# Group Communication Supporting Mobile Video Conferencing - A Hybrid Perspective

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# Agenda

- Starting Point: Moviecast
  - Mobile Video Coding
  - Efficient Mobile Group Communication?
- SIP-based Mesh Construction
- Mobile SSM: Tree Morphing
- Hybrid Mobile Multicast
- Conclusions & Outlook



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# Application - Moviecast: Mobile Video & Multicast

- Videoconferencing on Handhelds
- Advanced Performance
- Integrated Group Communication
- Cebit ’08: First H.264 Software Encoder on Mobiles



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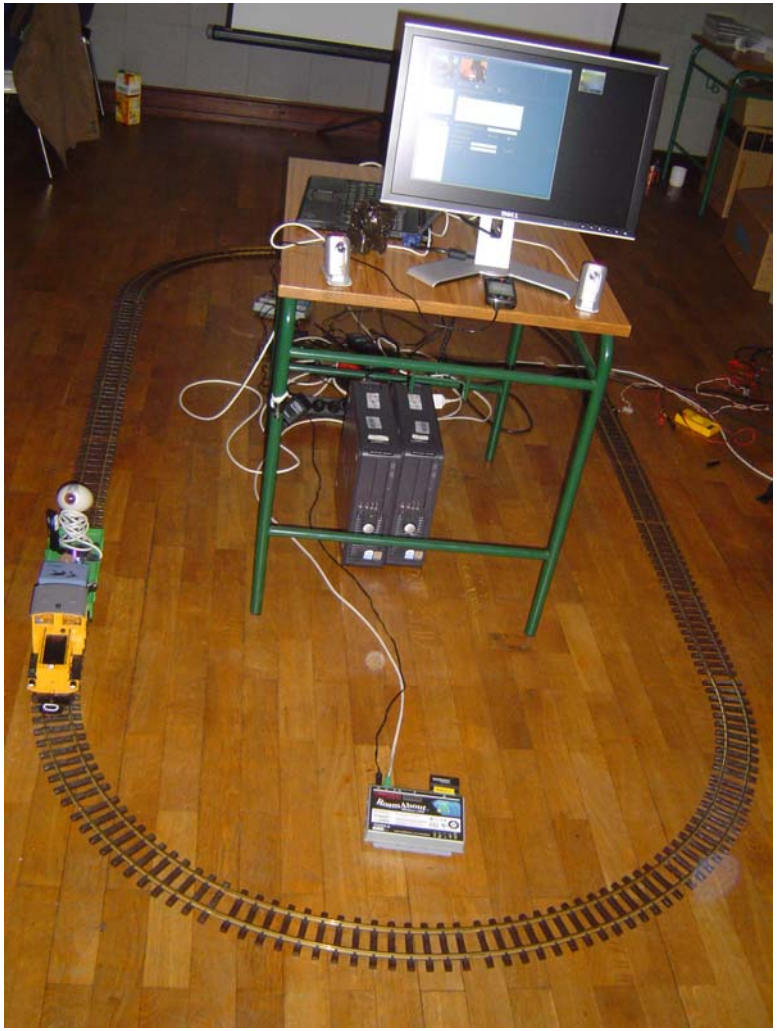
# Requirements

- Rigid real-time constraints - (50 – 100 ms)
- Scalable, resource-adaptive video encoding
- Mobility support on network layer
- Group communication enabled by network layer
- Encryption to secure all communication
- Focus on standard compliant signalling + communication

# Starting Point

- daViKo Video Conference Software
- H.264 Codec
- Peer-to-Peer Communication Model
- Simple User Localisation
- IPv4 & IPv6 – Unicast & Multicast
- Windows & Linux

# Moviecast Showcases

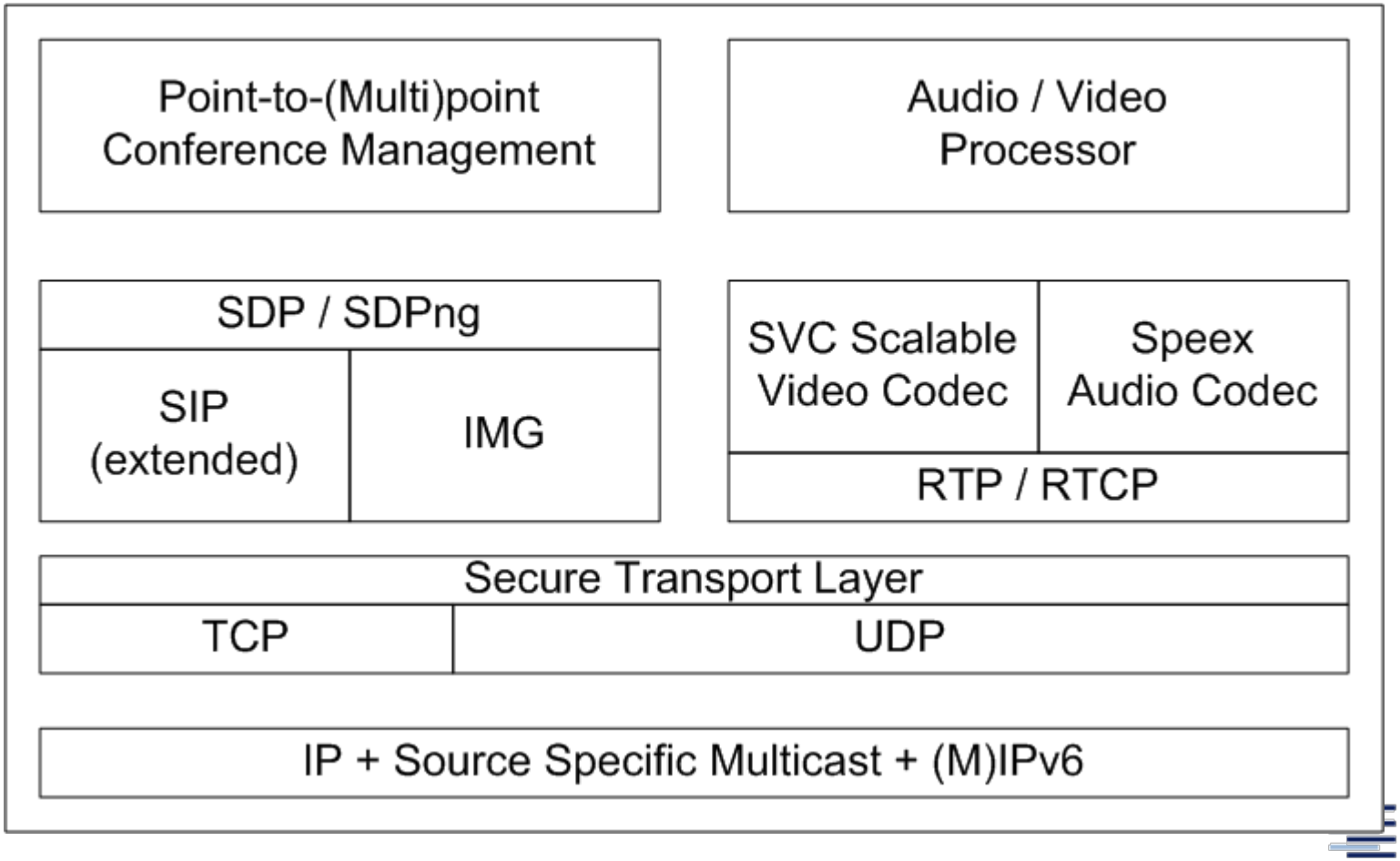


- Video from Train
- Video on Handheld

# Building Blocks

- Scalable, highly optimised video codec:
  Based on emerging SVC standard
- Software stack:
  Secure mobile group conferencing library
- Network layer advancements:
  P2P mobile group conferencing in real-time
- User interfaces

# Layered Software Stack

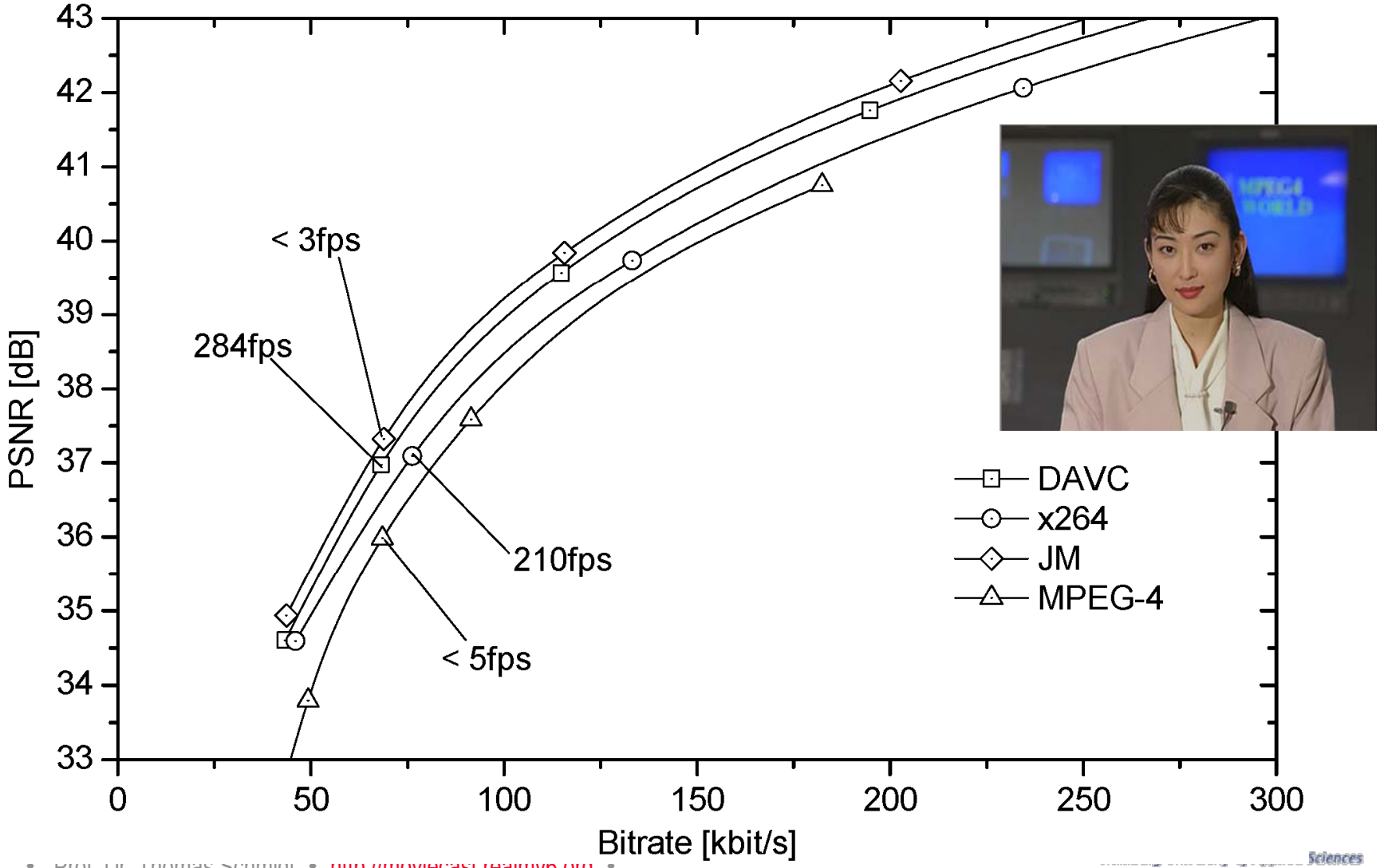


# DAVC – H.264 Software Codec

- Baseline profile
- Fast motion estimation strategy (diamond search)
- Fast Rate Distortion-based mode decision Algorithm

  (skip mode decision depending on RD weight function )
- Early termination conditions (skip mode depending on residual thresholds )
- Compare with X264 2end at MSU measurements (Feb 08)
- Compared with JM (using all rd optimation modes)

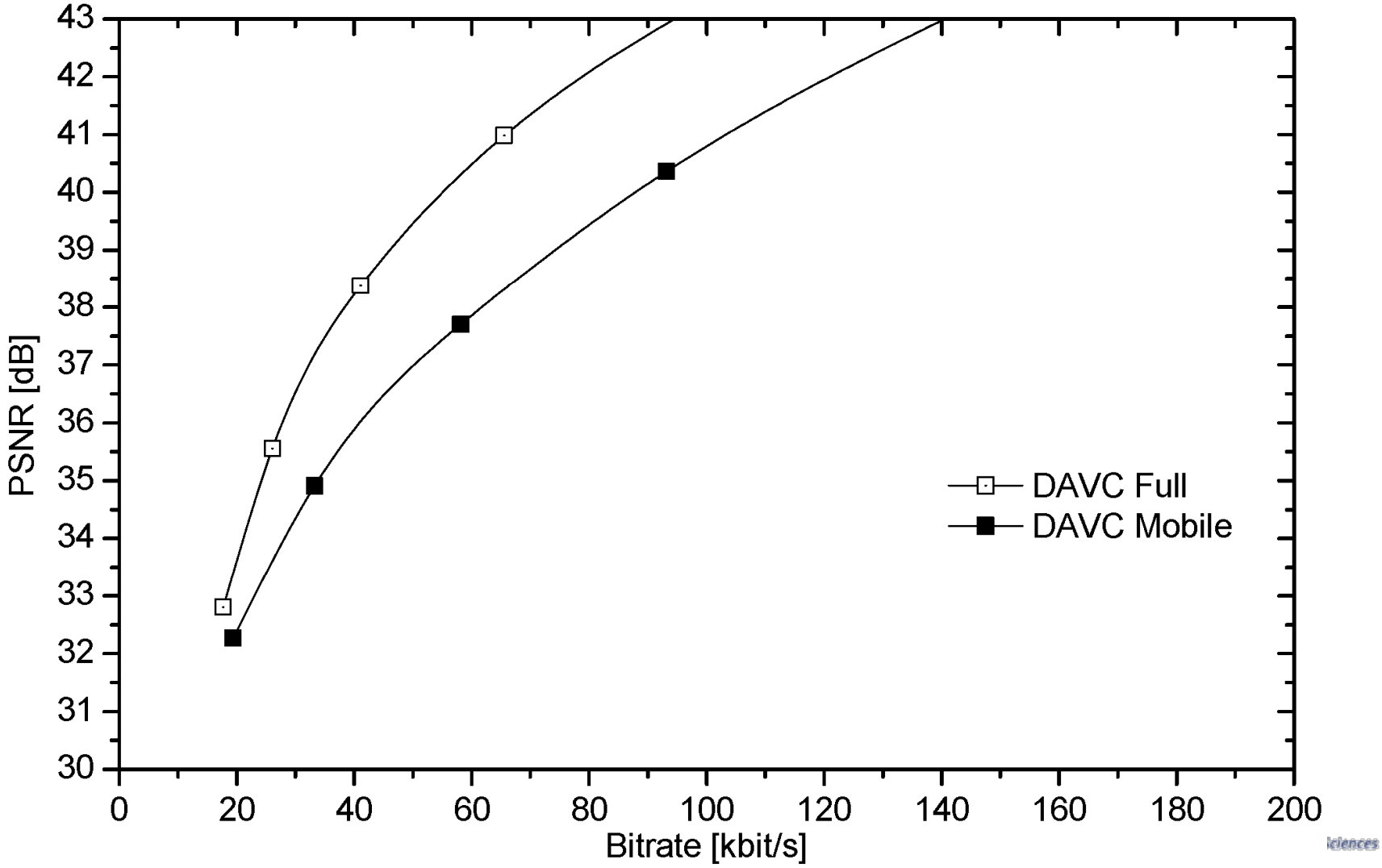
# DAVC – Performance (Akiyo)



# DAVC Mobile – Optimized Real-Time Software Codec for Mobiles

- o Optimized Code for mobile processor platform
  - Current support for XScale & Intel Atom
  - Prototype on Windows Mobile 6
  - Optimization ongoing
- o Real-Time compliance on 520 MHz XScale (ASUS P735)
  - 13 – 15 fps QCIF encoding
  - 30 fps QCIF decoding
  - 5 / 10 fps QCIF encoding + decoding in parallel
- o Reduced Codec complexity
  - Motion compensation restricted to 16 x 16 blocks
  - Moderate performance degradation

# DAVC Mobile – Performance (Akiyo)



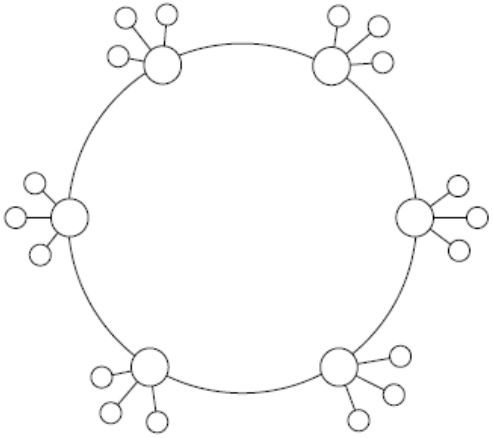
# Group Communication

Problem: Design an efficient, robust standard-compliant group communication layer.

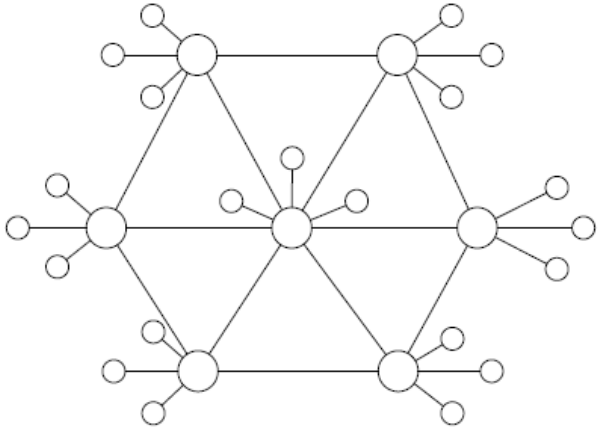
Our approaches:

- Source Specific Multicast initiated by SIP
  - Easy, scalable and elegant
  - But: deployment & NAT problem
- Application-layer meshing with SIP
  - Hybrid solution: Super peers to aid mobiles & traverse NATs
  - Meshing strategy depends on # of participants
- Application-layer multicast based on DHTs
  - Bi-directional Scalable Adaptive Multicast (Bi-dir SAM)
  - Currently under investigation

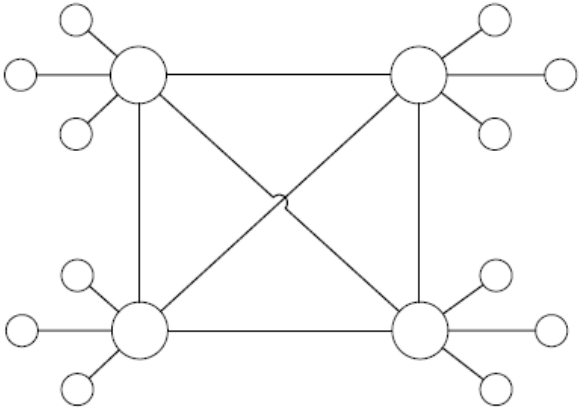
# SIP Mesh Communication Layer



(a) Ring



(b) Polygon



(c) Full mesh

- Full mesh enables 1-hop routing
- Favorable for moderate conference sizes
- Critical: Determine device capabilities to build optimized overlays

# SIP Primitives for Meshing

- Super peers form a distributed conference Focus
- Attaching clients to super peers: REFER method

```
REFER sip:lucy@psychic.org SIP/2.0
...
CSeq: 9380 REFER
Refer-To: <sip:hypnotic-talks@vain-focus.circles.com>
Content-Length: 0
```

- Transferring client sessions from unsuitable peers:

```
INVITE sip:lucy@psychic.org SIP/2.0
...
CSeq: 1199 INVITE
Contact: <sip:hypnotic-talks@my-focus.circles.com>
Content-Type: application/sdp
```

# Device Capabilities

- Adaptive meshing requires a priori knowledge of peer properties:
  - System class: CPU & Memory limits
  - Display & camera restrictions
  - NAT / firewall detection
  - Sustained bandwidth (beyond link capacity)
- Problem: bandwidth estimation
  - Quick reasonable up- and downstream estimates
  - Approach: send variably sized nonintrusive probe packets
  - Measure delay variations
  - Work still experimental

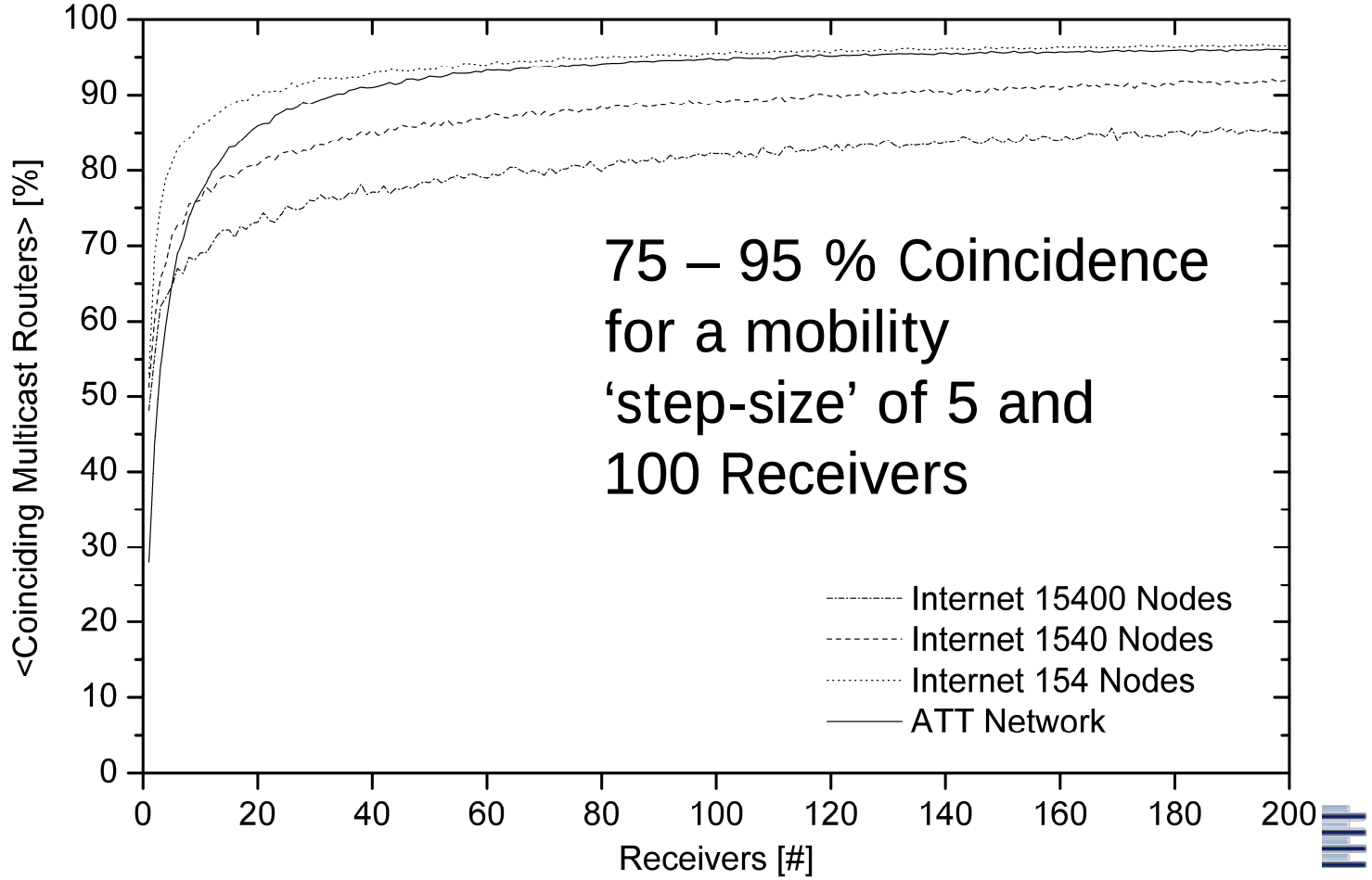
# Problem: Mobile SSM Sources

- Real-time constraints (50 – 100 ms)
- SSM was designed for known, fixed sources
- On source handover, the delivery tree rooting at the source invalidates
- Address duality: Source filtering in routers and receivers
  - Logical Group Identifier: Home Address (HoA)
  - Topological Tree Locator: Care-of Address (CoA)
- Decoupling: Source cannot control receiver initiated updates
  - May loose receivers on handover

# Solutions

- Statically Rooted Distribution Trees
  - Handover compliant to Mobile IPv6
  - Packets are tunneled via the Home Agent
    - Additional undesired latencies
    - Single Source of Failure
- Reconstruction of Distribution Trees
  - Separate multicast control tree with information about source address changes or
  - Bicasting data into an old and a new tree via anchor points (APs)
- Tree Modification Schemes
  - Attempt to re-use (overwrite) established states

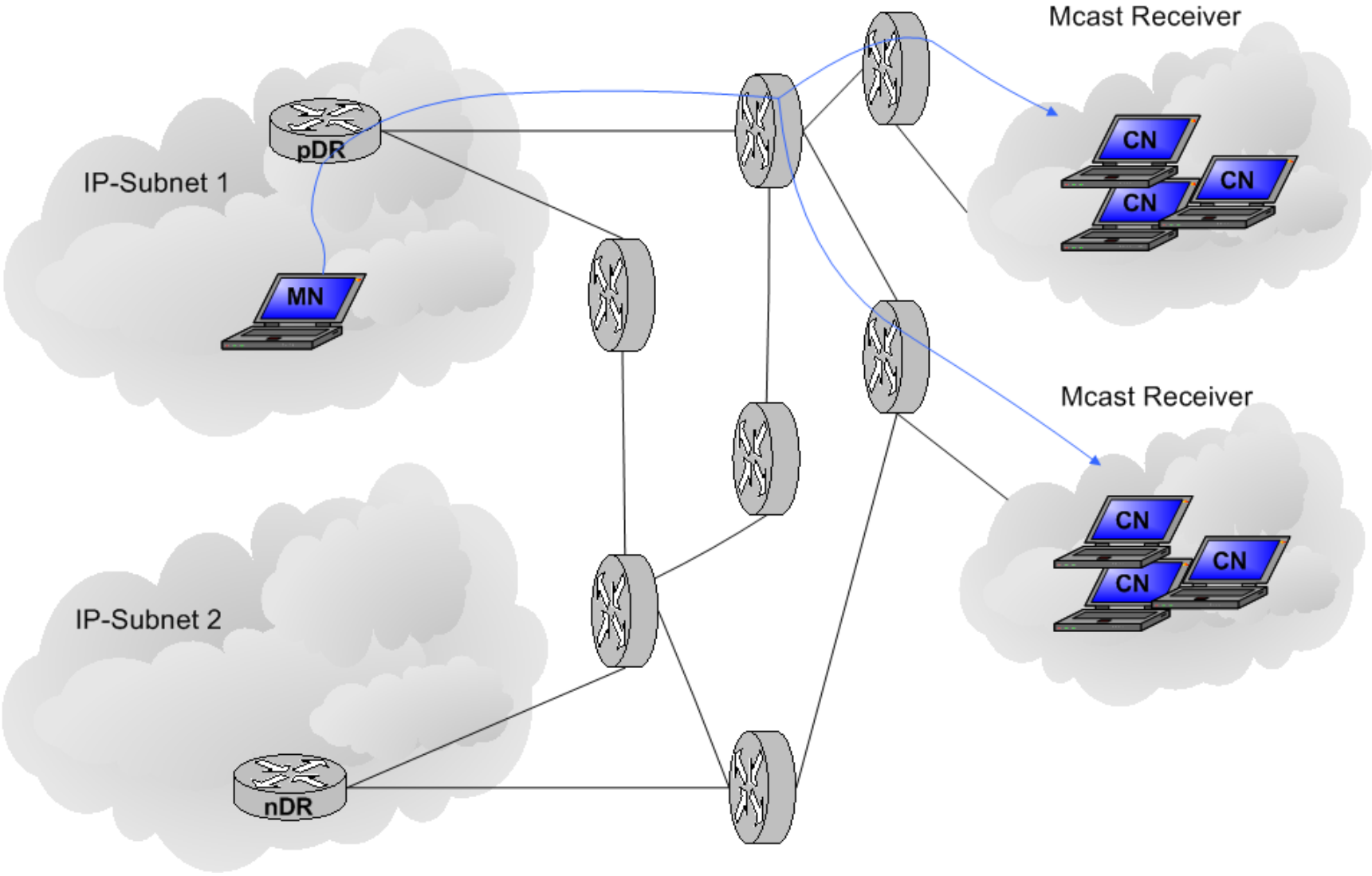
# Multicast Forwarding States: Change of Distribution Trees under Mobility



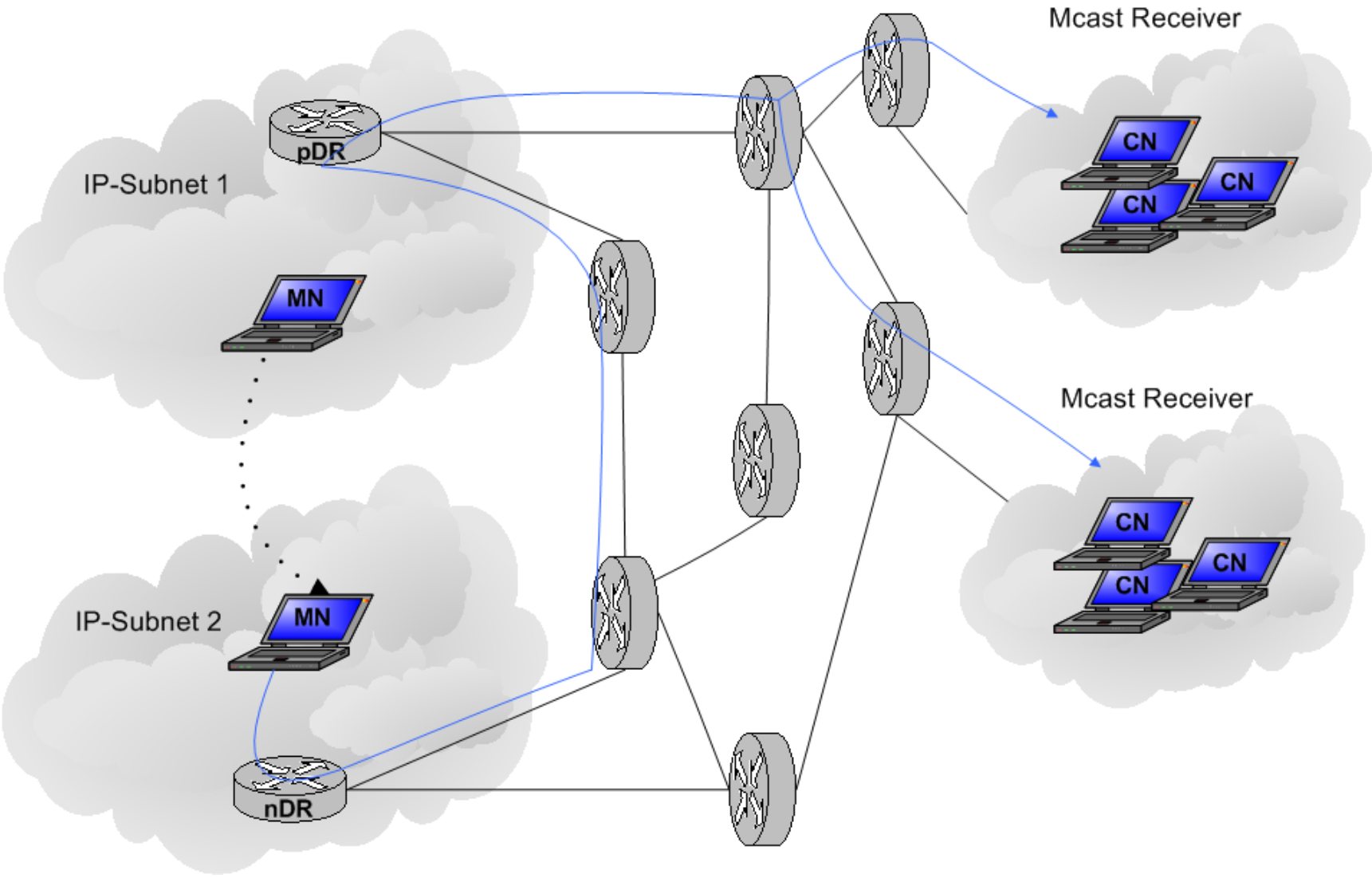
# Enhanced Tree Morphing: Routing for mobile SSM sources

- o Preserve previous trees:
  - Keep contact subsequent to handover
- o Idea: Morph previous into next tree:
  - Elongate root (modify RPF-Check)
    - Send packets to previous root of delivery tree
  - Discover shortcuts, but re-use common parts of trees
  - Dismiss unneeded branches
  - A new SPT is generated
- o Need to change routing
  - Extend (CoA,G) states to (CoA,G,HoA)

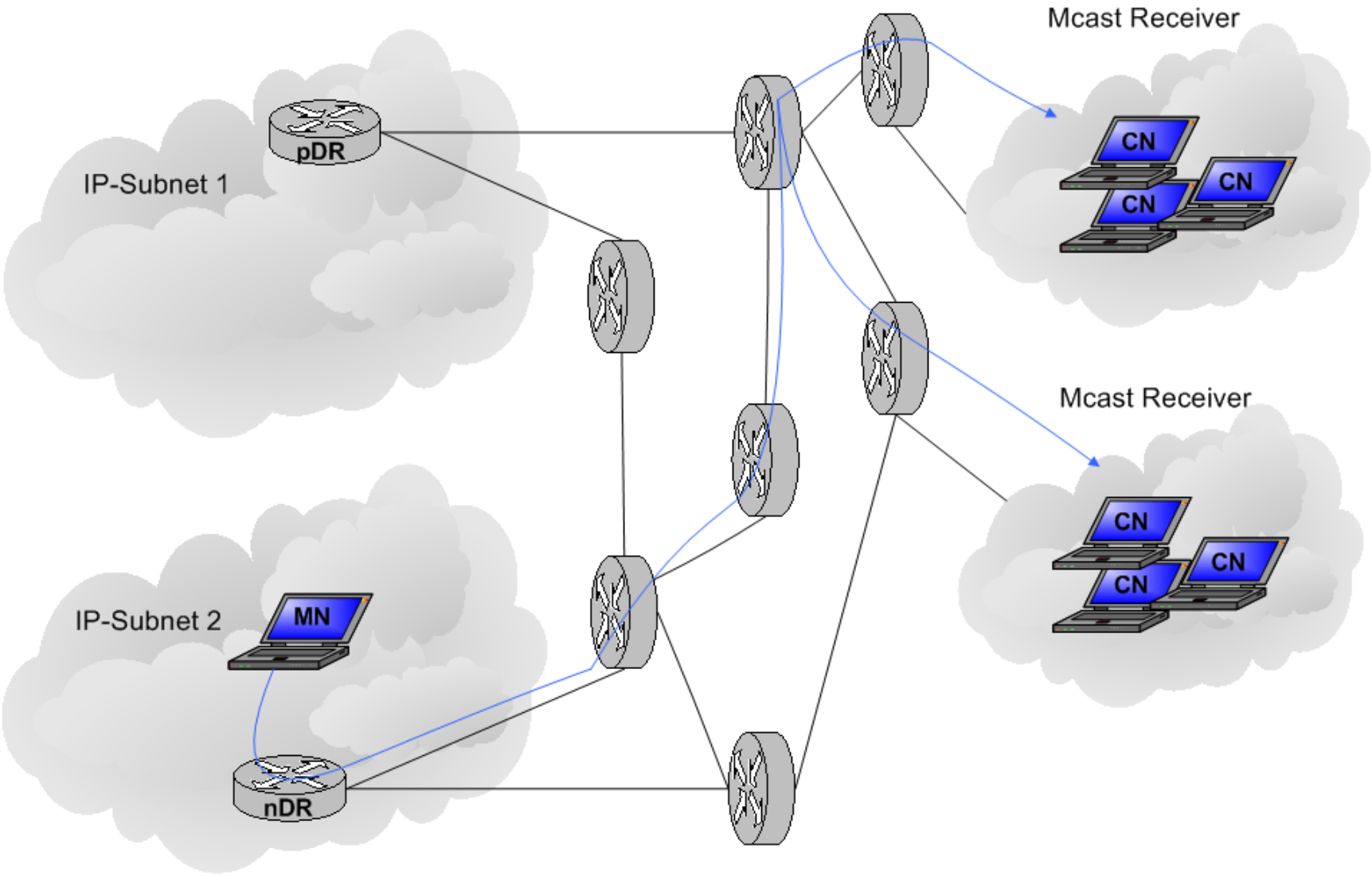
# Enhanced Tree Morphing: Initial Phase



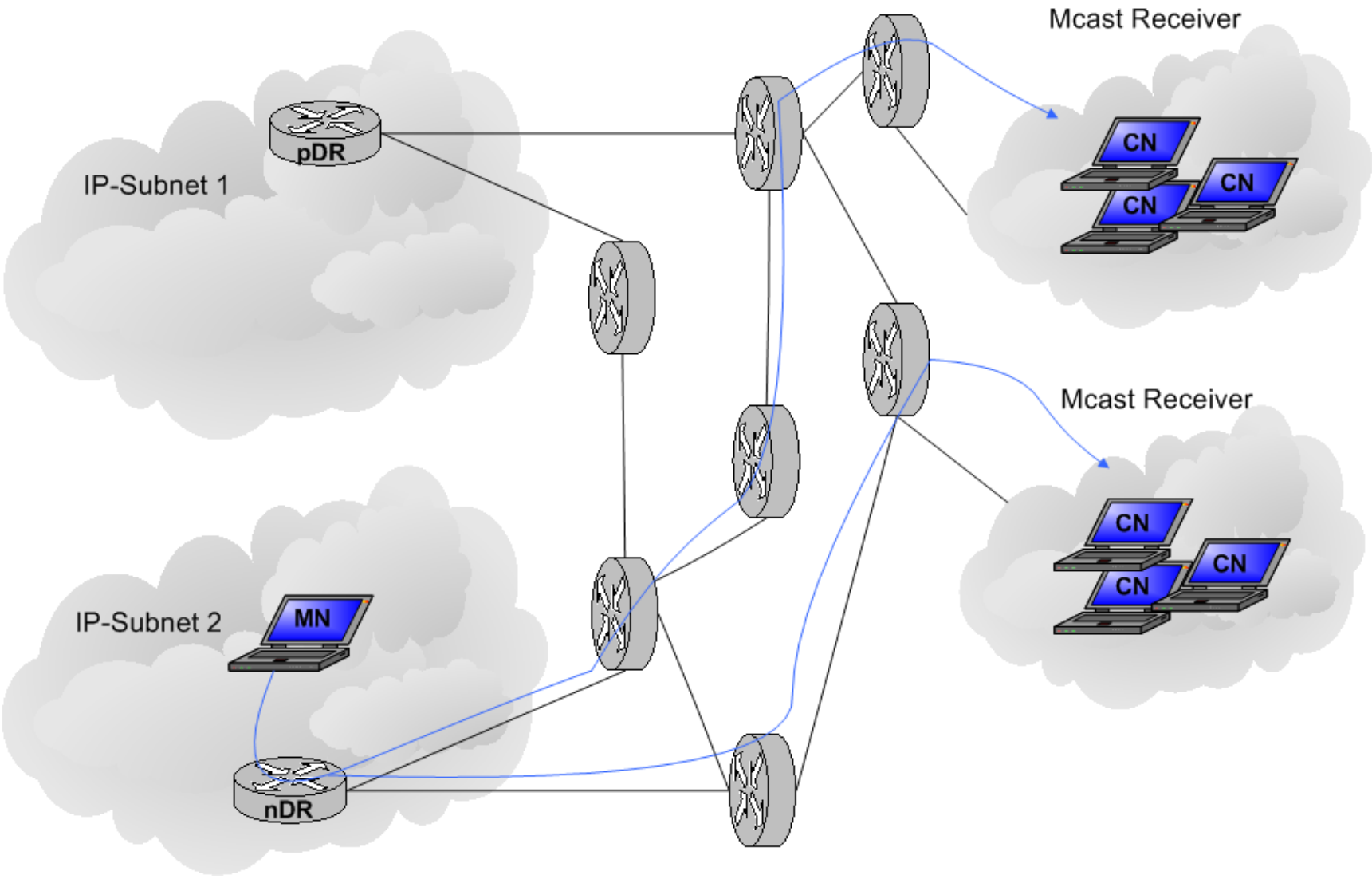
# Root Elongation Phase via Unicast



# First Shortcut



# Optimized Tree



# Design of the Tree Morphing Protocol

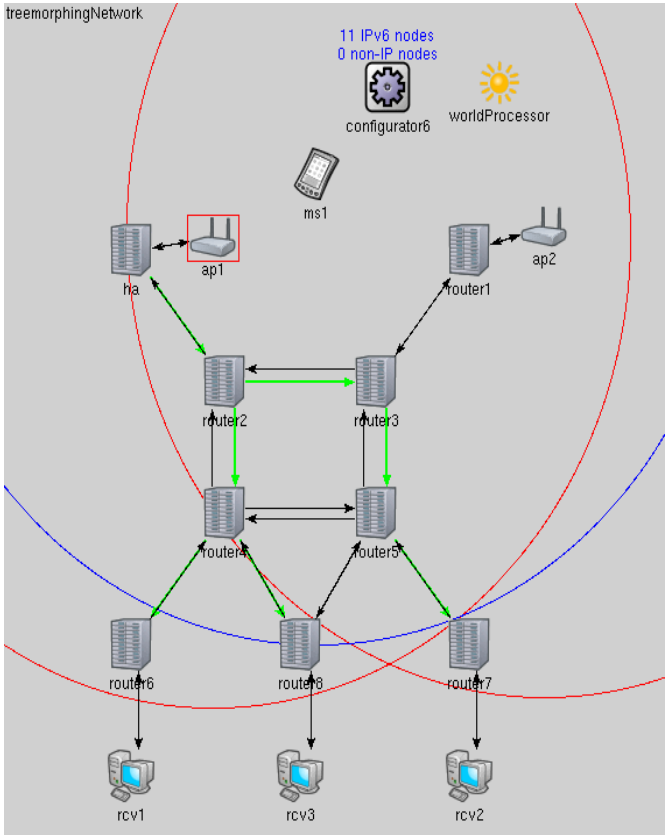
- State update - necessary information
  - Group context (HoA, G)
  - Tree topology (nCoA, G)
- Router Alert Option instructs routers, to further inspect the packet
- “Piggy-backing” of update information for previous tree
  - Eliminates additional update packets
- Minimum extension to existing mobility messages
  - Re-use of existing Mobile IPv6 headers
- Security and robustness of updates via CGAs

# Benefits of Tree Morphing Protocol

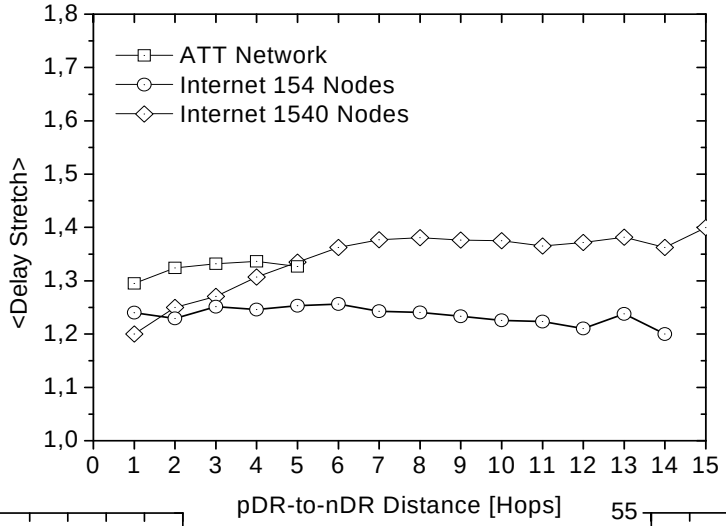
- Signaling of updates by combining existing IPv6 headers
  - Router Alert Option is slight addition to existing Mobile IPv6 Binding Update
  - Packet processing is well-defined and already well tested
- Only tree elongation based on dedicated update packet
  - Inserting the update message into the data stream does not introduce additional packets

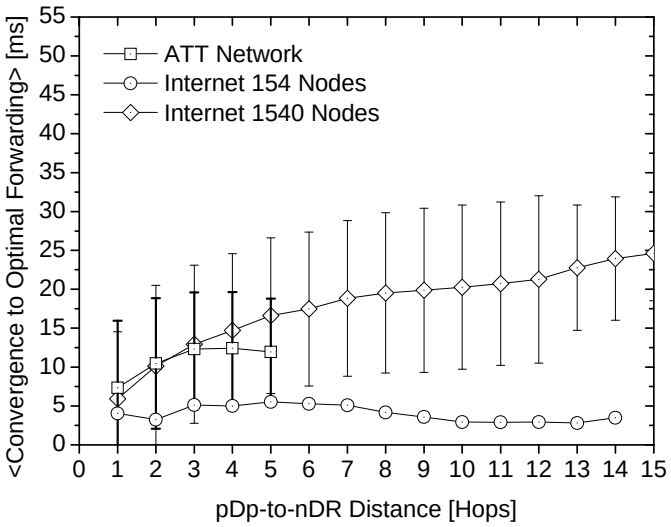
# Simulation

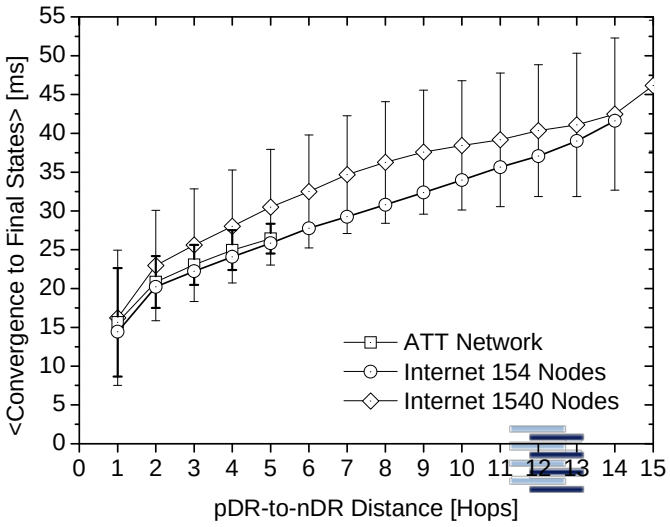
- OMNeT++ with IPv6Suite
- Performance Metrics
  - Delay Stretch
  - Optimal Forwarding Time
  - Final Convergence Time
  - State Convergence under Rapid Movement



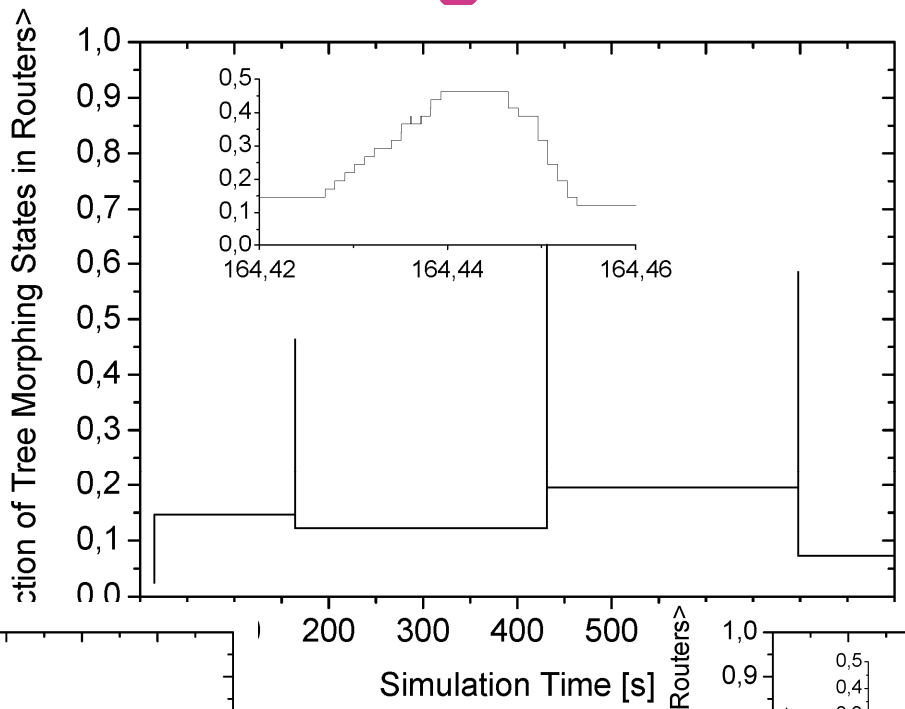
# Simulating Real-world Topologies Single-Provider Network and Internet

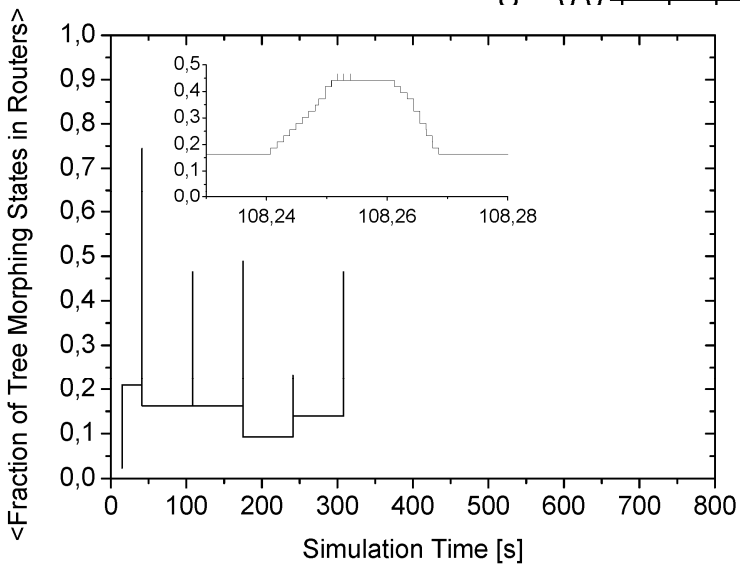


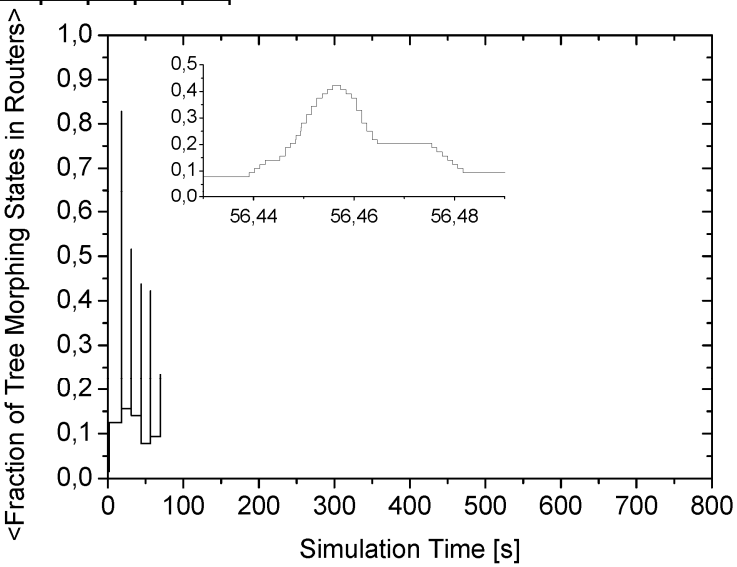



# Simulating Rapid Movement: Router State Convergence



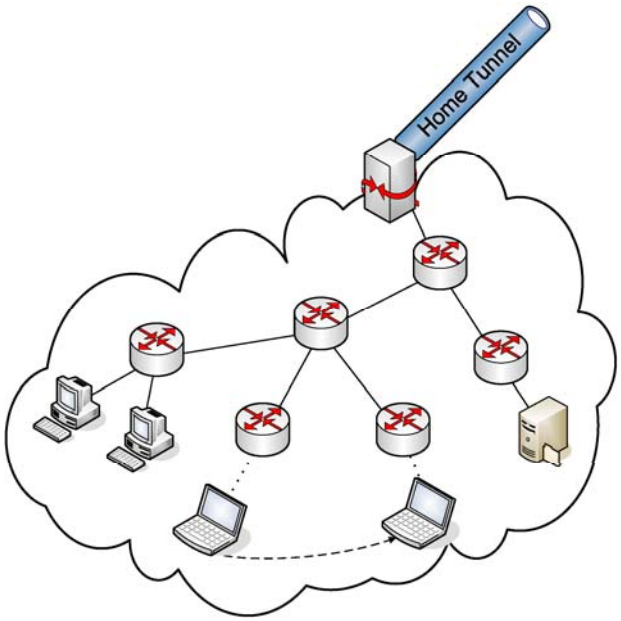



# Hybrid (Mobile) Multicast: Motivation

- In search of a mobility-agnostic group communication layer, in the sense of
  - mobile receivers activate pre-established states
  - mobile sources may send from any location
- BIDIR-PIM fulfils requirements for interior domains
- No globally available equivalent
- Deployment of new multicast routing protocols in the backbone is problematic

# Architectural Approach




Starting Point:

- Native multicast at end system domain
- Gateways as interdomain connectors
- Typically (ptp-) tunneled – can we do better?
- Gateways are part of the Internet edge domains
- Can operate a DHT – without affecting the core



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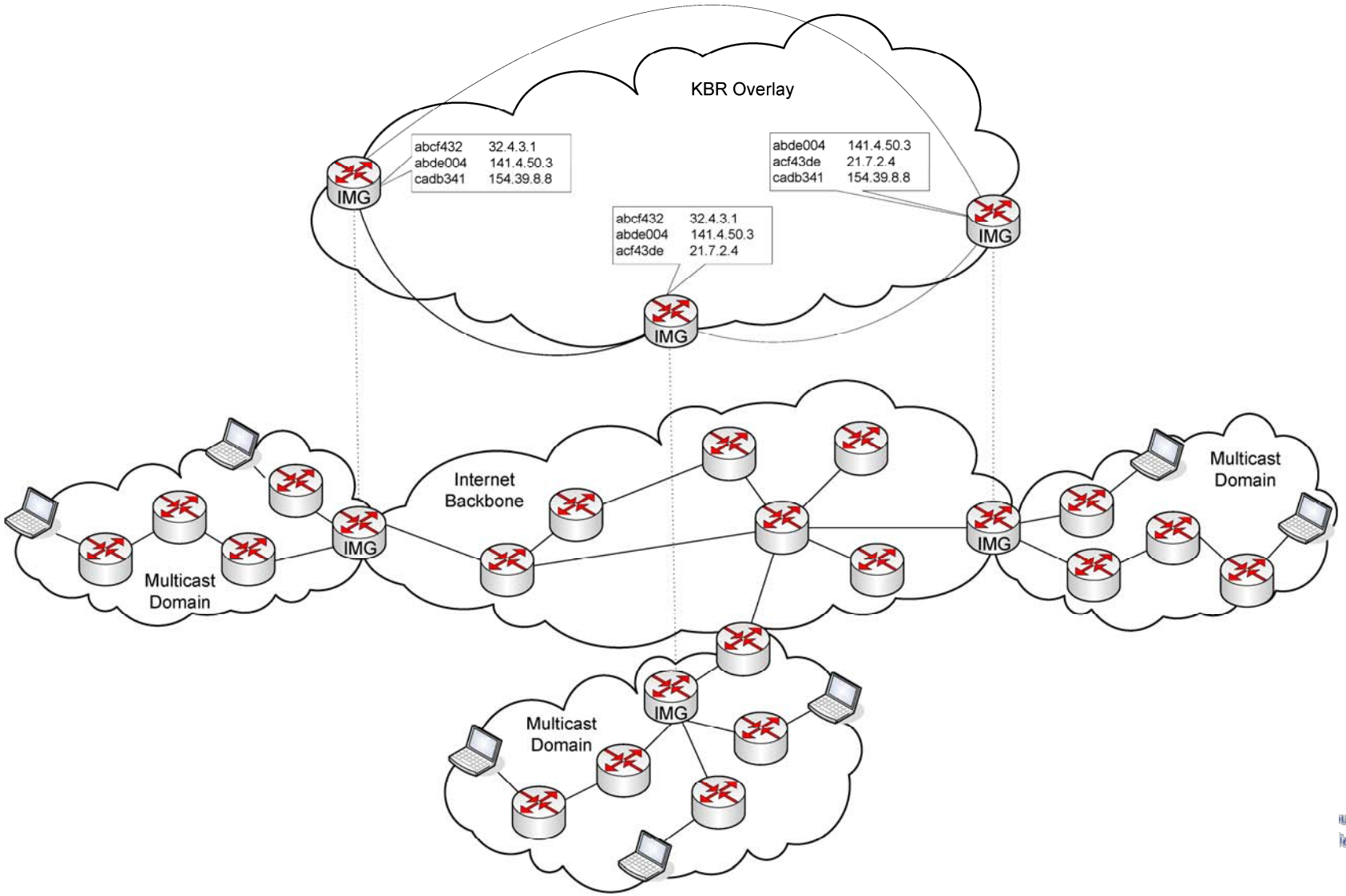
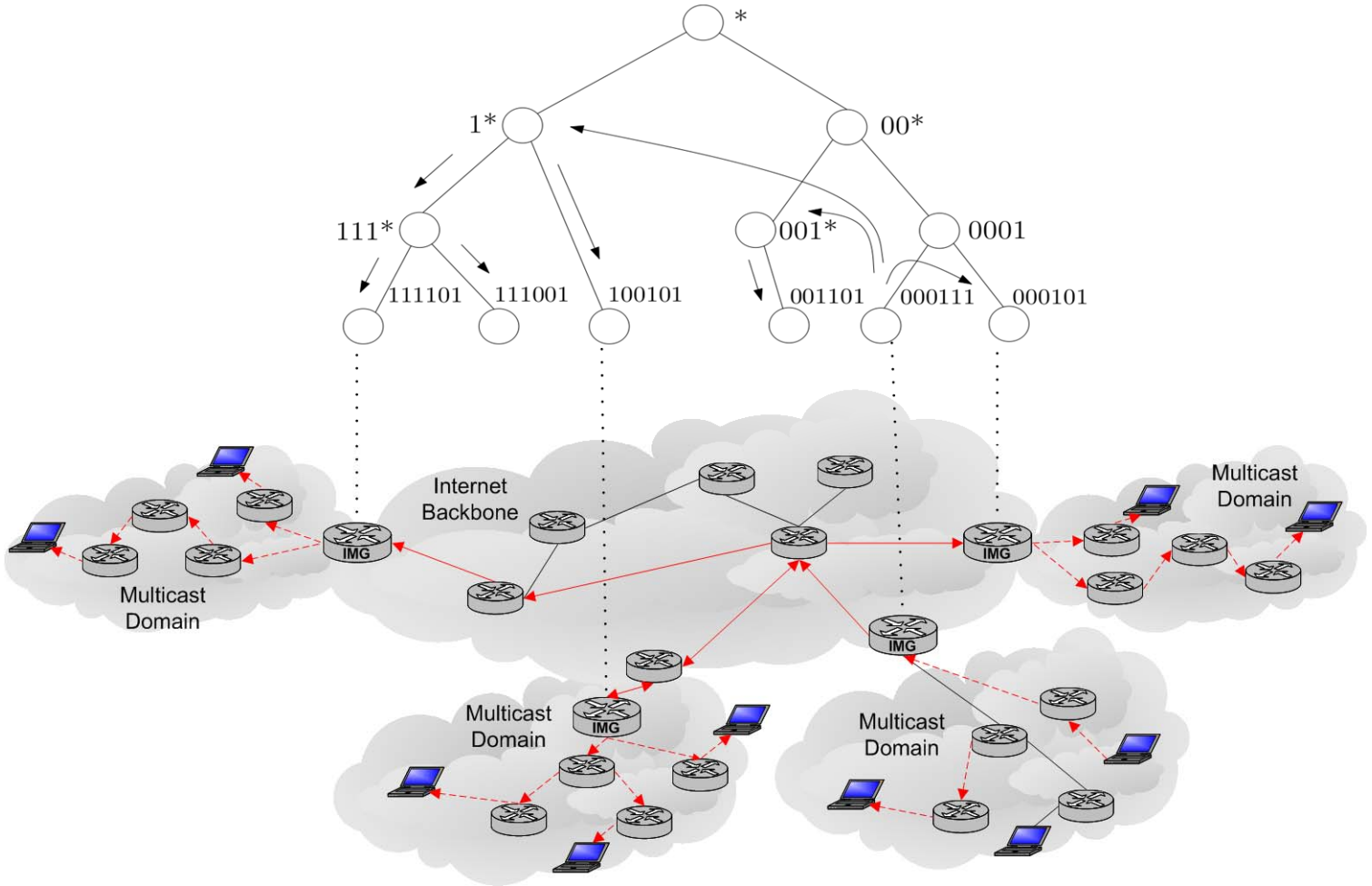
# Hybrid Shared Tree Architecture



# How to Make this Mobility-Agnostic?

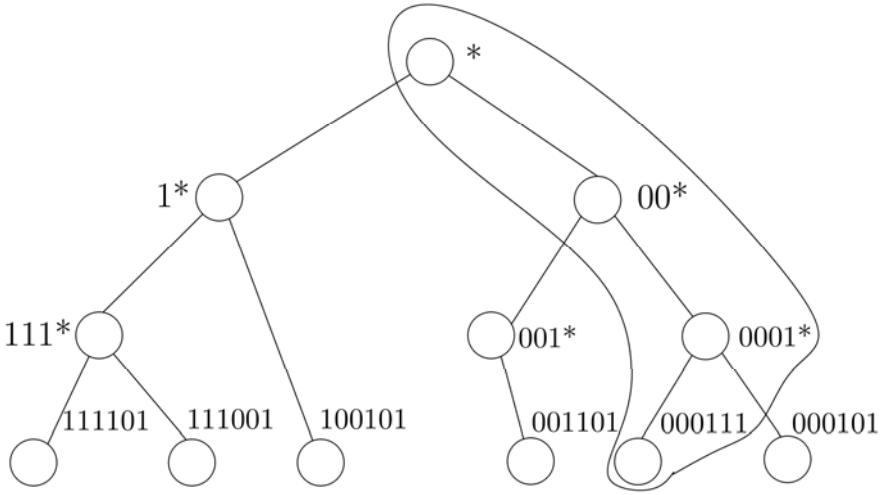
- o Use BIDIR-PIM in the underlay (end domains)
- o Provide transparent Interdomain Multicast Gateways (IMGs)
- o Design a Mobility-Agnostic Overlay Multicast
  - Approach: BIDIR-SAM
    Key-based routing on a shared virtual prefix-tree
  - Guides packet distribution along source-specific shortest paths (in prefix space)
  - Prefix tree is common knowledge to all IMGs

# HST Distribution According to a Shared Virtual Prefix Tree



# BIDIR-SAM: Scalable Adaptive Multicast on Bi-directional Shared Prefix Trees

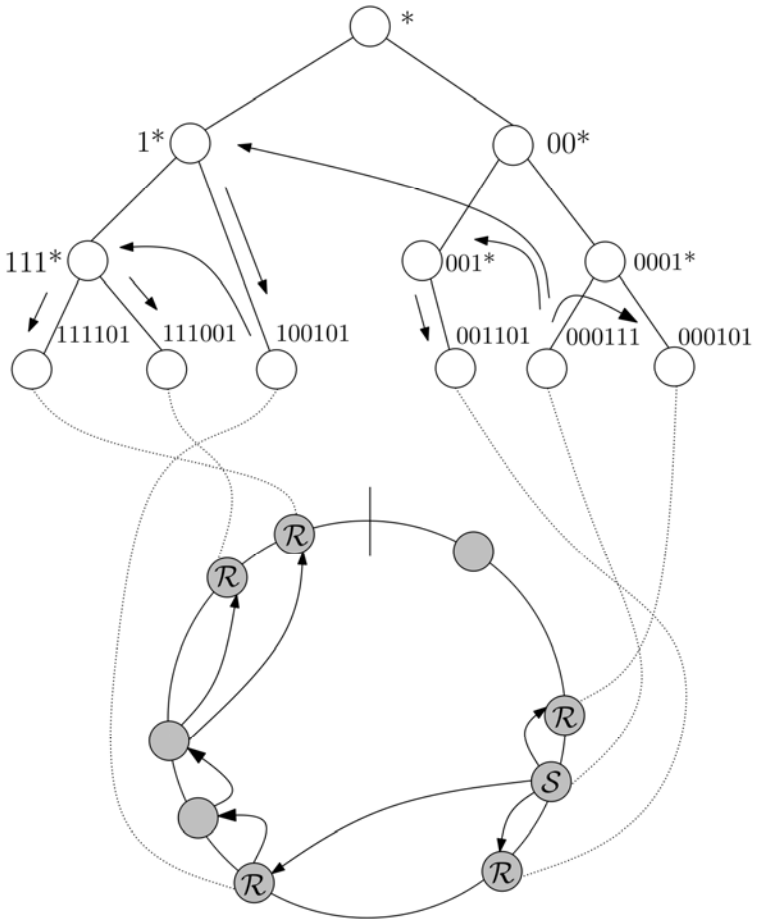
- Every IMG has an overlay address: hash(IMG ID)
- IMGs learn about all group memberships
  - Membership updates are distributed to subtrees
- For each group, IMGs construct a common prefix tree
  - IMGs of multicast receiver domains represent leaves
  - Inner vertices correspond to longest common prefix
  - Vertices on path to root share prefix with node itself



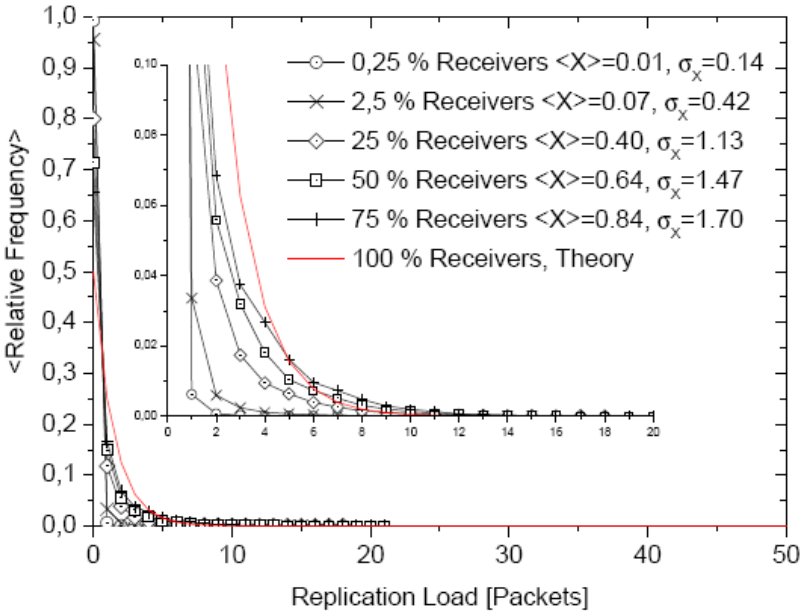

- Tree will be used as bi-directional shared tree

# Routing

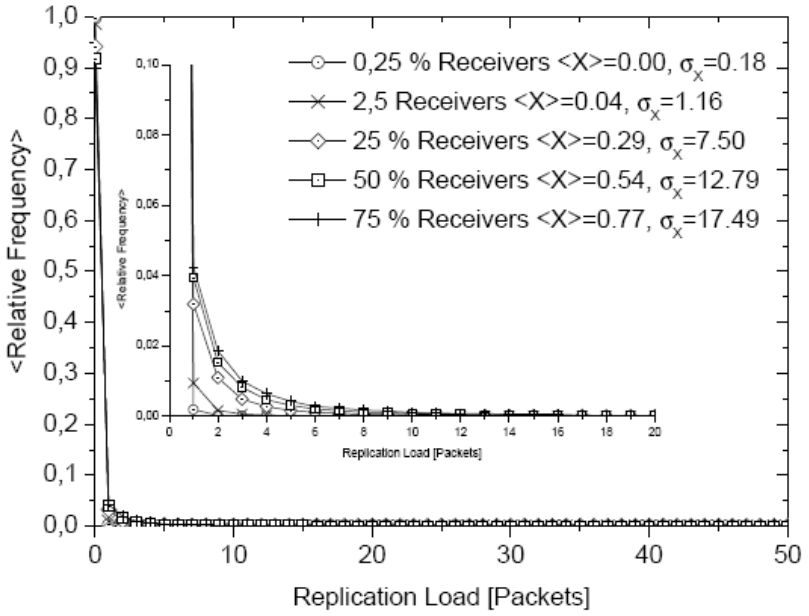
- Prefix tree is a routing overlay to the DHT
- Source node determines its position on the tree
  - Longest common prefix
- Multicast traffic distributed to prefix neighbors
  - Only downward flows
- Underlay routing correspondence extracted from Pastry routing table



# Performance View: Replication Load




(a) BIDIR-SAM




(b) Scribe



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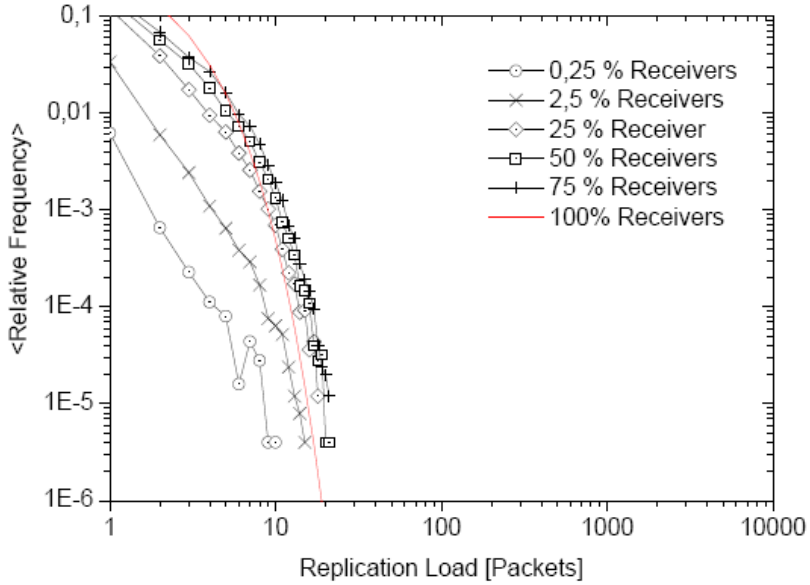
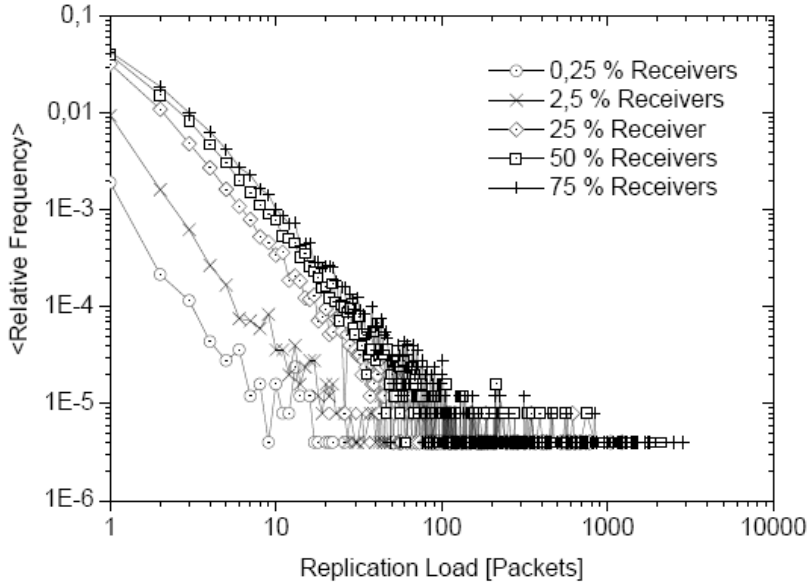
# Replication Load: Tails

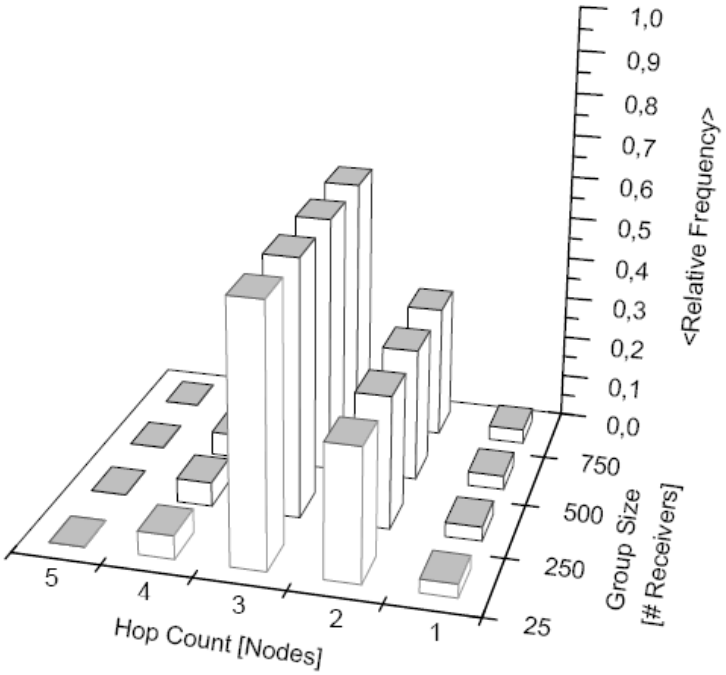



(c) BIDIR-SAM

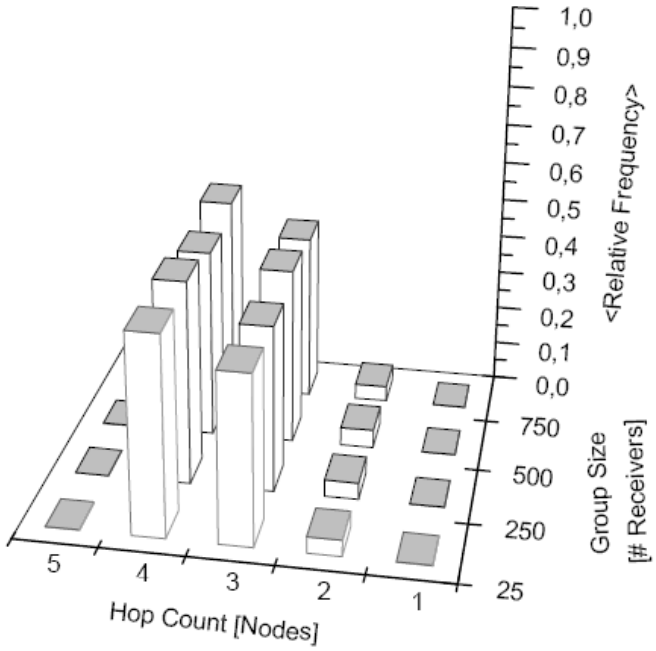



(d) Scribe

# Hop Count at 1.000 Nodes




(e) BIDIR-SAM




(f) Scribe

# Integration with BIDIR-PIM

- Place IMG on Rendezvous Link
- All traffic originating from the underlay arrives there
  - IMG can intercept and forward to overlay
- Any initial receiver subscription for a group will be signaled up to the RP link
  - IMG can intercept JOIN and signal to the overlay
- IMG function will remain fully transparent to BIDIR-PIM

# Resume

- Mobile & Video communication are essential stimulants for (mobile) group communication
- Various technological challenges
  - SIP-based predictive mesh construction
  - Mobility support for SSM sources
  - Mobility-agnostic hybrid multicast
- Promising: Lightweight & Infrastructure-agnostic to make things work, scale and foster an open community of collaboration

# Outlook: Future Applications

- Seamless Integration of User Generated Video Content from Mobiles
- User Generated Video Groups (MyIPTV)
- „Semantic“ P2P Group Networks
- Larger Deloyment Projects (Including Feedback & Evaluation)

→ Project Partners Welcome

# References


- Hans L. Cycon, Thomas C. Schmidt, Gabriel Hege, Matthias Wählisch, Detlev Marpe, Mark Palkow, *Peer-to-Peer Videoconferencing with H.264 Software Codec for Mobiles*, **In:** *WoWMoM08 - The 9th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks - Workshop on Mobile Video Delivery (MoViD),* IEEE Press, June 2008.
- Thomas C. Schmidt, Matthias Wählisch, Godred Fairhurst, *Multicast Mobility in MIPv6: Problem Statement and Brief Survey*, IRTF Internet Draft -- work in progress, No. 05, November 2008.
- Thomas C. Schmidt, Matthias Wählisch, Maik Wodarz, *Fast Adaptive Routing Supporting Mobile Senders in Source Specific Multicast, Telecommunication Systems,* Berlin, Heidelberg:Springer Verlag, 2009. (in press)
- Thomas C. Schmidt, Matthias Wählisch, Olaf Christ, Gabriel Hege, *AuthoCast - a mobility-compliant protocol framework for multicast sender authentication*, Security and Communication Networks, Vol. **1**, No. 6, pp. 495 -- 509, Wiley \& Sons, Ltd, December 2008.
- Matthias Wählisch, Thomas C. Schmidt, *Between Underlay and Overlay: On Deployable Efficient Mobility-agnostic Group Communication Services, Internet Research,* Vol. **17**, No. 5, pp. 519--534, November 2007.
- Matthias Wählisch, *Scalable Adaptive Group Communication on Bi-directional Shared Prefix Trees,* Technical Report, Freie Universität Berlin, September 2008.

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# Thank You!

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