**Project**  
IEEE 802.20 Working Group on Mobile Broadband Wireless Access  
[http://grouper.ieee.org/groups/802/20/](http://grouper.ieee.org/groups/802/20/)

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<th><strong>Title</strong></th>
<th>Requirements to Support Network Layer Mobility</th>
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<tr>
<td><strong>Date Submitted</strong></td>
<td>2003-05-05</td>
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| **Re:** | MBWA Call for Contributions |
| **Abstract** | This document reviewed IP-based network layer mobility protocols discussed in IETF. In particular, Fast-handoff for Mobile IP (FMIP), a protocol to support IP-based cellular communications, is described in details. These protocols require lower layers’ support, such as layer two triggers, to work perfectly. This document indicated requirements for lower layers in order to support network layer mobility management. |
| **Purpose** | This document is provided as network requirements for 802.20 standards. |
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Requirements to Support Network Layer Mobility

Gang Wu and Alper Yegin
DoCoMo USA Labs
Overview

• Handover events necessitate both network-layer and lower layers actions

• Network-layer needs information from link-layer to better respond to handovers
  – Need to establish IP connectivity as fast as possible

• IP needs standards-based interface with the lower layers, e.g., IEEE 802 links
Mobile IP Handovers

- Slow, because:
  - IP stack has to detect the movement by listening to router advertisements
  - Configure a new IP address (DHCP or IPv6 address auto-configuration)
  - Send binding update to home agent
- Doing these after the handover creates considerable delays for IP-layer connectivity

Too many packet loss during handover for realtime applications
Fast Handovers for Mobile IPv6

• Basic idea:
  – Anticipate movement with the help of link layer (triggers)
  – Prepare network and host in advance
    • Anticipated handover: pre-configured CoA
      – Initiated by Mobile Node, Source/Target Network
    • Bi-directional Tunnel-based Handover (BETH): defer to acquire CoA
      – Initiated by Source network or target network
  – After L2 movement, L3 is ready to serve
    • Done!

• IETF Mobile IP WG work item:
  – draft-ietf-mobileip-fast-mipv6-06
Slow vs. Fast!

- **Standard Mobile IPv6 handover:**
  - L2 handover
  - Duplicate address detection
  - Router discovery
  - Send binding update to previous access router

- **Fast Mobile IPv6 handover:**
  - Send binding update to previous access router
  - L2 handover
  - Duplicate address detection
IP Signaling

correspondent node

Internet

data

Foreign network

data

current AR

new AR

mobile node
IP Signaling

correspondent node

Internet

Foreign network

HI

Hack

new AR

current AR

Proxy RS

F-BU

Proxy RA

mobile node
IP Signaling

foreign network

F-Back

CISCO SYSTEMS

mobile node

correspondent node

Internet

new AR

current AR
IP Signaling

correspondent node

Internet

Foreign network

old AR

current AR

mobile node

NA

CISCO SYSTEMS

CISCO SYSTEMS
Protocol Events

Pre-trigger latency | L2 blackout | L3 blackout

Pre-trigger

Mobile node

PrRtSol | PrRtAdv | F-Back

AR1

F-BU | Link-down | Link-up

HI

Hack

AR2

NA, or F-NA

F-Back, or RA+NAack, or first data packet

Pre-trigger latency

time
FMIP Needs...

- FMIP needs link-layer to provide some indications that handover is imminent or (at least) it has just happened
Link-layer Triggers

- An abstraction of a notification from link-layer (potentially including parameter information) that a certain event has happened or is about to happen

- IETF draft:
  - draft-manyfolks-l2-mobilereq-01
Link-layer Triggers

- Link Up
- Link Down
- Source Trigger
- Target Trigger
- Mobile Trigger

- First, AP1 receives source trigger, AP2 receives target trigger, mobile receives mobile trigger
- Then, AP1 and client receive link down
- Finally, AP2 and client receive link up

- Not all link-layer technologies can produce all of these triggers
- Not all IP-layer mechanisms need all of these triggers
Use of Link-layer Triggers

• IP handovers
  – Mobile IP, FMIPv4/v6 rely on the existence of a subset of triggers
    • High performance, efficient mobility management
  – Clean-up state
    • Access router can flush ARP and ND cache entries when the host detaches from the link
  – Faster router discovery
    • Access router can send unsolicited router advertisements as soon as it detects the new host

• Context transfers
  – Access router can take context transfer actions upon detecting handovers
Link-layer Triggers and Handover

Source trigger, Target trigger, Mobile trigger

Link down

L2 handover

L3 handover: preparation

L3 handover: completion

Link up

time
Link-layer Triggers Protocol

• When the link-layer access device is not co-located with the access router, a protocol is needed to carry event notifications

• IETF draft:
  – draft-yegin-l2-triggers-00.txt
Link Layer Triggers

<table>
<thead>
<tr>
<th>Name</th>
<th>Recipient</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link Up</td>
<td>nAR or MN</td>
<td>$\text{MN}<em>{\text{MAC}}$ or $\text{nAR}</em>{\text{MAC}}$</td>
</tr>
<tr>
<td>Link Down</td>
<td>oAR or MN</td>
<td>$\text{MN}<em>{\text{MAC}}$ or $\text{oAR}</em>{\text{MAC}}$</td>
</tr>
<tr>
<td>Mobile Trigger</td>
<td>MN</td>
<td>$\text{nAR}_{\text{MAC}}$</td>
</tr>
<tr>
<td>Source-network Trigger</td>
<td>oAR</td>
<td>$\text{nAR}<em>{\text{MAC}}$ and $\text{MN}</em>{\text{MAC}}$</td>
</tr>
<tr>
<td>Target-network Trigger</td>
<td>nAR</td>
<td>$\text{oAR}<em>{\text{MAC}}$ and $\text{MN}</em>{\text{MAC}}$</td>
</tr>
</tbody>
</table>
## FMIP + Link Layer Trigger

<table>
<thead>
<tr>
<th></th>
<th>oSMIP</th>
<th>mFMIP</th>
<th>sFMIP</th>
<th>tFMIP</th>
<th>sBETH</th>
<th>tBETH</th>
</tr>
</thead>
<tbody>
<tr>
<td>LinkUp</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Link Down</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Mobile Trigger</td>
<td></td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source Trigger</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Target Trigger</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>
An Experimental Platform

• Software
  – RedHat Linux 7.2 (kernel 2.4.16 and 2.4.18)
  – Mobile IPv6: MIPL developed by HUT
  – Fast Mobile IPv6: in-house
  – Real Time Traffic Generator: in-house
  – Wireless Handover Emulator: in-house

• Hardware
  – AR: Pentium III 800MHz PC
  – MN and CN: IBM T23 laptop
  – Wired Network Connection: 100Mbps
  – Wireless Network Connection: Configurable
Handover Emulation Test Bed

- Wireless Layer 2 Emulator
- L2 Trigger Emulator
- Handover Emulator Switch
- Mobile Node
- Access Router
- Access Router
- Home Agent
- Correspondent Node

- Emulated Wireless Links
- Control Network
- Backbone Data Network
## Traffic Model

<table>
<thead>
<tr>
<th>Simulated Radio BW</th>
<th>Actual Radio BW</th>
<th>UDP Payload Size</th>
<th>Packet Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6kbps</td>
<td>44kbps</td>
<td>20Bytes</td>
<td>20ms</td>
</tr>
<tr>
<td>64kbps</td>
<td>98.4kbps</td>
<td>128Bytes</td>
<td>20ms</td>
</tr>
<tr>
<td>384kbps</td>
<td>418.4kbps</td>
<td>768Bytes</td>
<td>20ms</td>
</tr>
</tbody>
</table>

Link Delay: 10ms  
Link Layer Blackout Time: 40ms
Average Packet Drops for Simulated 9.6 kbps Wireless Link

![Graph showing the average packet drops for different mobile IP variants over pre-handover trigger times](image-url)
Average Packet Drops for Simulated 64 kbps Wireless Link

![Graph showing average packet drops over pre-handover trigger time for mFMIPv6, sBETH, and oSMIPv6.]
Average Packet Drops for Simulated 384 kbps Wireless Link

Packets Dropped

Pre-handover Trigger Time (ms)

mFMIPv6  sBETH  oSMIPv6
Frequency of High/Low Drop Rate for 64 kbps Wireless Link
Observations

- sMIPv6 packet loss number is controlled by the frequency of router advertisement.
- mFMIPv6 is sensitive to pre-trigger timing.
- As link bandwidth increases, pre-trigger time required for mFMIPv6 decrease.
- sBETHv6 reduces packet loss reliably, in regardless of pre-triggering time.
- In worst case, mFMIPv6 performance is on par with oSMIP; in best one, mFMIPv6 performance is on par with sBETHv6.
Recommendation to IEEE

- Formal definition of IEEE 802 link-layer events for IP-layer’s consumption
- Definition of an API for IP to obtain relevant triggers
- Support standardization of Link-layer Triggers Protocol at IETF (or, alternatively, make it an IEEE-only standard)
- .... so that IP operates better on IEEE 802 links