Mobility in IPv6 Networks

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MI Pv6 Release - Mobility on the Rise?
What may we expect?

- Devices using Home Address while away
- ‘Workspaces’ roaming between local subnets
  + Improvements on handover performance
  + 3G Mobiles operating IP
  + ...
- VoIP/VCoIP conferencing: real-time mobility
- Group communication by Mobile Multicast
Agenda

- Mobility Approaches
- Real-time Mobility
- Performance Analysis
- Multicast Mobility
- Conclusions & Outlook
IP Mobility Approaches

- Application: SIP Handover
  - SIP-server as application specific home agent

- Transport: Mobile SCTP
  - Stateful transport handover (doubly bound)

- Multicast-based IP Mobility Support
  - Mobile with personal multicast address

- Mobile IPv6
  - Stateless, transport transparent handover
Mobile IPv6

- IP-Subnet 1
- IP-Subnet 2
- Register
- Address Reconfiguration
- Sending Binding Updates
- Binding Update
- Binding Update
- HA
- MN
- CN
VoIP/ VCoI P
Real-Time Requirements

Latency $\approx< 100$ ms

Jitter $\approx< 50$ ms

Packet loss $\approx< 1$ %

Interruption: 100 ms $\approx 1$ spoken syllable

$\rightarrow$ 100 ms are critical bound
Local Handover Measurements: Empirical Results
Improvement: L2-Trigger & L2 Handover

IP - Reduce
- MAX_RA_DELAY_TIME ≈ 1 – 3 ms
- MAX_RTR_SOLICITATION_DELAY ≈ 1 – 3 ms

802.11b - Schulzrinne et al.:
Selective Scan + Cache
MI Pv6 Handover: Topology Problem

- Generally HA and CN are at Significant Distance

- Handover Time:

\[ t_{\text{handoff}} = t_{\text{local}} + t_{\text{BU-of-HA}} + t_{\text{BU-of-CN}} \]

\[ \approx t_{\text{local}} + \frac{3}{2} t_{\text{CN}} + 2t_{\text{HA}} \]

- Jitter Enhancement:

\[ \frac{\text{Jitter}_{\text{handoff}}}{\text{Jitter}_{\text{stationary}}} \approx \frac{t_{\text{HA}} + t_{\text{CN}}}{t_{\text{CN}}} \]

- Essential: Eliminate HA/CN RTT Dependence
Predictive Handover: Fast MI Pv6
Reactive Handover with Proxies: Hierarchical MI Pv6
Handover Analysis:
Predictive vers. Reactive

Relevant criteria

► Handover performance: packet loss, delay + jitter
► Number of performed handovers
► Number of processed handovers
Handover Performance

Simple analytical model:

- Compare reactive vers. predictive handover
- Characteristic to problem:
  Router distance $t_{l3}$
- Charac. to predictive HO:
  $2t_{l3} - t_{L2}$
- Charac. to reactive HO:
  $t_{l3} + t_{L2}$
Stochastic Simulation

- Constant bit rate traffic from CN/HA (at 10 ms)
- Random perturbations ($\xi$) at each link
- Parameters:
  - Anticipation Time: $<x> = 50 \text{ ms}, \xi = 30 \text{ ms}$
  - L2 Handoff: $<x> = 50 \text{ ms}, \xi = 10 \text{ ms}$
  - Local Links: $<x> = 2 \text{ ms}, \xi = 1 \text{ ms}$
Simulation: Packet Loss

![Packet Loss Graph](image)
Number of Handovers

Relevant quantities:
- Cell residence time
- Call holding time
- AR-to-MAP ratio

Modelling assumptions:
- Cell residence & call holding time exp. distributed (homogeneous distribution)
Expected # of Handovers

Analytical result:

\[ \rho = \text{Call-to-mobility factor} \]

\[ k = \text{AR-to-MAP ratio} \]

\[ E[HO] = \frac{1}{k\rho^2} + \frac{1}{\sqrt{k\rho}} \]
Handover Prediction Analysis:
Mobility Simulation

Models:
- Random Waypoint
- Random Direction
  (both with & without boundaries)
Handovers
Erroneous Predictions

About 50% Bad Predictions
Mobile Group Conferencing

- Bi-directional multicast capabilities needed
- Mcast applications source address aware
- Problem: asymmetric, slow convergence
  - up to $\approx 30$ s at listener
  - up to $\approx 3$ min at sender
  - Routing source address dependent through source or shared trees
- Comply with unicast mobility infrastructure
Multicast Mobility Approaches

- Bi-directional Tunneling
  - Hide all movement by tunneling via Home Agent

- Remote Subscription
  - Show all movement by local multicast subscription

- Agent Based
  - Compromise: Intermediate agents shield Mobile
Fast Multicast Protocol for MIPv6

draft-suh-mipshop-fmcast-mip6-00

- Remote subscription with agent support
- Mobile multicast reception only
- Built on Fast Handovers for MIPv6 (FMIPv6)
  - Predictive handovers based on L2 : L3 map
  - Handled at access routers
- Extends signalling of FMIPv6 by multicast address option
M-FMI Pv6: Prediction
M-FMI Pv6: Forwarding
M-FMI Pv6: Handover
M-FMI Pv6: Completion
Seamless Multicast Handover in a HMI Pv6 Environment

draft-schmidt-waehlisch-mhmipv6-02

- Agent based: MAP as Multicast agent
- Mobile multicast reception and source
- Built on Hierarchical MIPv6 (HMIPv6)
  - Micro mobile handovers hidden by MAP
  - Reactive handovers between MAPs
  - Unicast (tunnel) forwarding MN : MAP
- Extends signalling of HMIPv6 by multicast advertisement flag
M-HMIP: Mobile Multicast

Mobile multicast listener anchored at MAP:
- Group membership management through MAP
- On handover: packet forwarding to MN through previous MAP
- On demand: switch to remote subscription

Mobile multicast sender anchored at MAP:
- Use Home Address Destination Option (CN must not verify BC on mcast)
- On handover: bi-cast through old and new MAP
- On rapid Movement: stay with established MAP
M-HMI P: Multicast Source
M-HMI P: MAP-Local Handover
M-HMIP: Inter-MAP Handover (1)
M-HMIP: Inter-MAP Handover (2)
Robustness

- Topology
  M-FMIPv6 and M-HMIPv6 both are unaffected by long distance topology (local ‘step size’ only)

- Rapid Movement
  M-FMIPv6: Forwarding will fail for handover intervals below signalling period
  M-HMIPv6: Forwarding will function for any handover frequency, but delays may increase
Signalling Overhead

M-FMIPv6:
- Advertisement
- 7 messages per handover (+MIPv6 +mcast)

M-HMIPv6:
- Advertisement
- 1 message per micromobile handover
- 2 messages per MAP handover (+MIPv6 +mcast)
Conclusions & Outlook

√ Mobile IPv6: Accelerations to real-time under way
  - Predictive & reactive handover concepts at agents

√ Two mobile multicast approaches: M-FMIPv6 (mcast listeners) & M-HMIPv6 (mcast listeners & senders)

√ M-FMIPv6:
  - Faster handovers at intermediate router distance ($\approx 20$ ms).
  - ‘Nervous’ Routing demands, will fail at rapid mobility

√ M-HMIPv6:
  - Reduced # of Handovers at compatible timing
  - ‘Smoothing’ mcast Routing, robust in rapid mobility

Future Development:
  • Analysis & simulations of multicast sceneries, optimisation