Large-Scale Measurement and Analysis of One-Way Delay in Hybrid Multicast Networks

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Motivation
Why Multicast

Evolution of Internet Applications

- IPTV, Software-Updates
- OSNs, MMORPGs, AV-Conferencing
- Sensor networks, Internet of Things

Common communication pattern

- Global distribution systems and interactive services
- Group communication: one-to-many and many-to-many

Demand for Internet-wide group communication service.

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Agenda

1. Hybrid Multicast
2. Methodology
3. Measurement Setup
4. Measurement Results
5. Conclusion & Outlook

Problem Statement

Multicast Challenges

- Many flavors (ASM, SSM) and technologies (IP, OLM, ALM)
- Divergent states of deployment, no global multicast service
- No standardized, generic API covering all multicast variants

Must select multicast technology at compile time!

Hybrid Multicast

- Inter-connect heterogeneous multicast technologies
- Approaches: Universal Multicast, Island Multicast, and H∀Mcast

Is hybrid multicast performance suitable
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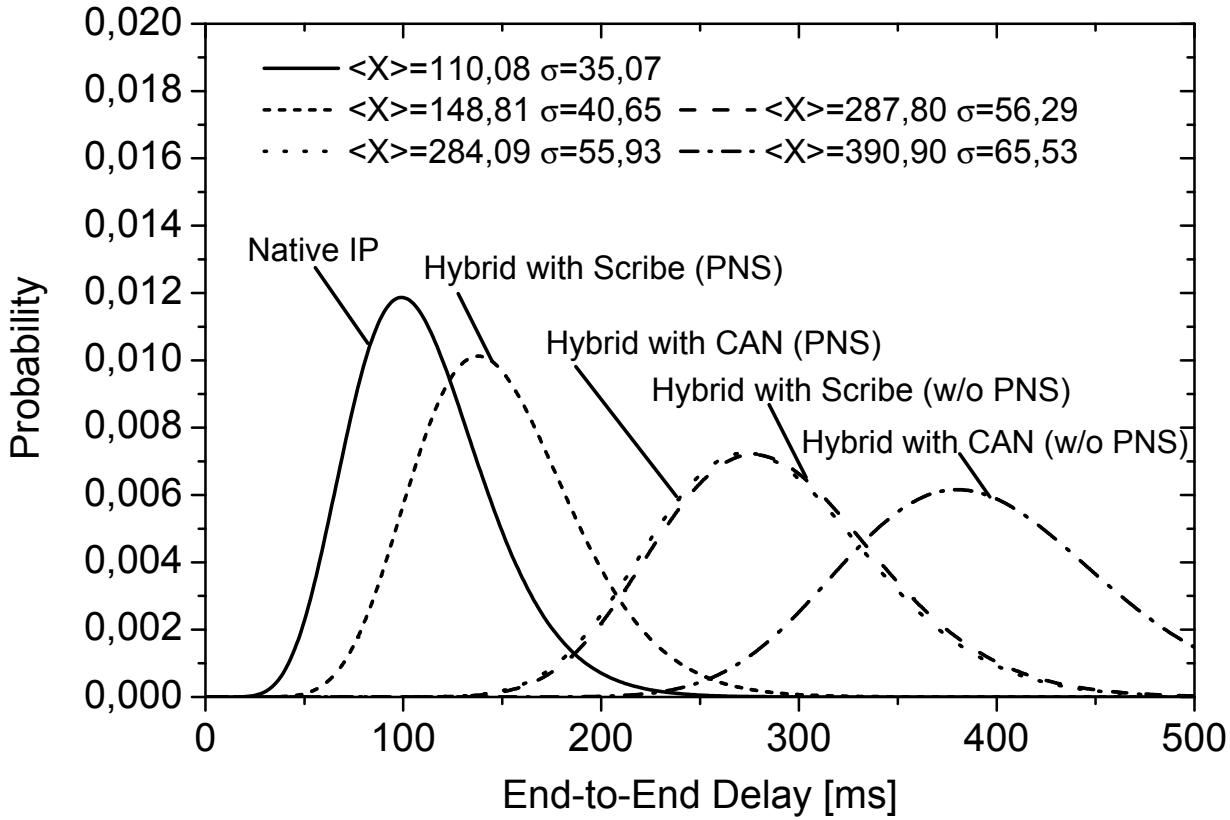
Simulation Results



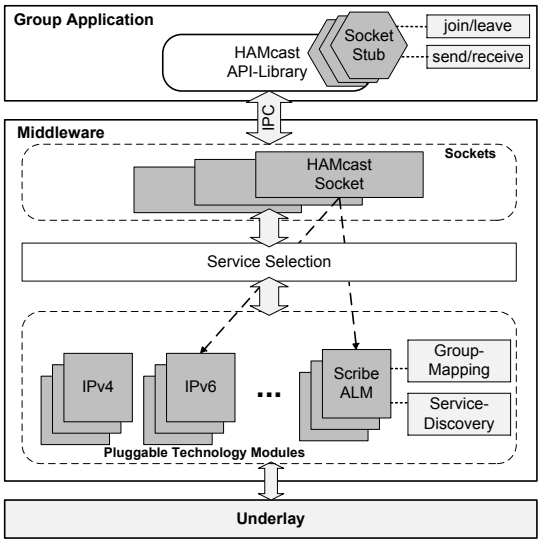
- Estimator for hybrid multicast schemes based on empirical data[1]

[1] **Wählisch et al.** *An a Priori Estimator for the Delay Distribution in Global Hyrid Multicast*, ACM SIGCOMM CoNEXT'09 Student Workshop

HAMcast

Overview

- Evolutionary architecture to enable a universal multicast service
- Common multicast API[2] with an abstract naming scheme introducing a locator-identifier split for multicast groups
- Inter-domain Multicast Gateways (IMGs) to connect multicast domains of different technologies and administration



Software Components

- Common Multicast API (C++, Java)
- System-centric Middleware (C/C++)
- Localhost socket based IPC API ↔ MW
- Technology modules (C/C++)

[2] **Wählisch et al.** *A Common API for Transparent Hybrid Multicast*, IRTF Draft

Evaluating Multicast

Measurement Considerations

- Multicast decouples sending and receiving nodes (connectionless)
- Typical unicast metrics such as RTT not suitable for multicast
- Analyzed metrics: one-way packet delays, link stress, routing paths
- Go large scale and real world: utilize Planet-Lab (PL) testbed

Multicast Packet Tracking

- Trace selected packets along paths in hybrid multicast networks
- Use extended packet tracking framework (Fraunhofer FOKUS)[a]

[a] **Santos et al.** *Multi-hop Packet Tracking for Experimental Facilities*, ACM SIGCOMM'10 Demo Session

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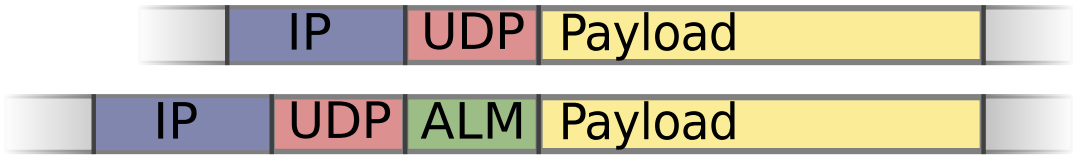

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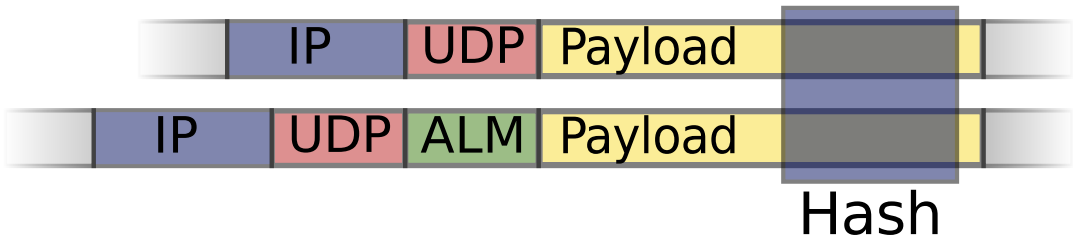

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Clock Synchronization

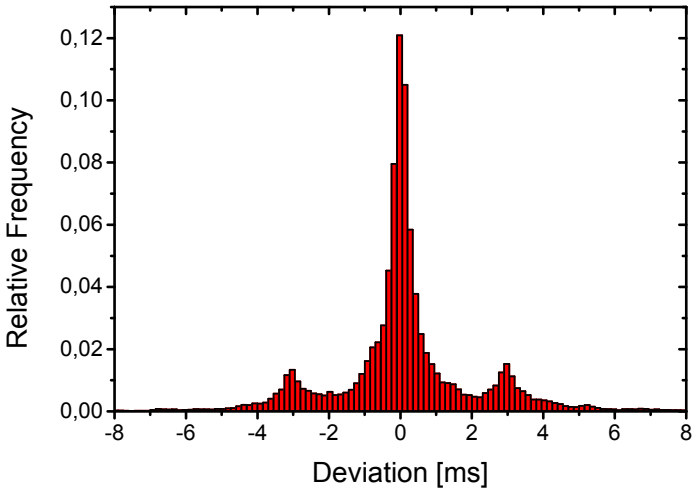
In the Planet-Lab Testbed

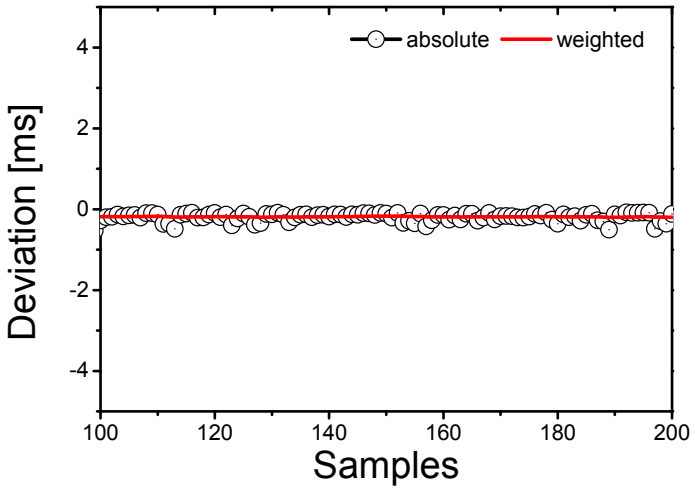
Problem

- Manual clock synchronization not allowed on PL nodes
- Average clock offset was $> 1\,s$ for most nodes

Solution

- Continuously save clock offset of each node during experiments
- Adapt packet timestamps before further processing steps
- Used weighted average of clock offset to counteract variability





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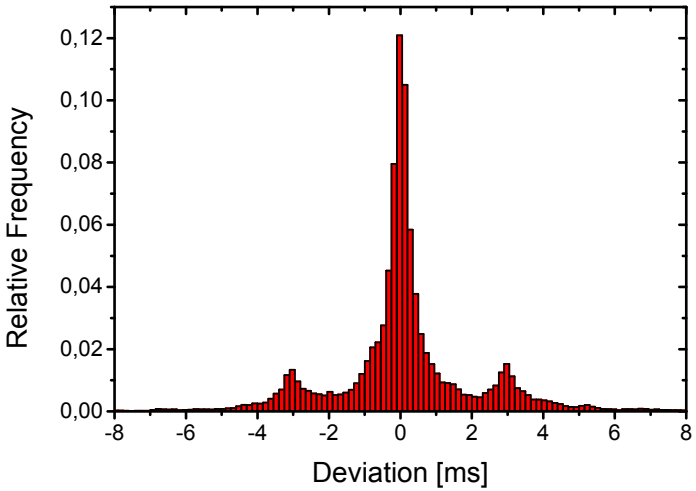
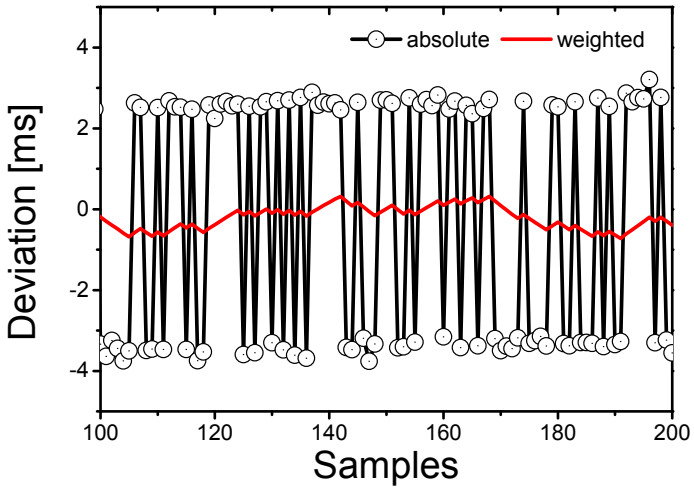
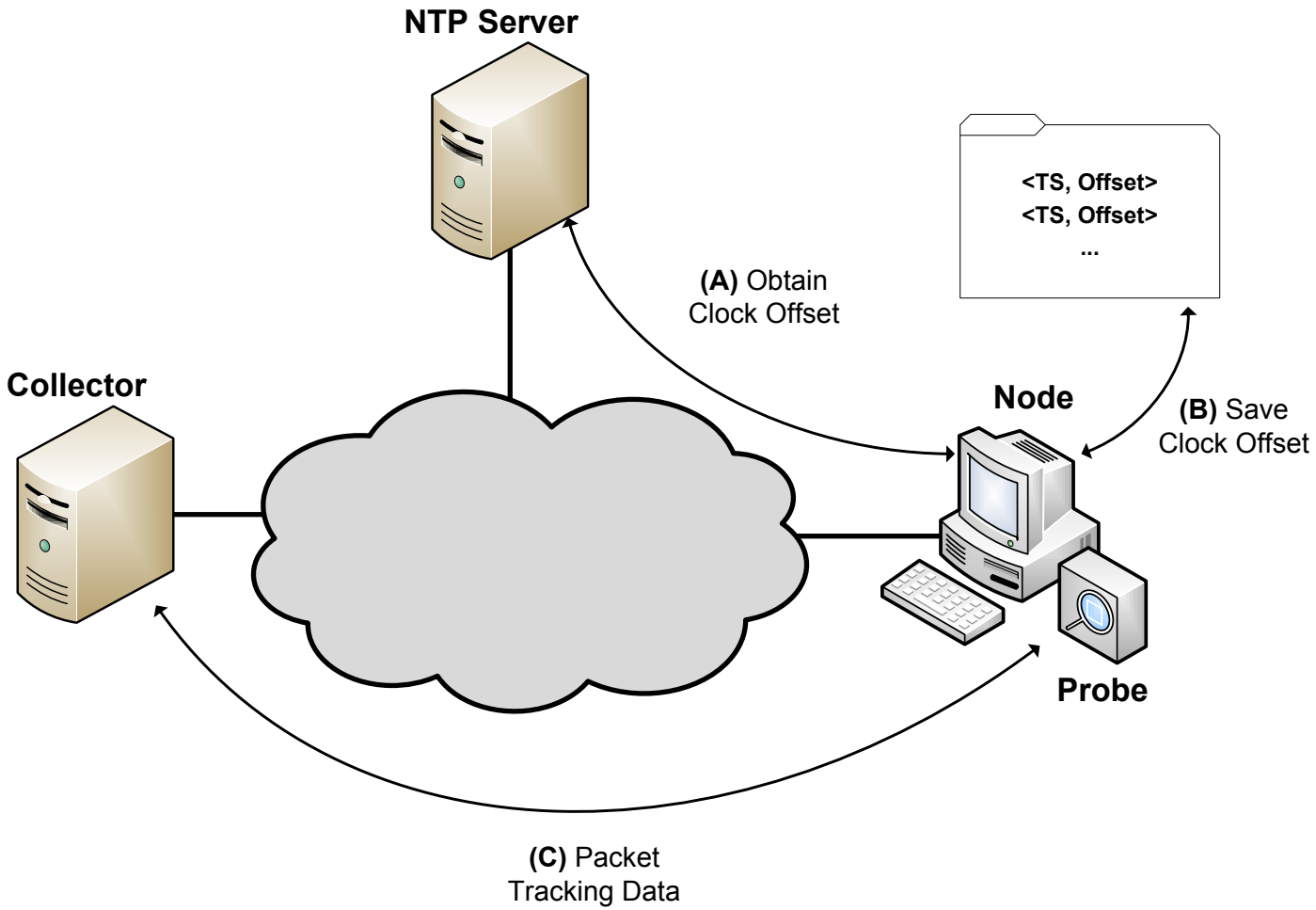




Framework

Overview on Components



Test Setup

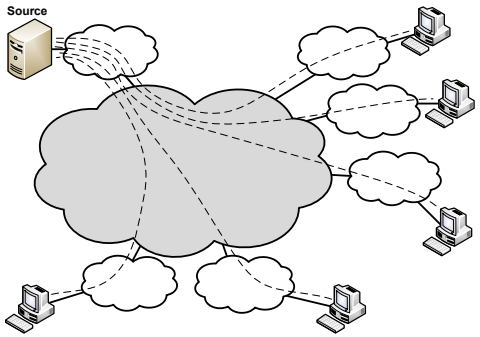
Deployment

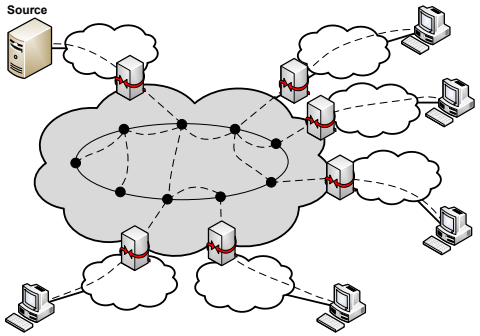
- 200 Nodes at 100 globally different Planet-Lab sites
- Hybrid multicast based on H∀Mcast implementation
- 100 receivers, other nodes as IMGs and multicast forwarder
- Messages with 1000 B **payload** at interval of 1 s

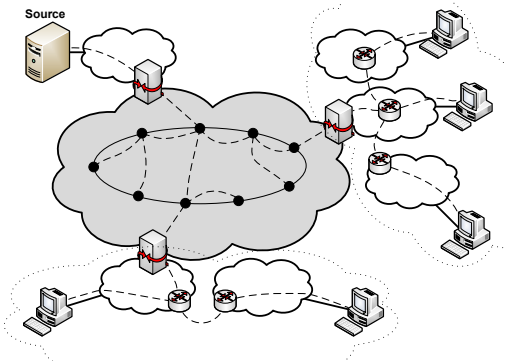
Multicast Technologies

- (emulate) IPv4 multicast in edge-network domains
- Scribe ALM to inter-connect multicast islands

Scenarios







Unicast

- Each receiver (N) known to sender
- N separate send operations

Hybrid Switched

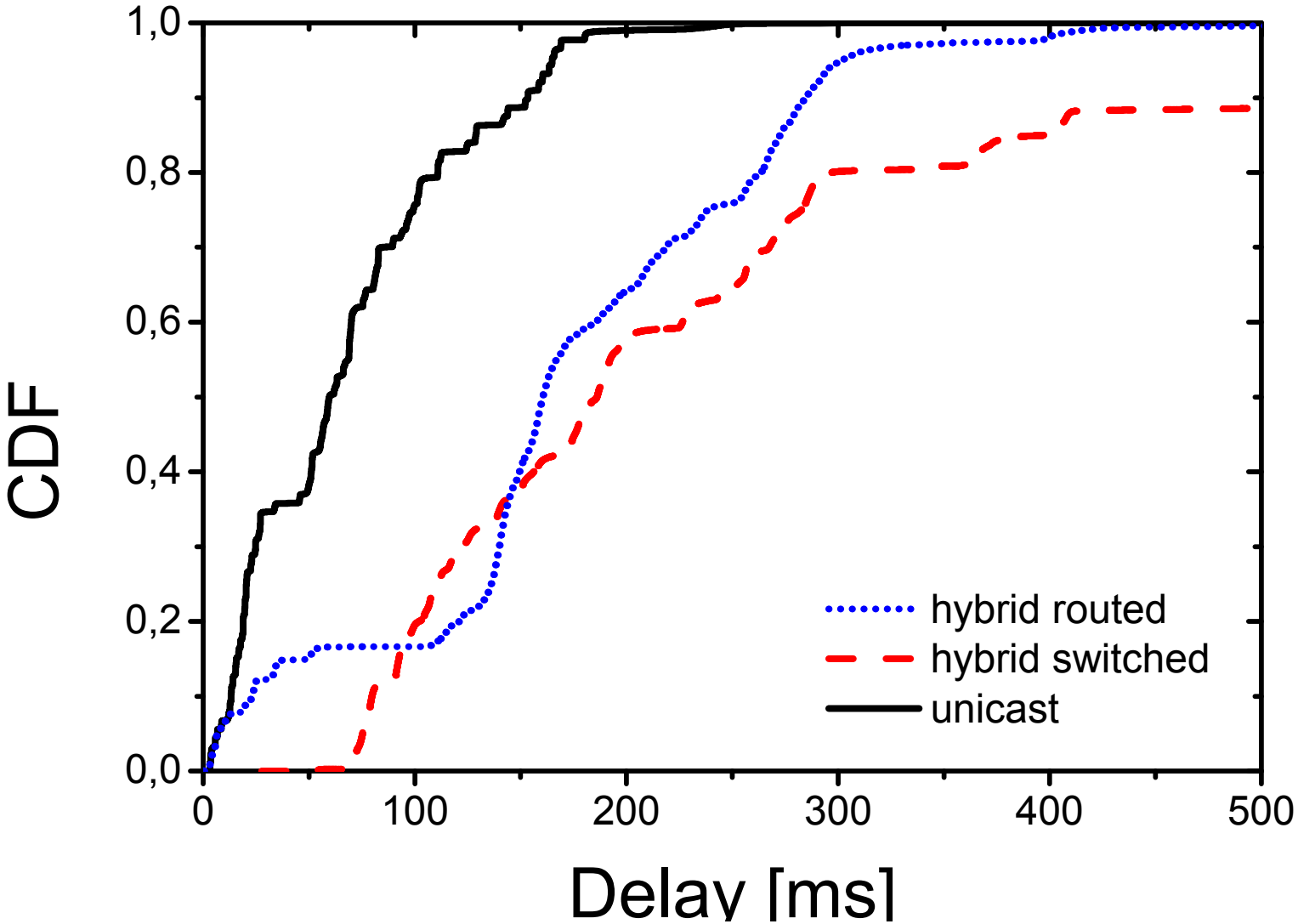
- Large overlay multicast domain
- 1 IMG and 1 IP receiver per site

Hybrid Routed

- Interconnect geographically close domains
- 1 IMG or forwarder and 1 receiver per site

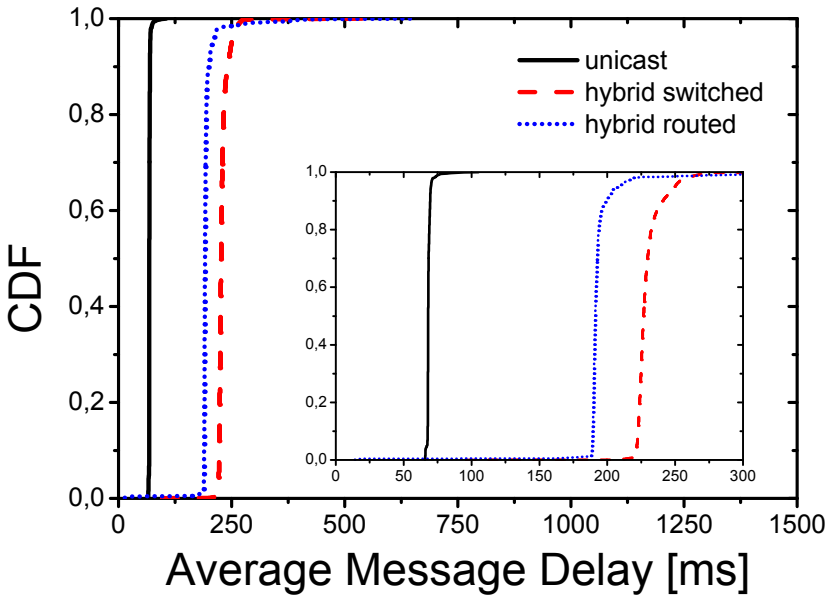
One-Way Message Delays I

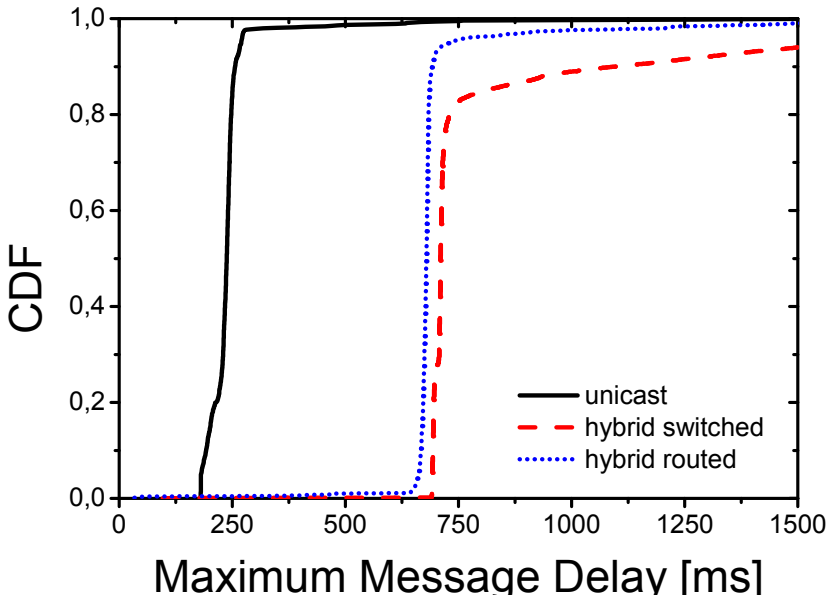
End-to-End Distribution



One-Way Message Delays II

Average & Maximum

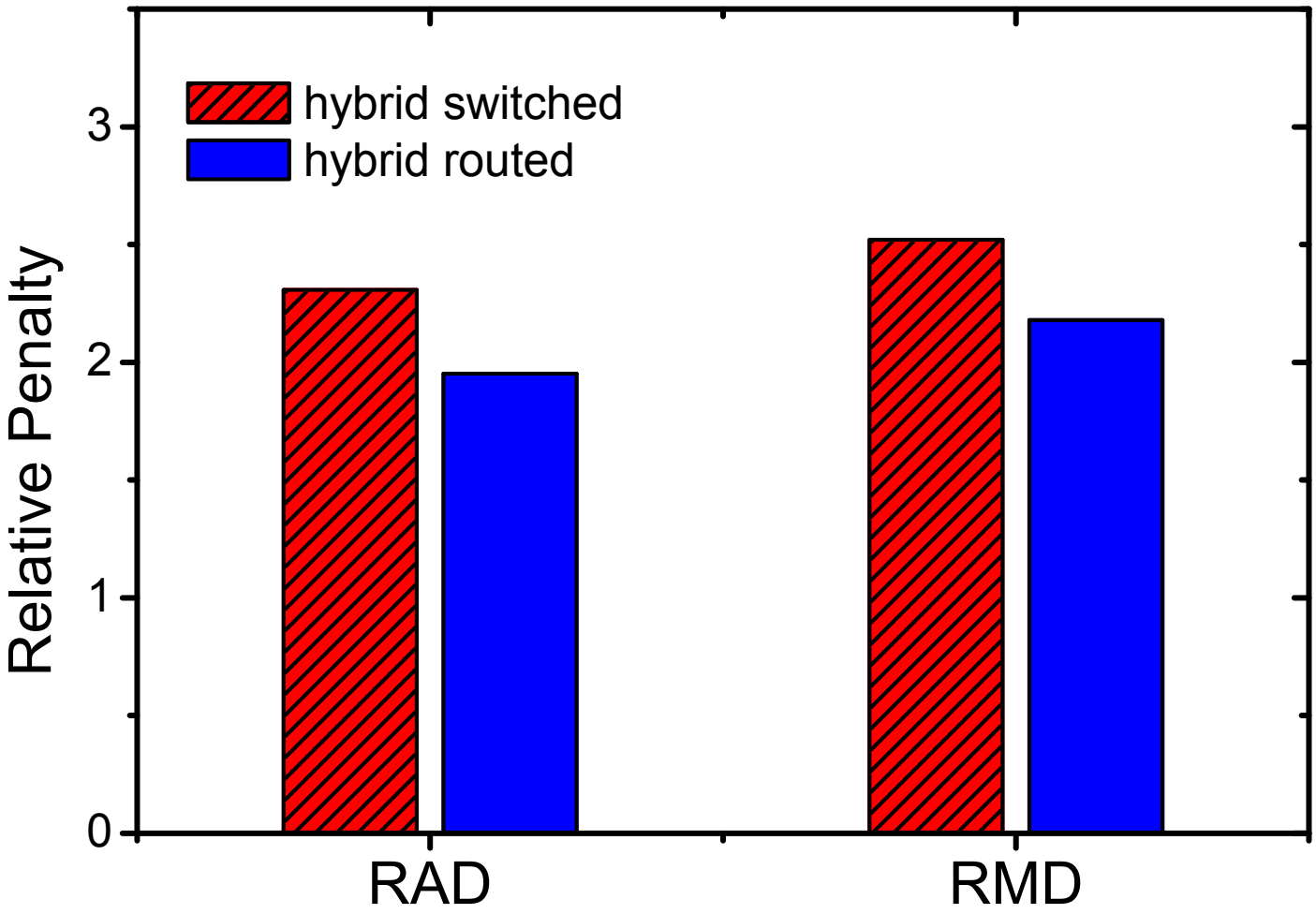




- Average and maximum message delays over all receivers
- Additional delay for hybrid schemes influenced by placement of Scribe rendez-vous point relative to sending nodes
- Hybrid routed limits maximum delay at around 700 ms

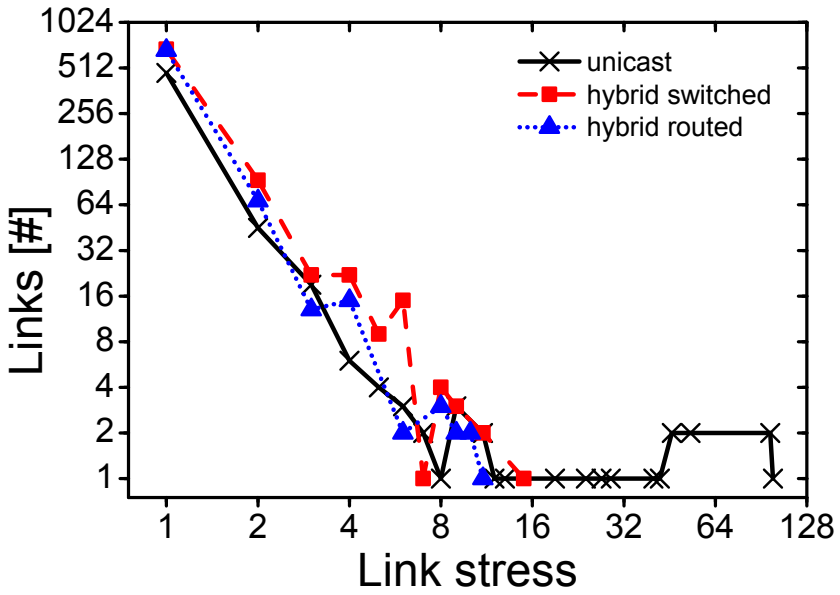
Relative Delay Penalty

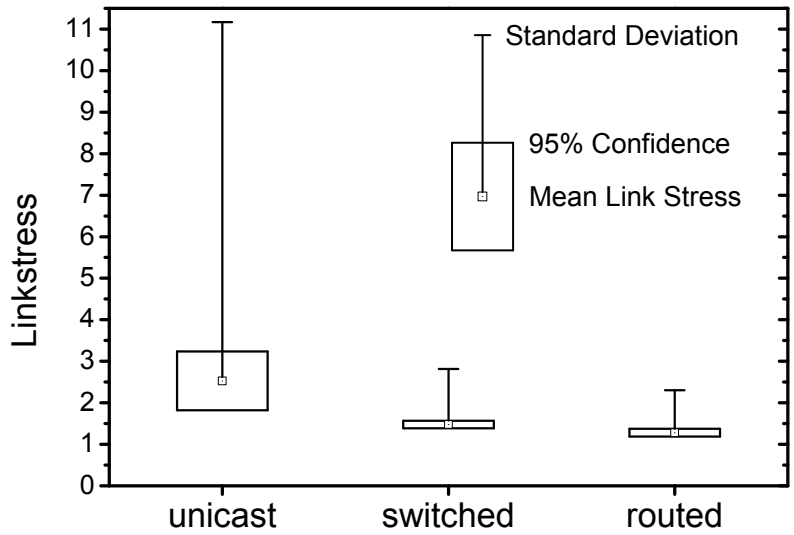
Average (RAD) and Maximum (RMD)



Link Stress Analysis

Absolute and Statistical Results





- Maximum link stress of unicast amounts to number of receivers
- Hybrid multicast limits link stress, thereby reducing network load
- Unicast exhibits large standard deviation and confidence interval

Conclusion & Outlook

Summary

- Method for large scale measurements of hybrid multicast in real-world deployment on the Planet-Lab testbed
- Results demonstrate feasibility and suitability of hybrid multicast communication for dissemination group applications
- Interactivity constrained by high deviation in packet delays
- Hybrid multicast limits link stress and eliminates bottlenecks

Future Work

- Analysis individual components of hybrid multicast system
- Improve performance for interactive group applications

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Thank you for your attention.
Questions?

iNET: `http://inet.cpt.haw-hamburg.de`
H∀Mcast: `http://hamcast.realmv6.org`

References

S. Meiling, D. Charousset, T. C. Schmidt, and M. Wählisch, "System-assisted Service Evolution for a Future Internet – The HAMcast Approach to Pervasive Multicast," in *Proc. of IEEE GLOBECOM 2010, Workshop MCS 2010*. Piscataway, NJ, USA: IEEE Press, Dec. 2010, pp. 913–917.

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