HMRA: Hierarchical Mobile Router Advertisement for Nested Mobile Networks

Hosik Cho, Eun Kyoung Paik, and Yanghee Choi
School of Electrical Engineering and Computer Science
Seoul National University, Korea
E-mail: hscho@mmlab.snu.ac.kr

Abstract *– This paper proposes Hierarchical Mobile Router Advertisement (HMRA) that manages hierarchy of the mobile routers in nested mobile networks. Nested mobile network contains mobile networks whose MR connected to the Internet via other mobile networks MR. Nested mobile networks have Router Advertisement (RA) confliction problem. In the nested mobile networks, a MR can receive the RA of a child MR as well as that of a parent MR. But the MR cannot distinguish which MR is its parent, i.e. intermediate MR to the Internet. To solve this RA confliction problem of nested mobile networks, this paper proposes hierarchical architecture of RA, HMRA. For the purpose of hierarchical management, we employ a field for age in the RA message. By setting the initial age of AR to max value and all MRs to zero, when new RA from the other MR is received, we can know the hierarchical relation by arranging the value of age field. The simulation result shows that a MR can recognize the RA from parent MR exactly. This scheme is essential for high degree nested mobile network to find a route toward the Internet, and reduces route set up time for frequent mobile networks.*

1. Introduction

In ubiquitous computing, electronic appliances usually have wireless communication capability with their own IP addresses. MobileIP Working Group in Internet Engineering Task Force (IETF) [1] proposed Mobile IP [2] to support mobility in IP networks. Mobile IP aims at maintaining transport or higher layer Internet connectivity while a host is moving.

Not only devices but also vehicles can be connected to the Internet [3]. Mobile devices can be connected to Internet even in vehicles. In addition, they can move in groups, e.g. a radio, a Personal Digital Assistants (PDA), and a mobile phone that belong to the same person can be organized together to form a Personal Area Network (PAN). Furthermore, PANs in a vehicle are also possible and this situation is referred to as a *nested mobile network*. Network Mobility (NEMO) working group in IETF [4] investigated this issue and extended the existing Mobile IP to support network mobility.

In the mobile network, the mobility of the entire network is viewed and managed as a single unit, which changes its point of attachment to the Internet through a mobile router (MR) [5]. A mobile network includes one or more mobile routers (MRs) that connect it to the global Internet. Mobile routers use Mobile IPv6 protocol to broadcast Router Advertisement message. Mobile Network Nodes (MNNs) under an MR can configure their address and know the connectivity to the MR by listening the RA. In the case of nested mobile network, MRs also use Mobile IPv6 RA mechanism to configure their address and connectivity.

Nested mobile networks contain MRs that are not directly attached to the Internet (i.e. connected to the Internet via another MR). Fig. 1 shows a simple illustration of nested mobile network. MRs have ingress and egress interfaces, and each interface can be wired or wireless. If an MR uses wired ingress interface, the RA of the MR is delivered to only nodes connected by wire. But if an MR uses wireless ingress interfaces, all nodes in its coverage receive the RA of the MR. So when a parent MR has wireless egress interface and a child MR has wireless egress interface, the parent MR can listen to the RA of the child MR. This situation can cause a problem called *RA confliction*, and to solve this problem this paper proposes the Router Advertisement mechanism called *Hierarchical Mobile Router Advertisement (HMRA)* for nested mobile networks.

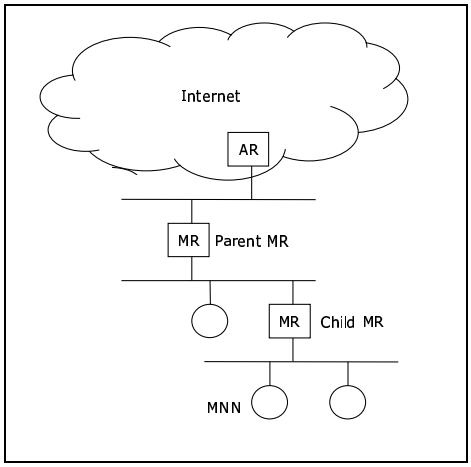

Fig. 1. A simple example of nested mobile network. One parent MR and one child MR compose two degree hierarchy of nested mobile network.

The rest of this paper is organized as follows. Section 2 introduces RA confliction problem of nested mobile network in detail and section 3 describes proposed hierarchy management scheme called Hierarchical Mobile Router Advertisement (HMRA). In Section 4, we search for the correctness of the proposed scheme when a mobile

* This work was supported in part by the Brain Korea 21 project of the Ministry of Education, and in part by the National Research Laboratory project of the Ministry of Science and Technology, 2003, Korea.

network moves into an arbitrary level of existing mobile network. Finally, Section 5 concludes this paper with further research work.

2. RA Confliction Problem

Mobile Routers (MRs) usually have ingress and egress interfaces. Especially when egress and ingress interfaces of an MR are both wireless, nested mobile networks have Router Advertisement (RA) confliction problem potentially. When MRs form nested mobile networks, an MR receives RA of the child MR as well as the parent MR for the open characteristics of wireless interface. But the MR cannot distinguish which MR is its parent. Fig. 2 shows the RA confliction problem of three degree nested mobile network. With existing RA scheme [6], MR2 receives both RAs of MR1 and MR3. So when MR2 receives the RA from MR3 earlier than the RA from MR1, MR2 may think it is under MR3 and forward its outgoing packets to MR3. In this situation if MR2 wants to send data to the outside of mobile network, the packets cannot be routed correctly.

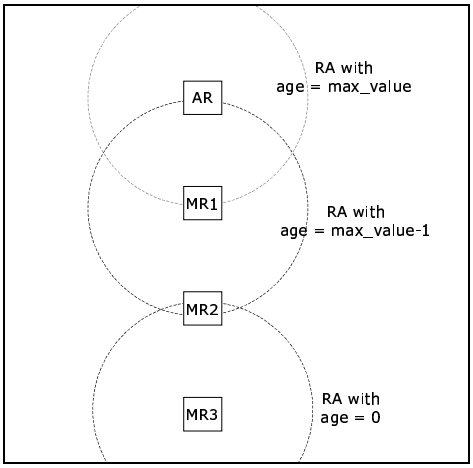

Fig. 2. RA confliction problem. Egress interface of MR2 can receive RA message of both MR1 and MR2. MR2 cannot decide which RA is from its parent MR.

RA confliction problem occurs since MRs and ARs broadcast RA messages simultaneously. Thus, additional information is needed in RA message for the management of hierarchy between MRs.

3. Hierarchical Mobile Router Advertisement

To solve the Router Advertisement (RA) confliction problem of nested mobile networks this paper proposes hierarchical architecture of RA, Hierarchical Mobile Router Advertisement (HMRA). HMRA is based on the information of hierarchy. For the purpose of hierarchical management, we employ a field for *age* in the RA message. Age is defined as decreasing value by the distance from Access Router (AR). Initially Access Router (AR) has age of maximum value and Mobile Routers have age of zero. In our scheme the maximum value of age means the maximum depth of hierarchy. When an MR receives an RA with an age value, the MR compares received age with its own age. So if the received age is less than or equal to its own age, the MR just ignores the RA. And if received age is bigger than its own age, the MR sets its own age to smaller age than the received age by one. So each MR can construct the parent-child relationship by using this age information.

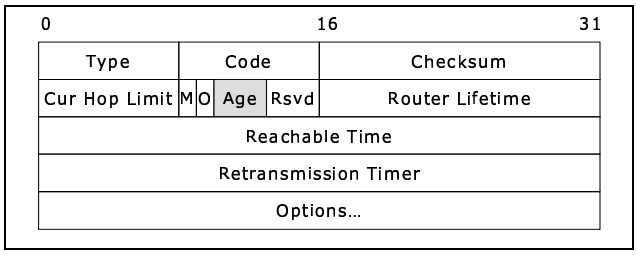

Fig. 3. RA message with age field. IPv6 RA message format is defined in RFC2461. This scheme uses three bit from reserved area for age information.

When an MR moved to other network, we can know the movement by the change of Care-of Address (CoA). So whenever an MR changes its point of attachment, the MR re-initializes its age to zero and re-calculates its age again using new RA. Fig. 3 shows the RA message format with age field and Fig. 4 shows the flow diagram of processing RA with age.

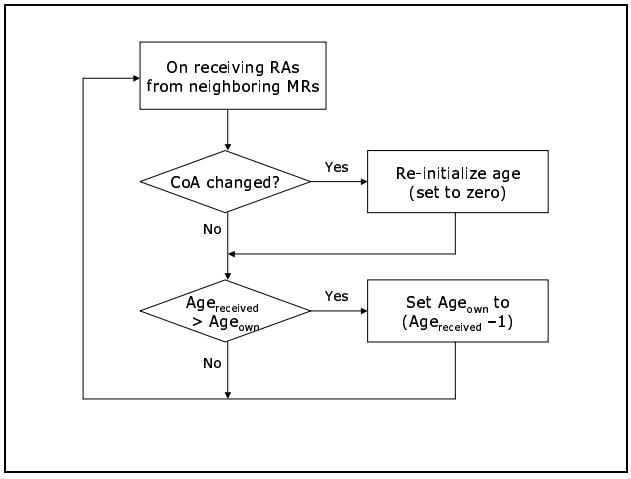

Fig. 4. Processing RA with Age. When CoA of MR is changed, MR set its age to zero. And when received age is bigger than its own age, MR set its age to smaller age than received age by one.

4. Hierarchy management with HMRA

HMRA is work not only when MRs form a nested mobile network, but also when a MR enters into an existing nested mobile network.

When an MR moves to the same level of other nested mobile network, the MR sets its age to zero and listens RA

from neighbor MRs. If the MR receives RA from the child MR before it receives from the parent MR, the MR thinks that the child MR is the parent. But after the MR receives RA of the parent MR, the MR corrects its age.

Fig. 5 shows the movement between the same levels. When (N)th level MR moves to (N)th level of other nested mobile network, the MR don't need to re-initialize or re-calculate its hierarchy information. In this case the MR receives RA from both parent MR and child MR, but the MR just set its parent from bigger aged RA.

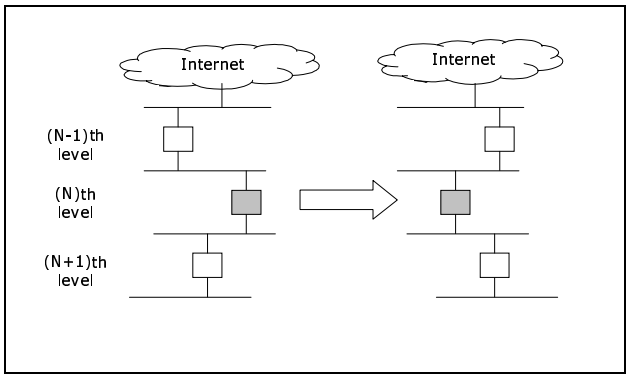

Fig. 5. The movement between the same levels of hierarchy. When (N)th level MR moves to (N)th level of other nested mobile network, the MR don't need to re-initialize or re-calculate its hierarchy information.

When an (N)th level MR moves to an (N-1)th level mobile network, the MR receives bigger or the same age of RA from neighbor MRs. In this case re-initializing of age is not necessary. The MR just ignores the RA of the same age and accepts the RA of bigger age and set its age to smaller age than received age by one. Fig. 6 shows the movement to an upper level mobile network.

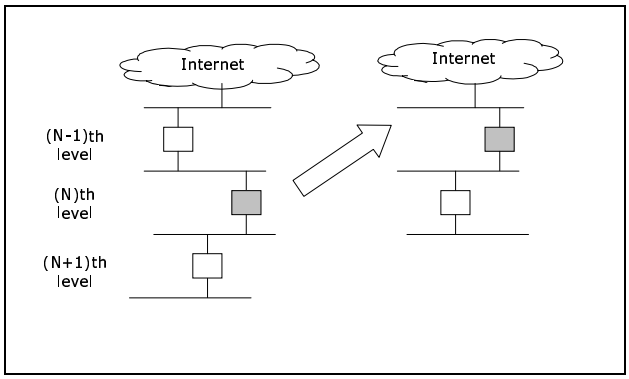

Fig. 6. The movement to an upper level mobile network. When (N)th level MR moves to (N-1)th level of other nested mobile network, the MR don't need to re-initialize its age but just re-calculate its age from bigger aged RA

When an (N)th level MR moves to an (N+1)th level mobile network, the MR sets its age to zero and listens to RA from the neighbor MRs. The next procedures are the same as the two cases above. Fig. 7 shows the movement to a lower level.

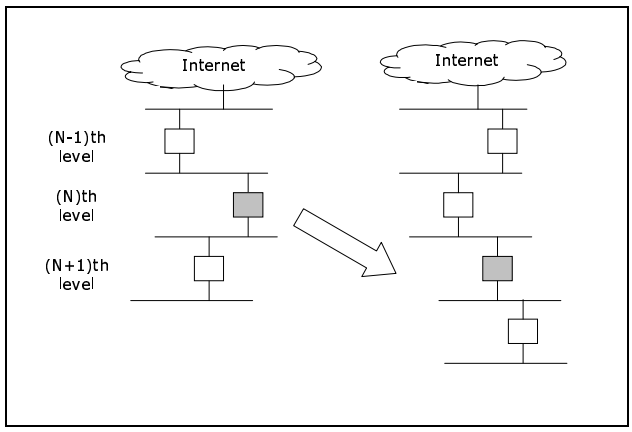

Fig. 7. The movement to an lower level mobile network. When (N)th level MR moves to (N+1)th level of other nested mobile network, the MR must re-initialize its age to zero and listen RA from neighbor MRs. The MR re-calculate its age from received ages.

Re-initializing process is necessary only when a MR moves to lower level of hierarchy but the MR don't know which level of hierarchy it moves. So whenever MR gets new CoA, performing re-initializing process is recommended.

5. Conclusion and Future work

With this proposed hierarchical RA scheme for nested mobile networks, Mobile Routers can decide the parent-child relationship without RA confliction problem. To implement this scheme it needs to modify RA message for the age field and RA procedures in MRs. By using this age information an MR can receive the RA from the parent MR and ignore the RA from the child MR. This scheme is helpful especially when the degree of nesting becomes higher and the movements between mobile networks more frequent. In our further research the received signal power will be parameterized and applied for deciding parent MR.

References

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