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ROHMIP : 이동망에서 확장된 HMIP를 적용한 경로 최적화

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ROHMIP : Route Optimization Employing HMIP Extension for Mobile Networks

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요 약

이동망지원프로토콜은 이동 라우터와 연결된 이동 노드들에게 망의 이동을 투명하게 함으로써, 위치 갱신 신호의 양을 감소시키지만, 최적화 되지 않은 경로선택과 다중 헤더를 요하는 문제점이 있다. 본 논문은 중첩된 이동 망 내에서 망의 이동에 따른 핸드오프의 지역화와 경로 최적화 그리고 특히 핸드오프 신호비용을 감소시키기 위하여 확장된 HMIP 기법을 적용한 경로 최적화 (ROHMIP) 기법을 제시한다. ROHMIP 기법에서 이동 망의 이동시 이동 라우터와 연결된 모든 이동망노드들(MNNs)을 대신하여 이동 라우터가 MAP에게 단지 자신의 바인딩 정보 갱신만을 통고한다. 따라서 이동망노드는 통신 노드에 위치갱신을 통보하지 않고 경로 최적화를 유지한다. 성능평가를 통하여 본 논문에서 제안된 기법이 전송지연, 핸드오프로 인한 지연과 신호의 양을 감소시킴을 보였다.

Abstract

Network Mobility Basic Support protocol reduces location-update signaling by making network movements transparent to the mobile nodes (MNs) behind the mobile router (MR), but causes some problems such as sub-optimal routing and multiple encapsulations. This paper proposes an Route Optimization Employing HMIP Extension for Mobile Networks (ROHMIP) scheme for nested mobile networks support which introduces HMIP concept with relation information between MNNs behind a MR and the MR in order to localize handoff, to optimize routing and especially reduce handoff signal overhead. With ROHMIP, a mobile network node (MNN) behind a MR performs route optimization with a correspondent node (CN) as the MR sends a binding update message (BU) to mobility anchor point (MAP) via root-MR on behalf of all active MNNs when the mobile network moves. This paper describes the new mechanisms and provides simulation results which indicate that our proposal reduces transmission delay, handoff latency and signaling overhead.

▸ Keyword : 이동 노드 (mobile node), 핸드오프 (handoff), 중첩된 이동 망 (nested mobile network), 경로최적화 (route optimization)

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Ⅰ. 서 론

The vast address space of IPv6 will enable mobile objects such as cars, trains, airplanes, or ships to carry an IPv6 network, in which many kinds of information devices can act as an IPv6 host having the IPv6 address. If at least one of the routers in the IPv6 network connects to a router on the Internet, any host in the IPv6 network can communicate with any host on the Internet.

the Network Mobility (NEMO) working group [1] of the Internet Engineering Task Force (IETF) has developed a conceptual architecture of a mobile network and a NEMO basic support protocol (NEMO Basic) [2] by extending the operation of the Mobile IPv6 (MIPv6) protocol [3].

A mobile network, which is composed of one or more IP subnets, moves as a single unit in the Internet topology [4]. It uses a MR as a gateway to provide Internet connectivity via an access router (AR) to the mobile network nodes (MNNs). The MNNs are categorized into three groups: local fixed nodes (LFNs), local mobile nodes (LMNs), and visiting mobile nodes (VMNs). The home addresses (HoAs) of the LFNs and LMNs are associated with the mobile network's IP subnet prefix, whereas the HoAs of the VMNs are associated with other networks. Therefore, a VMN arriving at a mobile network first configures a care-of address (CoA) from the mobile network's IP prefix and then registers the CoA with its HA. A VMN may represent a single host or a network itself, such as a PAN (personal area network), resulting in nested mobility. In the case of nesting, MRs belonging to each mobile network form a hierarchy, with the (upper) parent-MR providing connectivity to (lower) sub-MRs.

In NEMO Basic, MRs associate their CoAs with their network prefix in the binding update messages (BUs) sent to their HA This provides connectivity of a MR and consequently to each MNN in the MR's mobile network. A major drawback of NEMO is that all communications to and from the mobile network must go through the MR-HA tunnel. This results in extra overhead and high delays. Moreover, with nested mobile networks, the problem increases with each nested level. Outbound packets must go through the HAs of all MRs of higher levels before reaching their destination. This is known as the "pinball problem" and causes high delay. Another major drawback of these IP-in-IP encapsulations is related to overhead. Indeed, each nested level introduces additional overhead which in turn increases the network load and the risk of congestion.

To deploy this mobile IP service widely, the Hierarchal Mobile IPv6 (HMIP) technology [5] is also being studied in IETF. By adding a mobility anchor point (MAP) in a visited network to manage local mobility there, we can limit HAs to providing only global or inter-MAP mobility management. This technology lets us to avoid frequent locational registration of MNs with HAs, which may be a long way from the MNs, and to reduce the time required for handovers.

Rho et al. [9] proposed that a mobility management router (MMR) is allowed to update the binding information of all MNNs in a mobile network without getting BUs from the MNNs as the MMR receives a BU from the MR in the mobile network, which significantly reduces signaling overhead and amount of packet loss than conventional protocols. In addition, nodes outside the mobile network can send packets to a MNN inside the mobile network without adding a source routing header. Nevertheless, in the approach presented in this paper when a MR moves within nested mobile network, each lower MR within the MR's mobile network should wait for being allocated a delegated prefix from its upper MR.

In response to overcome some of aforementioned drawbacks, Our proposed scheme reduces the number of control messages and the handoff latency as it enables an MAP to just update the binding information for MNNs behind a MR, using a BU from the MR instead of the MNNs behind the MR when the

MR moves locally within the MAP domain. This scheme also enables packets to be optimally routed to MNNs in the mobile network via MAP. The remainder of this paper is organized as follows: Section 2 summarizes the related literature. Section 3 describes our proposed scheme on supporting network mobility. A performance evaluation of the proposed architecture and mechanisms is described in Section 4. Finally, in Section 5, we present some concluding remarks.

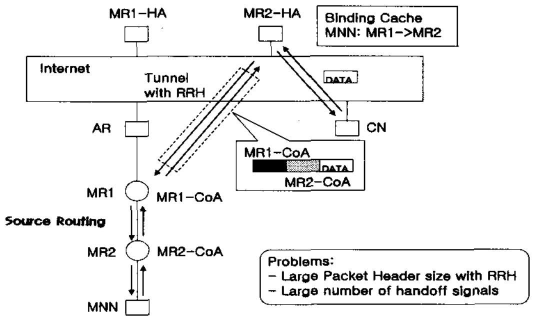

그림 1. 역 라우팅 헤더
Fig 1. Reverse Routing Header

II. Related Work

Route optimization is a mechanism that not only shortens the data delivery path between a MN and CN, but also reduces the potential level of encapsulation. Nevertheless, route optimization requires some route update signaling and/or additional information in the IP headers of data packets to enable packets to follow the optimal path and reach their destination intact. The generic consideration in designing a route optimization scheme is to use a minimum of signaling and/or additional information in the packet header.

Some solutions to the problems of route optimization in NEMO have been published [6-7].

2.1 Reverse Routing Header (RRH)

Thubert et al. [6] proposed the use of a new routing header, routing header (RH) type 4, also called a reverse routing header (RRH), for MNN-originated outbound packets, and a modified RH type 2 for inbound packets destined for MNN, as shown in Fig1. The RH type 4 collects the CoAs of all nested MRs, which are later included in the modified RH type 2 to reduce the number of nested encapsulations for inbound packets. This scheme, however, optimizes the path between the HA and the MR serving the MNN, not between the CN and MR. Moreover, it requires MRs to modify packet headers, which would increase computational overheads.

2.2 Prefix Delegation (PD)

K-J Lee et al. [7] proposed that PD protocols are enabled at the AR, the MRs, and the MNNs where they delegate a prefix to the MNNs attached under the nest, as shown in Fig2. When MNNs performs the route optimization, it uses the CoA generated from the prefix advertised with the PD protocols. Since this CoA is topologically correct, it allows to bypass the bi-directional tunnel established between the MR and its HA.

As these schemes require MNNs to configure their CoAs every time the network moves, it could possibly cause a binding implosion problem [8].

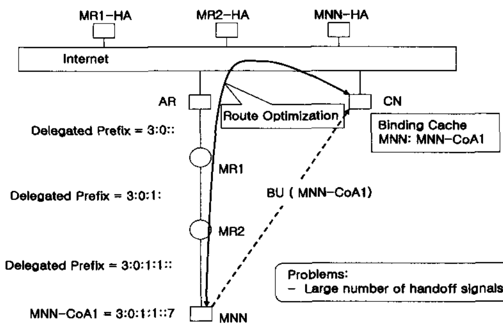

그림 2. 프리픽스 할당
Fig 2. Prefix Delegation

III. Proposed Route Optimization Scheme

We describe the operations of the ROHMIP scheme to provide the route optimization for a nested NEMO which has multiple levels of MRs.

3.1 Mobility Management

In our scheme, all MRs keep a binding cache, which we call MR-binding cache (MR-BC) for all the nested mobile routers behind them. Additionally, the MAP keeps another binding cache (MAP-BC) for all active MNNs that have ongoing communication sessions with CNs. The MR-BC is used to store binding between the local CoAs (LCoAs) of nested MRs and their mobile network prefixes (MNPs). As shown in Fig.3, when the sub-MR (MR3) attached to a parent-MR (MR2), MR3 sends a routing update message (RU) to MR2 to register the MR3's LCoA (MR3-LCoA) and the MR3's MNP (MNP3). MR2 use this information to forward a packet addressed to the MNN1-LCoA. Similarly, MR2 registers its LCoA and all mobile network prefixes (MNP2, MNP3) with MR1 by sending RU (MR2-LCoA, MNP2, MNP3). In other words, if a MR (MR3) detects the movement of its mobile network, it sends a RU to the parent-MR (MR2), containing the MR3's LCoA and MR3's MNP. Then, the parent-MR (MR2) updates its binding cache entry and resends the RU to its parent-MR (MR1) recursively.

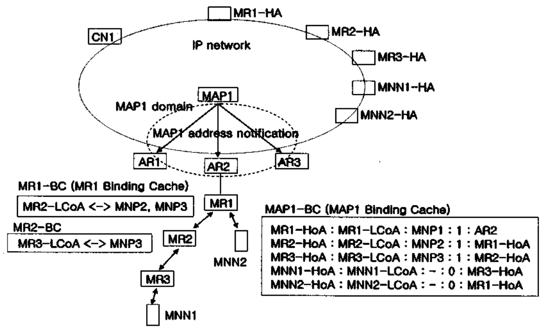

그림 3. 제안된 라우팅 기법을 설명하기 위한 중첩된 이동 망 구조
Fig 3. Nested Mobile Network Architecture for proposed routing method

At this time, the RU from the parent-MR (MR2) contains MR2-LCoA and MR2-MNP (MNP2), and sub-MR's MNP (MR3-MNP), with MR2-LCoA being used as next hop address for MR1 to send packets destined to MR2 or MR3. In conclusion, if a RU reaches the root-MR, the routing update procedure is completed. To localize handoff signals, reduce handoff latency time and support route optimization in this scheme, the MAP maintains binding information for all MNNs and MRs in its domain in its binding cache (MAP-BC). MAP-BC is composed of HoA, LCoA, MNP, MR/MNN, and parent-MR field as shown in Fig. 3.

Our proposed scheme applies the hierarchical location management method to a mobile network and manages the location of the mobile network and MNNs within it hierarchically. MAP1 periodically sends its address to ARs, which are connected as subordinates of MAP1. When root-MR (MR1) connects to AR2, MR1 sends a router solicitation message (RS) containing a request for MAP address and MNP. Next, AR2 sends a router advertisement message (RA) to MR1, containing MAP1 address and AR2-prefix. Then, MR1 creates its LCoA using AR2-prefix, sets MAP1 address as its regional CoA (RCoA). MR1 then sends a BU containing MR1-HoA, MR1-LCoA, MR1-MNP (MNP1), 1 (meaning a MR) and its parent MR (AR2) to MAP. MAP1 register the information to bind the MR1-LCoA and MR1-HoA, MR1-MNP, 1, and AR2. After this, MR1 sends a BU to its HA (MR1-HA) to register MAP1 address as its RCoA. Next, MR1 sends a RA to MNNs in its mobile network, containing MAP1 address and its MNP (MNP1).

Each MNN behind MR1 also detects new MAP address in the case where MR1 is already connected to AR2. The MNN (MNN2) creates MNN2-LCoA and its RCoA (MAP1 address) from the RA received from MR1. MNN2 sends a BU with MNN2-HoA, MNN2-LCoA, 0 (Not a MR) and its parent MR (MR1-HoA) to MAP1, and a BU containing the MAP1 address and MNN2-HoA to its HA (MNN2-HA). At this time, MAP1 caches the relation information to bind MNN2-HoA, MNN2-LCoA, 0 (Not a MR), and MR1-HoA. Other sub MRs and other MNNs in Fig. 3 could be applied the same procedures as above-mentioned method.

3.2 ROHMIP Routing Procedure

Our paper extends HMIPv6 to support nested NEMO. Fig. 4 shows the sequence of route optimization from CN1 to MNN1. MNN1 sends a BU to CN1 to register binding information that MNN1-RCoA is MAP1 address. On arrival of the BU, the CN1 creates a binding between the MNN1-HoA and MAP1 address mentioned in the alternate CoA option field. In this situation, CN1 can send packets destined to MNN1 via MAP1 using RH type 2. RH type 2 is an extension header defined in MIPv6. MAP1 checks the home address option (HAO) field of the RH type 2 header of an inbound packet to get the HoA of the MNN1 that the packet is addressed to. The MNN1's HoA (MNN1-HoA) is used to search for the corresponding LCoA (MNN1-LCoA) in the MAP1-BC. MAP1 encapsulates this packet with MNN1-LCoA after searching for it in its binding cache and transmits the packet to MNN1.

Similarly, MNN-oriented outbound packets have the MAP address and the address of the CN in the source and destination address fields, respectively. These packets are tunneled to the MAP using the MAP address as the destination address and the MNN-LCoA as the source address in the outer IP header. The MAP decapsulates and forwards the packet normally to the CN.

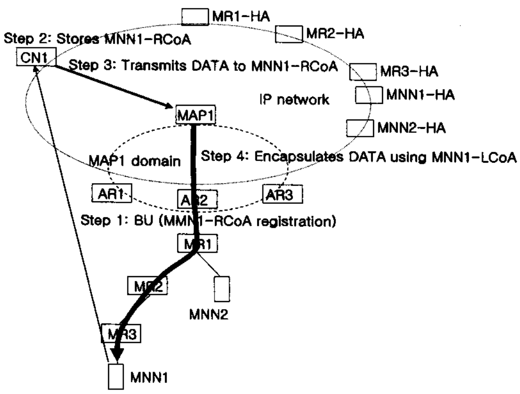

그림 4. 제안된 ROHMIP 스킴을 적용한 CN으로 부터의 경로 최적화를 위한 절차
Fig 4. Procedures - Optimization of the route from a CN in proposed ROHMIP scheme

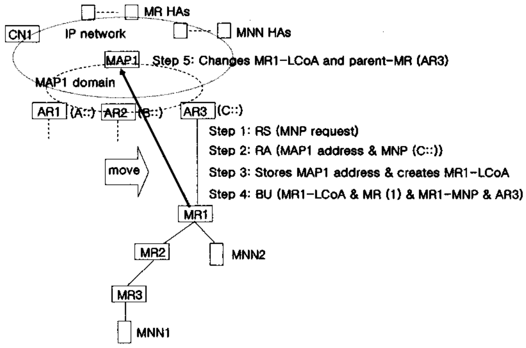

그림 5. 이동 망의 핸드오프
Fig 5. Procedures - Mobile Networks Handoff

Fig. 5 shows the procedure of mobile networks handoff within the same MAP1 domain where MR1 performs the handoff to a new link and configures a new LCoA. MR1 then sends a BU just to MAP1 containing its new LCoA and parent MR's address which is AR3. Then, MAP1 updates the LCoA and parent MR's address for MR1. The need to send BUs from each MNN within mobile networks managed by MR1 to MAP1 is eliminated like NEMO Basic. That means our scheme avoids increasing signaling volume due to handoff management. However, if the MAP address is changed, it is necessary to updates the MAP addresses of MNNs and sub-MRs within MR1's nested mobile network.

IV. Performance Analysis

We have evaluated ROHMIP, NEMO Basic, RRH, AHS [9], using network simulator 2 (NS-2) [10]. The simulation is performed using the network topology shown in Fig. 6.

In this network topology, an MR's mobile network can detect its movement due to the RA from different upper MR. The simulation time was seconds, and the date in the first 2 seconds was discarded because the network initializing procedure was executed during the time. We evaluated each scheme assuming 5, 10, and 100 MNNs in the mobile network.

The performance of our proposal is evaluated in terms of end-to-end packet delay, handoff latency and the number of handoff signals. All the parameters that are needed by the model can be seen in Table 1.

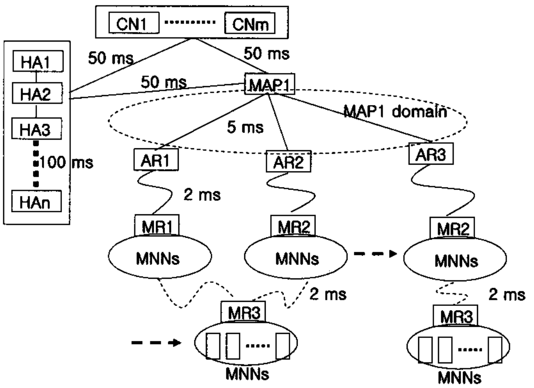

그림 6. 시뮬레이션을 위한 망 모델
Fig 6. Network Model for Simulation

표 1. 모의실험을 위한 매개변수
Table. I. Parameters for simulation

Specification for UDP communication
Application VoIP (G.729) Direction: CNs => MNNs Packet rate: 100 pps Packet size: 1500 bytes BU size: 112 bytes BACK size: 96 bytes
Handoff interval: 2 ms
L2 disconnection time: 20 ms
Processing time in the HA: 0.005 ms Processing time in the MAP: 0.003 ms Processing time in the router: 0.001 ms
Wired link: 100 Mbps tCN-HA, tHA-MAP, tCN-MAP: 50 ms tMAP-AR: 5 ms
Wireliss link (link delay): 11 Mbps (2 ms)

4.1 End-to-End Packet Delay

Packet transmission delay measurements from a CN to a MNN in the mobile network are depicted in Fig. 7. This is related to the reduction of the number of nested tunnels. Indeed, the proposed solution requires only a unique tunnel from MAP to MNN regardless of the number of nested levels in the mobile network. The packets, in NEMO Basic, must pass through multiple tunnels from the MNN to MN-HA. The packet transmission delay saving time between ROHMIP and RRH method is about 50 ms regardless of nesting level. RRH method is superior to NEMO Basic but is inferior to ROHMIP because of going through MNN-HA. ROHMIP and AHS offer similar levels of performance since both of optimize routing.

4.2 Handoff Latency

Handoff latency is the mean time from handoff initiation to completion. We assume that a mobile

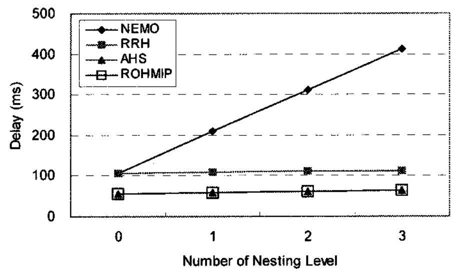

그림 7. 패킷 전송 지연
Fig 7. Packet Delivery Delay

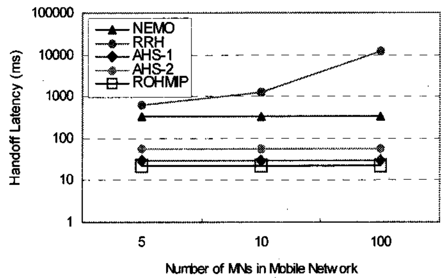

그림 8. 핸드오프 지연
Fig 8. Handoff Latency

network is assumed to move locally at nesting level 2 within MAP domain. The performance ration of ROHMIP to NEMO Basic is 0.07, regardless of the number of MNNs. If the MR-HA is located farther from the mobile network than was considered in this simulation environment, the degree of superiority of ROHMIP would increase. On the other hand, the performance of ROHMIP to RRH depends on the number of MNNs, e.g., 0.04 with 5 MNNs, 0.002 with 100 MNNs. This shows that ROHMIP has lower handoff latency than RRH. The superiority of ROHMIP over RRH is due to the fact that the BU destination is only the MAP in ROHMIP, compared to all CNs and all HAs in RRH. In short, ROHMIP is much better than RRH. Finally, both ROHMIP and AHS offer low handoff latency, in case that a mobile network moves locally at nesting level 2 within the MAP domain such as when MR3's mobile network performs a handoff between MR1 and MR2 in Fig. 6. AHS-1 in Fig. 8 shows the handoff latency of MR3 due to the handoff between MR1 and MR2.

However, when considering the handoff of a MR2's nested NEMO including MR3's mobile network within MAP1 domain, AHS has longer handoff latency compared to ROHMIP because MR3 have to wait to get a longer delegated prefix from MR2 by prefix delegation operations required in AHS after MR2 gets a delegated prefix. AHS-2 in Fig. 8 shows the handoff latency of MR3 due to the movement of upper MR (MR2) in Fig. 6. Thus, the handoff latency of lower MR in AHS increases dramatically compared to ROHMIP as the hop distance between the MR and its upper/ancestor MR increases when the upper/ancestor MR including the MR's mobile network moves.

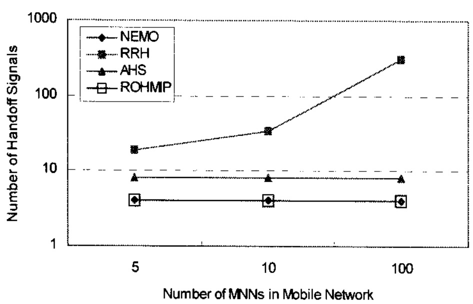

그림 9. 핸드오프 신호의 수
Fig 9. Number of Handoff Signals

4.3 Handoff Signals

The handoff signals are - RS, RA, BU and BACK [3]. Fig. 9 shows the number of handoff signals required in each scheme whenever handoff occurs. With regard to signaling overheads, both NEMO Basic and ROHMIP offer low and constant values, while AHS also offer low and constant values, added prefix delegation operation to them. On the other hand, in RRH, increasing the numbers of MNNs increases the number of handoff signals. If the number of MNNs is 100, ROHMIP provides about the same level of performance as NEMO Basic, while it requires about 300 fewer handoff signals than RRH.

V. Conclusion

The NEMO Basic provides advantages by reducing location update overheads. However, it has the side effect of increasing packet delivery overheads due to pinball routing and multi-layer encapsulation of data packets. To solve this problem, this paper has a new mobility management mechanism for optimizing the end-to-end route for MNNs/MRs within a nested mobile network environment. Furthermore, by extending MAP in HMIP with relation information between a MR and MNNs behind the MR and slightly changing in the implementation of the NEMO Basic in the local components of a mobile network such as MRs and MNNs, the proposed approach could provide more effective route optimization that would reduce the burden of location registration for handoffs. The ROHMIP enables a CN to forward packets directly to the MAP without any tunneling, which reduces packet delays and encapsulation overhead in the core network. It also reduces handoff latency and the volume of handoff signals. Our future subjects of study include investigating security issues between MRs and distributing the processing load by locating multiple MRs in a mobile network while retaining most of the predicted benefits.

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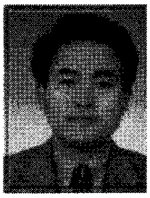
〈관심분야〉 wireless sensor networks, mobile communications, video communication



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