Multicast

Introduction
Link State Multicast
Distance Vector Multicast
PIM

What is Multicast?

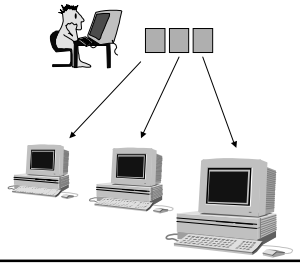
- Unicast:
  - Single sender, single receiver
- Broadcast:
  - Single sender, global receivers
- Multicast:
  - Single sender, selected receivers

Why do we need Multicast?

- Newsgroups/mailing-lists
- Videoconferencing
- Internet games
- Interactive chatlines
- Distance learning
- Internet Jukebox
- Video on demand

The Simple Approach: Multicast as Multiple Unicasts

Subject: class project
To: sh4mn@virginia.edu, rt5zw@virginia.edu, xr9w@virginia.edu

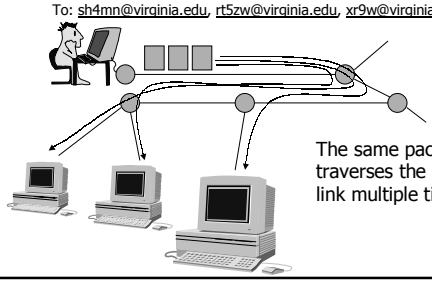


An independent copy is made at the sender for each recipient

Problem?

Problem with Multiple Unicasts

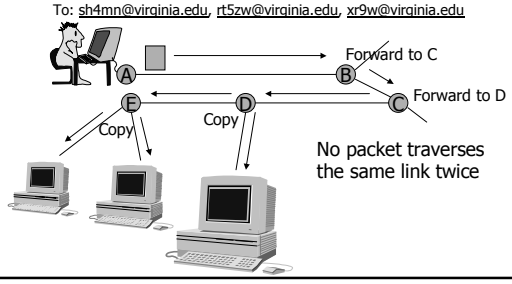
Subject: class project
To: sh4mn@virginia.edu, rt5zw@virginia.edu, xr9w@virginia.edu



The same packet traverses the same link multiple times.

"Native" Multicast

Subject: class project
To: sh4mn@virginia.edu, rt5zw@virginia.edu, xr9w@virginia.edu



No packet traverses the same link twice

Network Support for Multicast

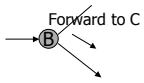
- Multicast addresses

Subject: class project
To: my_project_group@virginia.edu

IP Multicast group 224.10.98.2

- Router support

Destination	Next hop (port)
224.10.98.2	C



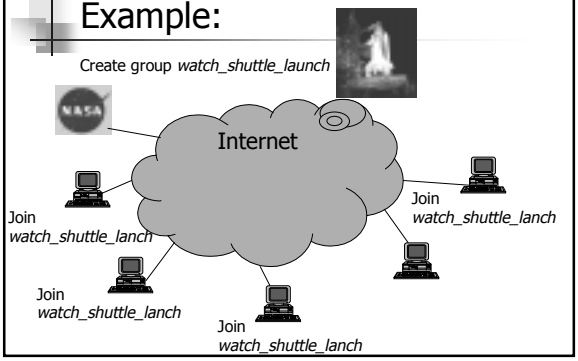
Operating System Support for Multicast

- The communication subsystem of the operating system (e.g., the socket implementation) must check for network support for multicast and use it when available
- If the sender OS implements multicast as multiple unicasts, network multicast might not be invoked

User Interface to Multicast

- *Create* Multicast Group
- *Join* Multicast Group
- *Leave* Multicast Group
- *Show* Group Membership
- Group Membership: The membership of a multicast group determines who is in the group.
  - Some multicast tools do not support showing group membership

Example:



How to set up the Routing Tables for Multicast?

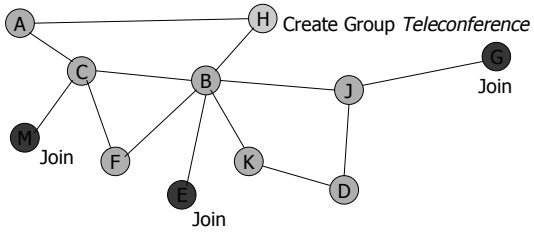
- Unlike network topology, multicast group membership changes dynamically
- Protocols are needed for setting up the routing tables to reflect current membership
- Do multicast protocols belong in the IP layer?

Link State Multicast

- Used in conjunction with link state routing
- Link state includes set of multicast groups who have members on the link
  - This state is set by *join* messages
- Given full knowledge of which groups have members on which links each router constructs a shortest-path multicast tree
- The multicast tree determines routing table entries

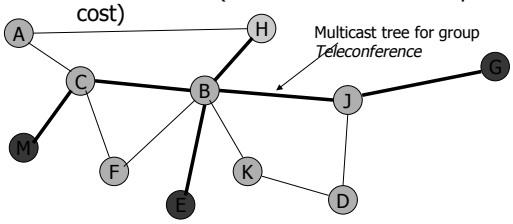
Example: Link State Multicast

- Yellow source wants to send to a multicast group G with members on red links

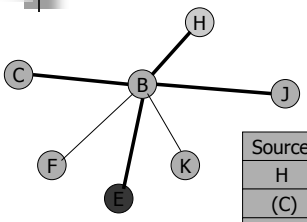


Example: Link State Multicast

- Dijkstra's algorithm finds the shortest path multicast tree (assume all links have equal cost)



Routing Tables



Source	Group	Next Hops
H	Z	C,E,J
(C)	Z	H,E,J
E	Z	C,H,J
(J)	Z	C,E,H

Problem

- Link state multicast potentially needs a routing table entry per source/group combination

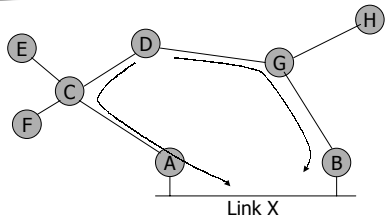
Distance Vector Multicast

- Used in conjunction with distance vector routing
- Creates a broadcast tree for each group
- Prunes the tree to only those recipients who express interest in group
- Good for very large (dense) multicast groups
- Not scalable in the number of groups due to initial broadcast (called reverse path broadcast)

Reverse Path Broadcast

- Whenever a router receives a multicast packet from source S it forwards it on all interfaces except the one where the packet came from
- Shortcomings:
  - Floods the network – no provision for excluding destinations not interested in the multicast
  - A packet may be forwarded to the same LAN multiple times if LAN has multiple routers

Example

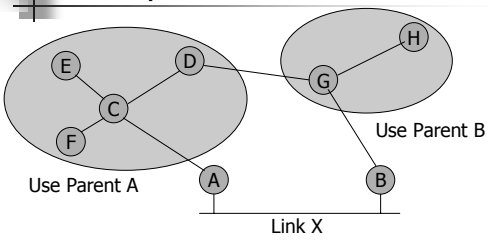


The same packet is forwarded to link X twice

Reverse Path Broadcast Optimization

- Designate one router as the parent router for each link relative to each source
- Only the parent forwards packets to link from that source
- The parent can be the closest router from the source to the link

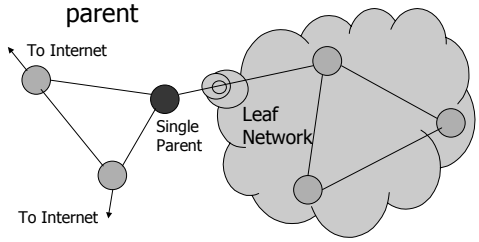
Example



A acts as parent of link X when source is red
B acts as parent of link X when source is blue

Definition: Leaf Networks

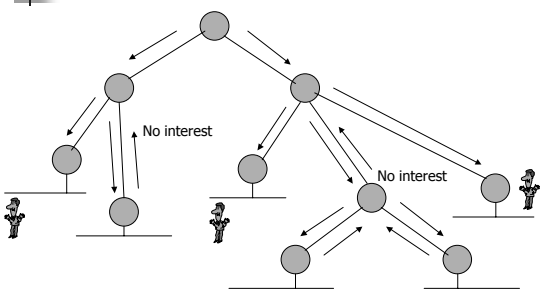
- A network is a leaf if it has only one parent



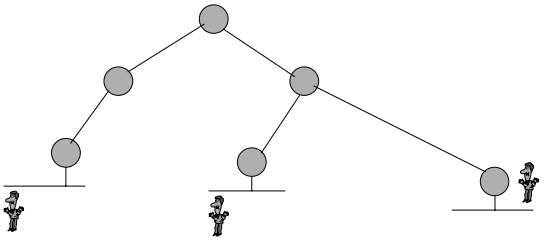
Reverse Path Multicast

- Flooding is used to announce group G
- Each host that joins group G announces its membership to G periodically
- Routers that are parents of leaf networks collect membership info
- Routers with no members in G propagate "no members of G here" up the shortest path in the distance update messages

Example



Example



Reverse Path Multicast

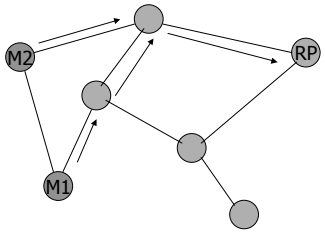
- Suitable for dense long-lived groups
  - Broadcasting popular events, e.g., from cnn.com
  - Watching NASA live shuttle launch feeds
- Not suitable for sparse or short-lived groups
  - Conference calls
  - Sending e-mail to multiple recepients

Protocol Independent Multicast

- Addresses multicast in sparse groups
- A rendezvous point (router), called RP, is assigned to each group
- Hosts send join messages to the RP
- The paths taken by these messages form branches of the multicast tree
  - Shared trees: used by all members
  - Source specific trees: used for multicasting messages of a particular source

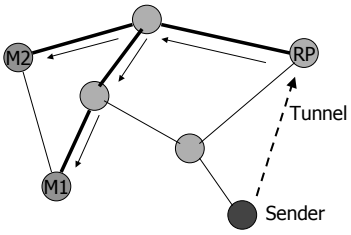
Joining a PIM group

- Member sends join message to RP



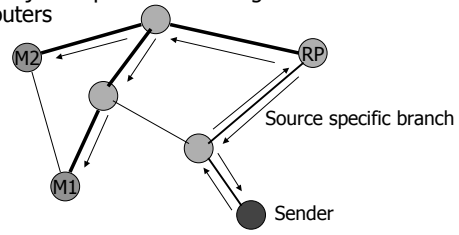
Multicasting to a PIM group

- Source tunnels message to RP
- RP does multicast



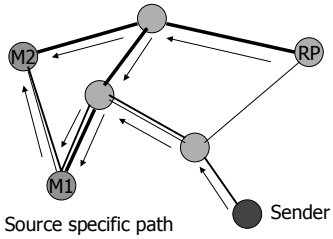
Optimization 1: Eliminate Tunneling for Heavy Senders

- RP sends source-specific join to sender
- The join deposits forwarding state in intermediate routers



Optimization 2: Create a Source Specific Tree

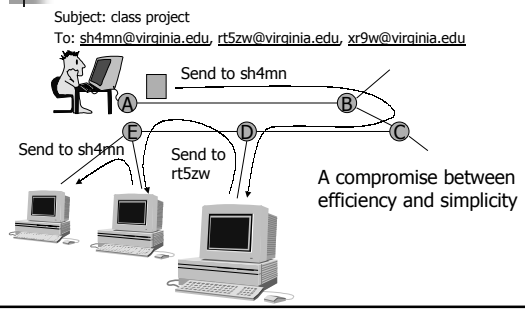
- Downstream router (e.g., M2) sends a source-specific join to the sender creating a new tree



Other Multicast Topics: Application Layer Multicast

- We do not really need network support for multicast
- Multicast algorithms can be implemented at the end hosts

Application Layer Multicast



Other Multicast Topics

- Atomic multicast
  - Ensuring that each message sent to a multicast group is received by either all receivers or no receivers at all
- Reliable Multicast
  - Ensuring that each message sent to a multicast group gets received reliably
- Ordered Multicast
  - Ensuring that all messages get received in the same order by all recipients

Project Idea

- Implement an application layer multicast service that guarantees atomic ordered multicast
  - Atomic ordered multicast may be used in online auctions, games, chat rooms, and wireless ad hoc networks.