks. When the MR including the MNN moves to an IPv4 network, it composes the IPv4 CoA and carries out the registration with the HA via the TA. In fact, an IPv4-IPv6 tunnel between the MR and the TA and an IPv6-IPv6 tunnel between the TA and the HA are then estab-

lished. If the MR moves to another link within an IPv4 network, only the TA-MR tunnel needs to be re-setup.

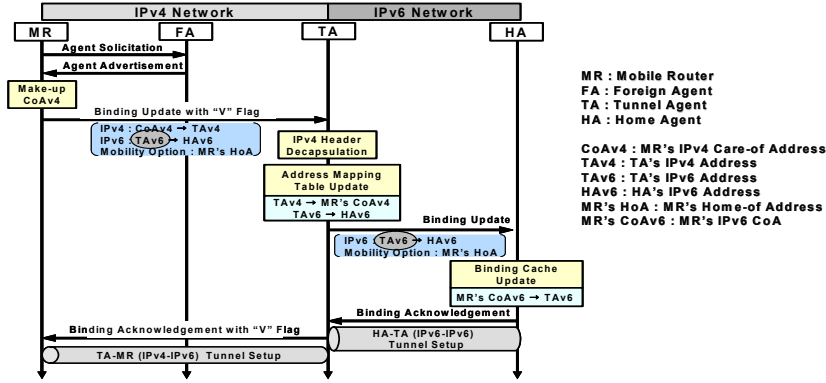
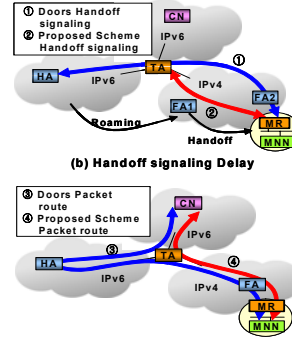


Fig. 2. Home registration process

#### 4 Performance Measures and Analysis

Symbol	Meaning	Value
$L_{CN-TA}$	IP header + payload length of the packet from CN to TA	
$L_{TA-HA}$	IP header + payload length of the packet from TA to HA	
$L_{HA-TA}$	IP header + payload length of the packet from HA to TA	
$L_{TA-FA}$	IP header + payload length of the packet from TA to FA	
$L_{FA-MR}$	IP header + payload length of the packet from FA to MR	
$L_{MR-MNN}$	IP header + payload length of the packet from MR to MNN	
$BW_{wired}$	Bandwidth of wired links	100 Mb/s
$BW_{wireless}$	Bandwidth of wireless links	11 Mb/s
$L_{wired}$	Propagation delay + link layer delay of wired links	0.5 ms
$L_{wireless}$	Propagation delay + link layer delay of wireless links	2 ms
$H_{6-H}$	Number of hops belong to HA's IPv6 Networks	
$H_{6-C}$	Number of hops belong to CN's IPv6 Networks	
$H_{4-M}$	Number of hops belong to MR's IPv4 Networks	

(a) Parameters for measuring performance



(c) The End-to-End Packet Delay

	Handoff Signaling Delay Performance Measurement	End-to-End Packet Delay Performance Measurement
Doors mechanism	① $HD = 2 \left( \frac{L_{FA-MR} \times H_{4-M}}{BW_{wired}} \right) + \left( \frac{L_{TA-HA} + L_{HA-TA}}{BW_{wired}} \right) \times H_{6-H} + 2 \left( \frac{L_{FA-MR}}{BW_{wireless}} \right) + 4L_{wired} + 2L_{wireless}$	③ $PD = \frac{L_{CN-TA} \times H_{6-C}}{BW_{wired}} + \left( \frac{L_{TA-HA} + L_{HA-TA}}{BW_{wired}} \right) \times H_{6-H} + \frac{L_{TA-FA} \times H_{4-M}}{BW_{wired}} + \frac{L_{FA-MR} \times L_{MR-MNN}}{BW_{wireless}} + 4L_{wired} + 2L_{wireless}$
Proposed mechanism	② $HD = 2 \left( \frac{L_{FA-MR} \times H_{4-M}}{BW_{wired}} \right) + 2 \left( \frac{L_{FA-MR}}{BW_{wireless}} \right) + 2L_{wired} + 2L_{wireless}$	④ $PD = \frac{L_{CN-TA} \times H_{6-C}}{BW_{wired}} + \frac{L_{TA-FA} \times H_{4-M}}{BW_{wired}} + \frac{L_{FA-MR} + L_{MR-MNN}}{BW_{wireless}} + 2L_{wired} + 2L_{wireless}$

(d) Performance Measurement

Fig. 3. Parameters, Network topology and scenario for delay evaluation

**Handoff Signaling Delay.** Figure 3(b) is the scenario which illustrates measuring the handoff delay value of an MR when it moves away from an HA. In Doors mechanism, the MR should communicate BU/BA messages with its own HA directly when it handoffs in an IPv4 network. But, in proposed scheme, a TA handles BU/BA messages in the case of handoff. So, it can be described as HD in Figure 3(d). And the

handoff delay is calculated by increasing the number of hops in an IPv4 network. As the graph in Figure 4(a) shows, we can expect faster handoff in the case of moving in an IPv4 network.

**Handoff Signaling Delay.** Figure 3(c) shows a scenario that an MNN moving to an IPv4 network communicates with a CN which is in the network including an HA and another IPv6 network. In Doors mechanism, the packet delay in the IPv6 network including the HA occurs because the MNN communicates with the CN through the HA. The proposed architecture forwards packets to an MR directly through the tunnel of a TA-MR without relaying to the HA. Therefore we can reduce the packet delay because the packet cannot be carried to the HA. And the procedure is shown as the formula like PD in Figure 3(d) and it measures the packet delay between CN and MNN by increasing the payload length. We can confirm that packet delay decreases as the payload length in Figure 4(b).

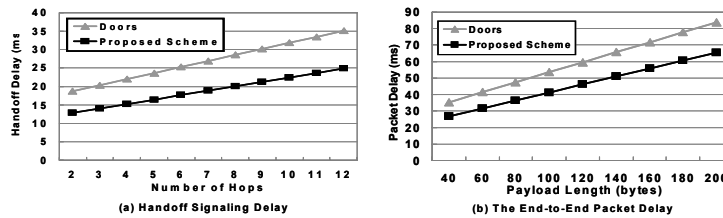


Fig. 4. Performance measures and analysis

## 5 Conclusion and Future Work

In this paper, we proposed a new mechanism for the mobility through a TA maintaining NEMO Tunnels when a MR moves from IPv6 to IPv4 networks. The tunnel overhead decreases by using an IPv4-IPv6 header through a TA-MR Tunnel. Also, additional binding messages decrease between HAs by registering to the TA. Results of performance measurement show that the proposed mechanism minimizes the handoff and the packet delay. The TA is used with 6to4, DSTM and NAT-PT. So, the TA supports transitions to mobile routers and mobile nodes as well as static hosts between IPv4 and IPv6 networks. In future work, we will implement and verify the proposed architecture of this paper.

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