Next generation networks with multiple access technologies

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Setting the scene
Heterogeneous access devices

New devices are equipped with wireless technologies. Many have more than one interface.
Heterogeneous access networks

Future access networks will be a combination of network technologies.
The HybriNet project

- **Today**
  - Fiber to homes
  - Hotspots in selected areas
  - Services like VoIP, TV

- **Project goals**
  - Combination of technologies
  - Mobility support
  - Services in both fiber and wireless access networks
  - Position WiMax
The choice of technology

- Mobile IP (MIP)
  - Network layer mobility
  - Transparent for upper layers
Introduction to MIP

Router solicitation
Introduction to MIP

Router solicitation

Router advertisement
Introduction to MIP

Binding update
Introduction to MIP

- Binding update
- Binding acknowledgement
Introduction to MIP

Packets from CN to MN
Introduction to MIP

Packets from CN to MN

Packets from MN to CN
Introduction to MIP (when route optimization is used)

Binding update

Packets from CN to MN

Packets from MN to CN
Flaw in MIP targeting wireless access networks

One binding for each MN in the HA

Problems may occur in position B
Multihomed MIP (M-MIP)

- Multihomed
- Multiple CoA bound to a home address
- Transparent for upper layers
- Dynamic evaluation of AP/BS
- Different CoAs can be used for different CHs
- Low handover delays
- The mobile device is in control....
Keep multiple bindings, use the one with best performance

Two bindings registered in position B
M-MIP

<table>
<thead>
<tr>
<th>Care-of address</th>
<th>Home address</th>
<th>RNL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Foreign agent</th>
<th>Care-of-address</th>
<th>RVM</th>
<th>RNL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Handover decisions

Problems in current handover decision parameters:

- Signal-to-noise ratio (SNR) could show good radio connection although there are many hosts attached to the same access point (AP selection). Also the SNR of different technologies cannot be compared.

- Bit error rate (BER) do not tell about the remaining capacity.

- Dynamic network layer metrics enables a better overview and the selection of a less utilized gateway or a path with higher throughput.
Parameters used for handover decision

Network layer metric based on MIP messages

\[ \bar{z}_n = \frac{1}{h} \text{rtt}_n + \frac{h-1}{h} \bar{z}_{n-1} \]  \hspace{1cm} (1)

\[ \bar{x}_n = \frac{1}{h} \bar{\delta}_n + \frac{h-1}{h} \bar{x}_{n-1} \]  \hspace{1cm} (2)

\[ V_n = \frac{1}{h} (\bar{\delta}_n - \bar{x}_n)^2 + \frac{h-1}{h} * V_{n-1} \]  \hspace{1cm} (3)

Relative Network-layer Load (RNL)

\[ RNL_n = \bar{z}_n + V_n \]  \hspace{1cm} (4)
M-MIP and heterogeneous access networks using RNL for handover decision
To enable mobility of single flows: Port-based M-MIP

- Different flows via different technologies
- Extensions needed to MIPv6 messages
  - Two new flags in the binding update header
  - A new option header to attach a port number
- The HA can direct different flows to the same HoA using different CoA
- A CH can use multiple addresses simultaneously.
- Flow mobility between devices
Port-based M-MIP

Multihomed extension to MIP

2 flags added to the binding update message

M-flag indicates multihomed bindings
S-flag informs the HA which binding to use as default selection
Port-based M-MIP

Flow-mobility extension to M-MIP

Flow mobility option header to be added to a BU

One or more option headers added to one BU

<table>
<thead>
<tr>
<th>8 bits</th>
<th>8 bits</th>
<th>8 bits</th>
<th>8 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port</td>
<td>Protocol</td>
<td>Option type</td>
<td>Option length</td>
</tr>
<tr>
<td>Not used</td>
<td>Not used</td>
<td>Not used</td>
<td>Not used</td>
</tr>
</tbody>
</table>
Port-based M-MIP

M-MIP extended binding cache/ binding table

The MH insert a binding in the local binding table for outgoing traffic

The HA insert a binding in the binding cache for incoming traffic

<table>
<thead>
<tr>
<th>HoA</th>
<th>CoA</th>
<th>Protocol</th>
<th>Port</th>
<th>Lifetime</th>
<th>Flags</th>
</tr>
</thead>
<tbody>
<tr>
<td>3ffe::a:b:c:d</td>
<td>3ffe::1::5:a:b:c:d</td>
<td>-1</td>
<td>-1</td>
<td>150</td>
<td>A/H/L/K/M/S</td>
</tr>
<tr>
<td>3ffe::a:b:c:d</td>
<td>3ffe::1::6:a:b:c:a</td>
<td>6</td>
<td>6935</td>
<td>200</td>
<td>A/H/L/K/M</td>
</tr>
<tr>
<td>3ffe::a:b:c:d</td>
<td>3ffe::1::a:a:b:c:d</td>
<td>17</td>
<td>7830</td>
<td>150</td>
<td>A/H/L/K/M</td>
</tr>
</tbody>
</table>
Evaluation of Port-based M-MIP

Evaluation topology
A roaming MN sends a simulated Skype video call to the CN.
MN handovers: WLAN $\rightarrow$ WiMAX $\rightarrow$ WLAN $\rightarrow$ UMTS $\rightarrow$ WLAN
Jitter (downlink)

Jitter @ 6 Kbits/s

- 802.11
- WiMax
- UMTS
Policies added for handover decision

- Cost function:
  - Evaluates available networks
  - \( S_i = w_c \cdot \ln C + w_p \cdot \ln P + w_b \cdot \ln B \)

- Parameters:
  - Power consumption (P)
  - Performance (RNL)
  - Cost (C)
Evaluation of Port-based M-MIP

Evaluation results
Prototype evaluation

Bandwidth (20kbps)

Jitter
Conclusions, Port-based MIP

- Multihomed extensions to Mobile IP
- Relative Network-layer Load
- Flow mobility extensions
- Basic policies
Future work

- Application control of flow mobility
- Extended policies to enhance handover
- Cross-layer context exchange
Questions?