Mobility in IPv6 Networks

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MIPv6 Release – Mobility on the Rise?

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What may we expect?

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

VESPA

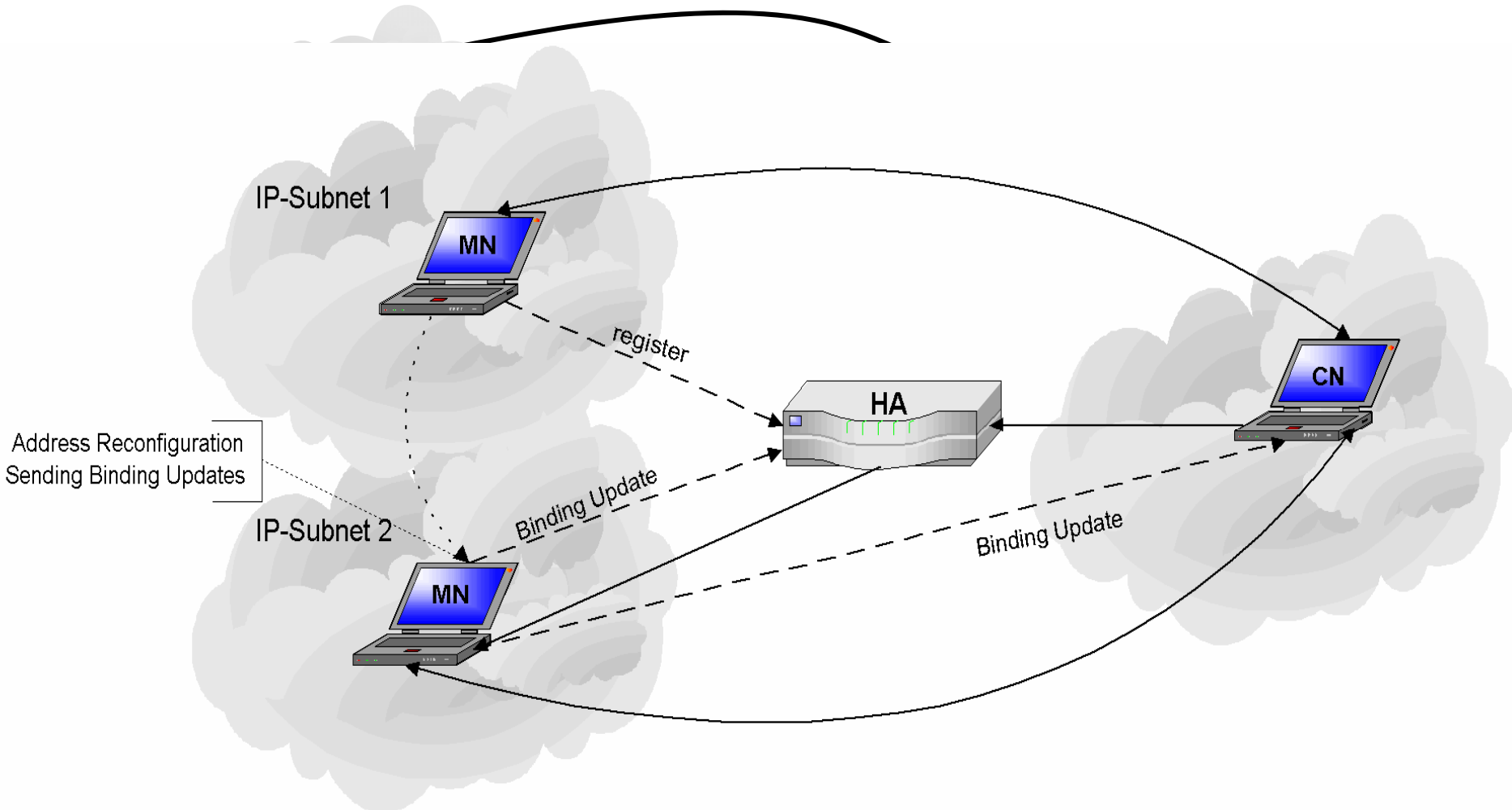
Agenda

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

IP Mobility Approaches

- o Application: SIP Handover
  - SIP-server as application specific home agent
- o Transport: Mobile SCTP
  - Stateful transport handover (doubly bound)
- o Multicast-based IP Mobility Support
  - Mobile with personal multicast address
- o Mobile IPv6
  - Stateless, transport transparent handover

Mobile IPv6


IP-Subnet 1
MN
register
HA
CN
Address Reconfiguration
Sending Binding Updates
Binding Update
IP-Subnet 2
Binding Update
MN

VoIP/VCoIP
Real-Time Requirements

! Latency $\approx<$ 100 ms

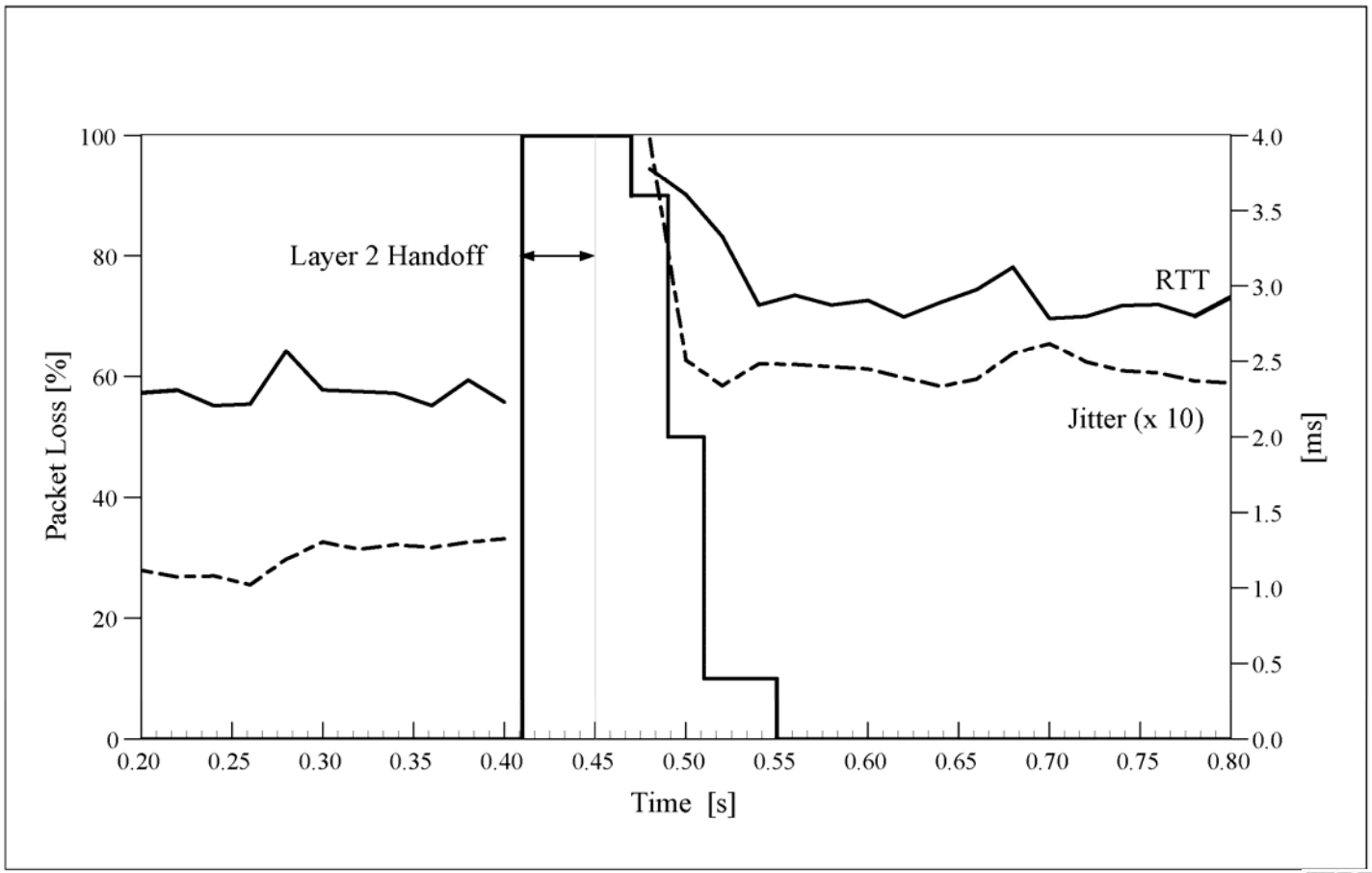
! Jitter $\approx<$ 50 ms

! Packet loss $\approx<$ 1 %

! Interruption: 100 ms $\approx$ 1 spoken syllable

$\rightarrow$ 100 ms are critical bound

Local Handover Measurements: Empirical Results



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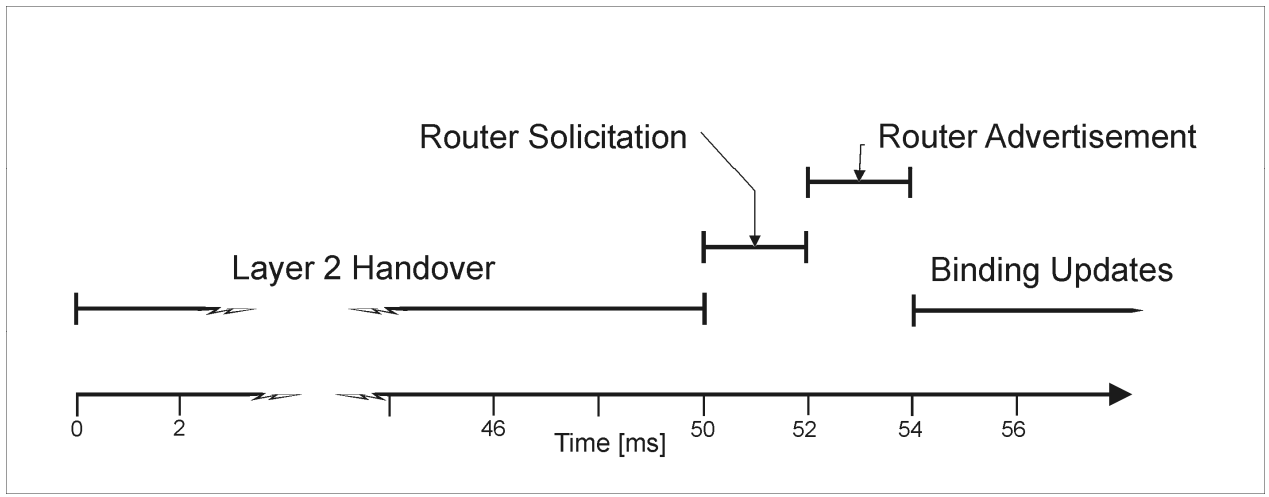
Improvement: L2-Trigger & L2 Handover



IP - Reduce

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

802.11b - Schulzrinne et al.:

Selective Scan + Cache

MIPv6 Handover: Topology Problem

- Generally HA and CN are at Significant Distance
- Handover Time:

$$t_{handoff} = t_{local} + t_{BU-of-HA} + t_{BU-of-CN}$$

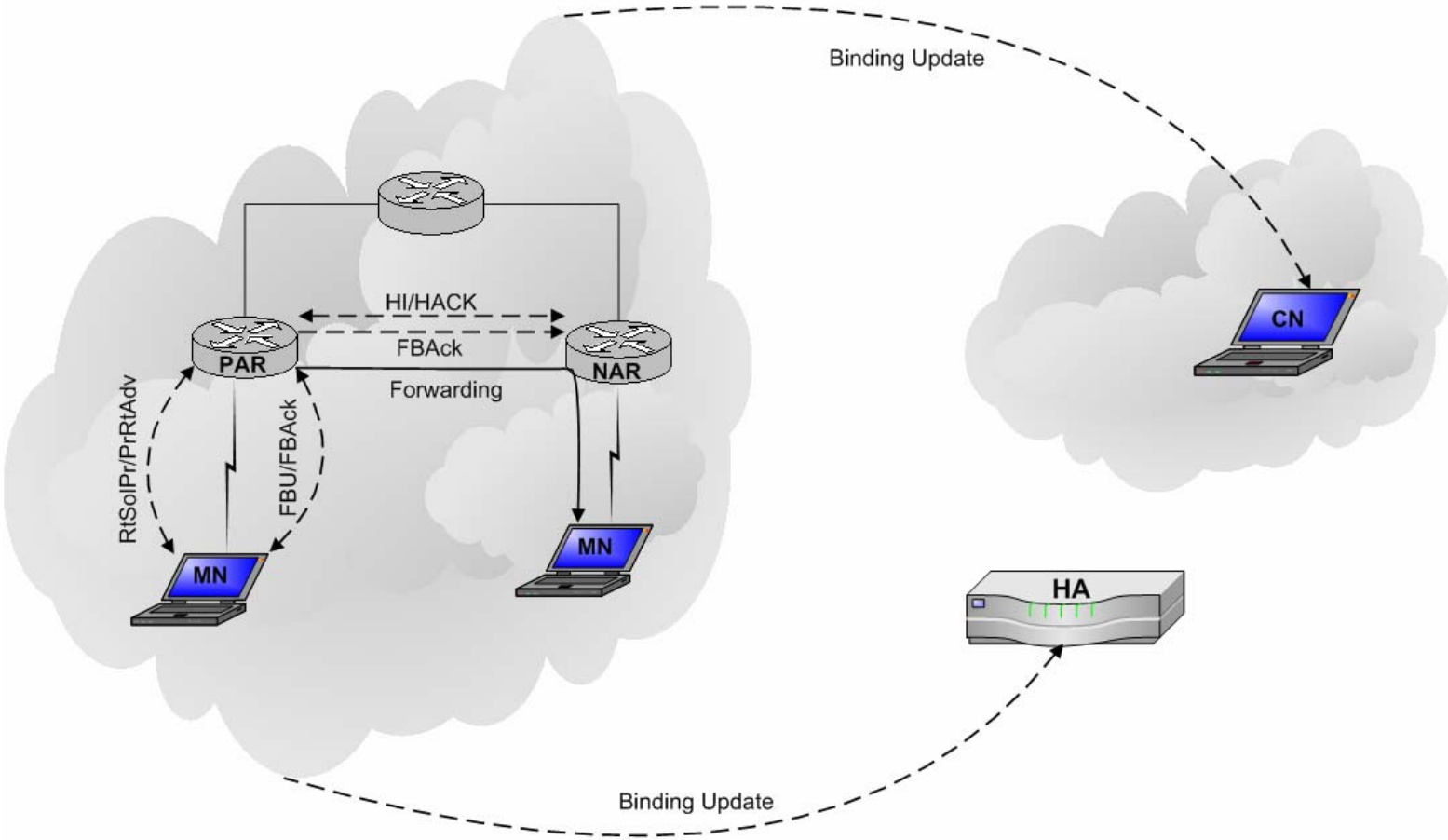
$$\approx t_{local} + \frac{3}{2} t_{CN} + 2t_{HA}$$

- Jitter Enhancement:

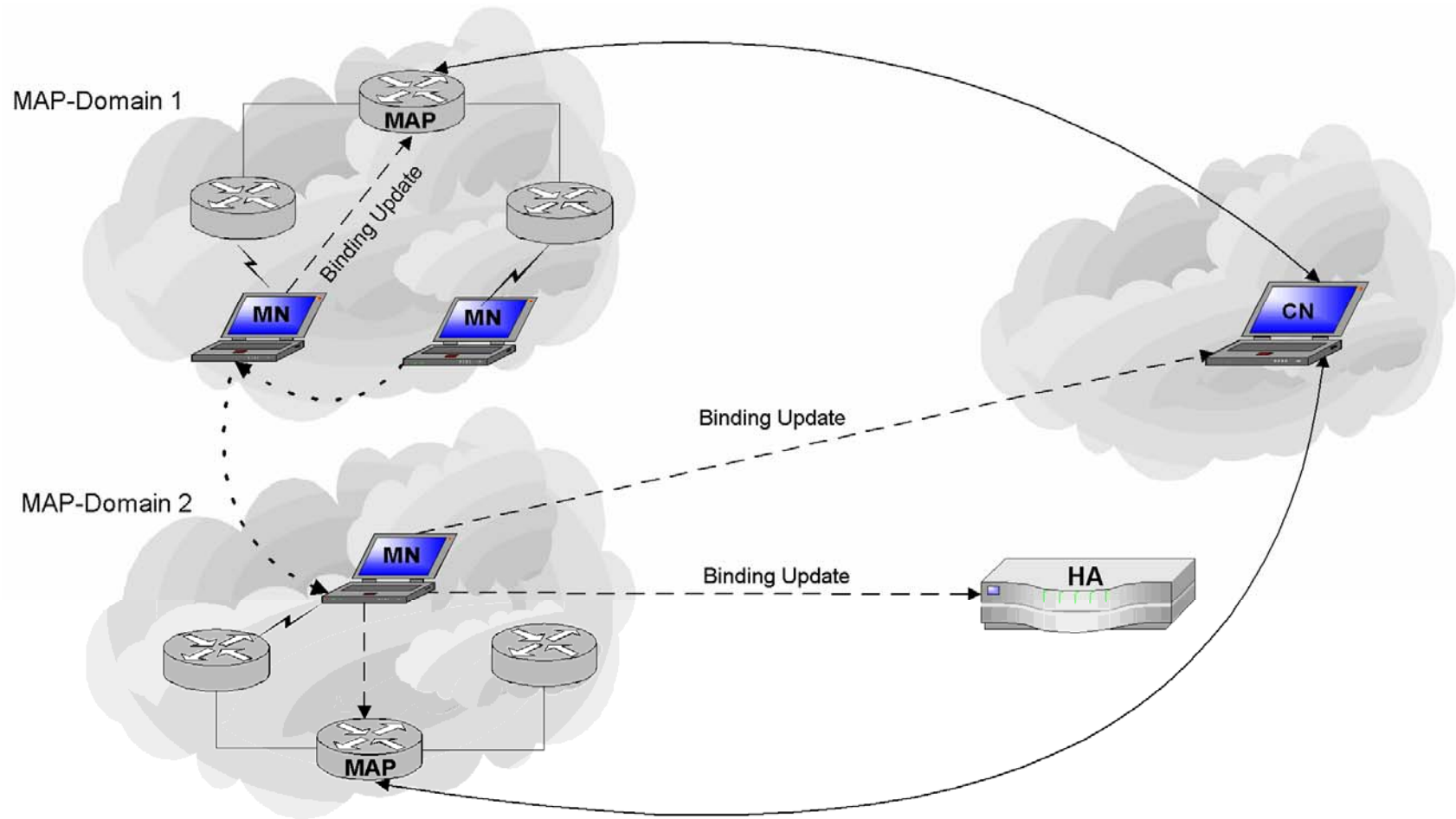
$$\frac{Jitter_{handoff}}{Jitter_{stationary}} \approx \frac{t_{HA} + t_{CN}}{t_{CN}}$$

- Essential: Eliminate HA/CN RTT Dependence

Predictive Handover: Fast MIPv6



Reactive Handover with Proxies: Hierarchical MIPv6

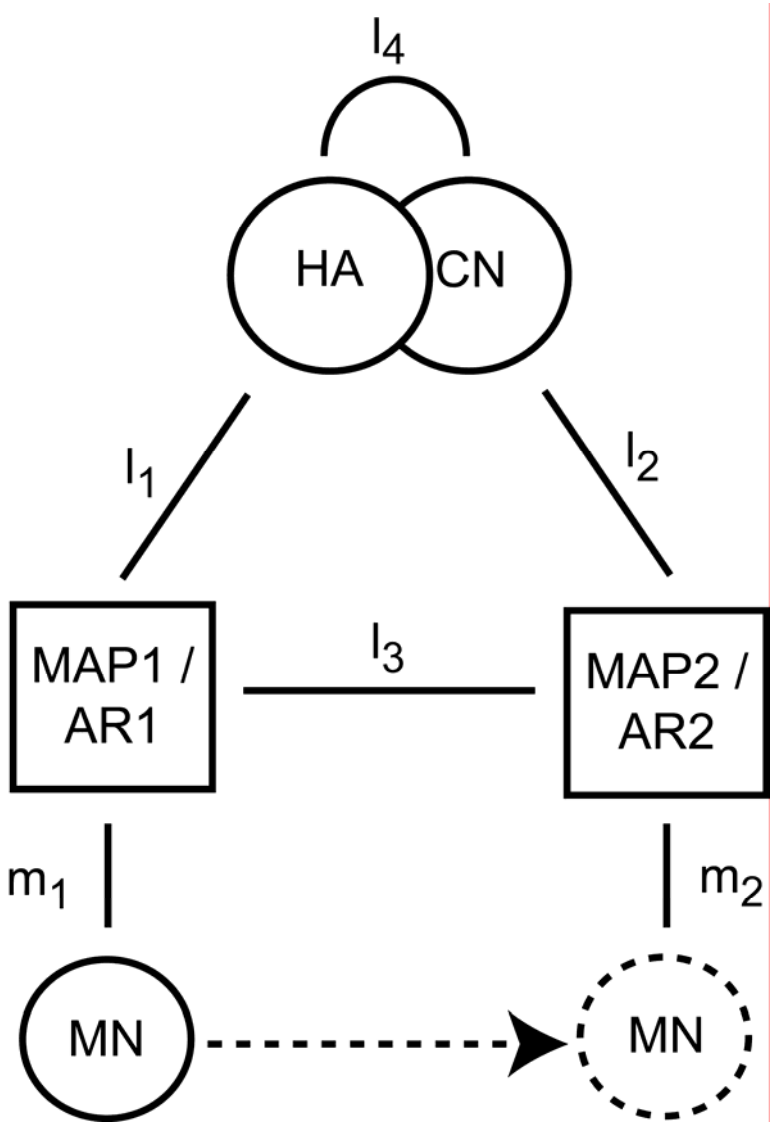


Handover Analysis: Predictive vers. Reactive

Relevant criteria

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

Handover Performance



Simple analytical model:

- o Compare reactive vers. predictive handover
- o Characteristic to problem: Router distance t_{l3}
- o Charac. to predictive HO:

$$2t_{l3} - t_{L2}$$

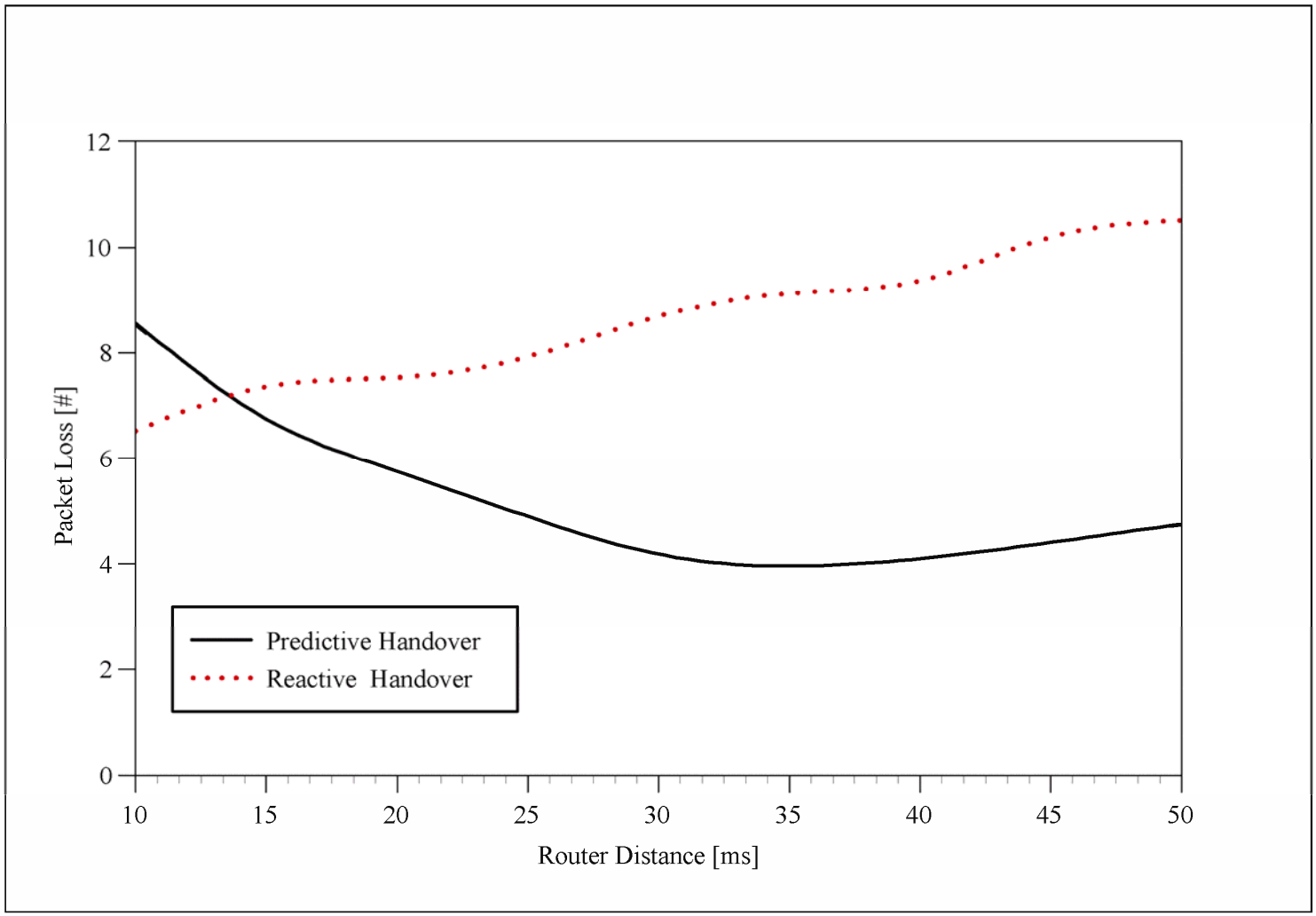
- o Charac. to reactive HO:

$$t_{l3} + t_{L2}$$

Stochastic Simulation

- Constant bit rate traffic from CN/HA (at 10 ms)
- Random perturbations (ξ) at each link
- Parameters:
  - Anticipation Time: **<x> = 50 ms, ξ = 30 ms**
  - L2 Handoff: **<x> = 50 ms, ξ = 10 ms**
  - Local Links: **<x> = 2 ms, ξ = 1 ms**

Simulation: Packet Loss



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)

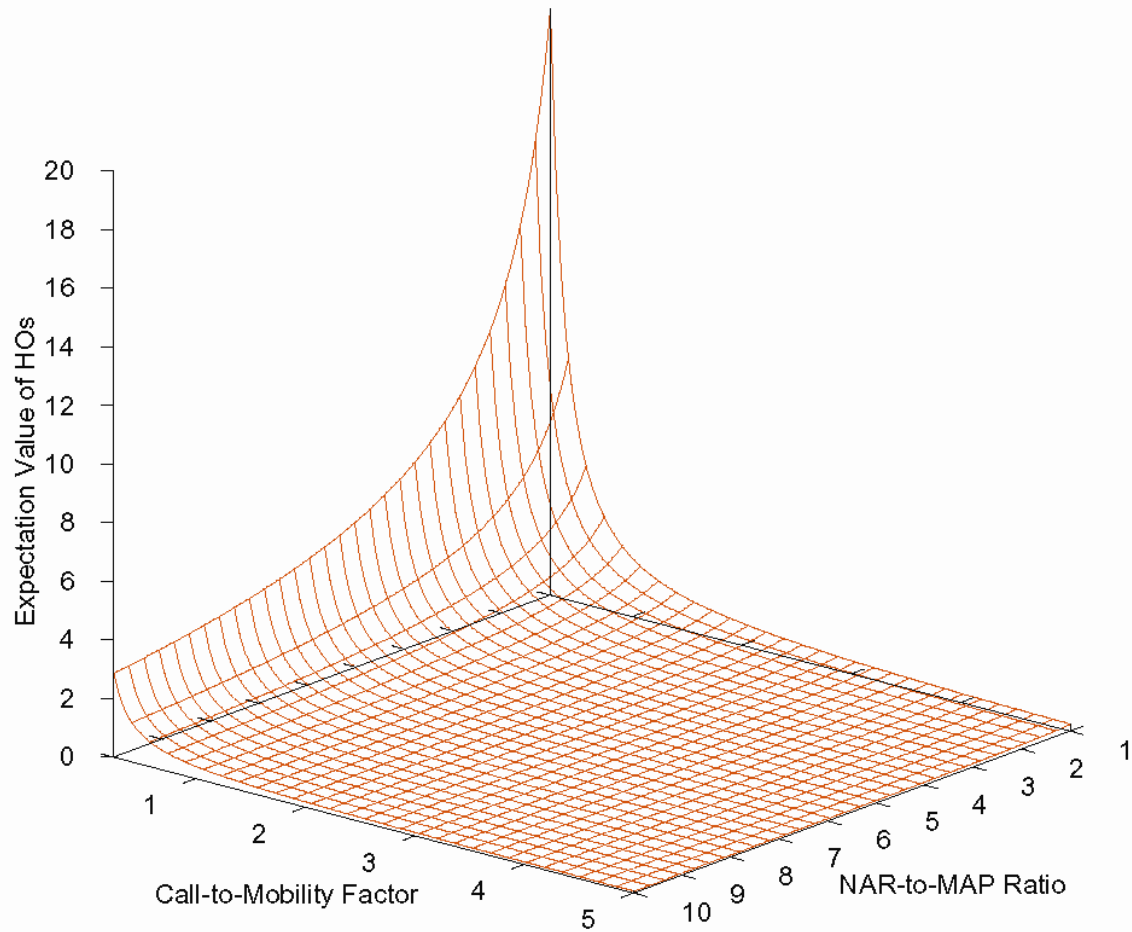
Expected # of Handovers

Analytical result:

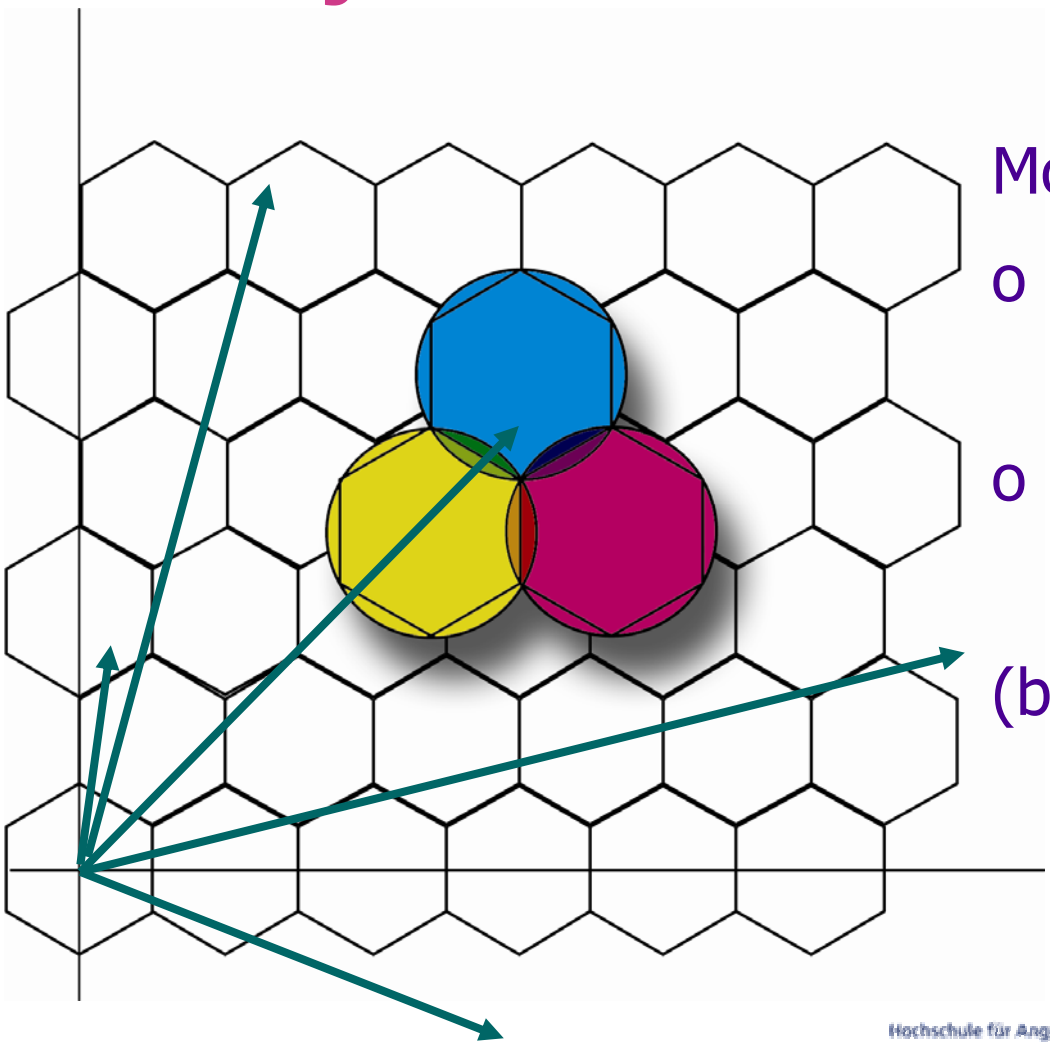
ρ = Call-to-mobility factor

k = AR-to-MAP ratio

$$E[HO] = \frac{1}{k\rho^2} + \frac{1}{\sqrt{k}\,\rho}$$



Handover Prediction Analysis: Mobility Simulation

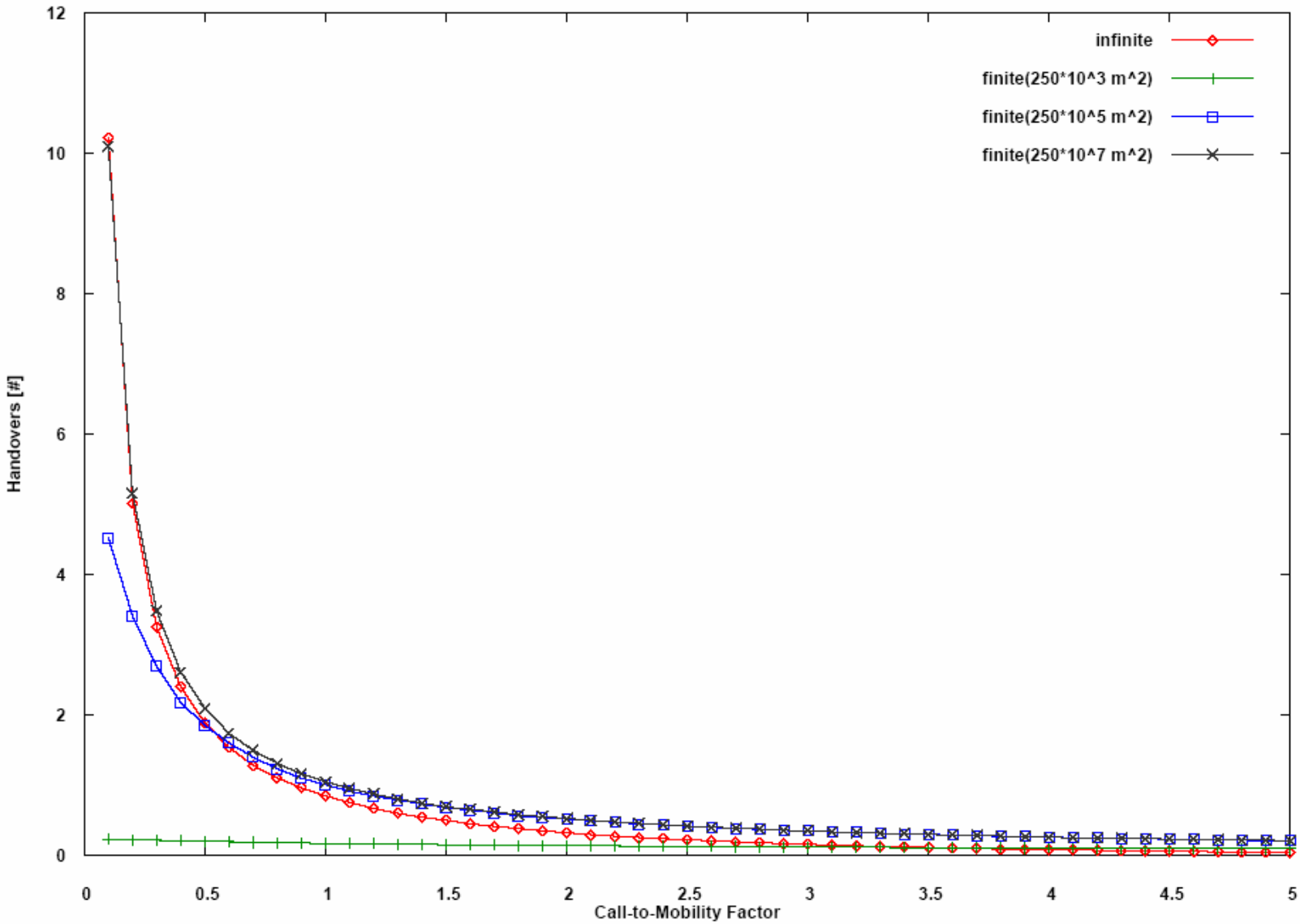


Models:

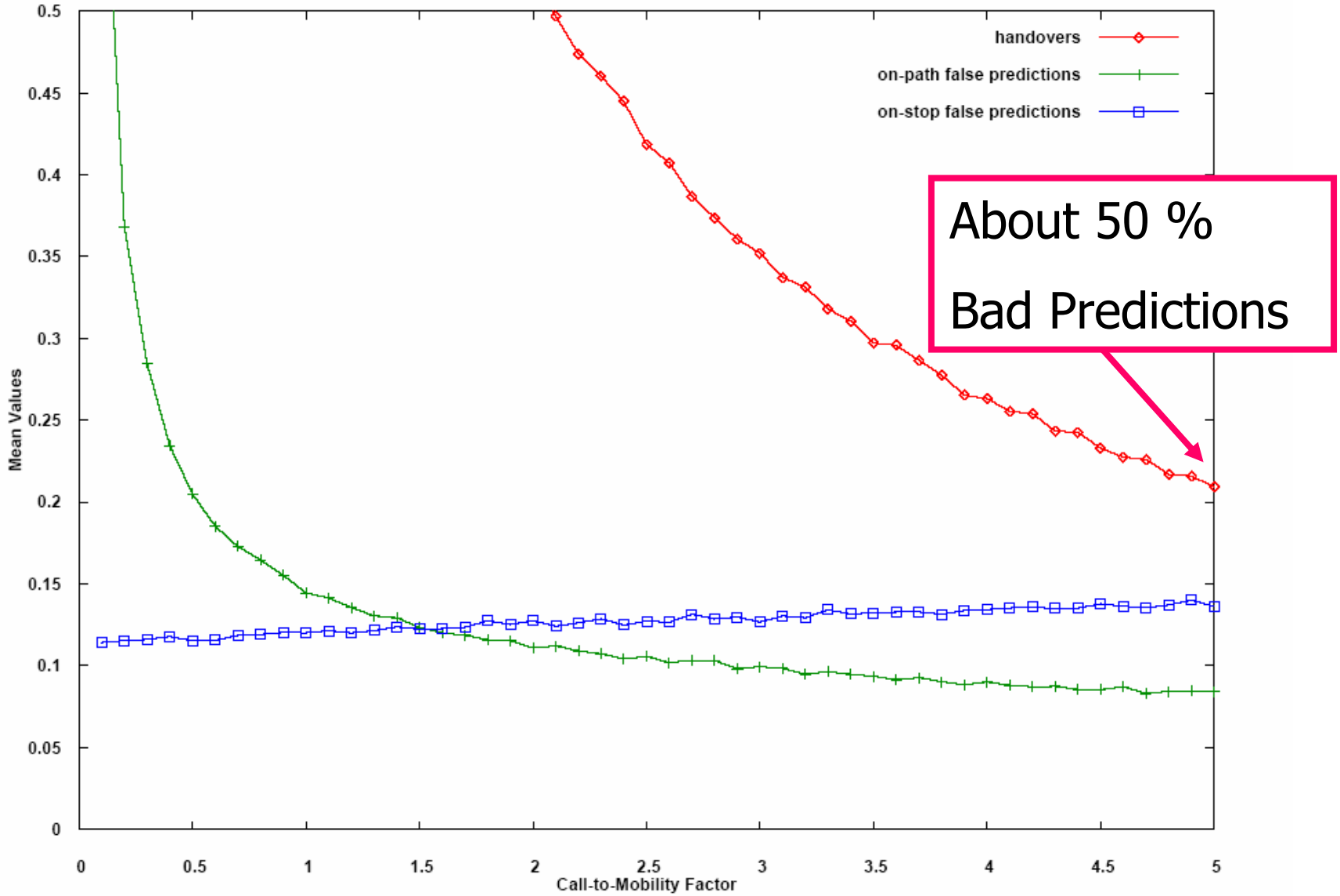
- Random Waypoint
- Random Direction

(both with & without boundaries)

Handovers


infinite
finite(250*10^3 m^2)
finite(250*10^5 m^2)
finite(250*10^7 m^2)
Handovers [#]
Call-to-Mobility Factor
0
2
4
6
8
10
12
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Erroneous Predictions



Mobile Group Conferencing

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

Multicast Mobility Approaches

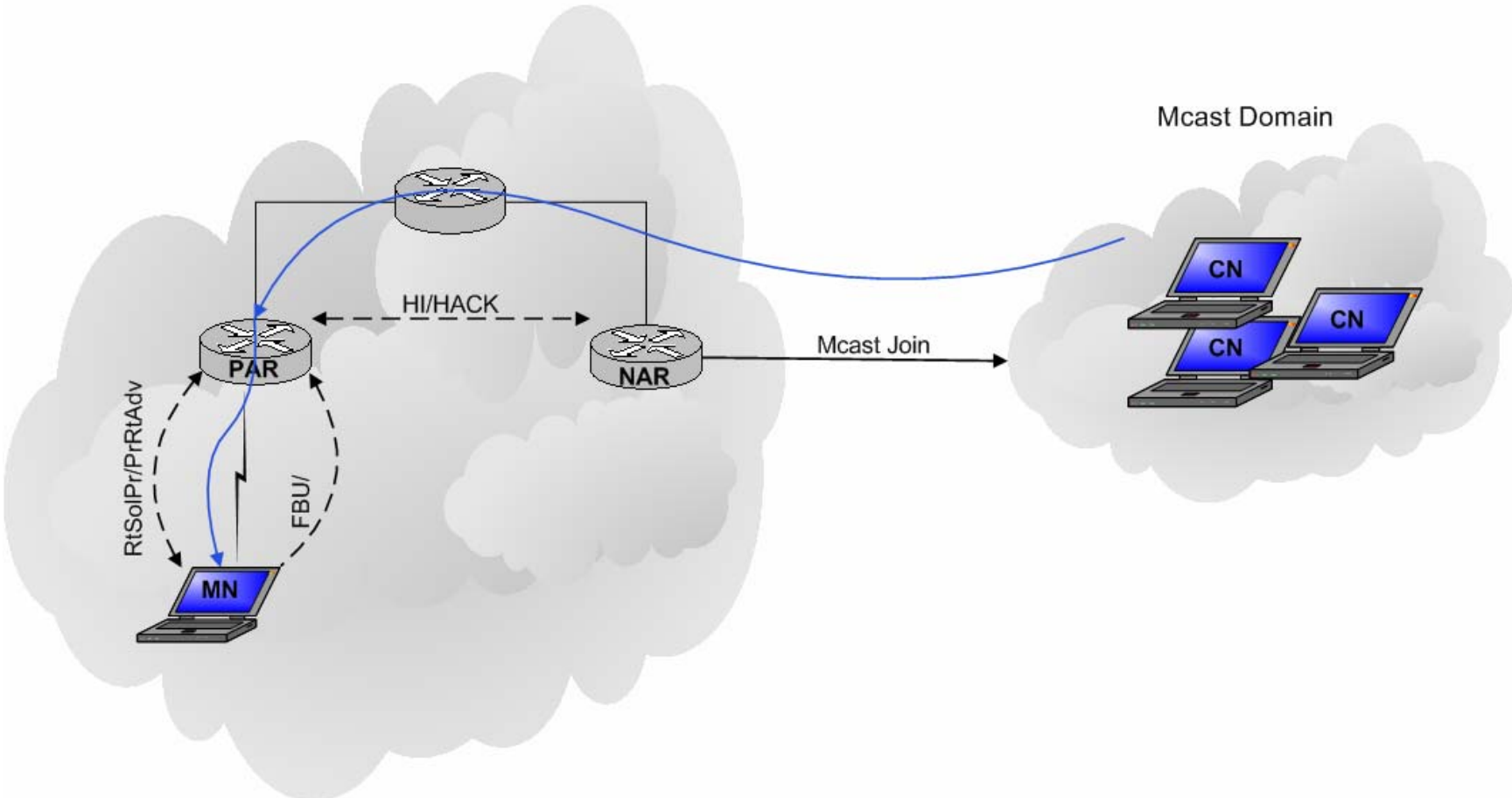
- o Bi-directional Tunneling
  - Hide all movement by tunneling via Home Agent
- o Remote Subscription
  - Show all movement by local multicast subscription
- o Agent Based
  - Compromise: Intermediate agents shield Mobile

Fast Multicast Protocol for MIPv6

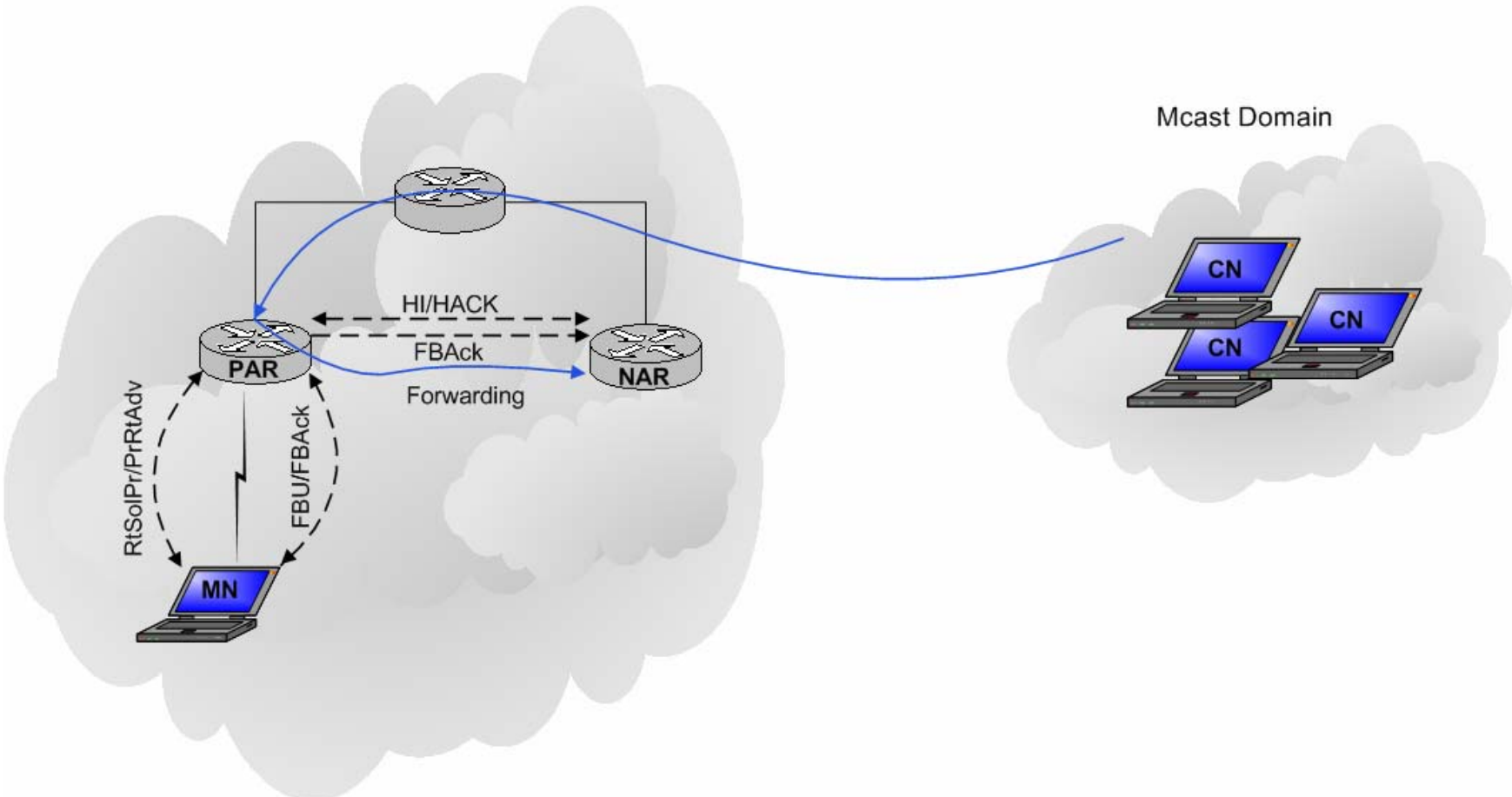
draft-suh-mipshop-fmcast-mip6-00

- o Remote subscription with agent support
- o Mobile multicast reception only
- o Built on Fast Handovers for MIPv6 (FMIPv6)
  - Predictive handovers based on L2 : L3 map
  - Handled at access routers
- o Extends signalling of FMIPv6 by multicast address option

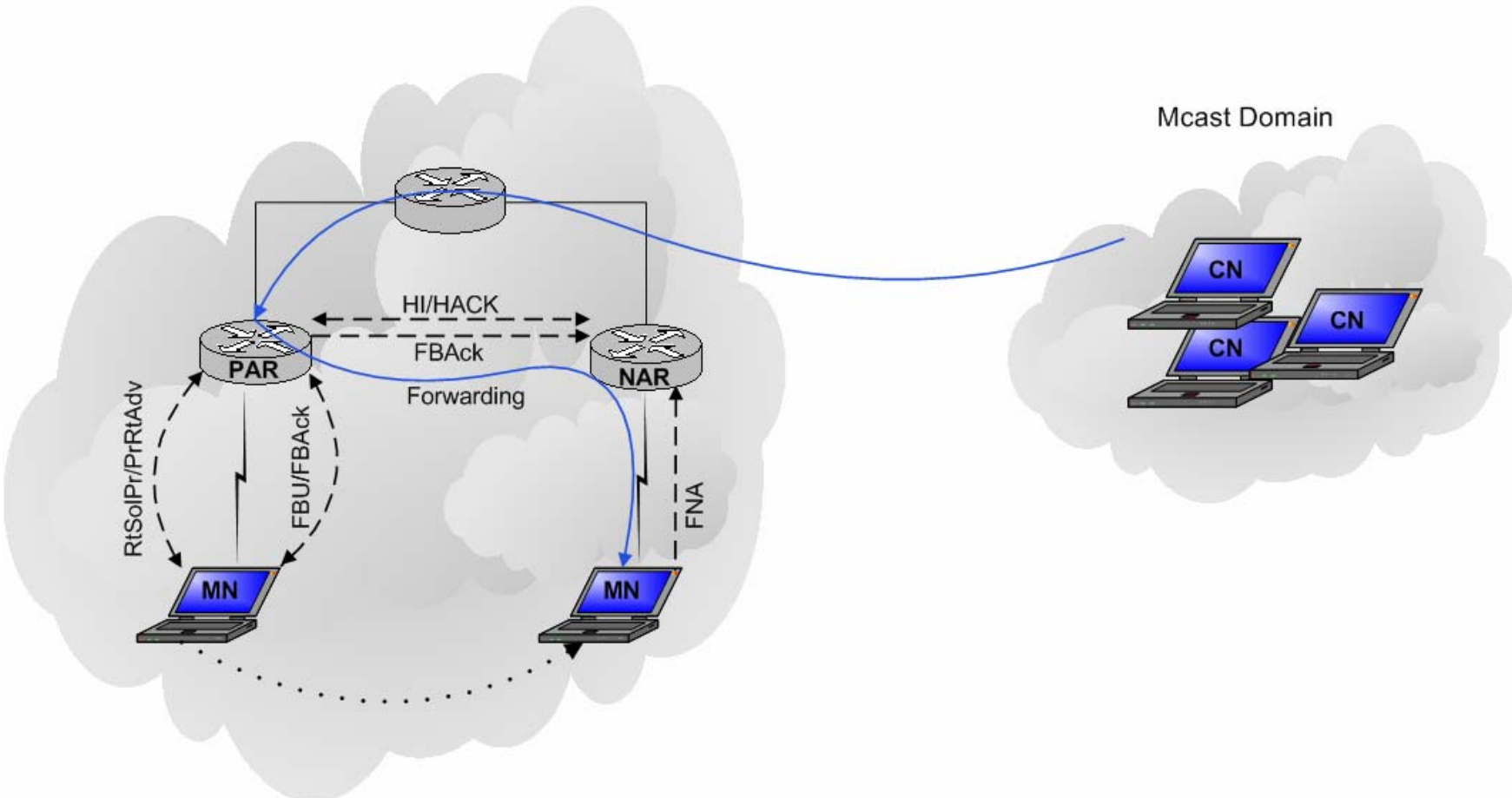
M-FMIPv6: Prediction



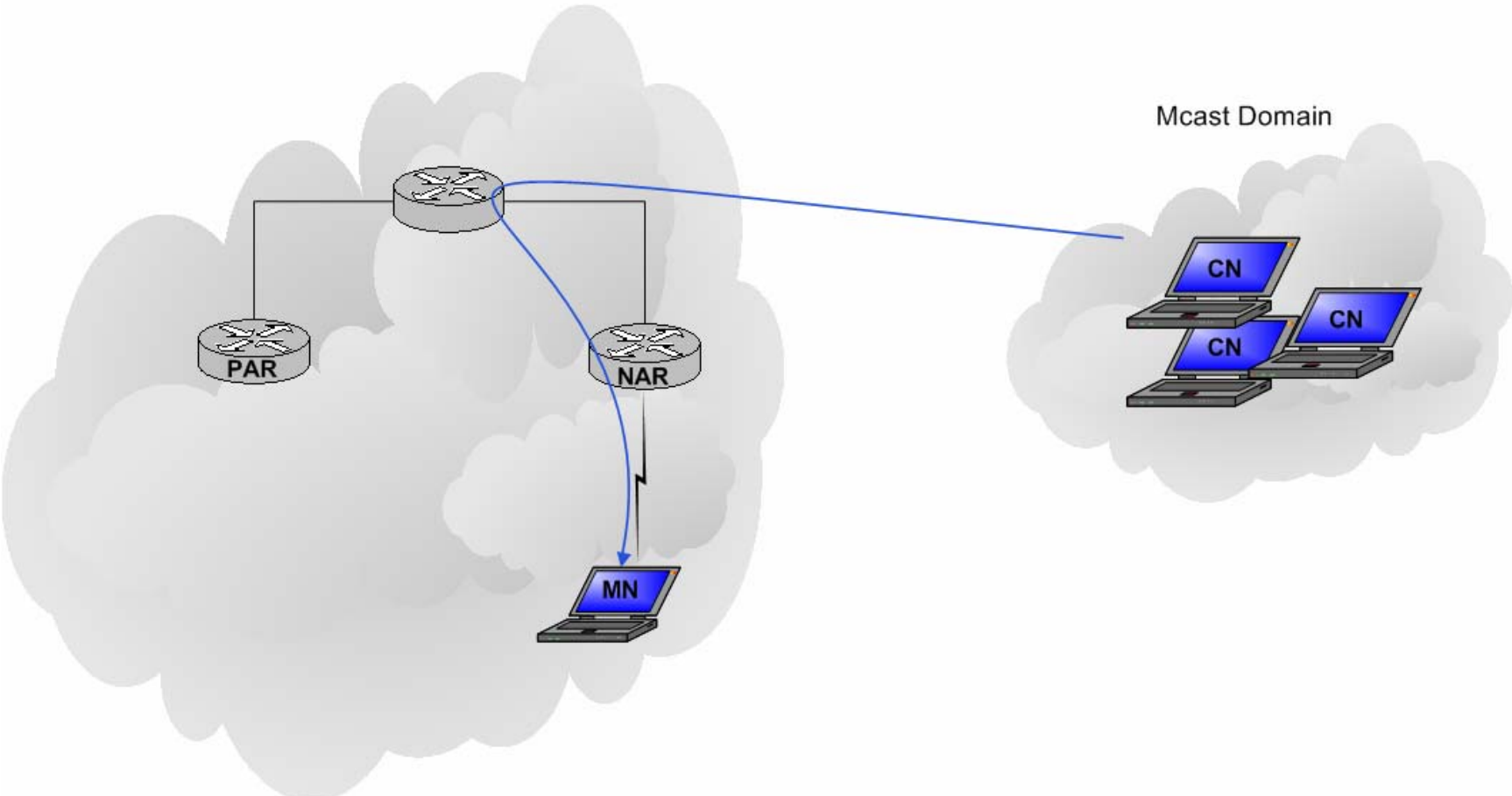
M-FMIPv6: Forwarding



M-FMIPv6: Handover



M-FMIPv6: Completion



Seamless Multicast Handover in a HMIPv6 Environment

draft-schmidt-waehlisch-mhmipv6-02

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

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M-HMIP: Mobile Multicast

Mobile multicast listener anchored at MAP:

o Group membership management through MAP

o On handover: packet forwarding to MN through previous MAP

o On demand: switch to remote subscription

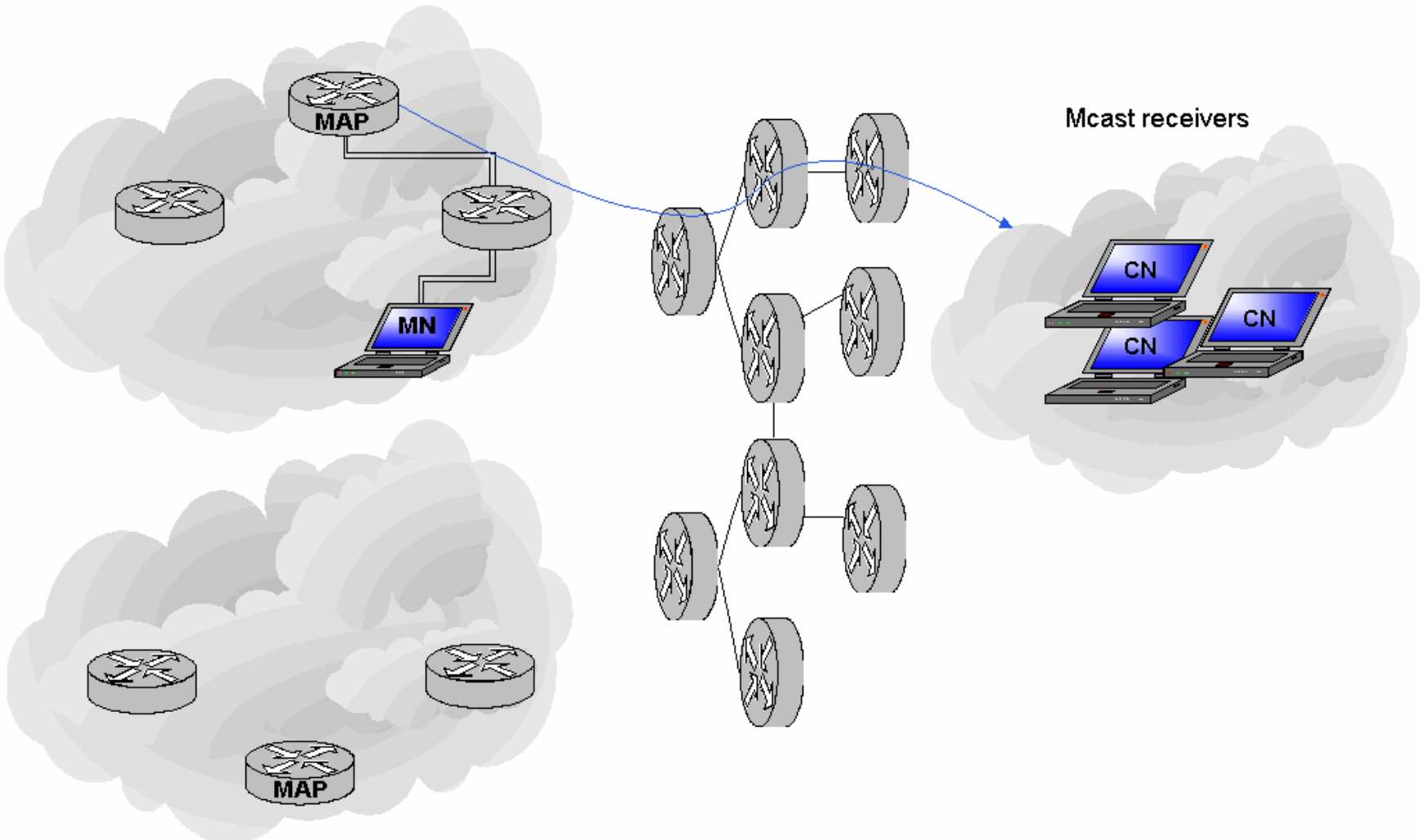
Mobile multicast sender anchored at MAP:

o Use Home Address Destination Option (CN must not verify BC on mcast)

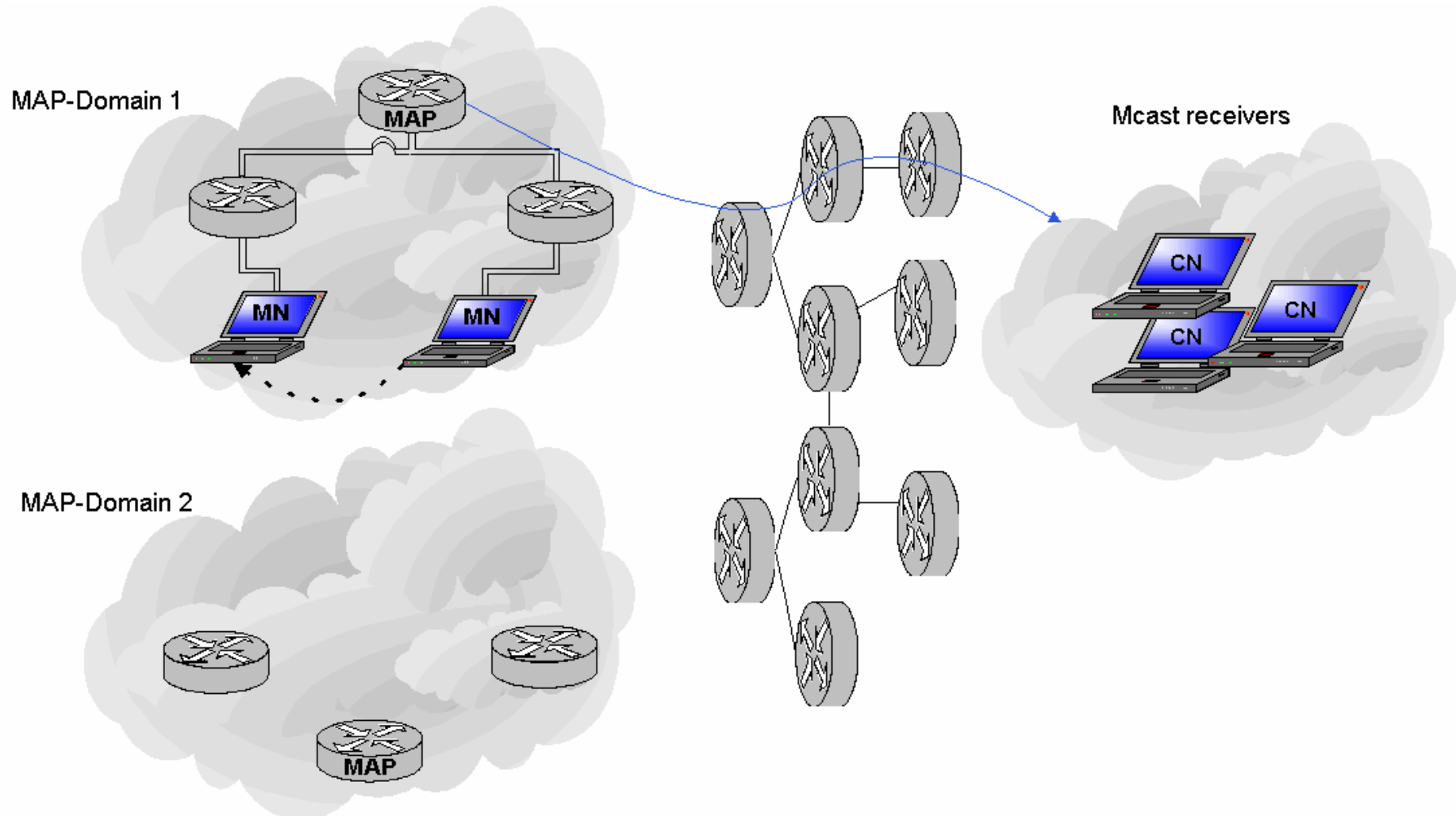
o On handover:
bi-cast through old and new MAP

o On rapid Movement:
stay with established MAP

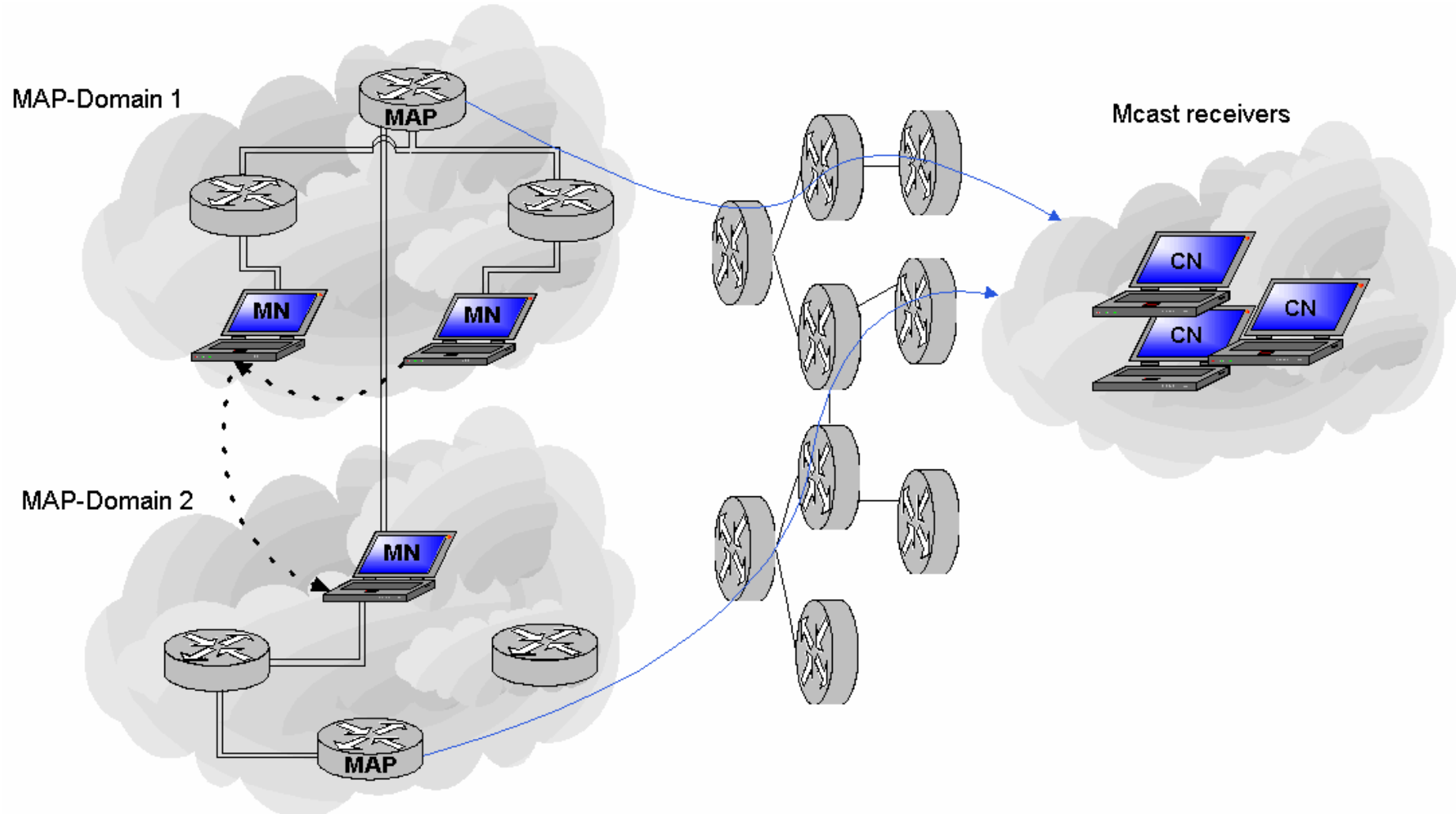
M-HMIP: Multicast Source



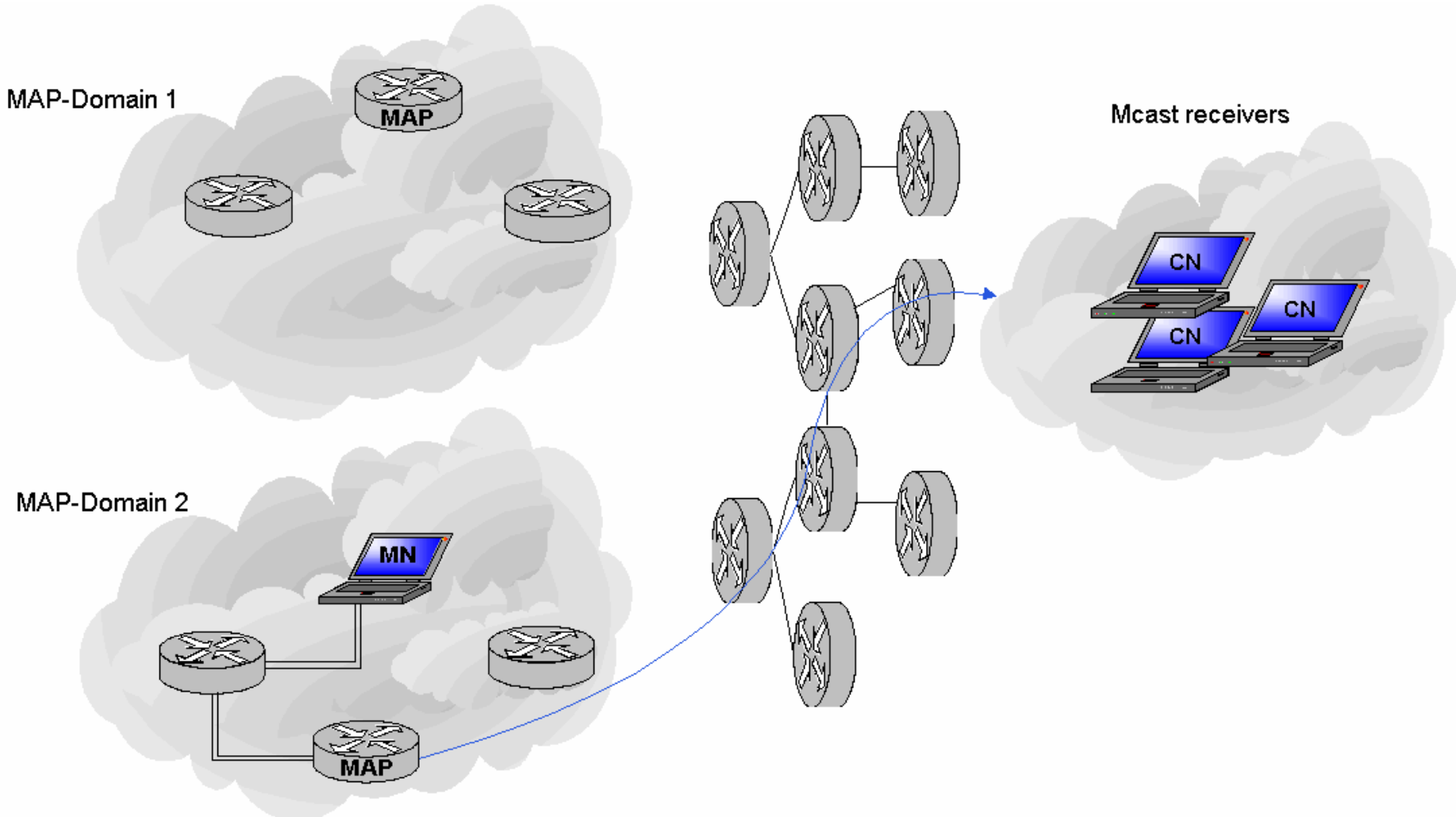
M-HMIP: MAP-Local Handover



M-HMIP: Inter-MAP Handover (1)



M-HMIP: Inter-MAP Handover (2)



Robustness

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