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Abstract

- Starting by showing the validity of a network-based approach
- MIPv6 (host based) vs. PMIPv6 (network-based)
  - qualitative and quantitative analyses
- Comparison among the various existing well-known mobility support protocols
- It is strongly expected that PMIPv6 will be a promising candidate solution for realizing the next-generation all-IP mobile networks.
All-IP mobile networks

- expected to combine the Internet and telecommunication networks
- networks in which IP is employed from a mobile subscriber to the access points (APs) that connect the wireless networks to the Internet.
One of the most important and challenging issues for next-generation all-IP mobile networks is mobility management.

Mobility management enables the serving networks to:

- Location management
- Handover management
Introduction

- **Mobile IPv6**
  - One of the most representative efforts on the way toward next generation all-IP mobile networks.
  - Handover latency, Packet loss, Signaling overhead
  - Not appear to receive widespread acceptance in the market

- **Proxy Mobile IPv6 (PMIPv6) is**
  - Being actively standardized by the IETF NETLMM working group
  - Expected to expedite the real deployment of IP mobility management.
Why Network-based Mobility Management?

**MIPv6 and MIPv4**
- Have been standardized for supporting host-based mobility on the Internet
- Utilize two IP address
  - HoA: represents the fixed address of a mobile node
  - CoA: changes with the IP subnet to which an MN is currently attached.
- Fundamental architectural aspects: same concept
- The role of the foreign agent in MIPv4 was replaced by AR in MIPv6.
MIPv6 and its various enhancements
- basically require protocol stack modification of the MN in order to support them.
- the requirement for modification of MNs may cause increased complexity on them.

network-based mobility management approach such as PMIPv6,
- the serving network handles the mobility management on behalf of the MN
- MN is not required to participate in any mobility-related signaling.
Compared to MIPv6 and its enhancements, PMIPv6 has the following salient features and advantages.

- **Deployment perspective**
  - not require any modification of MNs. Be expected to accelerate the practical deployment of PMIPv6.

- **Performance perspective**
  - the serving network controls the mobility management on behalf of the MN. So message can be reduced.

- **Network service provider perspective**
  - that is not dependent on any access-technology-specific protocol, so it could be used in any IP-based network.
The design goals the IETF NETLMM working group aims to cover are very extensive. The primary features of such goals are as follows:

- Support for unmodified MNs
- Support for IPv4 and IPv6
- Efficient use of wireless resources
- Link technology agnostic
- Handover performance improvement
Once an MN enters its PMIPv6 domain

- performs access authentication,
- serving network ensures that the MN is always on its home network and can obtain its HoA on any access network.
- the serving network assigns a unique home network prefix to each MN, and conceptually this prefix always follows the MN wherever it moves within a PMIPv6 domain.
- From the perspective of the MN, the entire PMIPv6 domain appears as its home network.
- It is needless to configure the CoA at the MN.
Overview of PMIPv6

- The new principal functional entities
  - mobile access gateway (MAG)
    - Runs on the AR
    - Detect MN’s movements and initiate mobility-related signaling with the MN’LMA on behalf of the MN.
    - Establishes a tunnel with LMA for enabling the MN to use an address from its home network prefix and emulates the MN’s home network on the access network for each MN.
Overview of PMIPv6

- local mobility anchor (LMA).
  - Similar to the HA in MIPv6
  - Main role: maintain reachability to the MN’s address while it moves around with in a PMIPv6 domain.
  - Includes a binding cache entry for each currently registered MN. more extended than that of the HA in MIPv6
    - the MN-Identifier, the MN’s home network prefix,
    - a flag indicating a proxy registration, the interface identifier of the bidirectional tunnel between the LMA and MAG.
  - Such information associates an MN with its serving MAG, and enables the relationship between the MAG and LMA to be maintained.
Overview of PMIPv6

Figure 1. Overview of PMIPv6.
Figure 2. Message flow in PMIPv6.
Message flow of MIPv6

MN

Router Solicitation

Router Advertisement

CoA DAD

BU

AR

BAck

forward packets

HA

CN

Home Test Init

Care-of Test Init

Home Test

Care-of Test

BU

Home Test Init

Home Test

BU

BAck
deliver packets
Message flow of HMIPv6

MN  AR  MAP  HA  CN

Router Solicitation  
Router Advertisement  
LCoA DAD  
BU  
RCoA DAD  
Back  
BU  
Home Test Init  
Care-of Test Init  
BU  
BU  
Home Test Init  
Home Test  
Care-of Test  
Home Test  
Care-of Test  
BU  
BU  
Back  
deliver packets

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Unlike MIPv6, a tunnel in PMIPv6 is established between the LMA and the MAG, and not an MN.

- (old) tunneling increases the bandwidth constraints on the wireless link and the processing burden on the MN.

Unlike MIPv6 and its various enhancements, the MN always obtains its unique home address while it moves within a PMIPv6 domain.
## Qualitative Analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>MIPv6</th>
<th>PMIPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility management type</td>
<td>Host-based mobility management</td>
<td>Network-based mobility management</td>
</tr>
<tr>
<td>Mobility scope</td>
<td>Global mobility</td>
<td>Localized mobility</td>
</tr>
<tr>
<td>Functionally correspondent entity</td>
<td>HA</td>
<td>LMA (i.e., HA functionality with additional capabilities)</td>
</tr>
<tr>
<td>Topologically correspondent entity</td>
<td>AR</td>
<td>MAG</td>
</tr>
<tr>
<td>MN modification</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Location registration message</td>
<td>Binding update message</td>
<td>Proxy binding update message</td>
</tr>
<tr>
<td>MN address</td>
<td>HoA or CoA</td>
<td>HoA (always)</td>
</tr>
<tr>
<td>Relation between tunnel and binding cache entry</td>
<td>1:1 relation (i.e., HA-MN tunnel)</td>
<td>1:1 relation (i.e., LMA-MAG tunnel)</td>
</tr>
<tr>
<td>Tunneling over wireless link</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td>Router advertisement type</td>
<td>Broadcast</td>
<td>Unicast</td>
</tr>
<tr>
<td>Lookup key in binding cache</td>
<td>HoA</td>
<td>MN identifier</td>
</tr>
<tr>
<td>Addressing model</td>
<td>Shared-prefix model</td>
<td>Per-MN-prefix model</td>
</tr>
<tr>
<td>Supported link type</td>
<td>Any type of link</td>
<td>Point-to-point link</td>
</tr>
<tr>
<td>Route optimization</td>
<td>Supported</td>
<td>Not supported</td>
</tr>
<tr>
<td>Movement detection</td>
<td>Required (performed by RS/RA)</td>
<td>Not required (performed by layer 2)</td>
</tr>
<tr>
<td>Duplicate address detection (DAD)</td>
<td>Performed at every subnet movement</td>
<td>Performed only one time (at initial movement into the domain)</td>
</tr>
<tr>
<td>Return routability</td>
<td>Required</td>
<td>Not required</td>
</tr>
</tbody>
</table>

*Table 1. Comparison between MIPv6 and PMIPv6.*
<table>
<thead>
<tr>
<th>Protocol criteria</th>
<th>MIPv4</th>
<th>MIPv6</th>
<th>HMIPv6</th>
<th>FMIPv6</th>
<th>Cellular IP</th>
<th>SIP</th>
<th>SCTP</th>
<th>PMIPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating layer</td>
<td>Network layer</td>
<td>Network layer</td>
<td>Network layer</td>
<td>Network layer</td>
<td>Network layer</td>
<td>Application layer</td>
<td>Transport layer</td>
<td>Network layer</td>
</tr>
<tr>
<td>Mobility scope</td>
<td>Global</td>
<td>Global</td>
<td>Local</td>
<td>Local/global</td>
<td>Local</td>
<td>Local/global</td>
<td>Local/global</td>
<td>Local</td>
</tr>
<tr>
<td>Location management</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Handover management</td>
<td>Yes (limited)</td>
<td>Yes (limited)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Required infrastructure</td>
<td>HA, FA</td>
<td>HA</td>
<td>HA, MAP</td>
<td>HA, enhanced AR</td>
<td>Enhanced BS</td>
<td>Registrar</td>
<td>None</td>
<td>LMA, MAG</td>
</tr>
<tr>
<td>MN modification</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Handover latency</td>
<td>Bad</td>
<td>Bad</td>
<td>Moderate</td>
<td>Good</td>
<td>Good</td>
<td>Bad</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Route optimization</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>—</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

1 Stateless address autoconfiguration is assumed.

Table 2. Comparison between PMIPv6 and various well-known mobility support protocols.
Figure 3. A simple analytical model for performance analysis.
Assume that the MNs are allowed to access a serving network after the AAA procedure is completed, and these access delays are assumed to be all the same for MIPv6, HMIPv6, and PMIPv6.

- Stateless address autoconfiguration
- All the delays mentioned above are symmetric.
- Delay between “MN and CN” < “MN and HA+ HA and CN”
- For simplicity and estimate the movement detection delay, router solicitation (RS) messages are not considered here. Thus, only RA messages can affect the movement detection of the MN.
**Basic Assumptions and Handover latency Analysis**

- **IP handover latency** can be as the sum
  - $T_{MD}$: movement detection delay
  - $T_{DAD}$: address configuration delay
  - $T_{AAA}$: the delay involved in performing the AAA procedure
  - $T_{REG}$: location registration delay

- Handover latency is defined as the time that elapses between the moment the layer 2 handover completes and the moment the MN can receive the first data packet after moving to the new point of attachment.
Basic Assumptions and Handover latency Analysis

\[ D_{HO}^{MIPv6} = T_{MD} + T_{DAD} + T_{AAA} + T_{REG}^{MIPv6} \quad (1) \]

where \( T_{REG}^{MIPv6} = 6(t_{mr} + t_{ra}) + 4t_{ah} + 2(t_{ac} + t_{hc}). \)

- MAP registration delay \( 2(t_{mr} + t_{ra} + t_{am}) \)

\[ D_{HO}^{HMIPv6} = T_{MD} + T_{DAD} + T_{AAA} + T_{REG}^{HMIPv6} \quad (2) \]

- the packet transmission delay from the MAG to the MN \( t_{mr} + t_{ra} \)

\[ D_{HO}^{PMIPv6} = T_{AAA} + T_{REG}^{PMIPv6} + t_{mr} + t_{ra} \quad (3) \]

where \( T_{REG}^{PMIPv6} = 2t_{am}. \)
Numerical Results

Parameters used are as follows

- $t_{mr} = 10$ ms
- Considering the relatively low bandwidth in the wireless link
- $t_{ra} = 2$ ms
- $t_{am} = t_{hc} = 10$ ms
- $t_{ah} = t_{ac} = 20$ ms
- $t_a = 3$ ms
- $MintInt = 30$ ms
- $MaxInt = 70$ ms
- $R = 1000$ ms $D = 1$

Figure 3. A simple analytical model for performance analysis.
Numerical Results
Numerical Results
Figure 4. Comparison between handover latencies in MIPv6, HMIPv6, and PMIPv6: a) impact of wireless link delay; b) impact of delay between MN and CN; c) impact of movement detection delay.
Conclusion

- this article is the first to provide qualitative and quantitative analyses of MIPv6 and PMIPv6.
- analysis results demonstrate the superiority of PMIPv6.
- PMIPv6 could be used as a localized mobility management protocol, whereas MIPv6 could be used as a global mobility management protocol.
MN default是要做DAD，但PMIPv6中MN他怎麼知道不用做DAD

答:由於MN只有剛在進入PMIPv6 domain中會收到RA以得到home network的prefix，觸發進行DAD確認是否有重覆IP，進入後只要不離開這個domain就一直是使用這個prefix，所以之後自然就不會做DAD。

請加上MIPv6 HMIPv6 message流程圖方便與PMIPv6比較

答:已加上P.16、P.17方便比較
是否RA特殊，為何不考慮RS

答: 詳見P.22第五點作者的假設，作者為了簡化movement detection delay分析環境(以RA的間隔計算當作計算參數)故只考慮分析在stateless autoconfiguration狀況下RA可以影響MN的the movement detection，而在stateful autoconfiguration下的RS和回覆他的RA若也考慮進用會增加分析的複雜度，作者他分析時並沒有考慮到。