Class IV Multicast

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Today's Plan

- Class IV - - - Multicast in general
  - What is multicast? What is IP multicast?
  - What is multicast for? How useful is it?
  - What do we need for IP multicast?
- Class V - - - Reliable multicast
  - Why not TCP?
  - What techniques have been proposed?

Class IV: Multicast in General

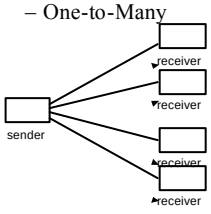
1. Concepts in Multicast
   - One-to-Many
   - IP Multicast
   - Specifying Recepients
2. Packet Delivery
   - Copying at routers
   - Mcast Support by Data Links
   - Routing
   - Mbone and Tunneling
- (cannot cover all aspects of multicast)

1. Concepts in Multicast

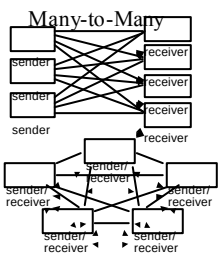
- Multicast?
- IP Multicast
- Specifying Recepients

1.1-1 What is Multicast?

- Communicating with many
  - One-to-Many



Many-to-Many



1.1-2 Multicast vs. Broadcast

- Broadcast to all connected recepients
  e.g., radio and TV broadcast

  vs
- Multicast to designated recepients
  e.g., conference calls
- Often need to distinguish. Remember.

1.1-3 What is it used for? (data)

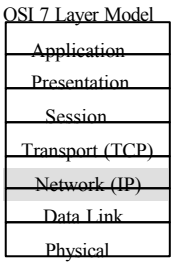
- Data delivery to many recepients
  - One to many data distribution
    - e.g., new price list to all branches
  - One to many program distribution
    - e.g., software upgrade in a company
  - Many to many data distribution (sharing)
    - e.g., WEB cache data (prefetching) sharing
    - e.g., shared white board (in video conferencing)

1.1-3 What is it used for? (stream)

- Stream data delivery to many recepients
  - One to many stream distribution
    - e.g., TV-like video broadcasting
    - MBONE ~ broadcasting lectures, conferences, NASA missions etc.
  - Many to many stream sharing
    - e.g., video conferencing

1.2-1 IP Multicast

- Multicast implemented in IP layer
  - *Recall:*
    IP layer realizes end-end reachability by chaining one-hop Data Links
  - M-cast may be implemented in other layers, e.g., Application layer



1.2-2 IP Multicast

- One-to-many packet delivery
  - from sender to recepients
- Over IP network
  - using various hop links
- Without reliability
  - packet losses, no flow control
- Efficiently
  - one copy per link

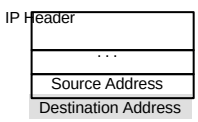
How to specify recepients?

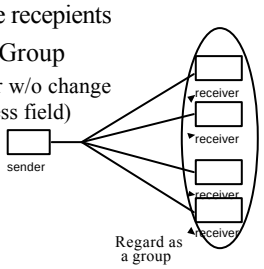
Utilizing link broad-cast capability?

TCP applicable?

1.3-1 Specifying Recepients

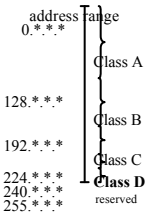
- A Group to designate recepients
- One IP address for a Group
  - ⇒ May use IP header w/o change (destination address field)

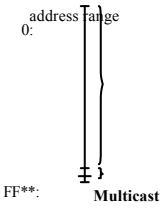




1.3-1 Specifying Recepients

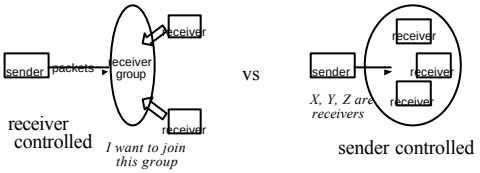
- Different prefix for distinction from unicast
  - Class-D in IPv4
  - Prefix 0xFF in IPv6





1.3-2 Forming a Group

- Each Receiver joins a group (instead of Sender control)

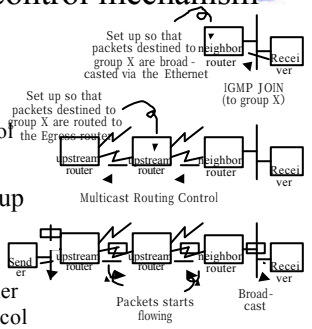


1.3-2 Forming a Group

- Anybody can join any group
  - TV-like control ~ tune on any TV station
- No sender control
  - Cannot restrict recepients
  - ⇒ Many discussions for controlled delivery
    - Receiver Authentication plus
    - Delivery Control (no delivery to unauthorized receivers)

1.3-3 Group control mechanism

- Receiver requests to *Join* group X
  - **I**nternet **G**roup **M**anagement **P**rotocol
  - query⇒report(join)
- Neighbor router sets up
  - a path to the receiver within the router
  - a route from the sender mcast routing protocol



Digression: Receiver scalability

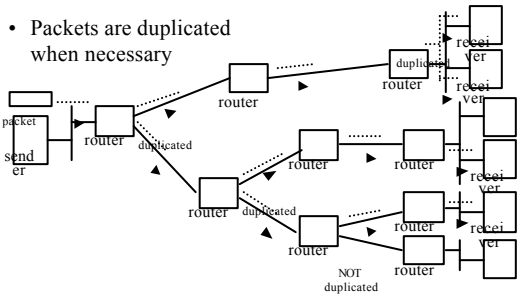
- Internet community emphasizes *Scalability*
- IP multicast is designed to be scalable
  - Number of receivers in a group
    - e.g., No "recepient list" included in IP header
  - Number of groups
    - Well…, IP address space limits the number, but...
  - Number of senders
    - Anybody can send packets to a group

2. Packet Delivery

- Copying at Routers
- Mcast Support by Data Links
- Routing
- Mbone and Tunneling

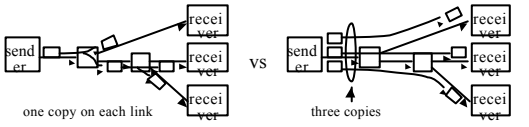
2.1-1 Duplicating Packets

- Packets are duplicated when necessary



2.1-2 Duplicating Packets

- Packets are duplicated ONLY when necessary
- Implies "at most one copy per link"
  ⇒ efficient link usage

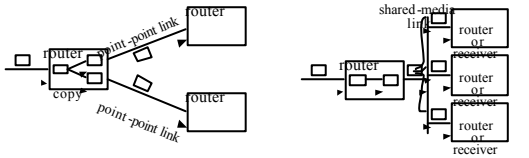


2.1-2 Lazy packet duplication

- More effective for streaming
  - A stream occupies fixed bandwidth for a long duration (minutes ~ tens of minutes)
    Compare with file transfer.
- Also effective for a large scale distribution
  - E.g., 10MB to 100~1000~10000 branches
    Data, programs, video clips, ...
  - E.g., 1MB to 10000~100000 consumers
    Programs, audio/video clips, …

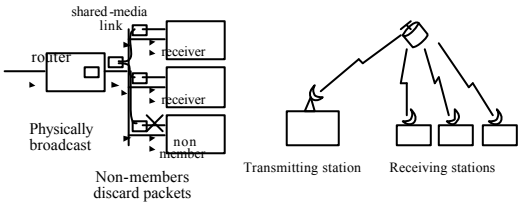
2.2-1 Mcast support by data links

- Point-point links
  ⇒ router duplicates
- Shared-media links
  ⇒ media duplicates



2.2-2 Mcast by shared media links

- Shared-media LANs
  - ethernet , token-ring, …
- Radio-wave networks
  - Esp., satellite
    ⇒ large distribution



Digression: History(1)

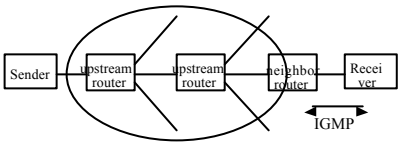
- '90: Added to IP-v4 unicast
  - RFC1112 (in 1989) Deering, S., "Host Extensions for IP Multicasting"
  - Join control by IGMP
    Multicast routing separate from unicast
- '95~: Internet exploded, but
  - Multicast not used extensively
  - Two limited usages:
    Data duplication within limited networks, and
    Mbone stream applications

Digression: History(2)

- '98 ~ : Reliable Multicast discussions
  - Many proposals from early '90s
  - IETF standardization discussion started
- Streaming applications commercialized
  - Real Networks, MS Media Player, Quick Time, ...
- '2000 ~ : IP-v6 deployment
  - IGMP migrated to IP-v6 ICMP
- Still limited use

2.3-1 Routing

- Establishes a path from sender to the neighbor router
  - neighbor router already knows Receiver by IGMP



Multicast Routing Protocol builds up a delivery tree

2.3-1 Routing

- Multicast routing table entry in routers
  - if forwarding multicast packet to address X is needed
  - (i.e., if a receiver of the group X is connected in the downstream)
- When a packet to X arrives,
  - the router transmits a copy to the link toward the receiver
- Static and Dynamic routing (just as unicast)
  - A number of dynamic routing protocols proposed

2.3-1 Mcast routing protocols (for dynamic routing)

- DVMRP
  - Distance vector multicast routing protocol
- MOSPF
  - Multicast extension of OSPF
- CBT (Core Based Tree)
- PIM
  - Protocol Independent Multicast
- BGP+ (inter-AS) and so on…

2.3-2 DVMRP

- Distance Vector type algorithm (RFC1075 1988)
  - Idea: Periodically exchange routing information with neighbor (similar to RIP)
  - Info (group addr to forward + hop counts) propagates from downstream up like a ripple
  - Select the shortest path if two or more paths exists
    - "Truncated Reverse Path Broadcasting (TRPB)"
    - Steve Deering, Proc Sigcomm 88
  - Flooding & pruning
    - Data flooding ⇒ prune a path if no delivery requested

2.3-2 DVMRP

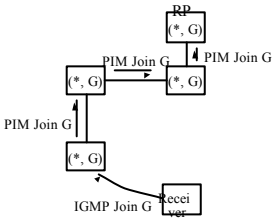
- Extensively used in Mbone construction
  - software *mrouted* distributed free
- Not recommended these days
  - Propagation delay, unstability, hop limit, …

2.3-3 PIM

- *Independent* to unicast routing protocol
- Two modes
  - Dense Mode (PIM-DM) (draft-ietf-pim-dm-new-v2-02.txt)
    - Effective when nodes are dense, similar to DVMRP
    - Based on neighborhood communication, flooding&pruning
  - Sparse Mode (PIM-SM) (RFC 2362)
    - Effective when nodes are sparse (distant)
    - Develops a distribution tree shared by all senders
    - May form a source-specific tree for efficiency

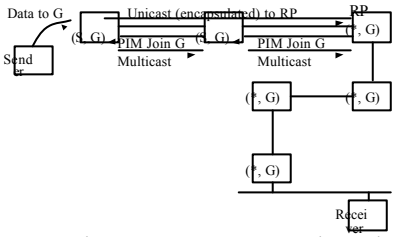
2.3-3 PIM-SM

- *Join* message to RP (Rendezvous Point)



2.3-3 PIM-SM

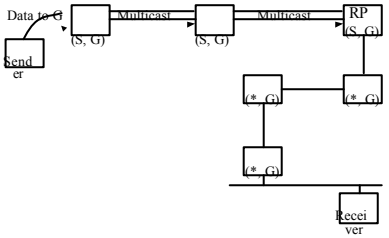
- Sender sends mcast data to RP via unicast tunnel



- RP sends *Join* message toward Sender

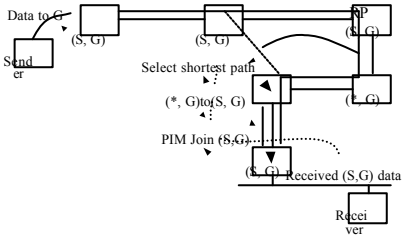
2.3-3 PIM-SM

- Sender sends mcast data to the tree



2.3-3 PIM-SM

- RP-initiated tree ⇒ Shortest path tree

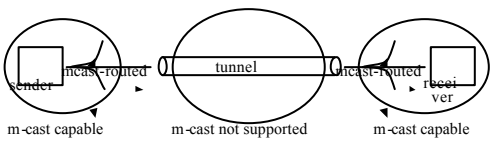


2.3-4 Other Mcast routing protocols

- MOSPF
  - Multicast extension of OSPF (Proteon) (RFC1584)
- CBT (Core Based Trees) (RFC2189)
- Others

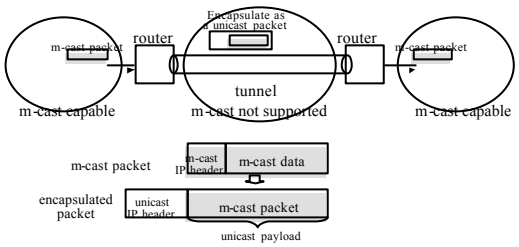
2.4-1 Tunneling and Mbone

- Routers need mcast routing support
  - No Mcast on internet backbone (ISP backbones)
- Tunnel links to pass thru non-mcast networks



2.4-2 Tunneling

- Encapsulate an Mcast packet in a Ucast packet



Digression: Mcast scope

- Scope: How far my mcast messages propagate?
  - Want to control the propagation limit
    - Link-local messages: e.g., finding something on the link
    - Site-local messages: ??
    - Within the country?? ~~ language problem
    - World wide
  - TTL control
    - Time-To-Live field: decremented by 1 when passed a router i.e., control by number of router hops
    - IPv6 introduced scopes: boundary routers control delivery

2.4-3 Mbone

- World-wide Multicast Backbone
  - Connects mcast-enabled sites world-wide
  - Via tunneling over non-mcast Internet backbones
- Recent reviving effort
  - http://www.ietforg/html.charters/mboned-charter.html
  - Internet Multicast Gap Analysis from the MBONED Working Group for the IESG
    draft-ietf-mboned-iesg-gap-analysis-00.txt

Summary

- Multicast reduces packet traffic
- IP Multicast implements mcast in IP layer
  - Addressing ~ Group Address
  - Receivers to join a group, IGMP
  - Mcast routing protocols for inter-router control
  - Slow deployment, MBONE
- IP⇒no reliability⇒next class on reliability