Group Communication Applications

- Broadcast audio/video
- Software distribution
- Web-cache updates
- Teleconferencing (audio, video, shared whiteboard, text editor)
- Multi-player games
- Server/service location
- Other distributed applications

Multicast – Efficient Data Distribution

Overview

- IP multicast service basics
- Multicast routing
- Multicast transport
- Overlay multicast
**IP Multicast Architecture**

- **Service model**
  - Host-to-router protocol (IGMP)
  - Multicast routing protocols (various)

**IP Multicast Service Model (rfc1112)**

- Each group identified by a single IP address
- Groups may be of any size
- Members of groups may be located anywhere in the Internet
- Members of groups can join and leave at will
- Senders need not be members
- Group membership not known explicitly
- Analogy:
  - Each multicast address is like a radio frequency, on which anyone can transmit, and to which anyone can tune-in.

**IP Multicast Addresses**

- Class D IP addresses
  - 224.0.0.0 – 239.255.255.255

- How to allocated these addresses?
  - Well-known multicast addresses, assigned by IANA
  - Transient multicast addresses, assigned and reclaimed dynamically, e.g., by “sdr” program

**IP Multicast Service**

- Sending – same as before
- Receiving – two new operations
  - Join-IP-Multicast-Group(group-address, interface)
  - Leave-IP-Multicast-Group(group-address, interface)
  - Receive multicast packets for joined groups via normal IP-Receive operation
Multicast Scope Control – Small TTLs

- TTL expanding-ring search to reach or find a nearby subset of a group

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Multicast Scope Control – Large TTLs

- Administrative TTL Boundaries to keep multicast traffic within an administrative domain, e.g., for privacy or resource reasons

Multicast Router Responsibilities

- Learn of the existence of multicast groups (through advertisement)
- Identify links with group members
- Establish state to route packets
  - Replicate packets on appropriate interfaces
  - Routing entry:
    - Src, incoming interface
    - List of outgoing interfaces
**IP Multicast Architecture**

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**Internet Group Management Protocol**

- End system to router protocol is IGMP
- Each host keeps track of which multicast groups are subscribed to
  - Socket API informs IGMP process of all joins
- Objective is to keep router up-to-date with group membership of entire LAN
  - Routers need not know who all the members are, only that members exist

**How IGMP Works**

- On each link, one router is elected the “querier”
- Querier periodically sends a Membership Query message to the all-systems group (224.0.0.1), with TTL = 1
- On receipt, hosts start random timers (between 0 and 10 seconds) for each multicast group to which they belong

**How IGMP Works (cont.)**

- When a host’s timer for group G expires, it sends a Membership Report to group G with TTL = 1
- Other members of G hear the report and stop their timers
- Routers hear all reports, and time out non-responding groups
How IGMP Works (cont.)

- Note that, in normal case, only one report message per group present is sent in response to a query.
- Query interval is typically 60-90 seconds.
- When a host first joins a group, it sends one or two immediate reports, instead of waiting for a query.

IP Multicast Architecture

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Multicast Routing

- Basic objective – build distribution tree for multicast packets.
- Multicast service model makes it hard
  - Anonymity
  - Dynamic join/leave.

Routing Techniques

- Flood and prune
  - Begin by flooding traffic to entire network.
  - Prune branches with no receivers.
  - Examples: DVMRP, PIM-DM.
  - Unwanted state where there are no receivers.
- Link-state multicast protocols
  - Routers advertise groups for which they have receivers to entire network.
  - Compute trees on demand.
  - Example: MOSPF.
  - Unwanted state where there are no senders.
Source-based Trees

- Router
- Source
- Receiver

Distance-Vector Multicast Routing

- DVMRP consists of two major components:
  - A conventional distance-vector routing protocol (like RIP)
  - A protocol for determining how to forward multicast packets, based on the routing table
- DVMRP router forwards a packet if
  - The packet arrived from the link used to reach the source of the packet (reverse path forwarding check – RPF)
  - If downstream links have not pruned the tree

Example Topology

Broadcast with Truncation
Prune

Graft

Steady State

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Implosion

Packet 1 is lost
All 4 receivers request a resend

Retransmission

- Re-transmitter
  - Options: sender, other receivers
- How to retransmit
  - Unicast, multicast, scoped multicast, retransmission group, ...
- Problem: Exposure

Exposure
Packet 1 does not reach R1; Receiver 1 requests a resend
Packet 1 resent to all 4 receivers

Ideal Recovery Model
Packet 1 reaches R1 but is lost before reaching other Receivers
Only one receiver sends NACK to the nearest S or R with packet
Repair sent only to those that need packet
Multicast Congestion Control

- What if receivers have very different bandwidths?
- Send at max?
- Send at min?
- Send at avg?

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Supporting Multicast on the Internet

At which layer should multicast be implemented?

Why has IP Multicast not become popular?

Multicast – Efficient Data Distribution
IP Multicast

- Highly efficient
- Good delay

End System Multicast

- Quick deployment
- All multicast state in end systems
- Computation at forwarding points simplifies support for higher level functionality

Potential Benefits Over IP Multicast

- Self-organize recipients into multicast delivery overlay tree
- Must be closely matched to real network topology to be efficient
- Performance concerns compared to IP Multicast
- Increase in delay
- Bandwidth waste (packet duplication)