Lecture 18: Multicast

CSE 123: Computer Networks
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Today: Multicast routing

- Multicast service model
- Host interface
- Host-router interactions (IGMP)
- Multicast Routing
  - Distance Vector
  - Link State
  - Shared tree
- Limiters
  - Deployment issues
  - Inter-domain routing
  - Operational/Economic issues
Multicast Motivation

- Efficient delivery to multiple destinations (e.g. video broadcast)

- Network-layer support for one-to-many addressing
  - Publish/subscribe communications model
  - Don’t need to know destinations

VS
Communications based on groups
- Special IP addresses represent “multicast groups”
- Anyone can join group to receive
- Anyone can send to group
  » Sender need not be part of group
- Dynamic group membership – can join and leave at will

Unreliable datagram service
- Extension to unicast IP
- Group membership not visible to hosts
- No synchronization

Explicit scoping to limit spread of packets
Three elements

- Host interface
  - Application visible multicast API
  - Multicast addressing
  - Link-layer mapping

- Host-Router interface
  - IGMP

- Router-Router interface
  - Multicast routing protocols
Host interface

- Senders (not much new)
  - Set TTL on multicast packets to limit “scope”
    » Scope can be administratively limited on per-group basis
  - Send packets to *multicast address*, represents a group
  - Unreliable transport (no acknowledgements)

- Receivers (two new interfaces)
  - Join multicast group (group address)
  - Leave multicast group (group address)
    » Typically implemented as a socket option in most networking API
Addressing

- Special address range:
  - Class D (3 MSBs set to 1) 224.0.0.0 - 239.255.255.255
  - Reserved by IANA for multicast

- Which address to use for a new group?
  - No standard
  - Global random selection
  - Per-domain addressing (MASC, GLOP)

- Which address to use to join an existing group?
  - No standard
  - Separate address distribution protocol (may use multicast)
Link-layer multicast

- Many link-layers protocols have multicast capability
  - Ethernet, FDDI

- Translate IP Multicast address into LL address
  - E.g. Map 28 bits of IP MC address in 23bit Ethernet MC addresses
  - Senders send and receive on link-layer MC addresses
  - Routers must listen on all possible LL MC addresses

- Not an issue for point-to-point links
Internet Group Management Protocol
  - Goal: communicate group membership between hosts and routers

Soft-state protocol
  - Hosts explicitly inform their router about membership
  - Must periodically refresh membership report
  - Routers implicitly timeout groups that aren’t refreshed
  - Why isn’t explicit “leave group” message sufficient?

Implemented in most of today’s routers and switches
• Router broadcasts membership query to 224.0.0.1 (all-systems group) with ttl=1
• Hosts start random timer (0-10 sec) for each group they have joined

• When a host’s timer expires for group G, send membership report to group G, with ttl=1
• When a member of G hears a report, they reset their timer for G
• Router times out groups that are not “refreshed” by some host’s report
Multicast Routing

- Goal: build distribution tree for multicast packets
  - Efficient tree (ideally, shortest path) w/low join/leave latency

- Source-based tree
  - **Flood and prune** (DVMRP, PIM-DM)
    - Send multicast traffic everywhere
    - Prune edges that are not actively subscribed to group
  - **Link-state** (MOSPF)
    - Routers flood groups they would like to receive
    - Compute shortest-path trees on demand

- Shared tree (CBT, PIM-SM)
  - Specify rendezvous point (RP) for group
  - Senders send packets to RP, receivers join at RP
  - RP multicasts to receivers; Fix-up tree for optimization
Source-based vs Shared

**Source-based tree**
- Efficient trees; low delay, even load
- Per-source state in routers (S,G)

**Shared-tree**
- Higher delay, skewed load
- Per-group state only (G)
Multicast today

- IP Multicast has generated 1000s of papers, but has not been widely deployed in the Internet...

- Why?
  - General deployment difficulties
  - Inter-domain multicast complexity
  - Economics of multi-source multicast
Multicast evolution

● How to deploy a new network-layer service?
 ◆ Difficult to change router software (heterogeneity, downtime)
 ◆ Difficult to change all routers

● Mbone (tunneling)
 ◆ Special multicast routers (built from PCs/Workstations)
 ◆ Construct virtual topology between them (overlay)
 ◆ Run routing protocol over virtual topology
 ◆ Virtual point-to-point links called **tunnels**
    » Multicast traffic encapsulated in IP datagrams
    » Multicast routers forward over tunnels according to computed
      virtual next-hop
Inter-domain Multicast

- Technical issues
  - How to exchange reachability information?
  - How to construct trees?
  - Who controls RP in shared tree?

- MBGP: reachability to multicast sources per prefix
- PIM-SM: shared tree multicast protocol
- MSDP: RP per group per AS, communication presence of group sources between RPs
- BGMP: alternative proposal, single shared tree with group addresses owned by individual ASs
Economic issues

- Domain independence
  - Do I want my customers MC controlled by an RP in a competitors domain?
  - Why run an RP for which I have no senders or receivers?

- Billing model
  - Inconsistent with input-rate-based billing
  - No group management (how big is group?)

- Group management
  - Who is in the group? Who can send? Security

- Network management

- Limited Multicast addresses
Summary

- Multicast service model
  - One-to-many, anonymous communication
  - Simple host interface

- Per-source tree routing
  - Efficient trees, $S^*G$ state explosion for large networks/groups

- Shared tree
  - More complex, fragile, hard to manage
  - Trees inefficient by as much as 2x
  - Only requires $G$ state on routers

- Economic issues matter in deployment
  - Killer app: TV over Internet (e.g., FIOS & Uverse)!
For next time…

- Read Ch. 5-5.2 in P&D
- HW #3 will be out this afternoon
- Keep moving on Project 2