Comparison and Evaluation of Application Level Multicast for Mobile Networks

Ingo Juchem

Email: ijuchem@cs.uni-goettingen.de

Comparison and Evaluation of Application Level Multicast for Mobile Networks

Two papers dealing with different aspects:

A Comparison of Network and Application Layer Multicast for Mobile IPv6 Networks

(A. Garyfalos, K. Almeroth, J. Finney)

An Evaluation of Scalable Application Multicast Built Using Peer-to-peer Overlays

(M. Castro, M. Jones, A-M. Kermarrec, A. Rowstron, M. Theimer, H. Wang, A. Wolman)

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Motivation:

- Need a way to address fast moving nodes in mobile environment
  - High mobility => high network resource usage
  - Idea: address a group of nodes instead of all or one: *multicast*
    - *Multicast*: one-to-group addressing – hierarchical groups
    - *Unicast*: one-to-one addressing - what about node moving out of range ? Rebuilding routing tables takes time
    - *Broadcast*: one-to-all addressing – high network stress
  - Current solution: *IP multicast* working on *Network Layer*
    - BUT: high complexity, not designed for mobile environment
  - New approach: *Application Layer Multicast (ALM)*

Application Layer Multicast (ALM):

Designed for easier use than IP multicast BUT not for mobile networks

- Idea: management of groups and packets shifted from IP routers on *Network Layer* to end hosts on *Application Layer,*

  construct *Overlay* on current network

- Claims to be independent of characteristics of underlying network,

  disregards node movement

- Questions:

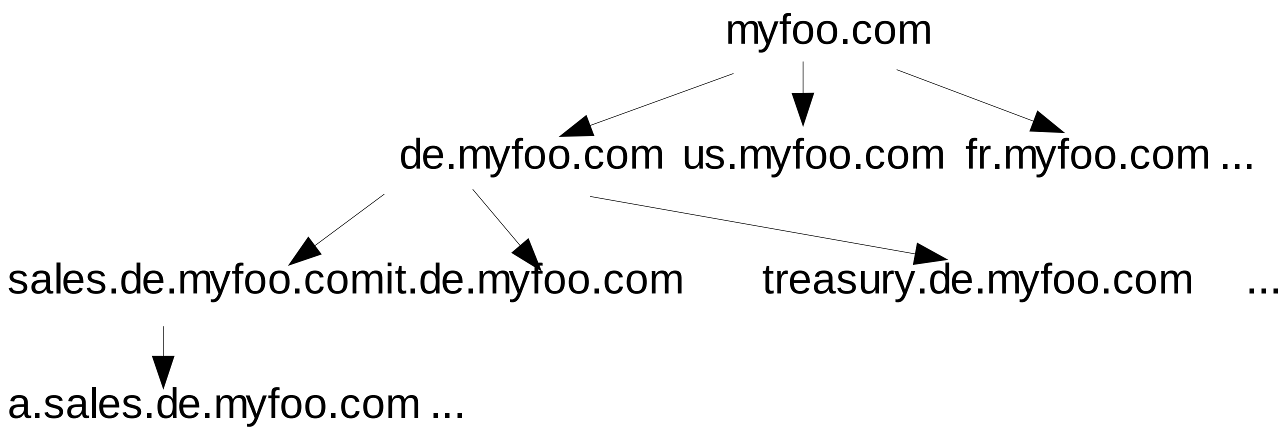
  Is this the final solution to problems of mobile networks ???

  How will ALM and Mobile IP work together ?

  How can ALM be implemented ?

Peer-to-peer overlays for ALM:

- Structured p2p overlay networks can be used to implement Internet-scale application level multicast
- Provide efficient routing in namespace by assigning parts of namespace to nodes:



- Protocols for p2p overlay networks: CAN, Chord, Pastry, Tapestry ...
- Multicast approach: *Flooding* or *Tree-building*
- Routing approaches: *d-dimensional hypercube* or *Cartesian hyperspace*
- Scalable and self-organising
- Problems:
  - Highly complex with many different adjustable parameters (Network-aware routing, Landmark-based Placement ...)
  - Each protocol uses different approach
  - No evaluation on performance of 4 combinations for mobile networks and how to measure it

Question: Even with this approach, will ALM work in mobile environment?

Impact of mobility on ALM:

- ALM may work well in wired networks but faces new problems in mobile IP:
  - Only concerned with network failure, not designed for node mobility
  - Mobile network consists of many different nodes (heterogeneous)
  - Need to care for node's capabilities (low battery etc.)
  - Depends on end hosts which WILL be less robust in mobile networks

=> Maybe ALM is not the final solution for mobile IP but has to evaluated

Question: Can peer-to-peer overlay networks be beneficial for ALM?

Approaches for peer-to-peer overlay networks:

- Content Adressible Network (CAN) Overlay Network
  - Nodes organized in groups in network space
  - Each node takes ownership of network portion, maintains routing table to neighbours
  - Routing:message forwarded to neighbour closer to destination
- Pastry Overlay Network
  - Uses 128-bit namespace to assign random nodeID to nodes
  - Routing: sends message to node whose nodeID is numerically closest to destination key by comparing a variable number of the ID's bits
  - Exploits network locality to reduce routing delays by measuring RTT when building routing tables

Approaches for peer-to-peer overlay networks - Multicast:

- Overlay-Per-Group implementations (Flooding):
  - Lookup function for joining clients requires distributed name service
  - CAN Flooding:broadcast algorithm - nodes forward messages to all neighbours
  - Pastry flooding: broadcast algorithm – node forwards message to all entries in node's routing table
- Tree-Per-Group implementations:
  - HERE: *Scribe* used (generic application-level multicast infrastructure)
  - Uses reverse path forwarding to build multicast tree per group, identified by groupID
  - Scalable, failure-tolerant decentralized algorithm

Evaluation:

- Which one is better: IP Multicast or Application Layer Multicast ?
- Important aspects of performance and metrics used to measure:
  - Network performance : *Relative delay penalty (RDP)*

$$RDP = \frac{ALM\ link\ cost}{IPmulticast\ link\ cost}$$

    - smaller value means ALM is better
    - 4 components for mobile receivers:

      IP multicast – home subscription (receiver is in home network)

      IP multicast – remote subscription (receiver in foreign network)

      ALM – reverse tunneling (packets tunneled through home agent)

      ALM – optimized routing (packets go directly to receiver)

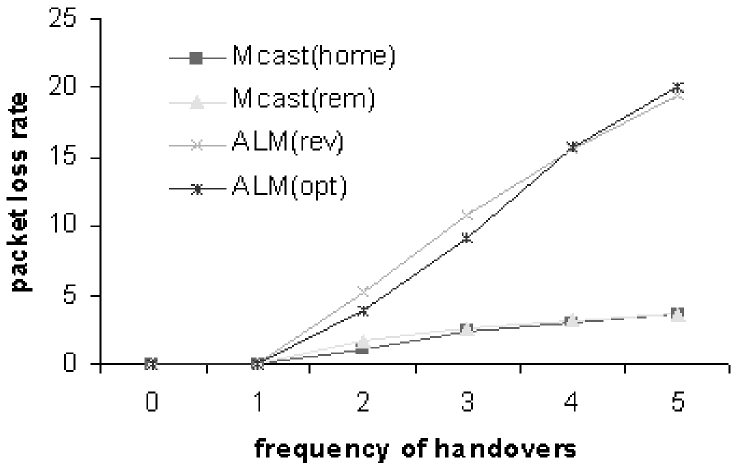
- Link stress : number of identical packets received by nodes
- Robustness: amount of packet loss in network

- Simulation model for comparison IP multicast vs. ALM:
  - 500 nodes, of which 10 – 200 are receivers

Results for comparison IPM - ALM:

- Robustness:
  - *Equal values for slow movement*
  - *Losses for ALM with fast movement*
  - *Loss rate increase faster for ALM*

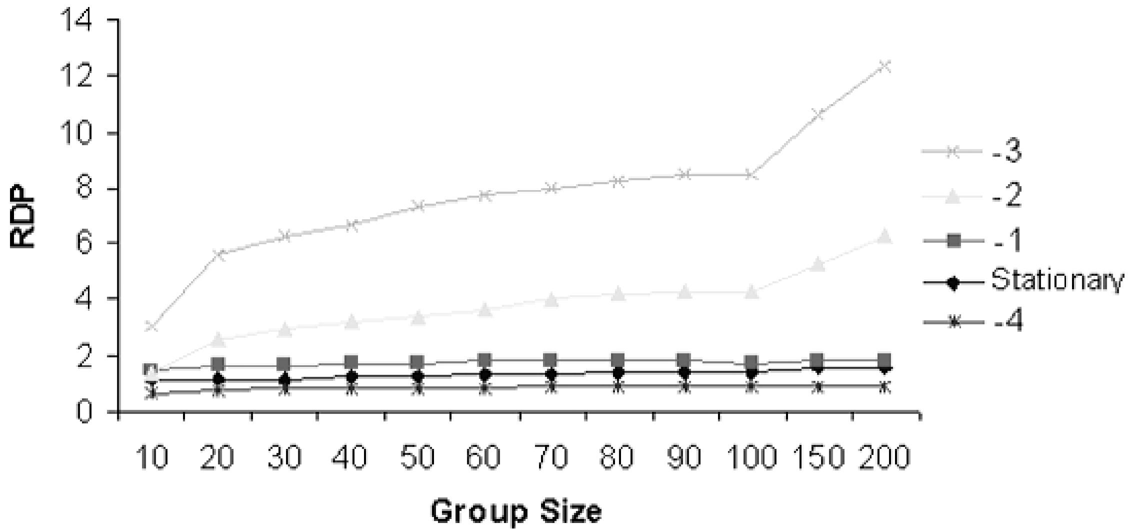
=> packet loss through mobility (additive path), ALM worse



Packet drop rates for ALM and IP multicast [f1]

Results for comparison IPM - ALM:

•RDP:



Effect of mobility on RDP [f2]

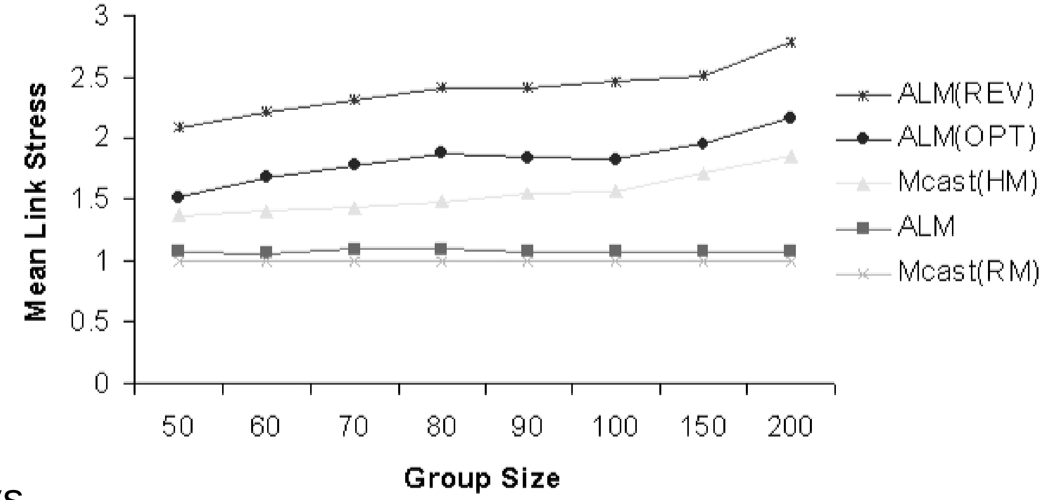
stationary: stationary nodes (1): ALM (rt) over IPM (hs) (2): ALM (or) over IPM (rs)

(3): ALM (rt) over IPM (or) (4) ALM (or) over IPM (hs)(1) = fast movement , (2) = slowmovement

=> ALM performance better with fast movement, IPM superior for less mobile nodes

Results for comparison IPM - ALM:

Link Stress:



Mean link stress for mobile hosts [f3]

- Mcast(rm) always
- ALM(REV) worst case scenario
- ALM(OPT) better than REV

=> ALM causes overhead, packets traverse link 1.7 times more than IPM

Conclusions for comparison IPM - ALM:

- **Robustness**: no advantage to IP Multicast for low mobility, BUT: add. Packet loss for ALM by increased node speed
- **RDP**:
  - low mobile nodes cause IP Multicast to perform better than ALM by factor 4-5, with high mobility factor decreases to 2
  - Metric depends on user behaviour: localized movement => smaller gain for IP Multicast
- **Link Stress**: with ALM about 1.7 times higher, generally increases with group size

=> **OVERALL**: Concerns confirmed. IP Multicast outperforms ALM in all aspects

Though no protocol support needed for ALM , questionable if it will ever work

Evaluation of ALM using peer-to-peer overlays:

- CAN and Pastry used for p2p overlay, each with flooding and tree-building
- Simulation model setup:
  - packet-level event simulator on five network topologies with 5000 routers and 80.000 end nodes
  - Two sets of experiments, (1) with single group, (2) with 1500 groups
- Same criteria used for measurement:
  - Relative Delay Penalty (RDP)
  - Link Stress
  - Duplicates

Results for evaluation of ALM using peer-to-peer overlays CAN:

- CAN results:
  - Enabling landmark-based assignment largest improvement for RDP
  - Flooding results:
    - Delay penalty independent from routing table size
    - Link Stress :
      - showed best numbers with landmark-based placement
      - 80.000 members joining a group causes more link stress and grows with routing table state size than sending a message to 80.000 members
    - Duplicates: impact neglectable

Results for evaluation of ALM using peer-to-peer overlays - Pastry:

- Pastry results:
  - Two optimizations used, topology-aware nodeID assignment (TOP) and topology-aware routing table construction (TART)
  - Flooding results:
    - RDP: Best results by combining TOP and TART, which reduces RDP by 60%
    - Link Stress : Average reduced to 30%
    - Duplicates: Increasing the number of matching bits *b* => better performance BUT duplicates rise enormously (up to factor 1000)
      - No problem, routing tables can be repaired at low costs

Results for evaluation of ALM using peer-to-peer overlays - Pastry:

- Tree-based results:
  - RDP: same results like flooding
  - Link Stress: even lower than with flooding
- Outcome:
  - Best combinations for p2p overlays:
    - for single large group: Pastry with Flooding & TOP
    - for many groups Pastry with tree-based & TART

Conclusion:

- ALM alone is no solution and performs even worse in mobile environment than IP multicast
- When using peer-to-peer overlay networks to provide ALM performance is much better but still worse than IP multicast
  - As Per-group-overlays (flooding) has many disadvantages,
    use tree-per-group multicast with Pastry
- Hybrid solution suggested with ALM for inter-domain and IPM for intra-domain
- ... or find another, better approach

Thank you for your interest !

[f1], [f2], [f3]: A. Garyfalos, K. Almeroth, J. Finney - A Comparison of Network and Application Layer Multicast for Mobile Ipv6 Networks, MSWiM'03 San Diego 2003