Week 4: Part 2
IP Multicast
IP multicast routing

Deliver messages to a subset of nodes – send to a *multicast address*

• How do we identify the recipients?
  – Enumerate them in the header?
    • What if we don’t know?
    • What if we have thousands of recipients?

• Use a **special IP address** to identify a group of receivers
  – A copy of the packet is delivered to all receivers associated with that group
  – **IPv4:** *Class D multicast IP address*
    • 32-bit address that starts with 1110 (224.0.0.0/4 = 224.0.0.0 – 239.255.255.255)
  – **IPv6:** 128-bit address with high-order bits 8 bits all 1 (*ff00:0:0:0:0:0:0:0/8*)
  – **Host group** = set of machines listening to a particular multicast address
    • A copy of the message is delivered to all receivers associated with that group
IP multicasting

• Can span multiple physical networks
• Dynamic membership
  – Machine can join or leave at any time
• No restriction on number of hosts in a group
• Machine does not need to be a member to send messages
• Efficient: Packets are replicated only when necessary
• Like IP, no delivery guarantees
IP multicast addresses

Addresses chosen arbitrarily for an application
  – Well-known addresses assigned by IANA

Internet Assigned Numbers Authority

IPv4 addresses: http://www.iana.org/assignments/multicast-addresses/multicast-addresses.xml
IPv6 addresses: https://www.iana.org/assignments/ipv6-multicast-addresses/ipv6-multicast-addresses.xhtml

  – Similar to ports – service-based allocation
    • For ports, we have:
      – FTP: port 21, SMTP: port 25, HTTP: port 80
    • For multicast, we have:

      224.0.0.1: all systems on this subnet
      224.0.0.2: all multicast routers on subnet
      224.0.23.173: Philips Health
      224.0.23.52: Amex Market Data
      224.0.12.0-63: Microsoft & MSNBC
      FF02:::9: RIP routers
Internet Group Management Protocol (IGMP)

- Operates between a host and its attached router
- Goal: *allow a router to determine to which of its networks to forward IP multicast traffic*
- IP protocol (IP protocol number 2)

Three message types

1. **Membership_query**
   - Sent by a router to all hosts on an interface (i.e., on the LAN) to determine the set of all multicast groups that have been joined by the hosts on that interface

2. **Membership_report**
   - Host response to a query or an initial join or a group

3. **Leave_group**
   - Host indicates that it is no longer interested
   - Optional: router infers this if the host does not respond to a query
Multicast Forwarding

- IGMP allows a host to subscribe to receive a multicast stream
- *What about the source?*
  - There is no protocol for the source!
  - It just sends one message to a class D address
  - Routers have to do the work
IGMP & Wide-Area Multicast Routing

Senders: no protocol!

Internet multicast routing

Receivers: IGMP
Multicast Forwarding

- **IGMP**: Internet Group Management Protocol
  - Designed for routers to talk with hosts on directly connected networks

- **PIM**: Protocol Independent Multicast
  - Multicast Routing Protocol for delivering packets across routers
  - Topology discovery is handled by other protocols
  - Two forms:
    - Dense Mode (PIM-DM)
    - Sparse Mode (PIM-SM)
Forward multicast packet to all connected routers

- Use a spanning tree and reverse path forwarding (RPF) to avoid loops
- Feedback & cut off if there are no interested receivers on a link
  - A router sends a prune message.
  - Periodically, routers send messages to refresh the prune state
- Flooding is initiated by the sender’s router
- Use Reverse path forwarding (RPF): avoid routing loops
  - Packet is duplicated & forwarded ONLY IF it was received via the link that is the shortest path to the sender
  - Shortest path is found by checking the router’s forwarding table to the source address
PIM-DM: Dense Mode Multicast – *flooding*

- **Advantage:**
  - Simple
  - Good if the packet is desired in most locations

- **Disadvantage:**
  - wasteful on the network, wasteful extra state & packet duplication on routers
PIM-SM: Sparse Mode Multicast

Initiated by the routers at each receiver

Each router requests a multicast feed with a PIM Join message

• Initiated by a router at the destination that gets an IGMP join
• Rendezvous Point: meeting place between receivers & source
  – Join messages propagate to a defined rendezvous point (RP)
  – Sender transmits only to the rendezvous point
  – RP announcement messages inform edge routes of rendezvous points
• A Prune message stops a feed

Advantage

• Packets go only where needed
• Creates extra state in routers only where needed
IP Multicast in use

• Initially exciting:
  – Internet radio, NASA shuttle missions, collaborative gaming

• But:
  – Few ISPs enabled it
  – For the user, required tapping into existing streams (not good for on-demand content)
  – Industry embraced unicast instead
IP Multicast in use: IPTV

• IPTV has emerged as the biggest user of IP multicast
  – Cable TV networks have migrated (or are migrating) to IP delivery

• Cable TV systems: aggregate bandwidth ~ 4.5 Gbps
  – Video streams: MPEG-2 or MPEG-4 (H.264)
  – MPEG-2 HD: ~30 Mbps \( \Rightarrow \) 150 channels = ~4.5 Gbps
  – MPEG-4 HD: ~6-9 Mbps; DVD quality: ~2 Mbps

• Multicast
  – Reduces the number of servers needed
  – Reduces the number of duplicate network streams
IP Multicast in use: IPTV

• Multicast allows one stream of data to be sent to multiple subscribers using a single address

• IGMP from the client
  – Subscribe to a TV channel
  – Change channels

• Use unicast for video on demand
The End