http://dx.doi.org/10.7236/JIWIT.2012.12.3.171
JIWIT 2012-3-22

미래 LISP 망에서의 망 이동성 지원 방안

A Network Mobility Support Scheme in Future LISP Network

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요 약 최근 복수개의 단말을 가진 사용자들이 끊김없는 연결성을 유지하기 위한 망 이동성 지원에 관한 연구가 진행되어 왔다. 본 논문에서는 LISP 구조에서 망 이동성 지원 스킴을 제안하였다. 제안된 스킴에서 모바일 라우터 접속 동안에 맵 서버에서 EID-to-RLOC 매핑 데이터베이스가 리프레쉬(refresh)된다. 또한 이동 망을 위한 자연스런(smooth) 핸드오프를 지원하기 위한 맵 갱신 방법을 제안하였으며, 성능 분석을 위해 제안된 스킴을 NEMO와 비교하였다.

Abstract Network mobility support has been taken into consideration for users who have multiple terminals to enjoy the seamless connectivity. This paper proposes a network mobility support scheme in the LISP architecture. During the mobile router attachment, the EID-to-RLOC mapping database is refreshed in the map server. Furthermore, map update is developed to support smooth handoff for the mobile network. An analysis of performance is given by comparing the proposed scheme with NEMO.

Key Words : network mobility, Identifier Locator Split, mapping database, mapping update

Ⅰ. Introduction

With the advance of wireless access technologies and the growth of mobile devices, the mobile networks, such as a set of hosts, such as Personal Area Network (PAN), Car Area Network (CAN) and transportation system (e.g. bus, train and airplane) may move as a unit and change its point of attachment to the Internet, that is, network mobility. Network mobility enables all the nodes within a mobile network to provide session continuity without requiring their involvement when the mobile network moves.[1]

In the traditional Internet architecture, IP address is used as the semantic of both the endpoint identifier and locator. The overloading of IP address brings many problems, including mobility and routing scalability. It is commonly recognized that mobility is an essential component in the future network. In order to solve this problem, the Internet Engineering Task Force (IETF) has developed some IP-layer protocols such as Mobile IPv6 (MIPv6)[2] and Proxy Mobile IPv6[3] to support seamless connectivity for mobile hosts. In order to bring network mobility into practice, several schemes were proposed and evaluated. Network Mobility Basic Protocol (NEMO) is one of the typical solutions which are discussed under one IETF working group. However

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these solutions are mostly proposed for current Internet framework.

Since early 2007 the Routing Research Group (RRG) under Internet Research Task Force (IRTF) has been working on a scalable and robust global routing system. The IRTF RRG aims to design an alternative architecture to meet aforementioned challenges. A new IETF working group, Locator/ID Separation Protocol (LISP), has been actively working since 2009. LISP[4] is a network-based protocol to separate IP addresses into Endpoint Identifiers (EIDs) and Routing Locators (RLOCs). This protocol requires no changes to host protocol stacks and minor changes to existing database infrastructures. However, LISP is historically designed for 'static' network environment, lacking of the details for mobility support, especially network mobility support.[5]

Accordingly, this paper proposes a new effective scheme to support network mobility in the LISP architecture.[6] Upon attachment of a Mobile Router (MR), the ITR/ETR sends map register to the local map server[7] for extending the EID-to-RLOC mapping database through the binding between the mobile network prefixes (MNPs) and the ITR/ETR. Then the map server will broadcast itself as a 'gateway' for the access of the mobile network. Meanwhile, the ITR/ETR also adds a host route to the MNPs which indicates that the next hop for MNPs is the MR. A map update mechanism is developed by the ITR/ETR to support smooth handoff. The performance is given by comparing the proposed scheme with NEMO.

Our work and contributions can be generalized as:

- The proposed network mobility scheme in LISP network keeps the characteristic of the LISP intact, such as routing scalability.
- We firstly extend the EID-to-RLOC mapping database through the binding between the mobile network prefix (MNPs) and the ITR/ETR. Furthermore, the scheme provides network mobility support without requirement to the MR.
- In order to support smooth mobility, a map update mechanism is developed. Once the mobile network moves into a new domain, the path will be reestablished immediately.

The rest of this paper is organized as follows: Section II discusses the related networks. Section III describes the proposed network mobility support scheme in the LISP architecture in detail. The performance analysis by comparing with NMEO basic protocol is presented in Section IV. Finally, the conclusions are discussed in Section V.

II. Related Works

In this section, the network mobility solutions are discussed and a brief description of the LISP architecture is given.

1. Network Mobility Solution

As an extension of MIPv6 protocol, NEMO[8] is standardized by IETF to support the network mobility and provides continuous Internet connectivity to the mobile network nodes (MNNs) via the MR. The MR has one or more egress interface(s) and one or more ingress interface(s), acting as a gateway between the mobile network and the rest of the Internet. Thus, the MR needs to maintain the Internet connectivity for the entire mobile network.

Fig. 1 depicts the network mobility scenario. The network where MR and MNNs originally register when they are not moving is denoted as their home network. While the MR and MNNs are in their home network, the MR is assigned a home address (MR-HA) and MNNs configure their IP addresses with a common MNP. When the MR moves to a foreign network, it could be configured a care-of-address (CoA) after receiving the route advertising (RA) message from the internet access router (AR), and then informs the new CoA and MNP to its HA. The HA maintains two bindings (a binding between new CoA and MR-HA, and a binding between MNP and MR-HA) and a tunnel is established between MR-HA and MR.

The HA sends a Neighbor Advertisement message[9] to all-nodes multicast address on the home link to advertise the HA's own link-layer address for its IP address on behalf of the MNN. When packets destined for MNNs arrive at the home network, the MR-HA intercepts them and tunnels them to the MR's current location.

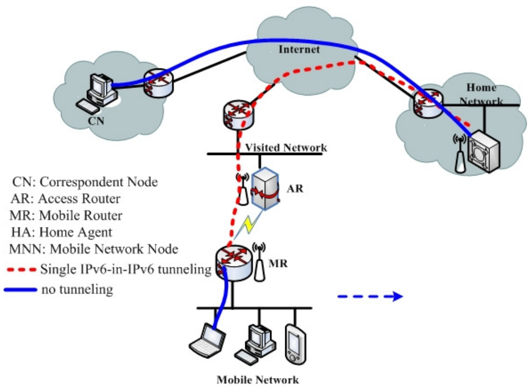

그림 1. 망 이동성 시나리오
Fig. 1. Network mobility scenario

2. LISP

Fig. 2 shows the architecture for the LISP network. It is mainly comprised of edge networks and core network. The edge networks provide network access to various end systems or hosts. They can be as dynamic as a wireless sensor network, ad hoc network, vehicular network, or moving network whose topology changes frequently due to mobility or intermittent connectivity. The edge networks are connected through one or more gateways to the core network. The core network can be regard as the transit network, which includes backbone routers to forward packets from the source edge network to the destination edge network. The backbone routers are ALT[10] routers which are also used by LISP to find EID-to-RLOC mapping. The ALT network is built using the Border Gateway Protocol (BGP)[11], the BCP multi-protocol extension, and the Generic Routing Encapsulation (GRE)[12] to construct an overlay network of devices (ALT Routers) which operate on EID-prefixes and use EIDs forwarding destinations.

One key benefit of LISP is that the hosts operate the same way as they do in current network end-system. The IP addresses that hosts use for tracking sockets, connections, and for sending and receiving packets can be kept intact. In LISP terminology, these IP addresses are called EIDs. Routers continue to forward packets based on IP destination addresses. When a packet is LISP encapsulated, these addresses are referred to as RLOCs. Most routers along a path between two hosts will not change; they continue to perform routing/forwarding lookups on the destination addresses. For routers between the source host and the ITR as well as routers from the ETR to the destination host, the destination address is an EID. For the routers between the Ingress Tunnel Router (ITR) and the Egress tunnel router (ETR), the destination address is an RLOC.[4]

The LISP network is a routing scalability networks. ID/Locator Separation has many advantages, including improved scalability of the routing system through greater aggregations of RLOCs and improved ingress traffic engineering.

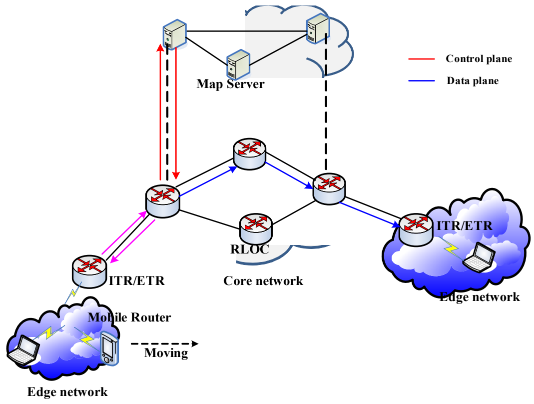

그림 2. LISP 망 구조
Fig. 2. Architecture of LISP network

3. Discussion

Although NEMO provides an approach to support network mobility, it remains has some problems, such as inefficient routing. In addition, the MR in NEMO is required to attend the mobility signaling procedure. On the contrary, LISP has many advantages which can be described as follows: (1) LISP supports routing scalability; (2) The anchor points in LISP architecture are distributed, and it can avoid the triangle routing problem; (3) The mobility support in LISP architecture is network-based, and it has no requirement to MR with the handoff function support, which is realized in the ITR/ETR. However, little attention has been focused on LISP with network mobility support. Therefore we propose a network mobility support scheme in LISP network.

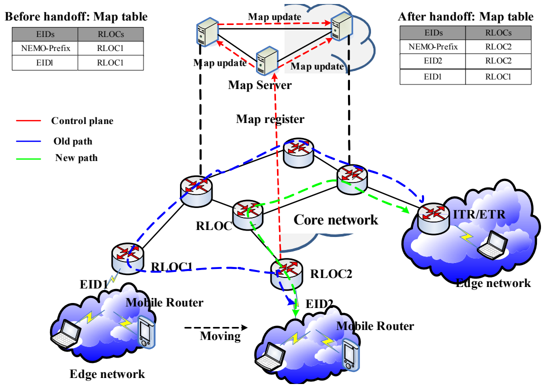

그림 3. LISP망에서의 제안된 망 이동성 지원 구조
Fig. 3. Architecture of the proposed network mobility support scheme in LISP network

III. Network Mobility Support Scheme in LISP Architecture

In this section, a network mobility support scheme in the LISP architecture is proposed in details.

1. Registration signaling procedure and communication initiation

Fig. 3 shows the architecture for the proposed network mobility support scheme in the LISP network. The mobile network connects to the Internet by the MR which acts as a gateway between the Internet and the mobile network. Whenever the MR attaches to the ITR/ETR, it should obtain a new locator from the ITR/ETR, which is marked as MR_EID. Then the MR should send a message to the ITR/ETR, and the message contains the MR_EID and MNP, as shown the step1 in Fig. 4. After receiving the MR's message, the ITR/ETR would do two things. First, the ITR/ETR would add a host route to the MNP which indicates that the next hop for MNPs is the MR. Second the ITR/ETR would send a Map-Register message to its local map server. The Map-Register message contains the MNP and MR_EID. Then the map server will broadcast itself as a 'gateway' for the access of the mobile network. Finally, the mapping database is extended to contain MNPs, as shown in Fig. 5.

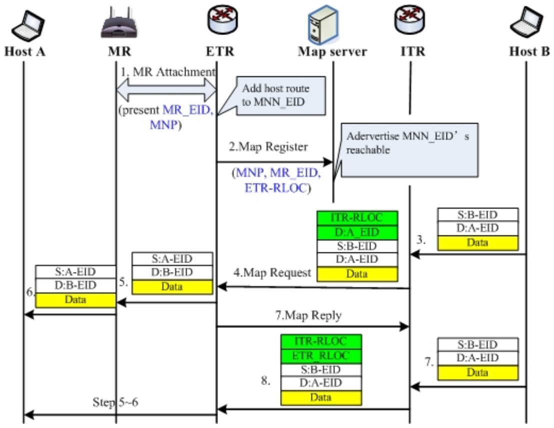

그림 4. 등록 신호 절차와 통신 초기화
Fig. 4. Register signaling procedure and communication initialization

RLOC	EID
RLOC1	MR_EID

RLOC	EID	EID
RLOC1	MR_EID	MNP

그림 5. LISP 망에서의 망 이동성 지원을 위한 맵 데이터베이스
Fig. 5. Map database in the proposed network mobility support scheme in LISP network

Let us use an example to illustrate how the scheme works. As shown in Fig. 3, the corresponding node (CN) wants to communication with MNN. CN sends packet to MNN first. After the ITR receiving the packet, it will search the MNN's EID-to-RLOC mapping in its local map cache. If it could not find, it would send an encapsulated Map-Request to the configured map server, here is the ETR1. The ETR1 would send back a Map-Reply which includes the MNN's EID-to-RLOC mapping. Thus when the ITR receives packets destined for the mobile network, it could find the EID-to-RLOC mapping in its local cache. Consequently, the traffic is delivered to ETR1 in the LISP encapsulated tunnel. The detailed procedure is shown in Fig. 4.

Since the old cache of an ITR/ETR cannot be updated immediately, these procedures can only guarantee the reachable of the MNN. For supporting smooth handoff, a map update procedure is proposed in the following section.

2. Handoff between different ITRs

When the mobile network moves into a new ITR/ETR, the MR would obtain a new MR_EID2 from the ETR2, as shown in Fig. 3. We propose a map update procedure to achieve smooth handoff. The handoff procedure is depicted in Fig. 6. Let us elaborate the procedure in two aspects: control plane and data plane. First in the control plane, whenever the new ITR/ETR receives the register message from the MR, it will send a Map-Register message to its local map server immediately. Through this message, the EID-to-RLOC mapping database is extended to contain the MNP. Then a map update message is sent to the previous ITR/ETR where the MR attached. Meanwhile, the ITR/ETR also adds a host route to the MNPs which indicates that the next hop for MNPs is the MR. After these steps, the path from a CN to the mobile network node will reestablish.

On the other hand, in the data plane, the path from a CN will be reestablished. However, the downstream packet from the CN to the MNN will not follow the shortest path. To solve this problem, a route optimization scheme is proposed as followed: After the mobile network has moved to a new domain, when its previous dwelling IRT/ETR receives the first packet from the corresponding node to the MNN, the ITR/ETR will send the new mapping update to the ITR/ETR which the CN attaches, as shown the step 7 in Fig. 6.

If the MNN sends upstream data packets to its CN firstly, when the ITR/ETR receives the first packet from the MNN, the new ITR/ETR will inform the new MNP-to-RLOC mapping to the ITR/ETR which the CN attaches. Once the corresponding ITR/ETR receives the new mapping, the path from the CN to the MNN will follow the optimal route.

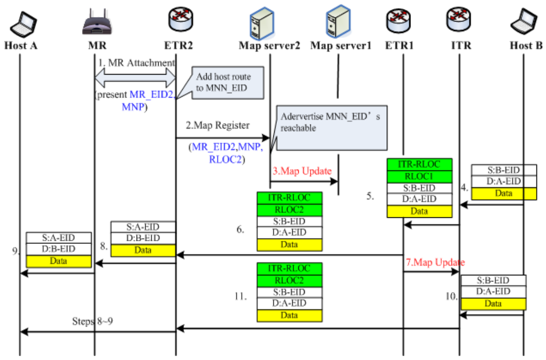

그림 6. 서로 다른 ITR/ETR사이의 이동망 핸드오버
Fig. 6. Mobile network handover between different ITR/ETR

IV. Performance Analysis

This section gives a handover latency analysis and compares the network mobility support scheme in LISP network with NEMO.

The analysis model is derived from Ping Dong.[13,14] From Ping Dong[13], MIPv6 handoff consists of three phases: movement detection, CoA acquisition and binding update. In general, an MN detects the movement by Routing Advertisement (RA) message. So the average handover latency of MIPv6 is:

$$E[t_{MIPv6\_handover}] = E[t_{MIPv6\_MD}] + E[t_{SOLI\_DELAY}] + \text{Retrans Timer} + t_{MIPv6\_BU} \quad (1)$$

Where $E[t_{MIPv6\_MD}]$, $E[t_{SOLI\_DELAY}]$, Retrans Timer and t_{MIPv6_BU} are the average delay of movement detection, the average delay of sending neighbor solicitation, the latency of waiting for response of neighbor solicitation message, and the latency for sending binding update, respectively.

In NEMO, the handover time of the mobile network is similar to that in MIPv6. Therefore,

$t_{NEMO\_handover} \approx E[t_{MIPv6\_handover}]$ (2)

In the proposed network mobility support in LISP network, the ITR/ETR is responsible for detecting the mobile network on its wireless link. Thus, its L3 handover has only the procedure of path reestablished, as shown in Fig. 7. However, because the MR does not participant the handoff procedure wholly, therefore

$t_{L3\_handover} < E[t_{MIPv6\_handover}]$ (3)

Therefore, the conclusion is $t_{L3\_handover} < t_{NEMO\_handover}$.

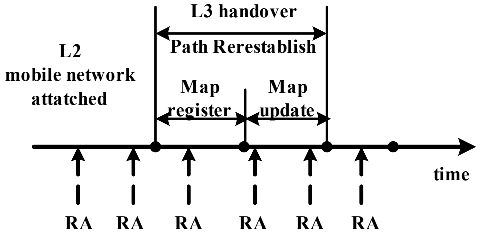

그림 7. 제안된 망 이동성 스킴의 LISP망 핸드오버 지연
Fig. 7. LISP network handover latency in the proposed network mobility scheme

The analysis of two schemes proceeds in terms of the following aspects: triangle routing problem, route scalability, the manner of anchor point deployed, MR's participant. The result of comparison is shown as Table 1. It is shown as follows:

- In NEMO, MR needs to participant in the handoff process by running MIP function[15]; however, the proposed scheme in the LISP network is network-based without special requirement to the MR.
- NEMO is an approach based on the current network; therefore it faces with the routing scalability problems, while the proposed scheme in the LISP network supports routing scalability by separating the IP addresses into EIDs and RLOCs.
- The manner of anchor point is centralized deployed in NEMO, while it is distributed in the proposed scheme in the LISP network.
- NEMO has the triangle routing problems, while it does not exist in the proposed scheme.

표 1. 성능 비교
Table 1. Performance comparison

	NEMO	LISP based network mobility support
MR's participant	Need MR's MIP function	Partially assist
Route scalability	Not support	Support
The manner of anchorpint deployement	Centralized	Distributed
Triangle routing	Exist	Not Exist

V. Conclusion

This paper proposes a network mobility support scheme in the LISP architecture. Through extending the EID-to-RLOC mapping database in the map server, the network can guarantee the seamless connectivity of the mobile network. Furthermore, map update is developed to support smooth handoff. Compared with NEMO approach, the proposed scheme in LISP network has the advantages of routing scalability and so on.

However, there are still some problems need to be solved in future. We will put our focuses on how to improve the fast handoff performance and multi-homing support and develop the simulation programs to evaluate the suggested mobility support scheme for quantitative comparison.

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