Broadcasting to Groups

- Many applications are not one-one
  - Broadcast
  - Group collaboration
  - Proxy/Cache updates
  - Resource Discovery
- Packets must reach a Group rather than a single destination
  - Group membership may be dynamic
  - More than one group member might be a source
- Idea: After a group is established
  - Interested receivers join the group
  - The network takes care of group management
  - Recall RSVP
The Multicast service Model

- Membership access control
  - open group: anyone can join
  - closed group: restrictions on joining
- Sender access control
  - anyone can send to group
  - anyone in group can send to group
  - only one host can send to group
- Packet delivery is best effort
Multicast and Layering

- Multicast can be implemented at different layers
  - data link layer
    - e.g. Ethernet multicast
  - network layer
    - e.g. IP multicast
  - application layer
    - e.g. as an overlay network like Kazaa

- Which layer is best?
Multicast Implementation Issues

- How are multicast packets addressed?
- How is join implemented?
- How is send implemented?
  - How does multicast traffic get routed?
    - This is easy at the link layer and hardest at the network layer
- How much state is kept and who keeps it?
Ethernet Multicast

- Reserve some Ethernet MAC addresses for multicast
- To join group G
  - network interface card (NIC) normally only listens for packets sent to unicast address A and broadcast address B
  - to join group G, NIC also listens for packets sent to multicast address G (NIC limits number of groups joined)
  - implemented in hardware, so efficient
- To send to group G
  - packet is flooded on all LAN segments, like broadcast
  - can waste bandwidth, but LANs should not be very large
- Only host NICs keep state about who has joined → scalable to large number of receivers, groups
Limitations of Data Link Layer Multicast

- Single LAN
  - limited to small number of hosts
  - limited to low diameter latency
  - essentially all the limitations of LANs compared to internetworks

- Broadcast doesn’t cut it in larger networks
IP Multicast: Interconnecting LANS

- Interconnected LANs
- LANs support link-level multicast
- Map globally unique multicast address to LAN-based multicast address (LAN-specific algorithm)
- IP Group addresses are class D addresses
  - 1110/28 or 224.0.0.0 to 239.255.255.255
Operates between Router and local Hosts, typically attached via a LAN (e.g., Ethernet)

- Query response architecture
1. Router periodically queries the local Hosts for group membership information
   - Can be specific or general
2. Hosts receiving query set a random timer before responding
3. First host to respond sends membership reports
4. All the other hosts observe the query and suppress their own reports.

- To Join send a group send an unsolicited Join
  - Start a group by joining it
- To leave don’t have to do anything
  - Soft state
Naïve Routing Option: Don’t change anything

Point-to-point routing

Group abstraction not implemented in the network
This approach does not scale...
Instead build trees

Copy data at routers
At most one copy of a data packet per link

- Routers keep track of groups in real-time
- “Path” computation is Tree computation

• LANs implement layer 2 multicast by broadcasting
Routing: Approaches

- Kinds of Trees
  - Shared Tree
  - Source Specific Trees
- Tree Computation Methods
- Intradomain Update methods
  - Build on unicast Link State: MOSPF
  - Build on unicast Distance Vector: DVMRP
  - Protocol Independent: PIM
- Interdomain routing: BGMP
  - This is still evolving…
Problems with
Network Layer Multicast

- Scales poorly with number of groups
  - A router must maintain state for every group that traverses it
  - many groups traverse core routers
- Supporting higher level functionality is difficult
  - NLM: best-effort multi-point delivery service
  - Reliability and congestion control for NLM complicated
- Deployment is difficult and slow
  - Difficult to debug problems given the service model
Assume reliability through retransmission

Sender can not keep state about each receiver
  - e.g., what receivers have received
  - number of receivers unknown and possibly very large

Sender can not retransmit every lost packet
  - even if only one receiver misses packet, sender must retransmit, lowering throughput

N(ACK) implosion
  - described next
(N)ACK Implosion

- (Positive) acknowledgements
  - ack every n received packets
  - what happens for multicast?
- Negative acknowledgements
  - only ack when data is lost
  - assume packet 2 is lost
NACK Implosion

- When a packet is lost all receivers in the subtree originated at the link where the packet is lost send NACKs.
Avoiding NACK Implosions

- Every node estimates distance (in time) from every other node
  - Information is carried in session reports (< 5% of bandwidth)
- Nodes use randomized function of distance to decide when to
  - Send a request repair
  - Reply to a request repair
ISPs charge by bandwidth

Broadcast Center

Remember what interdomain protocols optimize for....

They make more money without multicast
Application Layer Multicast

- Provide multicast functionality above the IP unicast
- Gateway nodes could be the hosts or multicast gateways in the network

Advantages
- No multicast dial-tone needed
- Performance can be optimized to application
  - Loss, priorities etc.
- More control over the topology of the tree
- Easier to monitor and control groups

Disadvantages
- Scale
- Performance if just implemented on the hosts (not gateways)
Summary

- Large amount of work on multicast routing
- Major problems
  - preventing flooding
  - minimizing state in routers
  - denial-of-service attacks
  - deployment
- Multicast can be implemented at different layers
  - lower layers optimize performance
  - higher layers provide more functionality
- IP Multicast still not widely deployed
  - Ethernet multicast is deployed
  - application layer multicast systems are promising