IP Multicast

Richard Yang

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Review

- New security issues
  - distributed denial of service
  - multicast security
  - incentive-compatible
  - others?
Why Multicast?

- Many applications require multicast communications
  - any examples?
- Why not use unicast?

IP Multicast

- Service model developed in [Deering & Cheriton 1990]
- Many years of effort to implement the service model
- Implemented in almost every OS and routers
IP Multicast Service Model

- A group is identified by a location-independent address (class D IP address: prefix 1110)
  - how many IP address? how to get an address?
- Anyone can send packets to a “logical” group address
  - why?
- Anyone can join/leave a group and receive packets
  - why?
- Normal, best-effort delivery semantics of IP

Implementation: Network Model

- Interconnected LANs
- LANs support link-level multicast
- Map globally unique multicast address to LAN-based multicast address (LAN-specific algorithm)
Implementation: LAN

- Multicast capability widely available on individual LANs
  - example: Ethernet multicast (prefix 00:00:5e)
- Use IGMP to maintain group membership on a LAN
  - when an application subscribes a group, the host will
    - turn on Ethernet multicast, and
    - send IGMP join message to the first hop router

Implementation: Across LANs

- Design goals
- Approaches
  - source tree:
    - Distance-vector multicast routing protocol (DVMRP)
  - shared tree:
    - Core-Based Tree
Distance Vector Multicast Routing

- An elegant extension to DV routing
- Use shortest path DV routes to determine if a link is on the source-rooted spanning tree
  - Reverse Path Flooding (RPF)
  - Reverse Path Broadcasting (RPB)
  - Reverse Path Multicasting (RPM)

Reverse Path Flooding (RPF)

- A router forwards a broadcast packet from source (S) iff it arrives via the shortest path from the router back to S
- A packet is replicated to all but the incoming interface
- Discussion
  - what are the problems?
Another Example

Reverse Path Broadcasting (RPB)

- Basic idea: forward a packet from S only on child links for S
- A child link of router x for source S: a link that has x as parent on the shortest path from the link to S
Reverse Path Multicast (RPM)

- Prune back transmission so that only absolutely necessary links carry traffic
- Use on-demand pruning so that the group state at a router scales with the number of active groups (not all groups)

Basic RPM Idea

- Prune (Source, Group) at a leaf router if no members
  - send No-Membership Report (NMR) up tree
- If all children of router R prune (S,G)
  - propagate prune for (S,G) to its parent
- What do you do when a member of a group (re)joins?
  - Graft
- Both NRM and graft messages are positively acknowledged
- On timeout:
  - prune dropped
  - flow is reinstated
  - downstream routers re-prune
- Note: again a soft-state approach
RMP Scaling

- What is the state requirements of RPM?
  - which routers maintain states?
  - what are the state requirement at a router?
- How to get better scaling?
  - Hierarchical multicast
  - Core-based trees (CBT)

Core Based Trees (CBT)

- Ballardie, Francis, and Crowcroft,
  - "Core Based Trees (CBT): An Architecture for Scalable Inter-Domain Multicast Routing", SIGCOMM 93
- Tree construction is receiver-based
  - a receiver sends a join message to the core
  - one tree per group
  - only nodes on tree maintain states
- A sender unicasts a packet to core and bounces it back to multicast group
- Reduce routing table state from $O(S \times G)$ to $O(G)$
Example: M3 Joins

- Group members: M1, M2

Example: M1 Sends Data

- Group members: M1, M2, M3
- M1 sends data
Discussion

- What are the problems of CBT?

IP Multicast Discussion

- Many years of research and many compelling applications
- Many of today’s routers implement IP multicast
  - Protocol Independent Multicast (PIM)
    - Sparse mode similar to CBT
    - Dense mode similar to DV-RMP
- IP multicast is still not widely deployed
  - why?
EXPRESS
[Holbrook & Cheriton '99]

- What are the modifications to the IP multicast service model?

Channel & Addressing

- IP multicast addresses
- Single-source multicast addresses (232.**.**)
Discussion

- What are the advantages of the Channel model?
  - for sender
  - for receiver
  - for ISP

Added API

- **Sender**
  - channelKey( channel, K(S, E) )
  - count = CountQuery( channel, countID, timeout )

- **Subscriber**
  - result = newSubscription( channel, [, K(S, E)] )
  - Count( channel, countId, count )