Reliable and Application layer Multicast

T-110.456
Content Networking in the Mobile Internet
Agenda

• Introduction to multicast
• Reliable multicast
• Application layer multicast
• Conclusions
Introduction to Multicast

• Why multicast?
  • to reduce network load
  • multiple recipients
  • multiple sources
  • multiple media
  • variable membership

• Problems
  • The Amount of control traffic explodes
  • extreme routing & protocol complexity
Introduction to Multicast

• Basics of IP multicast
  • Network layer
  • Addressing
    – an address to group of receivers instead of a single receiver
    – mapping that addr. onto data-link layer mcast address if they exist
    – IPv4: D class address 224.0.0.0 – 239.255.255.255
  • Groups
    – Computers wanting the multicast have to register to a multicast group (Join)
    – unlimited group size
    – host can be a member of several groups at the same time
    – sender does not need to belong to any group
  • Routing
    – An effective distribution of packets to receivers through networks
    – Steiner tree would be optimal for multicast, but not maintainable
    – Always a compromise
Introduction to Multicast

- Basics of IP multicast
  - Techniques & algorithms
    - Flooding – simple, but does not scale
    - Spanning tree – easy, but not efficient
    - Reverse-Path Forwarding (RPF) – group not considered
    - Truncated RPF – group considered, used in MBONE, doesn’t scale
    - Steiner tree – optimal algorithm, but not practical
  - Protocols
    - IGMP – Internet Group Management Protocol v.2
    - DVMRP (Distance Vector Multicast Routing Protocol)
    - MOSPF
    - PIM (Protocol Independent Multicast)
      - Sparse Mode for highly distributed groups
      - Dense Mode for highly concentrated groups
      - PIM-SM is most widely used multicast routing protocol
Reliable Multicast

- Reliable vs. Best Effort
  - e.g. software distribution vs. streaming
  - analogy to TCP(reliable protocol) over IP(unreliable)
  - Reliable multicast protocol on top of IP multicast

- Guarantees that all group members receive data in order without loss, duplication or corruption.

- Problems:
  - Feedback implosion problem
    - feedback from the receivers fill the network
  - Crying baby problem
    - only couple of packet lossy receivers slow down the entire multicast session
Reliable Multicast

- Reliable Multicast Techniques (1)
  - ACK-based loss reporting
  - NAK-based loss reporting
  - Distributed loss recovery
  - Router-assisted loss recovery
  - FEC (Forward error correction)-based
Reliable Multicast

- Reliable Multicast Techniques (2)
- ACK-based loss reporting
  - SCE - Single-Connection Emulation protocol
    - The simplest reliable multicast protocol
    - Data sent multicast, but receivers ACK IP unicast
    - Works great in small groups, but does not scale
    - ACK implosion - receivers send ACK at the same time. ACK aggregators or designated routers act as retransmission points.
  - ACK-based loss reporting
Reliable Multicast

- Reliable Multicast Techniques (3)
  - NAK-based loss reporting
    - receivers responsible for detecting losses (sequence numbers) and request retransmissions for themselves – receiver driven protocol
    - receivers send Negative ACKs if losses
  - better reliability and better throughput than in ACK-based
  - NAK implosion causes problems
Reliable Multicast

- Reliable Multicast Techniques (4)
  - Distributed loss recovery
    - based on NAK
    - packets retransmitted by nearby group members
    - speeds up recovery and prevents network overloading
    - tree based topologies define Designated Receivers, which do the retransmitting
  - subgroup hierarchies called fusion trees. Recovering from losses by
    - Multicast with duplicate avoidance – NAKS and repairs multicast
    - cascaded unicast – NAKs and repairs unicast
    - hybrid – NAKs unicast to DR, repairs multicast to subgroup
  - more protocol overhead since the receivers need to be aware of the nearby network topology
    - who retransmits to who
    - locality information
Reliable Multicast

- Reliable Multicast Techniques (5)
  - Router-Assisted Recovery
    - seems to be the trend in general purpose multicast
    - reliable multicast support added to routers
      - buffering
      - soft state retransmission
      - rich multicast forwarding semantics
  - may have effect in the performance of the routers
  - FEC (forward error correction)-based recovery
    - error correction data (CRC:s) etc. encoded in the packets
    - reliable, but slow
    - large overhead
    - usually special-purpose applications e.g. software distribution
Application Layer Multicast

- All routers cannot be changed to support IP & Reliable Multicast overnight
- Instead an Overlay Network of Intelligent nodes capable of receiving data and sending it to multiple downstream peers.
  - TCP
  - Nodes are usually general purpose computers
- Application layer multicast builds the multicast transport on top of the conventional unicast transport
Application Layer Multicast

- Overlay setup
  - physical overlay setup
  - overlay nodes scattered in the networks
- Tree organization
- Content distribution
- End-user subscription
Application Layer Multicast

- Building the distribution tree
  - Goal: scalable loop-free overlay topology
    - Peer discovery
      - point of contact
      - multicast expanding-ring search
      - manual mesh (preconfigured)
  - Neighbor selection
    - reduced amount of peers
  - Parent selection
    - Optimizing bandwidth, delay, jitter, reliability etc.
  - Tree maintenance
    - recover from network and node failures
    - adapt to the changing network
    - improving the network performance
# Conclusions

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<tr>
<th>Reliable Multicast (based on IP Multicast)</th>
<th>Application Layer Multicast (based on Overlay Network)</th>
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<tbody>
<tr>
<td>• General purpose</td>
<td>• Easy deployment</td>
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<tr>
<td>• Far more effective when broadcasting!</td>
<td>• Effective transport (application specific)</td>
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<tr>
<td>• Utilizes link bandwidth more efficiently</td>
<td>• Asynchronous Delivery (relies on unicast protocols)</td>
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<tr>
<td>• Well suited for LARGE scale</td>
<td>• Application layer routing (more data available to make transmitting decisions)</td>
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<td>• Needs support from routers</td>
<td>• Versatility</td>
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<td>• Future: Overlay Multicast in Mobile Ad Hoc network etc.</td>
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Thank You!