Multicast

- Introduction
- Group management
- Routing
- Real-time transfer and control protocols
- Resource reservation
- Session management
- MBone
Introduction

- There are three ways to transport data in computer networks:
  + Unicast
  + Broadcast
  + Multicast
- Broadcast and multicast require special group addresses
Unicast
Broadcast
Multicast
Protocols

- Group management
- Routing
- Real-time transfer and control protocols
- Resource reservation
- Session management
Group Management

1. Group addresses
2. Mechanism to join the groups
3. Routing protocols
4. Generation and control of the data
Group Addresses

- **IPv4: class D**
  - addresses 224.0.0.0 - 239.255.255.255
  - addresses 244.0.0.0 - 244.255.255.255 are reserved for routing etc.

- **IPv6:**
  - flags: fourth bit tells whether the route is permanent
  - scope: tells how wide the group is
IPv4 vs. IPv6

IPv4 Class D

4 bits 28 bits
1110 Multicast Group ID

IPv6

8 bits 4 bits 4 bits 112 bits
11111111 flags scope Multicast Group ID
Joining to The Groups

- Two alternatives:
  + A) The computer tells the router it wants to join a group
  + B) The router announces the groups and asks the hosts to join
- The latter case uses the Internet Group Management Protocol (IGMP) protocol
Routing

- The router looks the next target from a routing table
- The routers exchange and update the information in the routing tables
- Two basic methods:
  + Distance Vector
  + Link Status
Routing table

**Figure 4.1** Example network and routing table.
Distance Vector

- Router tell its distance to other routers to its neighbors
- Easy to compute
- Does not work well, if there are often disconnections between routers
- Does not scale well
Operation

Computation at A when distance vector from B arrives

\[
\text{Cost to go to B} \quad + \quad \text{Cost to destination from B} = \text{Cost to destination via B}
\]

\[
\begin{align*}
\text{Current cost from A} & \quad \min \\
\text{New cost} & = \text{New distance vector for A}
\end{align*}
\]
Link Status

- The routers exchange information about connections instead of distances to other routers
- The receiving router updates the information about the available routers
- The routes are calculated using the Dijkstra’s shortest path algorithm
- This method scales better
Multicast Routing

- Multicast routing is also based on routing tables
- In addition, the routers build a multicast tree
- The dynamic changes of the multicast tree is the problem
  + Old members leave and new join the Multicast tree
- The biggest problem is scaling
Pruning

• The multicast trees can grow very big, so they have to be pruned constantly
• Branches, which do not have hosts, are removed from the multicast tree
Flooding

- Flooding is the easiest way to build the multicast trees
- Multicast packets are flooded to all output ports of the router
- A router forwards those packets which it has not seen previously
- Unnecessary branches can be pruned later on
Pruning

Source \((G)\)

Prune message

Prune message

Prune message

\(G\)
Multicast Routing Protocols

- Distance-Vector Multicast Routing Protocol (DVMRP)
- Multicast Extension to Open Shortest Path First (MOSPF)
- Protocol Independent Multicast (PIM)
DVMRP

- Distance Vector Multicast Routing Protocol (DVMRP) is based on RPM algorithm
- Original Mbone routing protocol
- Easy to implement
- Does not scale well
- Works well only with distance vector routing protocols
MOSPF

- Multicast Extension to Open Shortest Path First (MOSPF) is based on link state method
- Multicast packets are flooded only to nearby area
- The tree is build as usual
- Then the tree is pruned to a multicast tree
Properties of the MOSPF

- Reacts fast
- Computation of the trees is heavy
- Works only with link state protocols
PIM

- Protocol Independent Multicast (PIM) is independent of the actual routing protocol
- Two versions:
  + Dense Mode (PIM-DM)
  + Sparse Mode (PIM-SM)
Real-time transfer protocols

- Protocol family
  + Real-Time Transport Protocol (RTP)
  + Real-Time Control Protocol (RTCP)
  + Real-Time Streaming Protocol (RTSP)

- Suitable for general continuous media transport - not just multimedia
Relationships of the protocols

- RTSP
- RTP/RTCP
- Reliable Multicast
- RSVP
- UDP
- TCP
- IP
RTP

- **Real-Time Transport Protocol (RTP)**
  + sequences numbers of the packets
  + time stamps
  + identification of different payloads
- **Operates usually on top of UDP**
- **Does not guarantee successful transport -> no QoS properties**
RTP and other protocols
RTCP

• Real-Time Control Protocol (RTCP) controls RTP connections

• Functions:
  1. Transfers information about the RTP connection (e.g., QoS)
  2. Transfers information about source of the RTP connection
  3. Limits the amount of control information (5 %)
  4. Transfers information about the session
RTSP

• Real-Time Streaming Protocol (RTSP) builds and manages the real-time transport connections
• Works well with RTP and RTCP protocols
• Has similar functions to the HTTP protocol
RTSP - Operation

Workstation
- Web browser
- Media Player

Web Server

Multimedia Server

HTTP GET

SETUP

PLAY

RTP video

RTP audio

PAUSE

TEARDOWN
Resource reservation

- Real-time transfer protocols do not alone quarantine QoS of real-time traffic
- Required resources have to be reserved separately from all routes of the route
- For this purpose, there are special protocols
- Best known protocol is Resource ReSerVation Protocol (RSVP)
RSVP

• RSVP is based on announcements made by the receivers
• The sender sends first a “Path” message
• If necessary, the routers can send “PathErr” message
RSVP (cont.)

• Routers record the connections
  + Soft state
  + each connection has a cleanup and restart counter

• The receiver sends the “Resv” message
  + at the same time, the QoS requirements are defined

• The “Resv” messages go through the routers
  + the routers check the resources and make final reservations
RSVP messages

Sender "Path" message Receiver 1

"Resv" messages Receiver 2

Receiver 3
Soft state

- Each connection has to be recorded
- The information is outdated after certain time period
- That is why the state is called soft
QoS requests

• The receivers use “Resv” messages to ask for certain QoS parameters
• Each router checks whether there is enough resources
• If there is, then the connection is recorded (soft state)
• If necessary, the requests can be combined (multicast)
RSVP combination

Connection point

Combined “Resv” message (31 Mbps)

“Resv” message (31 Mbps)

“Resv” message (15 Mbps)
RSVP status

• Not in wide use

• Problems
  + scaling of the method (control, connections, reestablishment of the connections)
  + good algorithm for checking resources does not exist
  + billing and bookkeeping difficult
Session management

• The available multicast sessions have to be advertised some how
• Thus directory services are needed
• Three protocols exist for this purpose: SDP, SAP, and SIP
SDP

- Session Description Protocol (SDP) distributes information about the available sessions and the attributes
- SDP is actually a format to announce the information
- Three parameter classes:
  - Session description
  - Time description
  - Media description
**SAP**

- Session Announcement Protocol (SAP) distributes the session descriptions to different directories
- Announcements are sent as multicast transmissions
- Email lists and www-pages are used more often, though
SIP

• Session Initiation Protocol (SIP) can be used, when certain participant have to be invited to the multicast session

• The participants can be persons or “robots”

• Robots are video-on-demand servers, video cameras, etc.

• SIP can use directory services when searching persons
Person search

1. Call henning@cs.columbia.edu
2. henning
3. hgs@play
4. Call hgs@play
5. 200 OK
6. 200 OK

cz@cs.tu-berlin-de

hgs@play
MBone

• Originally developed in research project
  + University of Southern California’s Information Sciences Institute
  + Massachusetts Institute of Technology
  + Xerox Palo Alto Research Center
  + Lawrence Berkeley National Laboratory

• DARPA Research Test bed, DARTNET -90
  + Unix workstation, T1 connections
MBone - development

32 subnetworks

IETF

DARTNet
multicast

audiocast

3000 subnetworks

32

91
92
93
94
95
96

vt
vat
nevat
ivs
wb
nv
nte
rat
sdr
Mbone archives

• Merit Networks
  + www.merit.edu/~mbone/index/titles.html

• Henning Schulzrinne
  + www.cs.columbia.edu/~hgs/rtp/

• Mbone FAQ