Computer Networks

Lecture on

Multicast solutions

Plan of This Lecture

- What is IP multicast?
- IP multicast basis
- Group Management Protocols for IPv4 & IPv6
- Multicast algorithms
- Multicast routing & transport protocols
- Problems of IP multicast

Why IP Multicast?

The aim is lower network load

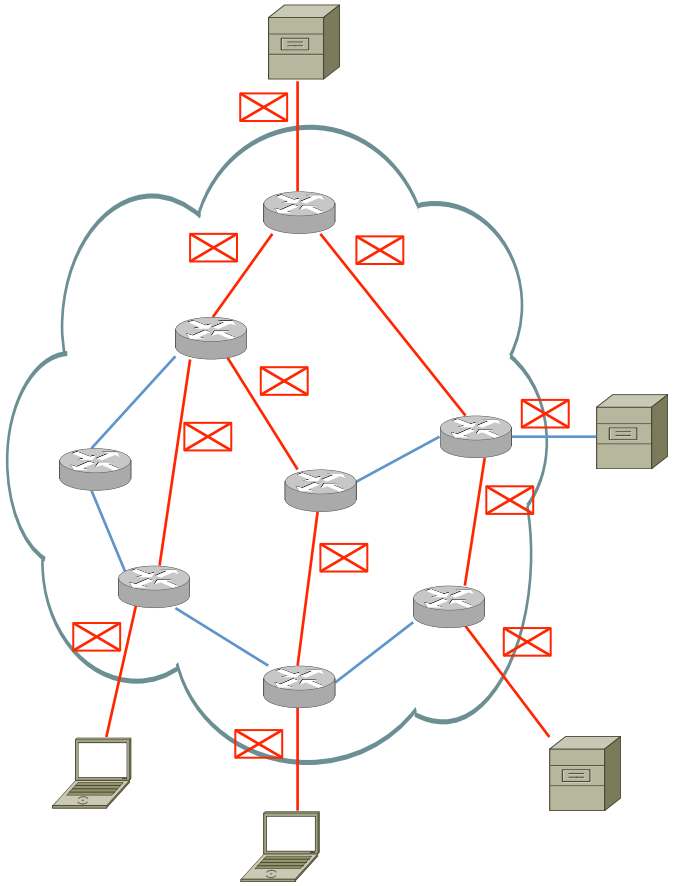
- Source sends 1 packet, network replicates it
- Support for streaming applications

A multicast group

- Sender does not have to be a group member
- No limits to members localization nor to their number

Advantages

- For network user
  - Faster data delivery
  - Lower processing load for the source of data
- For network owner
  - Can sell more bandwidth



Applications

Type of multicast services

- Open 1-to-many
  - IP radio
  - diffusion of stock exchange results
  - conferences, e.g.: IETF meetings, senate assembly
  - transmissions of great events, e.g.: human or robot space missions
- Paid 1-to-many
  - IP TV
  - software updates
- Open many-to-many
  - advertisement boards
  - meteorology photos diffusions
- Paid many-to-many
  - teleconferences
  - on-line games

Big variety of technical requirements

- group size – tens … millions
- density – sparse, dense
- needed bandwidth
- transmission time
- rate of occurrence
- reliable or not
- QoS constrained
- Authentication, Authorization and Accounting

- Global IP multicast is feasible only for huge groups
- Not all ISPs support it – accounting problems
- Big number of application layer multicast solutions

IP Multicast Basis

1. IGMP - *Internet Group Management Protocol* in IPv4

   MLD - *Multicast Listener Discovery* in IPv6

   - works in a LAN segment

2. DVMRP, MOSPF, PIM - routing protocols

3. MBONE - multicast backbone

   - Network of routers, which support multicast routing protocols
   - IP unicast tunnel may be created to get the MBONE access
   - MBON is free & still in use
     - ISPs have difficulty computing charges for multicast traffic

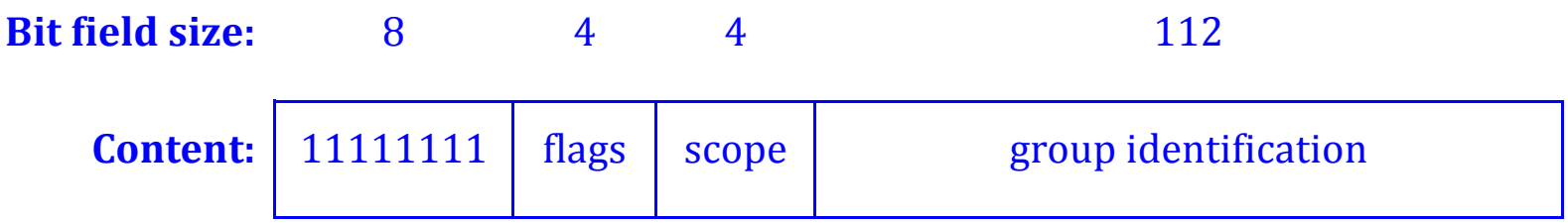
IPv4 Multicast Addressing

Class D 224.0.0.0 ÷ 239.255.255.255

Managed by IANA - Internet Assigned Numbers Authority

224.0.0.0	reserved
224.0.0.1 ÷ 224.0.0.255	routing protocols
239.0.0.0 ÷ 239.255.255.255	private space
224.0.0.1	all subnet systems
224.0.0.2	all subnet routers
224.0.0.4	all DVMRP routers
224.0.0.5	all OSPF routers
224.0.1.11	IETF-1 Audio
224.0.1.12	IETF-1 Video
224.0.1.7	Audio News
224.0.1.16	Music Service
…	

IPv6 Multicast Addressing



- Flags bit 0 - IANA permanently or transient assigned
- Scope examples:
  - interface-local
  - link-local
  - site-local
  - organization-local
  - global

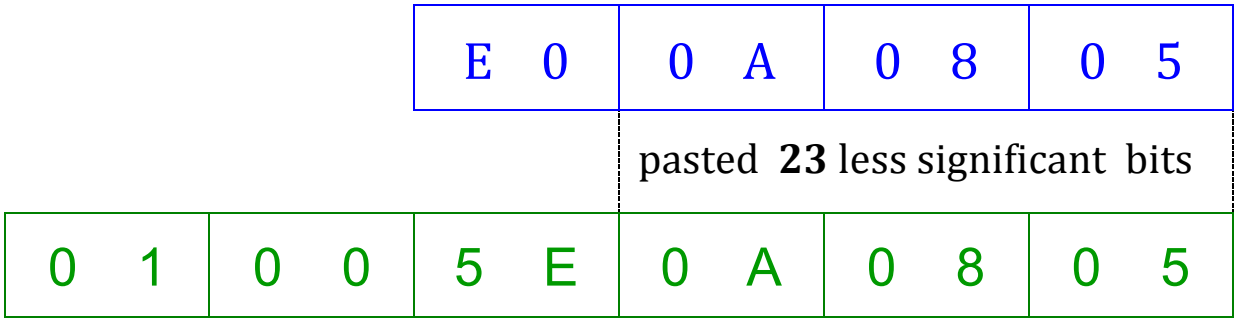
Ethernet Network Interface Card

Delivers multicast frames

- all received
- only when promiscuous mode is set
- with hardware filtering

IPv4 address mapping

D class prefix is: 1110...



5 bits are not pasted

IGMP - Internet Group Management Protocol

- Ver.1

  Broadcast between hosts and routers in a LAN segment 224.0.0.1 TTL = 1

  - Host reports to the routers

    HMR Host Membership Report

  - Router periodically asks the LAN segment 10 sec. default

    HMQ Host Membership Query

    host respond after a random delay

- Ver.2

  A router with the lowest IP address support multicast in the segment

  - Group Specific Query – reports about specific group address
  - Leave Group to 224.0.0.2
  - Widely supported by operating systems

- Ver.3 – *enable to listen only to specified sources*

  - Group Source Report
  - Inclusion Group Source Report
  - Exclusion Group Source Report

MLD – Multicast Listener Discovery

Is embedded in ICMPv6

- MLDv1 is similar to IGMPv2
- MLDv2 similar to IGMPv3

- Windows Vista and later support MLDv2
- FreeBSD 8 includes support for MLDv2

Multicast Algorithms

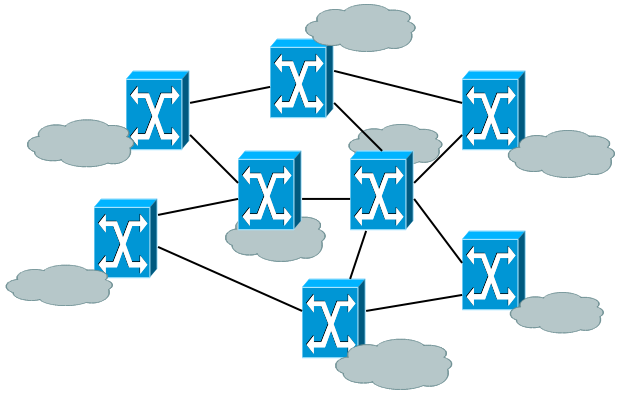
- Packets flooding

  first arrival → retransmission by other interfaces

  next arrival → discard

  A node has to store observed packets.

  - very easy to implement
  - non scalable
  - congest networks
  - heavy load of router memory

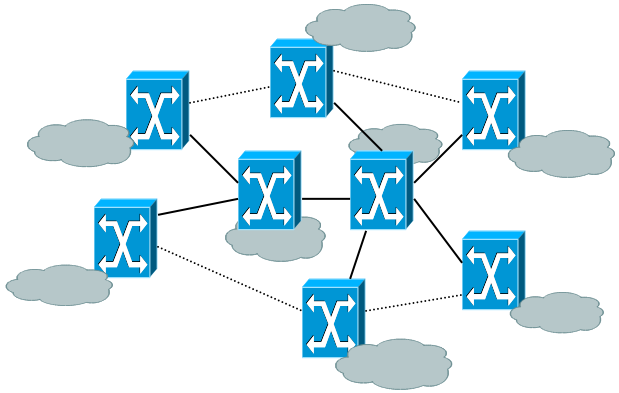


- Spanning tree - one tree in the network

  One route between any 2 routers

  Packets go via these routes

  - easy to implement
  - small number of links cumulate packet flow



- RPB - Reverse Path Broadcasting

  Retransmission only when packet arrives from the shortest path

  An optimization: do not retransmit to the neighbour who is not on our slave link

  Individual tree for every pair (source, group)

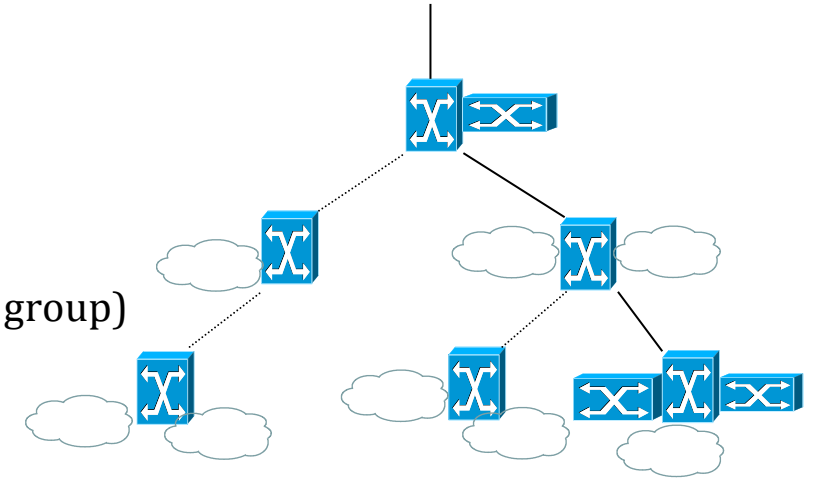
  - efficient
  - do not consider group membership

- RPM - Reverse Path Multicasting

  Cuts non-active branches step by step

  Recreates all the tree periodically

  - packet storm during recreation
  - every router stores data about every pair (source group)



- Core-Based Tree

  One tree for every group

  CBT can have many roots

  - balanced network load
  - efficient router implementation
  - packet flow concentrated near roots
  - longer paths

Multicast Routing Protocols

PIM Protocol Independent Multicast

- Sparse mode – few LAN number with many multicast streams

  there are meeting points
- Dense mode – many recipients

  Reverse Path Multicasting algorithm

DVMRP Distance Vector Multicast Routing Protocol

- RPB algorithm – based on RIP but counts hops to the source
- Fast recovery of cut branch mechanism
- Dominant protocol in MBONE
- Many critics about its scalability
- Its hierarchical version is developed – uses region identifiers

MOSPF Multicast Open Shortest Path Protocol

OSPF extension, thus it works in networks where OSPF is used

- Propagates topology data inside an Autonomous System
  - hierarchy of subregions
  - balanced interface load
- Very efficient where are small number of active pairs (source, group)
- Can serve huge multicast data flow

MBGP Multicast BGP

- Allows different types of addresses (*address families*) to be distributed in parallel
- It is external routing protocol!

Multicast Layer 2 Support

The aim is to diffuse multicast streams only via ports where are

- listener hosts
- routers expecting those streams

Important for IP TV deployments

- IGMP/MLD snooping
  - passive
  - active - optimize router load by IGMP/MLD messages
- IGMP Proxy – fast join/leave
- CISCO Group Management Protocol CGMP
- PIM / DVMRP Snooping (in transit LANs)
- Cisco Router Group Management Protocol RGMP

Multicast Transport Protocols

- IP multicast via UDP - no reliability!
- TCP is a point 2 point protocol
- There are no widely accepted MTP

Problems:

- group management scalability
- ACKs or NAKs aggregation
- nodes in a distribution tree have to buffer packets for retransmission

Java library to build reliable multicast on application level (uses IP multicast):

http://www.jgroups.org

Reliable Multicast transport

- Application layer solutions
  - MFTP – Multicast File Transfer Protocol
  - IRC – Internet Relay Chat
  - ESM – End System Multicast
  - …

- Protocols to be deployed by ISPs
  - RMTP – Reliable Multicast Transfer Protocol
  - XTP – Xpress Transport Protocol
  - STORM – STructure-Oriented Resilient Multicast
  - PGM – Pragmatic General Multicast
  - …

Problems of IP Multicast

- Routers cannot support big number of groups – limit are hundreds ÷ thousands
  - Multicast addresses cannot be aggregated
  - Solutions
    - Source routing – destination addresses carried by packet
      Explicit Multicast RFC 5058
      Bit-indexed addressing RFC 8279
    - Recursive multicast – support by unicast paths/tunnels
- Slow reconstruction of multicast trees after node/link failure (PIM, MOSPF, DVMRP)
  - Cumulated retransmissions if reliable multicast
- Lack of security
  - No authentication in IGMP/MLD
  - VLAN per group are created in many private networks
- 802.11 is very slow for broadcast and multicast frames

Summary

- What is IP multicast?
  - Applications that need multicast
- IP multicast basis
  - IPv4 & IPv6 multicast addressing
  - Ethernet network interface card
- Group Management Protocols
  - IGMP for IPv4
  - Multicast Listener Discovery is a part of ICMPv6
- Multicast algorithms
- Multicast Routing Protocols – PIM, DVMRP, MOSPF, MBGP
- Multicast layer 2 support
- Reliable multicast transport
  - Application layer solutions
  - Protocols to be deployed by ISPs
- Problems of IP multicast

Questions

1. Why do we use IP multicast?
2. What are the applications that need multicast transmission?
3. Does an Ethernet switch should recognize IGMP messages?
4. Why does a LAN edge router have to support IGMP?
5. What new functions do support IGMP v2 and IGMP v3 when comparing to IGMP v1?
6. What is MBONE?
7. Do IPv6 networks contain MBONE?
8. Can an Ethernet interface filter multicast addresses?
9. Describe the principal multicast routing algorithms (at least 3).
10. What is the important difference between unicast and multicast routing protocols?
11. Mention at least 3 multicast routing protocols.
12. Can one set a multicast address in a TCP header?
13. How can we build a reliable multicast application?
14. What are the main difficulties in reliable multicast projects?
15. Why does a router cannot support a big number of multicast groups?

Questions for curious minds

1. What is the idea of explicit multi-unicast (Xcast)?
2. How does Internet Relay Chat work?