Layer 3 Mobility Support in IP-Networks

C. Blondia

Department of Mathematics and Computer Science

University of Antwerp - Belgium

chris.blondia@ua.ac.be

Joint work with O. Casals, L. Cerda, (UPC, Barcelona, Spain)
N. Van den Wijngaert, P. De Cleyn and G. Willems (UA)

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The First COST-IST(EU)-NSF(USA) Workshop on EXCHANGES & TRENDS IN NETWORKING

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Outline

- **Mobile IP: operation and shortcomings**
- **L3 Mobility solutions**
- **L3 Mobility solutions using L2 Triggers**
- **Mobility Management: Performance Issues**
- **L3 Mobility Management: Research Issues**
- **Related Papers**

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Mobile IP

- **Mobile IP (MIP) provides a means to roam among networks without changing IP addresses**
- **2 addresses are associated with a Mobile Node (MN) at all times (when away from the home network):**
  - **Home Address: address of the MN on its home network**
  - **Care-of Address: temporary address on a foreign network**
- **New routing/signaling entities**
  - **Home Agent: on the home network, provides central mapping of home address to care-of address; tunnels traffic to care-of address**
  - **Foreign Agent: tunneling endpoint (when using foreign agent care-of addresses)**

Mobile IP: Operation
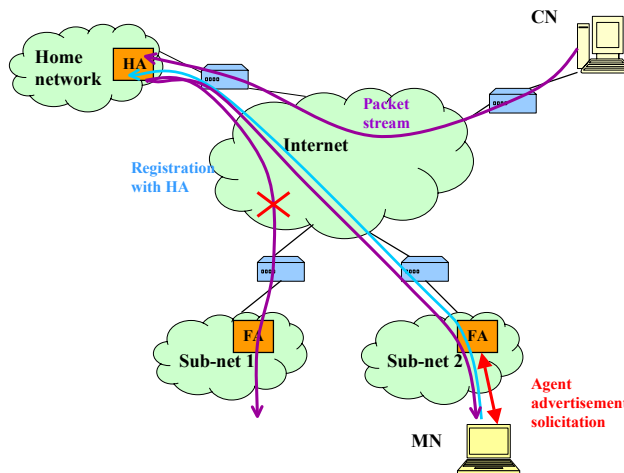
Shortcomings of plain MIP

- **Plain Mobile IP has 2 sources for delay/packet loss:**
  - **MN communicates with a directly connected FA**
    - **Registration can only start after L2 handoff to new FA has completed**
  - **Registration latency**
    - **Registration process takes time to complete during which MN is unable to receive packets**
- **Performance consequences:**
  - **Packet loss at oFA**
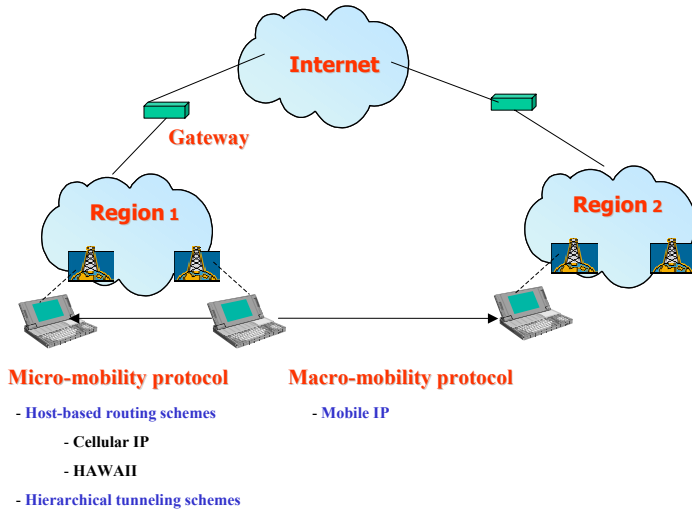   - **After L2 Line Down, MN is not reachable anymore via oFA**
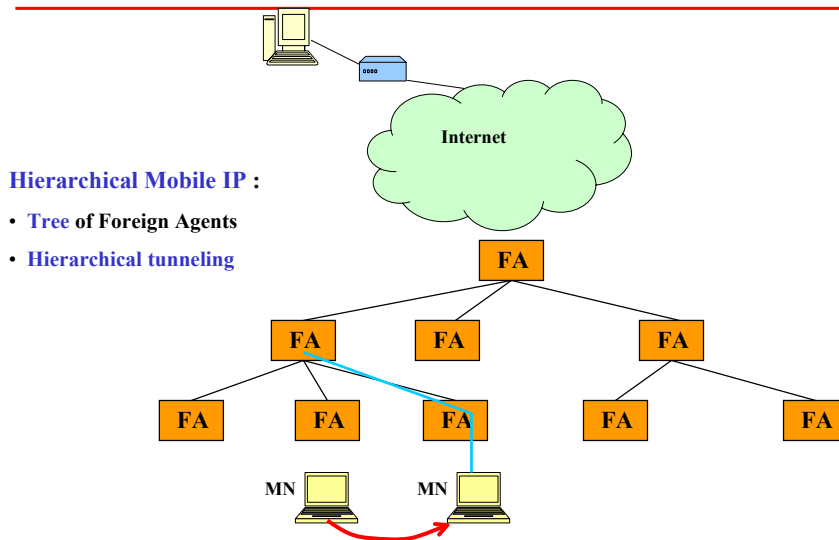
L3 Mobility Solutions

- **Keep time to perform L3 Handoff small**
  - **Micro-mobility vs. macro-mobility**
    - **Local movements are dealt with locally**
  - **Example: Hierarchical Mobile IP**
  - **Registration can only start after L2 handoff to nFA has completed**
- **Avoid losing packets by bicasting**
  - **Send temporarily packets to both oFA and nFA**
  - **Example: Cellular IP (soft handoff)**
- **Avoid losing packets in oFA by Buffering and Packet Forwarding**
  - **After L2 Line Down: buffer packets in oFA**
  - **After L2 Line Up: forward packets to nFA**
  - **Example: HAWAII MSF scheme**
- **Avoid losing packets in nFA by Buffering**
  - **When packets are forwarded from oFA to nFA before registration completed**
  - **Example: Optimized Smooth Handoff**
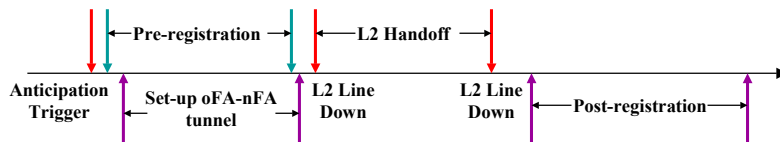
Micro- vs. Macro-Mobility

Internet

Gateway

Region 1

Region 2

Micro-mobility protocol

- Host-based routing schemes
  - Cellular IP
  - HAWAII
- Hierarchical tunneling schemes

Macro-mobility protocol

- Mobile IP

Hierarchical Mobile IP

Internet

Hierarchical Mobile IP :

- **Tree** of Foreign Agents
- **Hierarchical tunneling**

FA

FA   FA   FA

FA   FA   FA   FA   FA

MN   MN

L3 Mobility using L2 Triggers

- **Pure L3 mobility solutions**


```
        ← L2 Handoff →      ← L3 Handoff →
  L2 Line        L2 Line  Start L3        End L3        time
  Down           Down     registration    registration
```

- **L3 mobility using L2 Triggers: Pre- and Post-Registration**


```
        ← Pre-registration →   ← L2 Handoff →
  Anticipation  Set-up oFA-nFA  L2 Line      L2 Line
  Trigger       tunnel          Down         Down    ← Post-registration →
```

Pre- and Post-Registration: conditions

- **Foreign Agents need to exchange and cache router advertisements**

- **Pre-Registration: Timing of triggers**
  - **Registration has to be finished before oFA L2 Line Down (possible packet loss in oFA)**
  - **If Registration is finished before nFA L2 Line Up, then packets need to be buffered in nFA**

- **Post-Registration: Timing Triggers**
  - **The Bi-directional Edge Tunnel (BET) between oFA and nFA has to be established before oFA L2 Line Down occurs**
  - **The packets that use the BET after the oFA L2 LD that arrive at the nFA before the nFA L2 Line Up, need to be buffered at the nFA**

Mobility Mgt: Performance Issues

- **Performance measures**
  - Packet loss in oFA and nFA and/or buffer dimensioning
  - Delay distribution of packets involved in handoff
  - Throughput of TCP
- **Performance models**
  - Analytical model
    - M/M/1 model with CBR traffic
  - ns-2 simulation
    - Used to produce handoff traces for mobility mechanisms over 802.11b, detailed simulation and TCP performance
  - OPNET simulation
    - Used for detailed simulation, TCP performance, scalability studies.

Example: Timing L2 Triggers
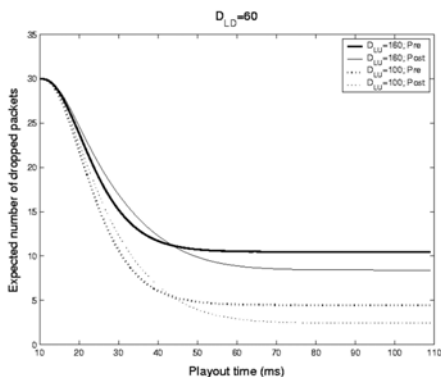
dropped packets due to expiration of the playout time for variable D_LU
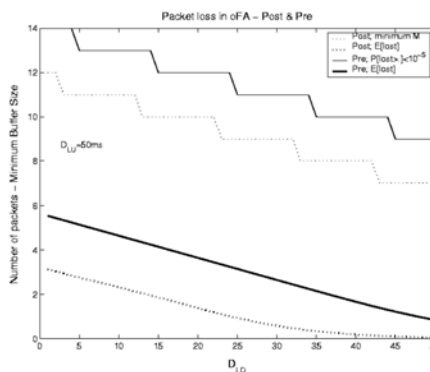
Required buffer capacity as a function of the timing of the L2 triggers

Future Work / Research Issues

- **Implementation over IEEE 802.11**
  - **IEEE802.11 has no specific triggers**
    - **Use IEEE802.11 beacon as Anticipation Trigger**
    - **Re-association messages used as Line Up Trigger**
  - **L2 handoff may take several 100 ms**
    - **Scanning of various channels to find the best Access Point**
    - **Use buffering to avoid packet loss**
- **Improve L3 handoff performance using location information**
  - **Access points along a highway**
  - **Mobile station's route determined (GPS)**

Related Papers

- **Performance Analysis of IP Micro-Mobility Handoff Protocols, PfHSN'2002, , Lecture Notes in Computer Science 2334**
- **Performance Analysis of a Forwarding Scheme for Handoff in HAWAII, Networking 2002, LCNS 2345**
- **Performance Analysis of Optimized Smooth Handoff in Mobile IP, MSWiM 2002**
- **Performance Evaluation of the Post-Registration Method, a Low Latency Handoff in MIPv4, ICC 2003**
- **Performance Comparison of Low Latency Mobile IP Schemes, WiOpt '03**
- **Low Latency Handoff Mechanisms and their Implementation in an IEEE802.11 Network, ITC 18, 2003**
- **Integration of IP Mobility in OPNET: Modelling and simulation, proceedings of OPNETWORK2002.**

http://win-www.uia.ac.be/u/pats/publications.html