Lecture 19: Multicast

CSE 123: Computer Networks
Stefan Savage
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
Service Model

- Communications based on groups
  - Special IP addresses represent “multicasting 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) 224.0.01- 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
IGMP

- 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
IGMP overview

- Router broadcasts *membership query* to 224.0.01 (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
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
- Homework 3 due next class
- Keep moving on Project 2