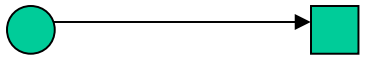
CSc 461/561
Multimedia Systems
Multicast

Jianping Pan

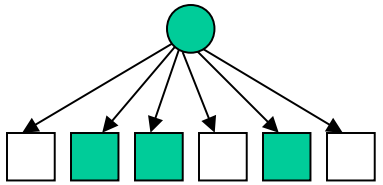
Spring 2015

What is multicast?

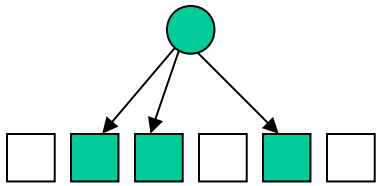
- Unicast: one sender, one receiver



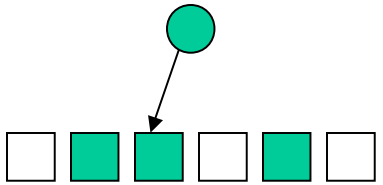
- Broadcast
  - one sender, all (possible) receivers



- Multicast
  - one sender, many willing receivers
  - many senders, many receivers

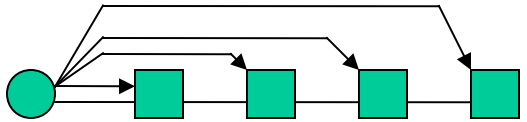


- Anycast
  - one sender, one of many possible receivers

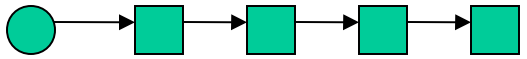


Why multicast?

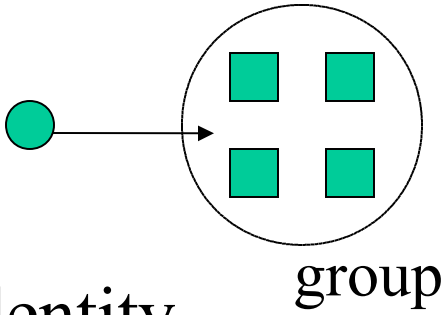
- Some applications involve many parties
  - e.g., webcasting, video conferencing
- Multicast can be emulated by
  - a bunch of unicast streams
  - too much replicated traffic!



- A better approach
  - replicate only when it is really necessary
  - IP multicast, application-layer multicast



IP multicast



- Receiver-oriented model
  - willing receivers with a common identity
    - IP multicast address (class D, 224-239.X.X.X)
    - receivers join a multicast group *explicitly*
  - senders does not care
    - senders: even no need to be a member of the group
    - send packets with destination to the group
  - best-effort network: bring packets to receivers
    - flow/error/congestion control: upper layer!

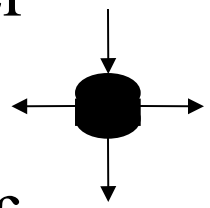
* Steve Deering attended high school at Shawnigan Lake School on Vancouver Island

IP multicast addresses

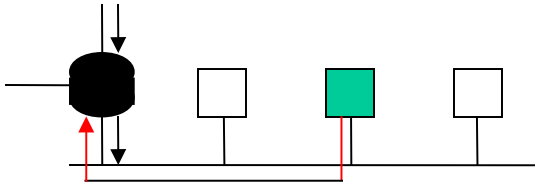
- Class D IP address
  - 224.0.0.0 - 239.255.255.255
  - 224.0.0.0 - 224.0.0.255
    - local network control block
    - 224.0.0.1: all hosts; 224.0.0.2: all routers
    - 224.0.0.22: IGMP
  - 224.0.1.0 - 224.0.1.255
    - inter-network control block
  - http://www.iana.org/assignments/multicast-addresses

How multicast is done?

- Shared media (i.e., multicast-capable)
  - e.g., Ethernet
  - multicast address: 01-00-5e-0xxxxxxx-X-X
  - mapped from IP multicast address as a filter
- Non-shared media (by replication)
  - e.g., routers receive packets from one interface
  - replicate and send through all other interfaces with reachable *active* multicast receivers

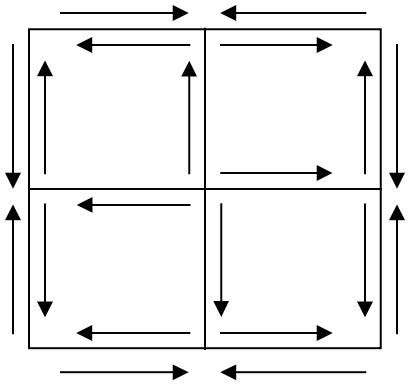


IGMP



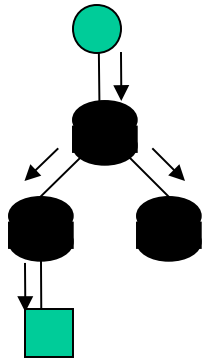
- Internet group management protocol
  - IGMP Join/Report sent by host
    - "I am here and forward me multicast packets"
  - IGMP Query sent by router with timer
    - "are you still there?"
    - membership refreshed by Report sent by host
  - IGMP Leave sent by host
    - explicit in IGMPv2: "I am leaving"
    - IGMPv3: source-specific joining and leaving

Flooding

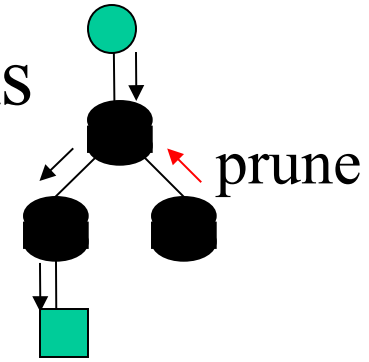


- Flooding
  - receive from one interface
  - send through all other interfaces
  - broadcast storm problem
- Controlled flooding
  - no packets appear on the same link twice
  - if the packet received before, drop it
  - only forward packet from *reverse* shortest path

Pruning



- Spanning tree
  - no packet received by any node twice!
  - one path from source to any receiver
- If no member in downstream networks
  - by IGMP etc
  - remove such branches
  - periodical flooding or explicit join necessary



Multicast routing

- Essentially, building a tree
  - sender-specific tree; or
  - shared tree, i.e., shared by many senders
- Ideally, the tree should be
  - low cost: overall (for sender) or for receiver
  - balanced among members
  - stable: w.r.t. node joining and leaving
  - it is a HARD problem!

Sender-specific tree

- Shortest path from sender to receivers
  - Dijkstra's algorithm
  - build the tree from the sender
  - add a node (not in the tree) closest to the sender
  - check whether this node can also reduce the sender's distance to other nodes in the tree
  - repeat until all nodes are in the tree
  - node distance should be non-negative

Shared tree

- Minimal spanning tree
  - global knowledge of network topology
  - begin with the link of minimal cost
  - construct tree gradually by adding more links of increasing cost until a tree is formed
- Center-based tree: one node as the “center”
  - Join message sent to the center
  - possibly meet a node already in the group

Multicast routing protocols

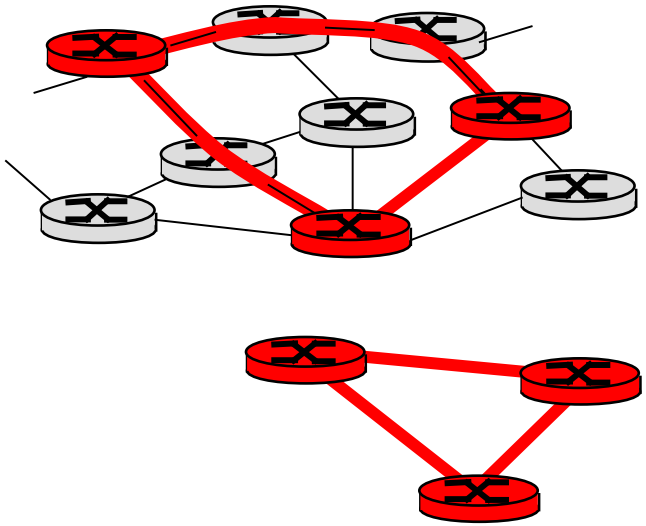
- DVMRP
  - extension to DVRP (distance vector-based)
  - flooding and pruning
  - sender-specific tree with reverse shortest path
- MOSPF
  - extension to OSPF (link state-based)
  - global knowledge of network topology, cost etc
  - shortest path tree

PIM

- Independent of underlying routing protocol
- Dense mode: densely packed members
  - sender-specific tree
  - flood and prune
  - reverse shortest path
- Sparse mode: widely scattered members
  - shared tree
  - center-based tree at rendezvous point

Mbone: multicast backbone

- Multicast tunneling
  - traverse "not multicast-capable" networks
  - with tunnel between multicast-capable nodes
    - routers or hosts
- MBone applications
  - vat: visual audio tool
  - wb: white board
  - sd: session directory



Application-layer multicast

- Inter-domain multicast is difficult
  - not only in technology, but also in policies
  - E.g., MBGP: multicast BGP (shared tree)
- Application-layer multicast
  - end-hosts act as multicast "router" to build trees
  - application-aware flow/error/congestion control
  - not as efficient as IP multicast
  - but provide more flexibility and easy-to-deploy

This lecture

- Multicast
  - IP multicast; IGMP
  - multicast routing
    - shortest-path tree
    - minimal spanning tree
- Explore-further question
  - discuss the pros and cons of “forward first received only” and “forward received on reverse shortest path only” in controlled flooding

Next lecture

- RTP/RTCP
  - 2nd Ed Chapter 15
  - REF: http://www.cs.columbia.edu/~hgs/rtp/