Week 4: Part 2
IP Multicast

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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 ($\text{ff00:0:0:0:0:0:0:0/8}$)
  - **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 – UDP at the transport layer
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
  FF02:0:0:0:0:0:0:9: 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 sender?*
  – 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!

Received hosts:
- recv host
- recv host
- recv host

Internet multicast routing
- PIM

Received hosts:
- recv host
- recv host
- recv host

IGMP
- recv host
- recv host
- recv host

Senders: no protocol!
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)
PIM-DM: Dense Mode Multicast – *flooding*

**Forward multicast packet to all connected routers**

- Each router forwards the multicast packet to all of its interfaces
- 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 a spanning tree and reverse path forwarding (RPF) to avoid 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
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
- Requires administration – setting up the RP & ensuring hosts can discover it
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

- Multicast allows one stream of data to be sent to multiple subscribers using a single address
  - Reduces the number of servers needed
  - Reduces the number of duplicate network streams

- IGMP from the set-top box
  - Change channel = join a new multicast group

- Use unicast for video on demand
The End