An Efficient Correspondent Registration to Reduce Signaling Overheads for Proxy Mobile IPv6

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Summary
This paper proposes an efficient correspondent registration mechanism to reduce the signaling overhead for the Proxy Mobile IPv6 (PMIPv6). In the proposed mechanism, the signaling overhead for the proxy home test via local mobility anchor (LMA) is eliminated in case of refreshments for the correspondent registration. Therefore, through the proposed mechanism, the burden of tunnels between mobility access gateways (MAGs) and LMA as well as LMA can be lessened. The performance of the proposed mechanism is analytically computed and simulated in view of the signaling overhead, which shows the proposed mechanism can enhance the existing mechanism.
Key words:
Proxy Mobile IPv6, Correspondent Registration, Signaling Overheads.

1. Introduction

In recent, the Proxy Mobile IPv6 (PMIPv6) is being standardized in Internet Engineer Task Force (IETF) [1][2]. This protocol to supporting mobility does not require the mobile node (MN) to be involved in the signaling required for mobility management. The mobility access gateway (MAG) in the network performs the signaling and does the mobility management on behalf of the MN. In the future, the PMIPv6 can be the L3 handover solution for wireless access networks.

When the MN moves and attaches to a new link connected to the new MAG in the PMIPv6 domain, the proxy care-of address (Proxy-CoA) is configured on the interface of the MAG and can be the transport endpoint of the tunnel between the MAG and the local mobility anchor (LMA). Through the *correspondent registration*, the MAG on behalf of MN, which is called the MAG_{MN}, provides information about their current location to the correspondent node (CN). In this correspondent registration, the return routability (RR) procedure is used for the CN to assure that Proxy Binding Updates (PBU) and Proxy Binding Acknowledgement (PBA) messages are exchanged with the right MAG_{MN}. Moreover, through the correspondent registration, the route optimization between the MAG_{MN} and the CN can be permitted, which means packets from the CN can be routed directly to the Proxy-CoA of the MN.

When the cached binding in CN is in active use but the binding's lifetime can be close to expiration after the correspondent registration for the handover, the CN sends the Proxy Binding Refresh (PBR) request to the MAG_{MN} to re-establish its binding with the MN. When the MAG_{MN} accepts the PBR request, the RR procedure including the proxy home test and the proxy care-of test is executed over again. And then, PBU and PBA are also performed over again. Therefore, the complete refreshment for the correspondent registration involves six message transmissions between the MAG_{MN} and the CN. This signaling overhead may be acceptable if refreshments are infrequent. However, higher refreshment causes more substantial signaling overhead. Therefore, if the one LMA is serving many MAGs and each MAG is also serving many MNs, the signaling overhead on tunnels between MAGs and LMA as well as on the LMA can be burdensome and affect on overall performance. These observations lead to the objective of the proposed correspondent registration to reduce the signaling overhead of a PMIPv6 as much as possible, in particular when the MN or the mobile CN does not move for a while.

Therefore, this paper proposes a new efficient correspondent registration mechanism to reduce signaling overheads for the PMIPv6. In the proposed mechanism, the signaling overhead for the proxy home test via LMA is eliminated in case of refreshments for correspondent registration. Therefore, through the proposed mechanism, the burden of tunnels between MAGs and LMA as well as LMA

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can be lessened. Finally, the performance of the proposed mechanism is analytically computed and simulated in view of the signaling overhead. Through the simulation result, the number of signaling messages with the proposed correspondent registration mechanism for PBR procedures is shown to be less than that with the existing mechanism. Therefore, when many MNs attach to the MAG_{MN} simultaneously and refresh correspondent registrations with their CNs, the performance superiority of the proposed mechanism might be more remarkable than one of the existing mechanism.

The paper is organized as follows. In Section 2, the problem statement is discussed. In Section 3, the new efficient correspondent registration mechanism is proposed. In Section 4, the performance of the proposed mechanism is analytically computed and simulated. Finally, conclusions are made in Section 5.

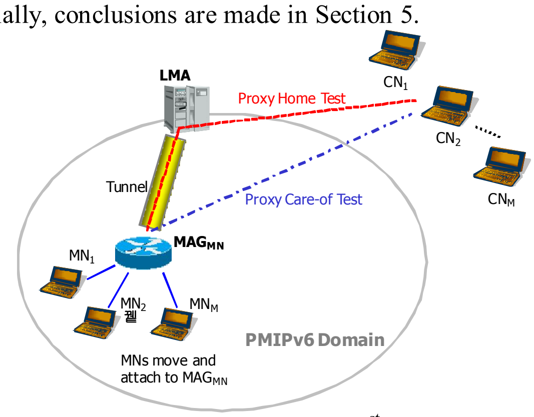

Figure 1. PMIPv6 Network (1st Scenario).

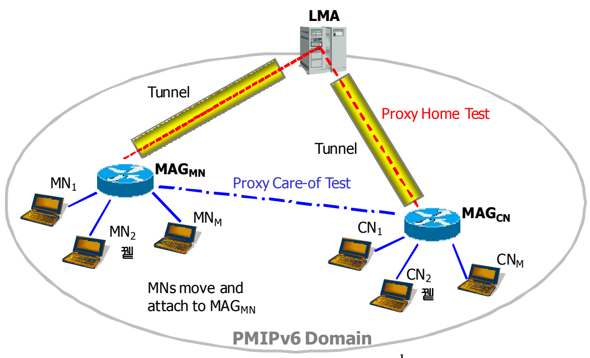

Figure 2. PMIPv6 Network (2nd Scenario).

2. Problem Statement

This paper considers the PMIPv6 based wireless access networks. As shown in Figure 1 and Figure 2, there are two scenarios according to the type of CN in PMIPv6 networks. The first scenario is that CNs have MIPv6 function and recognize PMIPv6 messages as shown in Figure 1. The second scenario is that CNs don't have MIPv6 function and are provided mobility support by PMIPv6 as shown in Figure 2. Thus, in the second scenario, the MAG on behalf of CN, which is called the MAG_{CN}, manages the mobility related signaling for CNs. For both scenarios, the MAG on behalf of MN, which is called the MAG_{MN}, manages the mobility related signaling for MNs.

When the MN moves and attaches to a new link connected to the new MAG (MAG_{MN}) in the PMIPv6 domain, the Proxy-CoA is configured on the interface of the MAG_{MN} and can be the transport endpoint of the tunnel between the MAG_{MN} and the LMA. The LMA views this address as the CoA of the MN and registers it in the binding cache entry (BCE) for that MN. The CN or the MAG_{CN} needs to verify the reachability of the Proxy-CoA as well as the MN's home address (MN-HoA). Thus, the MAG_{MN} provides information about MN's current location to the CN or the MAG_{CN}. This happens through the *correspondent registration*. In this correspondent registration, the RR procedure is used for the CN or the MAG_{CN} to assure that PBU and Proxy Binding Acknowledgement (PBA) messages are exchanged with the right MAG_{MN}. Moreover, through the correspondent registration, the route optimization between the MAG_{MN} and the CN or the MAG_{CN} can be permitted, which means packets from the CN or the MAG_{CN} can be routed directly to the Proxy-CoA of the MN.

When the cached binding in the CN or the MAG_{CN} is in active use but the binding's lifetime can be close to expiration after the correspondent registration for the handover, the CN or the MAG_{CN} sends the Proxy Binding Refresh (PBR) request to the MAG_{MN} to re-establish its binding with the MN. When the MAG_{MN} accepts the PBR request, the RR procedure including the proxy home test and the proxy care-of test is executed over again. The proxy home test message is sent through the tunnel between the MAG_{MN} and the LMA, and then the LMA intercepts and forwards it to the CN or the MAG_{CN}. On the other hand, the proxy care-of test message is sent directly to the CN or the MAG_{CN}, not sent via the tunnel and the LMA. Routes for these test messages are plotted in Figure 1 and Figure 2. And then, PBU and PBA are also performed over again. Therefore, the complete refreshment for the correspondent registration involves six message transmissions between the MAG_{MN} and the CN or the MAG_{CN}, which needs the signaling overhead totaling about 376 bytes [3]. This signaling overhead may be acceptable if refreshments are infrequent. However, higher refreshment causes more substantial signaling overhead. For example, the MAG_{MN} that refreshes the correspondent registration once every 3 minutes generates an average of 16.3 bits/s of signaling traffic if the MN communicates with a stationary CN. It increases if the CN is mobile. This signaling overhead may be negligible when the nodes communicate, but it can be an issue for MNs or CNs that are inactive and stay at the same location for a while. Moreover, this can be significant compared to a highly compressed multimedia stream. Therefore, if the one LMA is serving many MAGs and each MAG is also serving many MNs, the signaling overhead on tunnels between MAGs and LMA as well as on the LMA can be burdensome and affect on overall performance.

These observations lead to the objective of the proposed efficient correspondent registration mechanism to reduce the signaling overhead of the PMIPv6 as much as possible.

3. Main Works

The overall procedure of the proposed correspondent registration mechanism to reduce the signaling overhead in PMIPv6 networks is described as follows:

▪ STEP 0 (Correspondent Registration for Handover):

This step is performed only once when a MN's handover occurs. When the MN moves and attaches to the new MAG (MAG_{MN}), the MAG_{MN} hashes the tokens together to form a 20 octet binding management keys using data exchanged during the RR procedure. This binding management key protects the integrity and authenticity of the PBU to the CN or the MAG_{CN} using a keyed-hash algorithm. At this moment, the binding management key is denoted by Kbm_{PBU} and is computed by the MAG_{MN} as follows:

$$\text{Kbm}_{PBU} = SHA1(\text{Proxy Home Kgt}_{PBU} \mid \text{Proxy Care} - \text{of Kgt}_{PBU})$$

where the proxy home keygen token (Proxy Home Kgt_{PBU}) and the proxy care-of keygen token (Proxy Care-of Kgt_{PBU}) are computed and given by the CN or the MAG_{CN} as follows:

$$\text{Proxy Home Kgt}_{PBU} = First[64,\ HMAC\_SHA1(\text{Kcn}, (\text{MN} - \text{HoA} \mid \text{Nonce} \mid 0))]$$

and

$$\text{Proxy Care-of Kgt}_{PBU} = First[64,\ HMAC\_SHA1(\text{Kcn}, (\text{Proxy} - \text{CoA} \mid \text{Nonce} \mid 1))].$$

In case of the 1st scenario of Figure 1, the correspondent registration procedure is performed between the MAG_{MN} and the CN. On the other hand, in case of the 2nd scenario in Figure 2, the correspondent registration procedure is performed between the MAG_{MN} and the MAG_{CN}.

▪ STEP 2 (Correspondent Registration for Refreshment):

When the cached binding in the CN or the MAG_{CN} is in active use but the binding's lifetime can be close to expiration after the correspondent registration for the handover in STEP 1, the PBR request is used by the CN or the MAG_{CN} to request the MAG_{MN} to re-establish its binding with the MN. When the MAG_{MN} accepts the PBR request, it sends the Proxy Care-of Test Init (PCoTI) message to the CN (in case of the 1st scenario) or the MAG_{CN} (in case of the 1st scenario) for the RR procedure. Then, the CN or the MAG_{CN} generates the proxy care-of keygen token for the PBR, called the Proxy Care-of Kgt_{PBR}. Then, the Proxy Care-of Test (PCoT) message including the Proxy Care-of Kgt_{PBR} is sent in response to a PCoTI message directly to the MAG_{MN}.

$$\text{Proxy Care-of Kgt}_{PBR} = First[64,\ HMAC\_SHA1(\text{Kcn}, (\text{Proxy} - \text{CoA} \mid \text{Kbm}_{Previous} \mid \text{Nonce} \mid 1))]. \quad (1)$$

After the proxy care-of test in the RR procedure, the MAG_{MN} hashes the tokens together to form a 20 octet binding management keys for PBR, called the Kbm_{PBR}, as follows:

$$\text{Kbm}_{PBR} = SHA1(\text{MN-HoA} \mid \text{Proxy-CoA} \mid \text{Proxy Care} - \text{of Kgt}_{PBR} \mid \text{Kbm}_{Previous}). \quad (2)$$

Then, this binding management key, Kbm_{PBR}, protects the integrity and authenticity of PBU and PBA between the MAG_{MN} and the CN or the MAG_{CN} using a keyed-hash algorithm.

At the first PBR procedure, $Kbm_{Previous}$ in (1) and (2) is set by Kbm_{PBU}, which is obtained from the MAG_{MN} through the correspondent registration for the handover in STEP 1. After then, it is the value obtained from the MAG_{MN} through the correspondent registration for the previous refreshment.

For the next PBR to refresh the correspondent registration, the proposed mechanism performs the STEP 2 again. When the MN moves and is attached to the new MAG, the proposed mechanism performs the STEP 1 again.

Therefore, in the proposed mechanism, the signaling overhead for the proxy home test via LMA is eliminated in case of refreshments for correspondent registration. Therefore, through the proposed mechanism, the burden of tunnels between MAGs and LMA as well as LMA can be lessened. In addition, as shown in STEP 2, the binding management key for PBR, Kbm_{PBR}, is computed from parameters such as MN-HoA, Proxy-CoA, Proxy Care-of Kgt_{PBR}, $Kbm_{Previous}$, which are also used for the existing correspondent registration in [2]. Therefore, the proposed mechanism supports the same security level with the existing correspondent registration mechanism.

4. Performance Analysis

When the MN moves and attaches from one link connected to the previous MAG to another link connected to the new MAG, and then the MN does not move again in a given duration D, the number of signaling messages can be computed for PBR procedures between the MAG_{MN} and the CN or the MAG_{CN} with lifetime is T.

With PBR procedures in the existing correspondent registration mechanism, the number of signaling messages between the MAG_{MN} and the CN or the MAG_{CN} can be computed as following:

$$N_{Existing} = 6 * \frac{D}{T}.$$

On the other hand, with PBR procedures in the proposed correspondent registration mechanism, the number of signaling messages between the MAG_{MN} and the CN or the MAG_{CN} can be computed as following:

$$N_{Proposed} = 6 + \left(\frac{D}{T} - 1\right) * 4 = 2 + 4 * \frac{D}{T}.$$

Therefore, the number of signaling messages between the MAG_{MN} and the CN or the MAG_{CN} with the proposed mechanism for PBR procedures is less than that with the existing mechanism. When the value of lifetime is $T = 60\text{sec}$ in a given duration $D = 600\text{sec}$, the number of signaling messages between the MAG_{MN} and the CN or the MAG_{CN} for the complete PBR procedure is reduced about 30% with the proposed mechanism as shown in Figure 3. Therefore, when many MNs attach to the MAG_{MN} simultaneously and refresh proxy binding with their CNs or MAG_{CN} as shown in Figure 1 and Figure 2, the performance enhancement of the proposed mechanism might be more remarkable than one of the existing mechanism.

5. Conclusions

In this paper, the efficient correspondent registration mechanism has been proposed to reduce the signaling overhead for the PMIPv6. In the proposed mechanism, the signaling overhead for the proxy home test via LMA has been eliminated in case of refreshments for correspondent registration. Therefore, through the proposed mechanism, the burden of tunnels between MAGs and LMA as well as LMA can be lessened. The performance of the proposed mechanism has been analytically computed and simulated in view of signaling overhead. Through the simulation result, the number of signaling messages with the proposed correspondent registration mechanism for PBR procedures has been shown to be less than that with the existing mechanism.

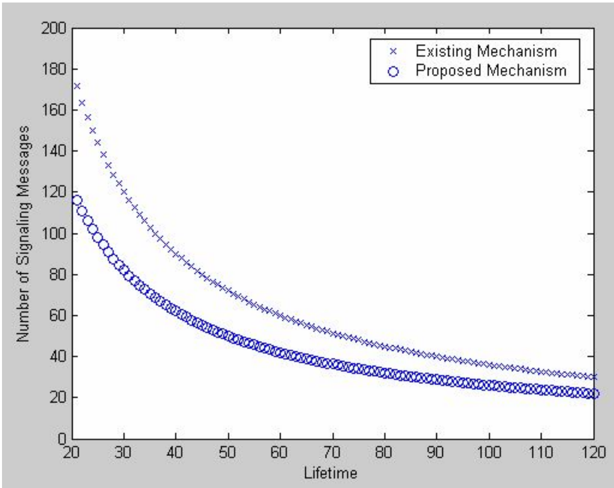

Figure 3. Comparison of Number of Signaling Messages

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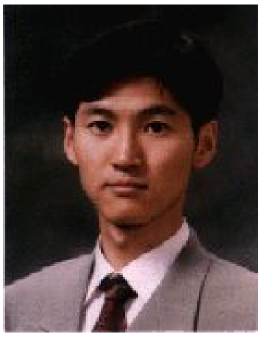

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