

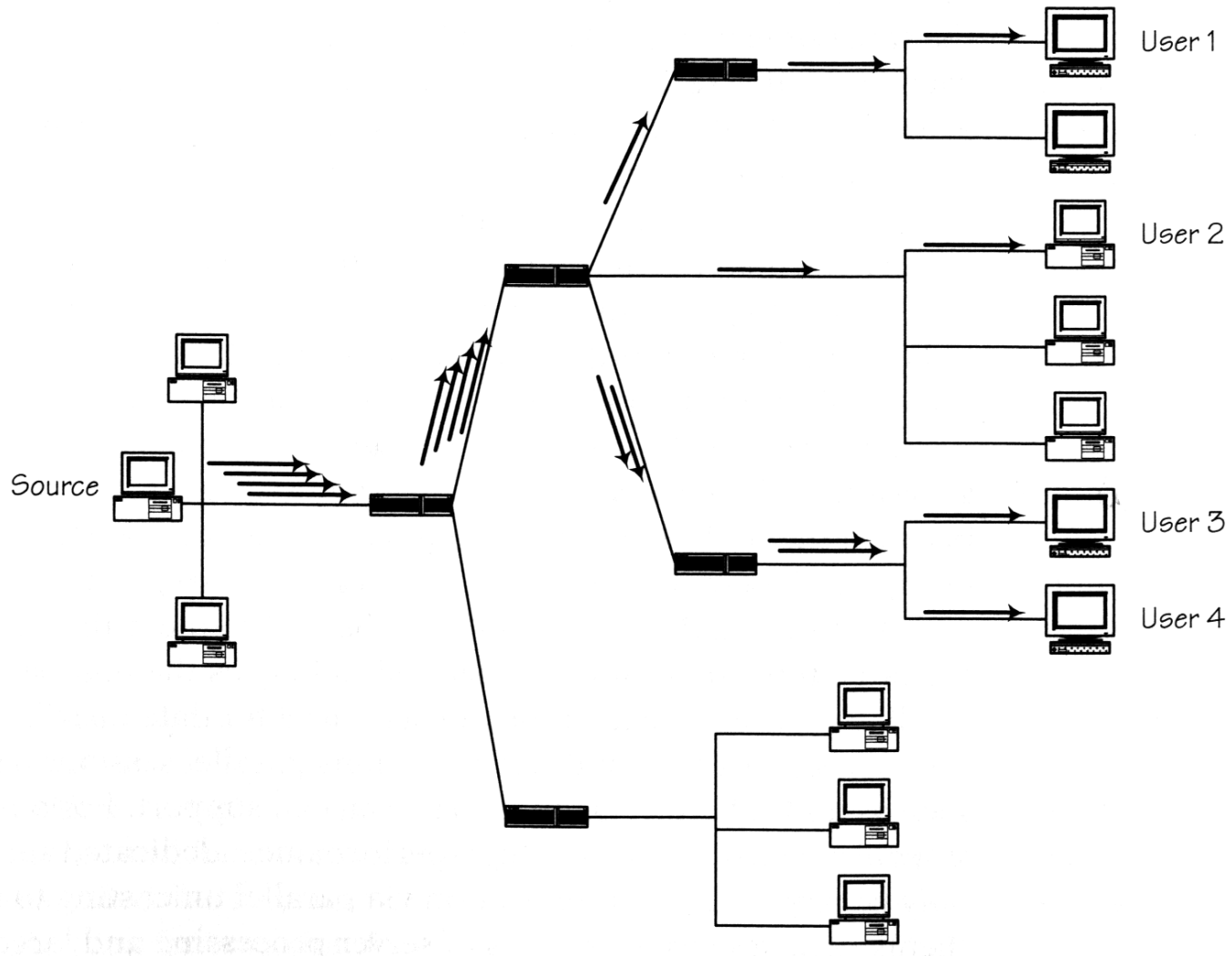
Multicast

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

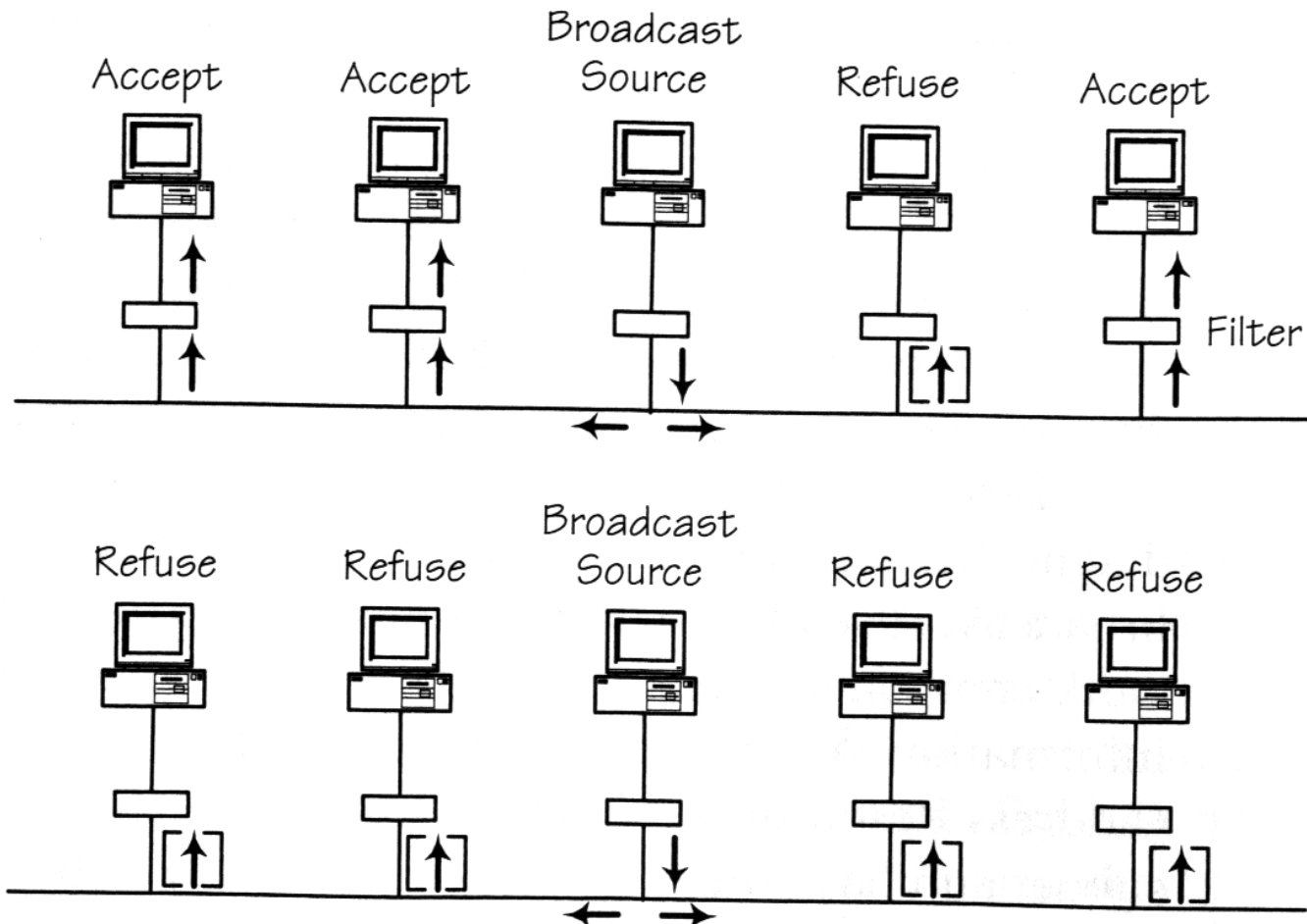
Introduction

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

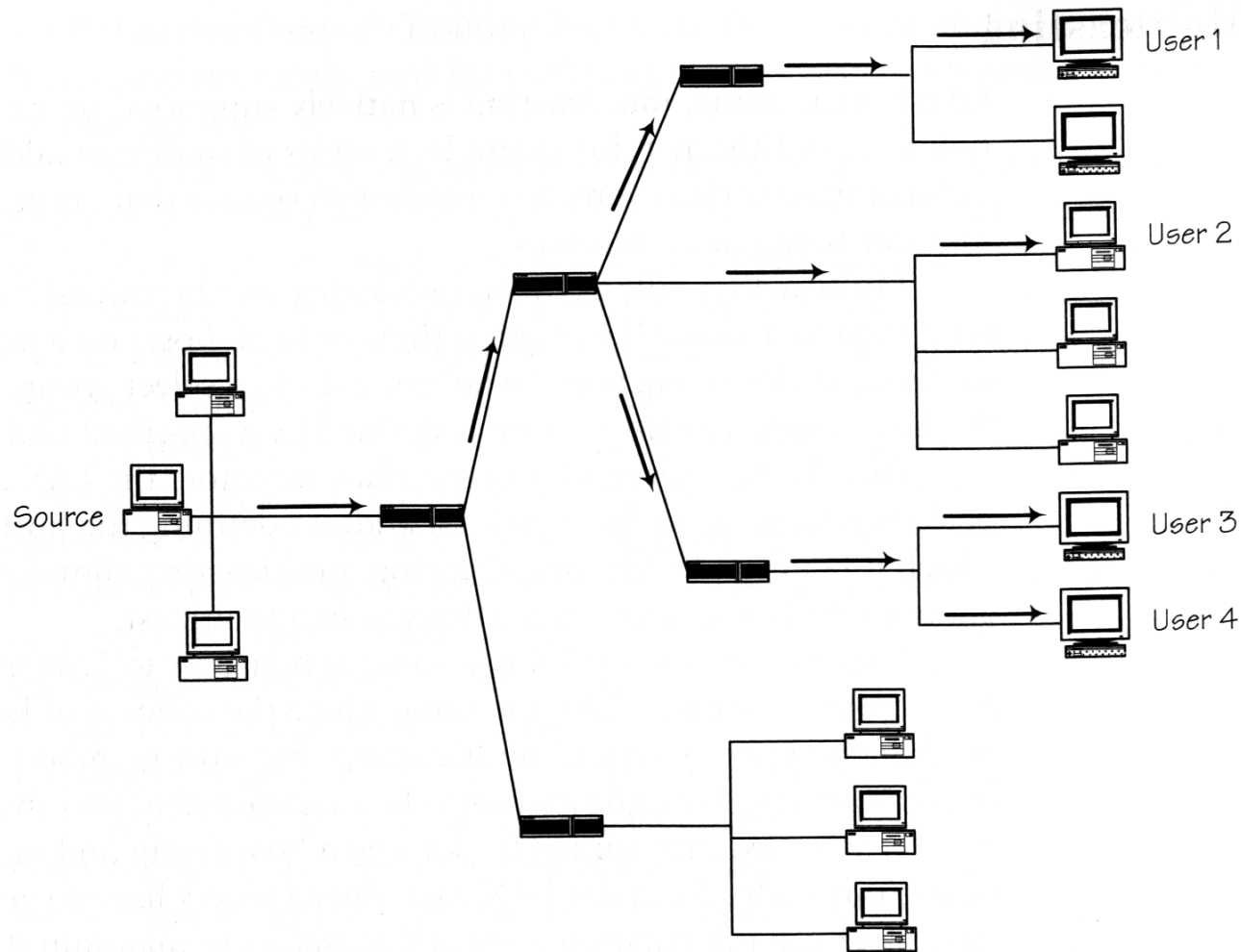
Unicast



Broadcast



Multicast



Protocols

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

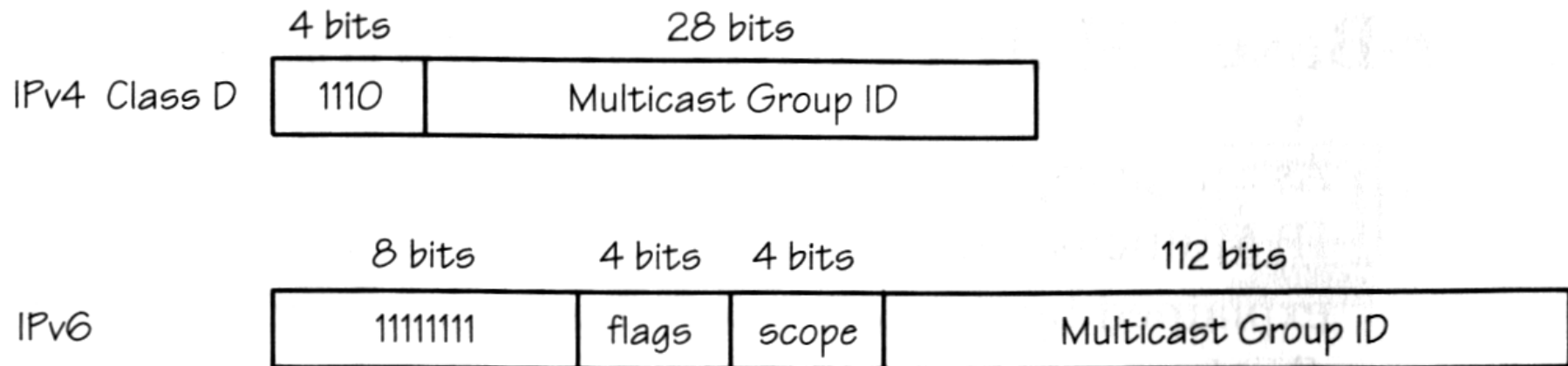
Group Management

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

Group Addresses

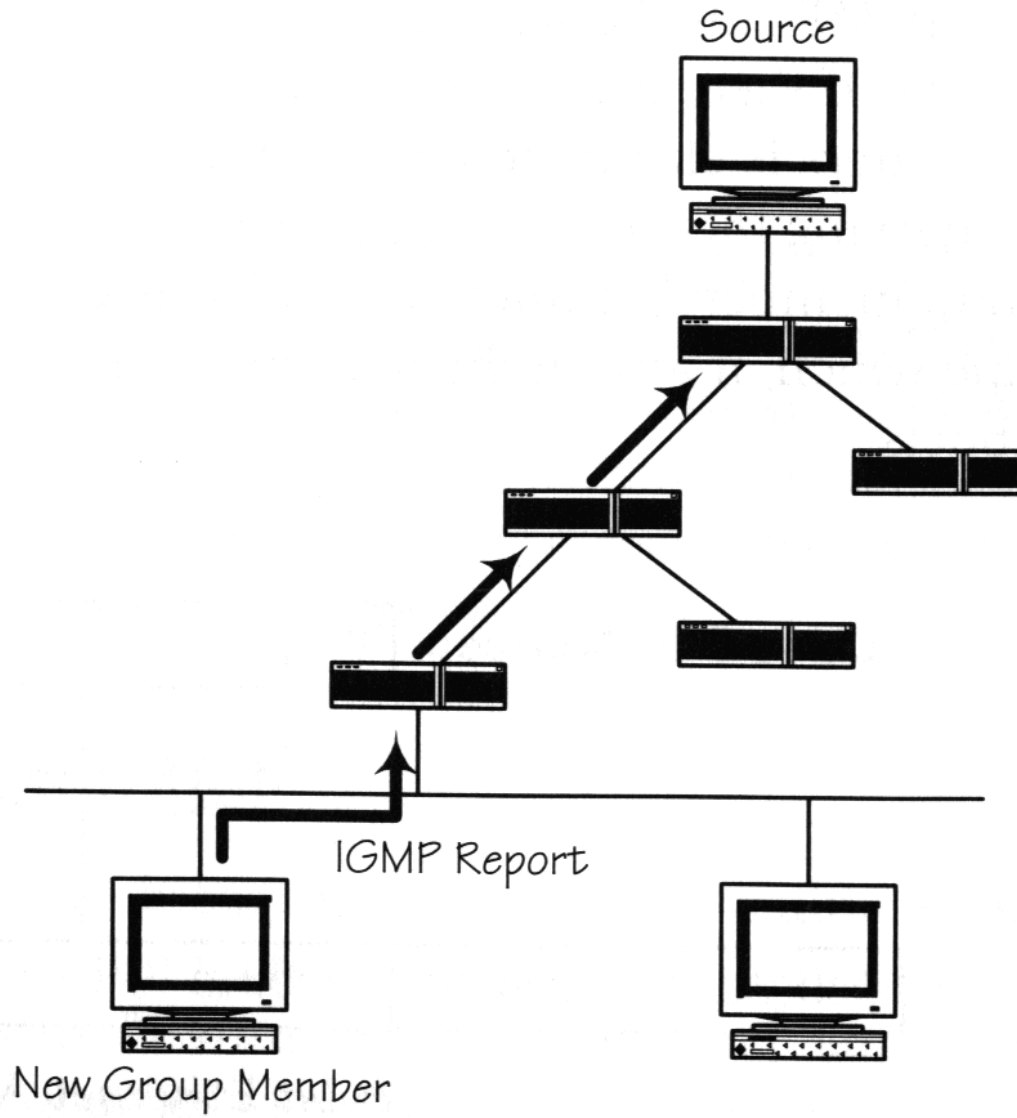
- IPv4: class D
 - + addresses 224.0.0.0 - 239.255.255.255
 - + addresses 244.0.0.0 - 244.255.255.255 are reserved for routing etc.
- IPv6:
 - + flags: fourth bit tells whether the route is permanent
 - + scope: tells how wide the group is

IPv4 vs. IPv6



Joining to The Groups

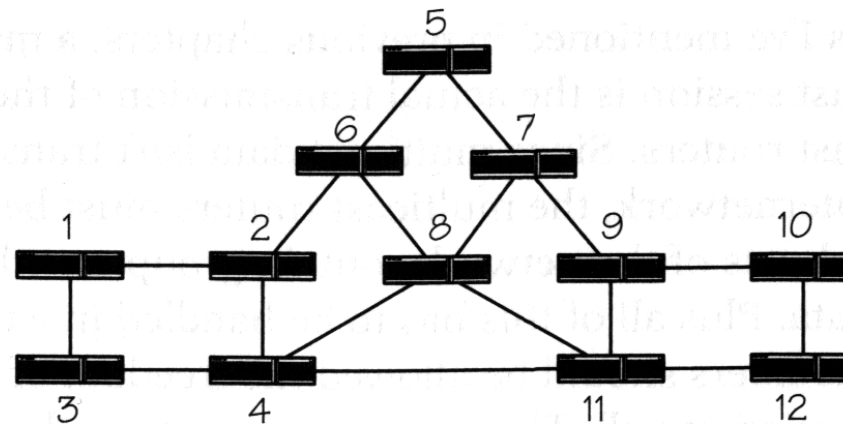
- Two alternatives:
 - + A) The computer tells the router it wants to join a group
 - + B) The router announces the groups and asks the hosts to join
- The latter case uses the Internet Group Management Protocol (IGMP) protocol



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



Routing Table at 1

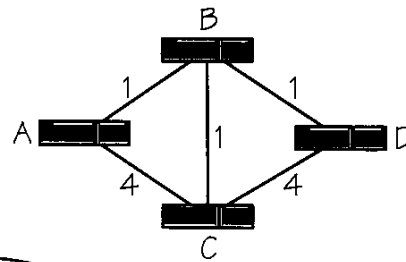
Destination	Next Hop	Destination	Next Hop
1	--	7	2
2	2	8	2
3	3	9	2
4	3	10	2
5	2	11	3
6	2	12	3

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 a often disconnections between routers
- Does not scale well

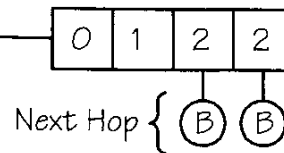
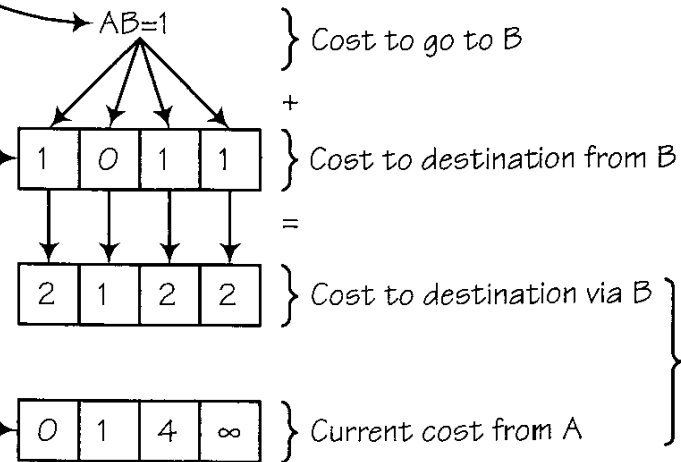
Operation



Initial

	A	B	C	D
A	0	1	4	∞
B	1	0	1	1
C	4	1	0	2
D	∞	1	2	0

Computation at A
when distance vector
from B arrives



New cost =
New distance vector
for A

Link Status

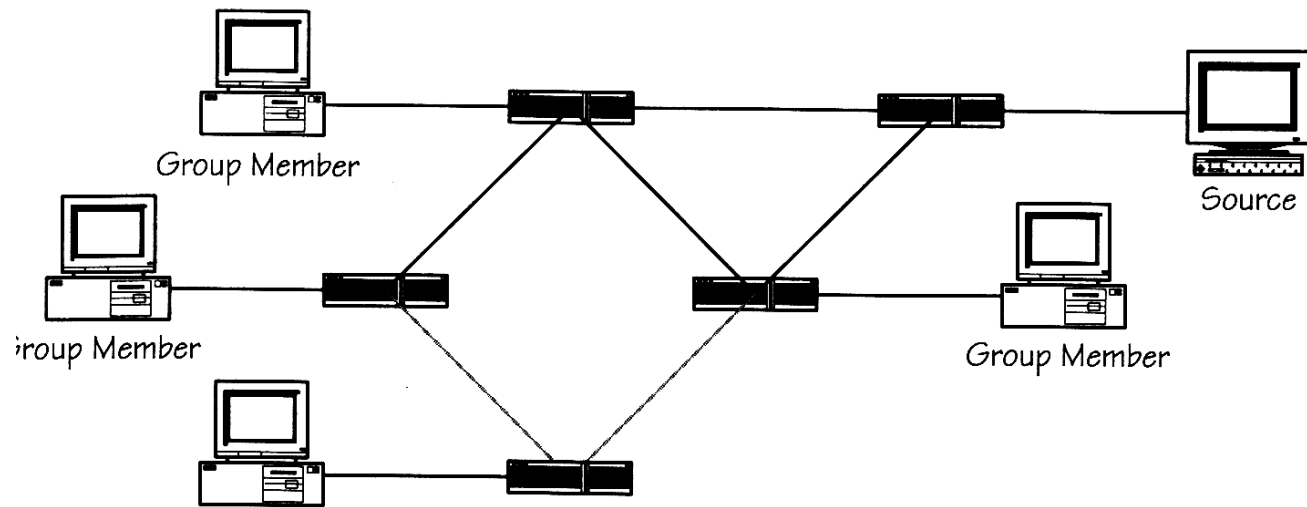
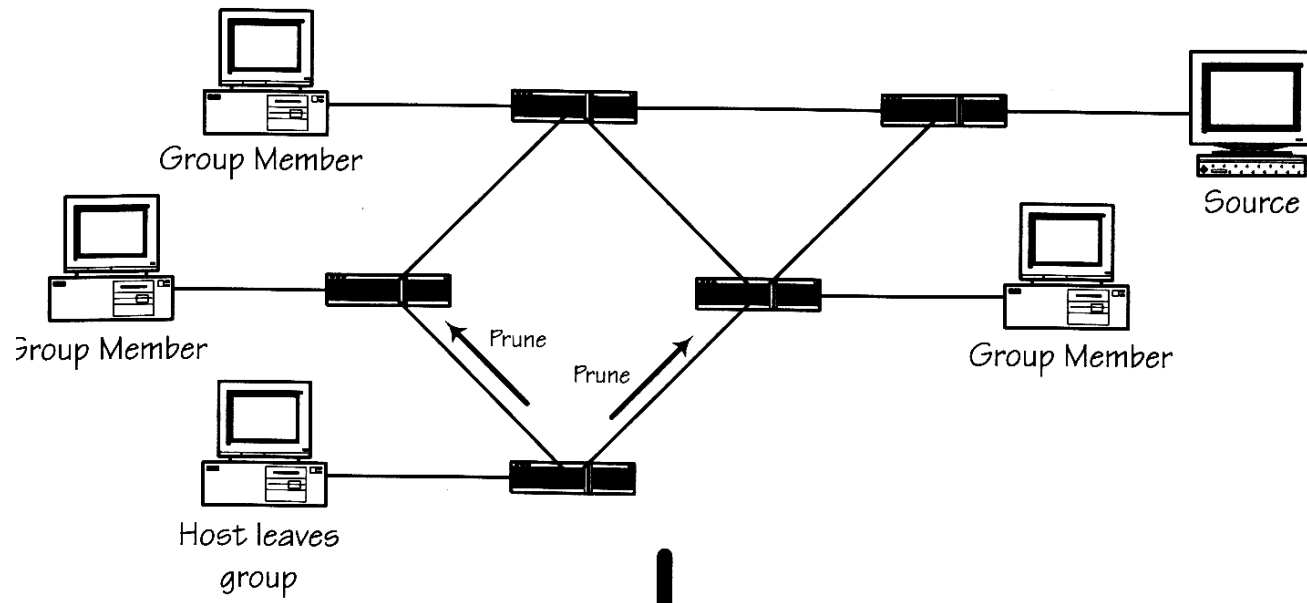
- The routers exchange information about connections instead of distances to other routers
- The receiving router updates the information about the available routers
- The routes are calculated using the Dijkstra's shortest path algorithm
- This method scales better

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

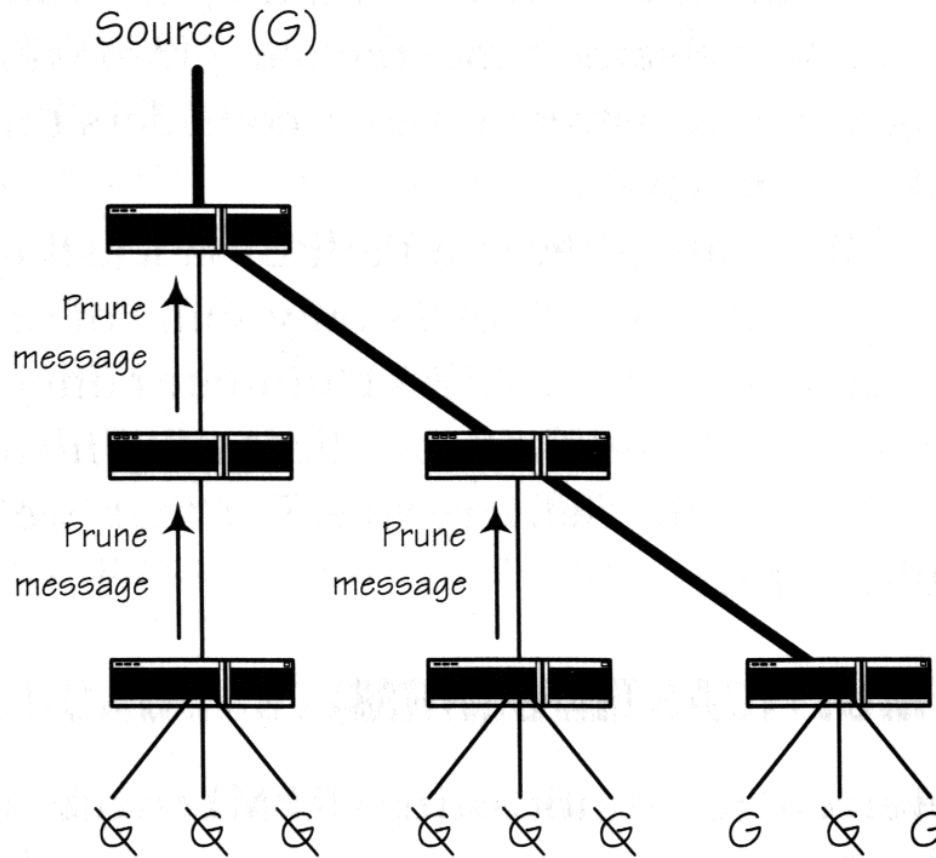
- The multicast trees can grow very big, so they have to be pruned constantly
- Branches, which do not have hosts, are removed from the multicast tree



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



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

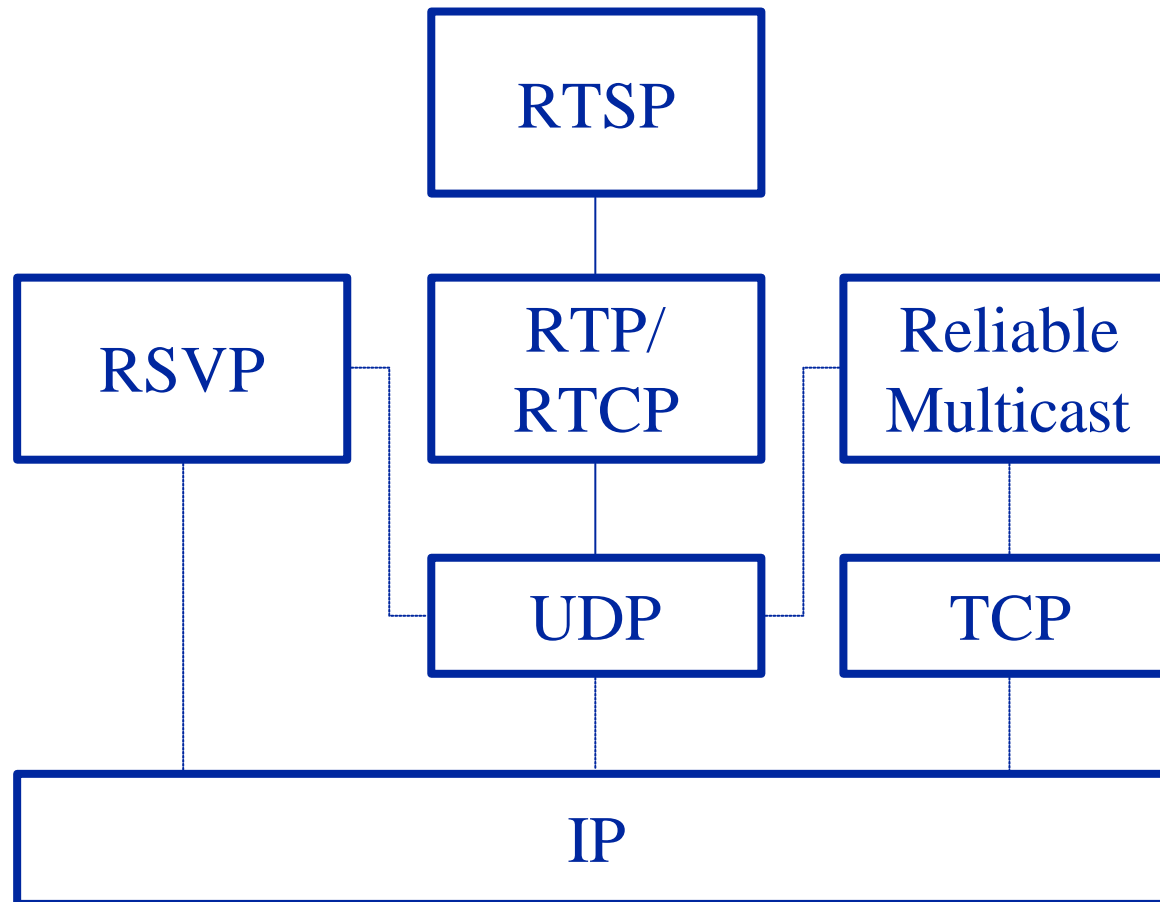
PIM

- 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

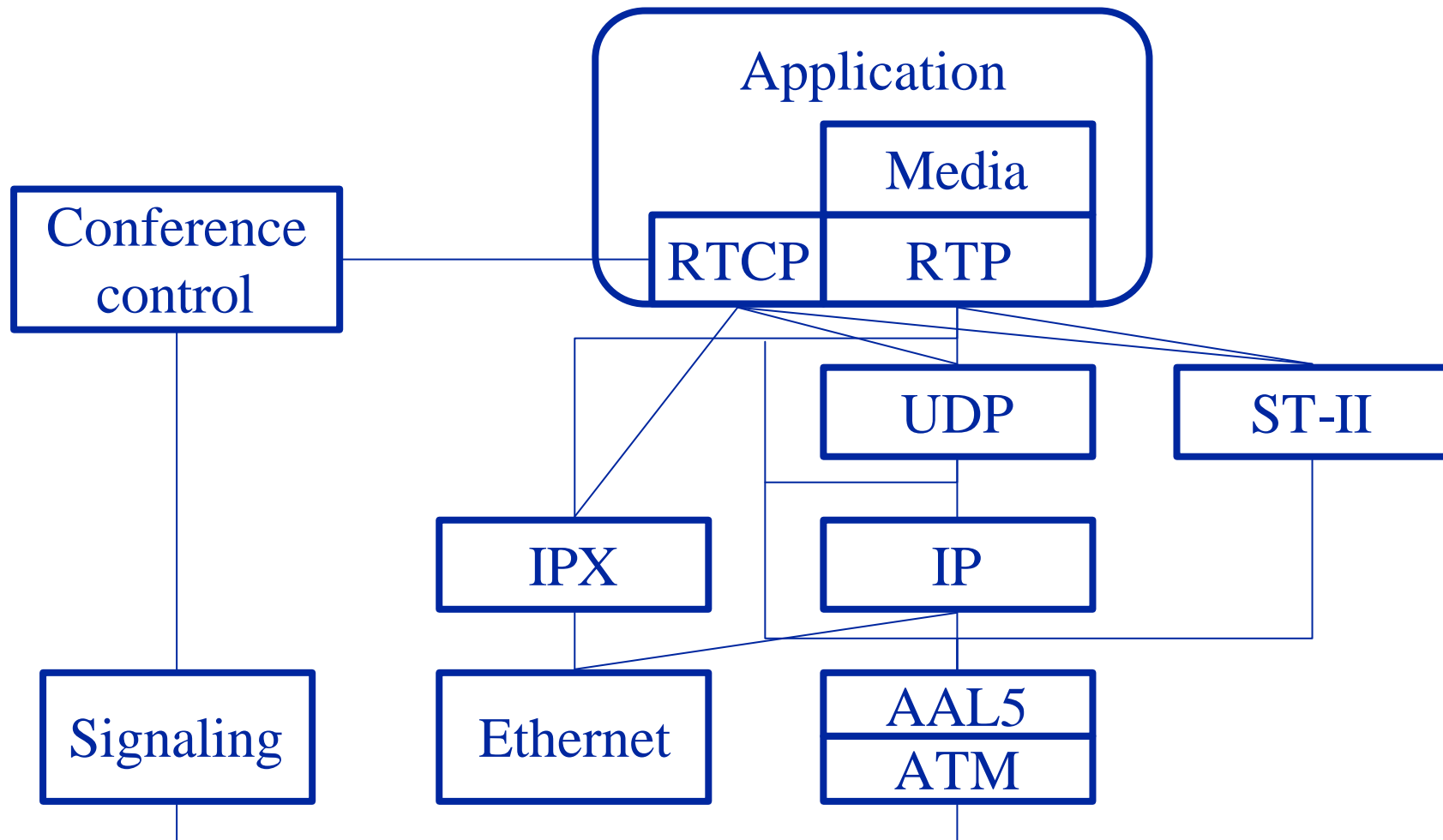
Relationships of the protocols



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



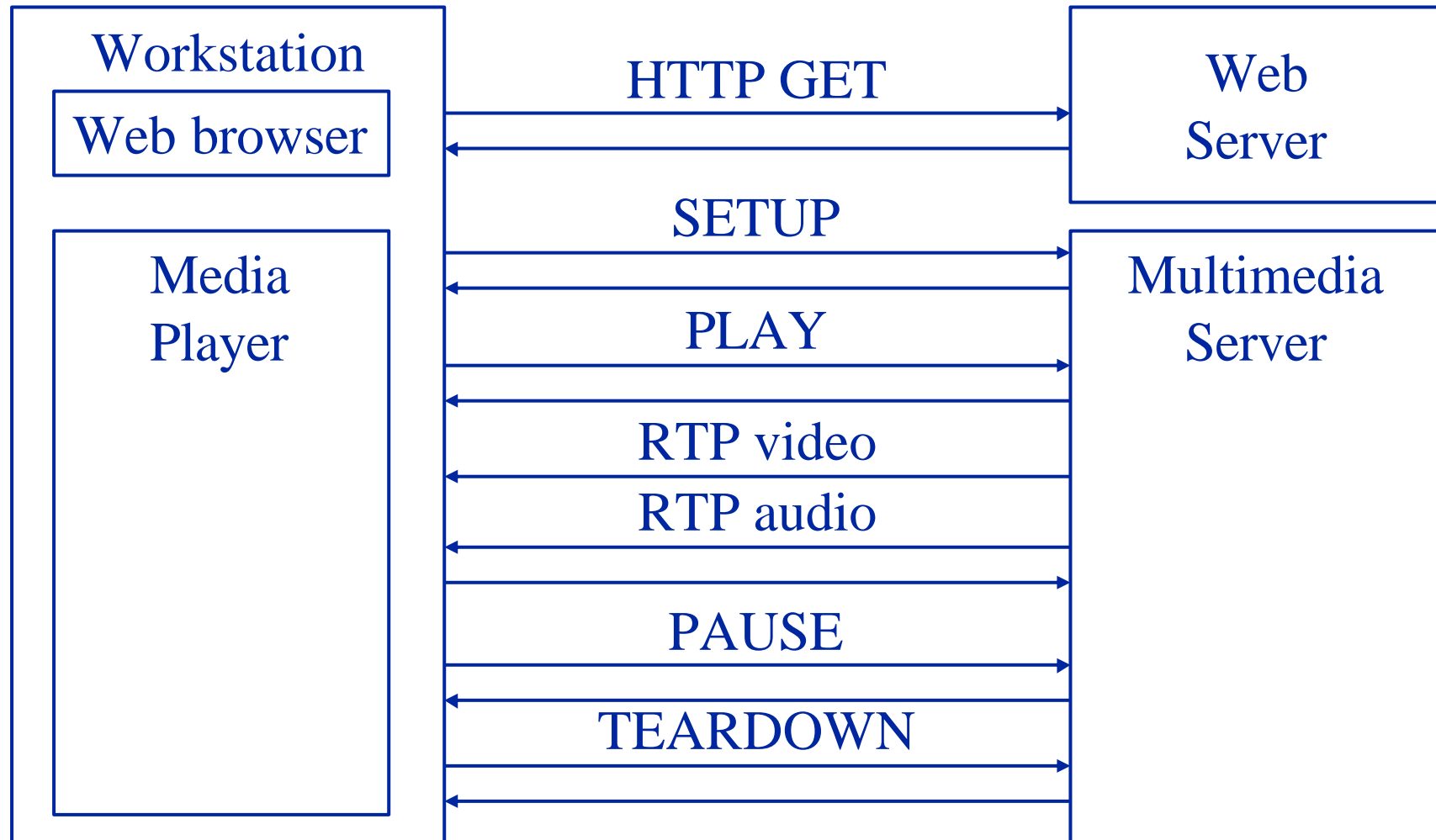
RTCP

- 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



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)

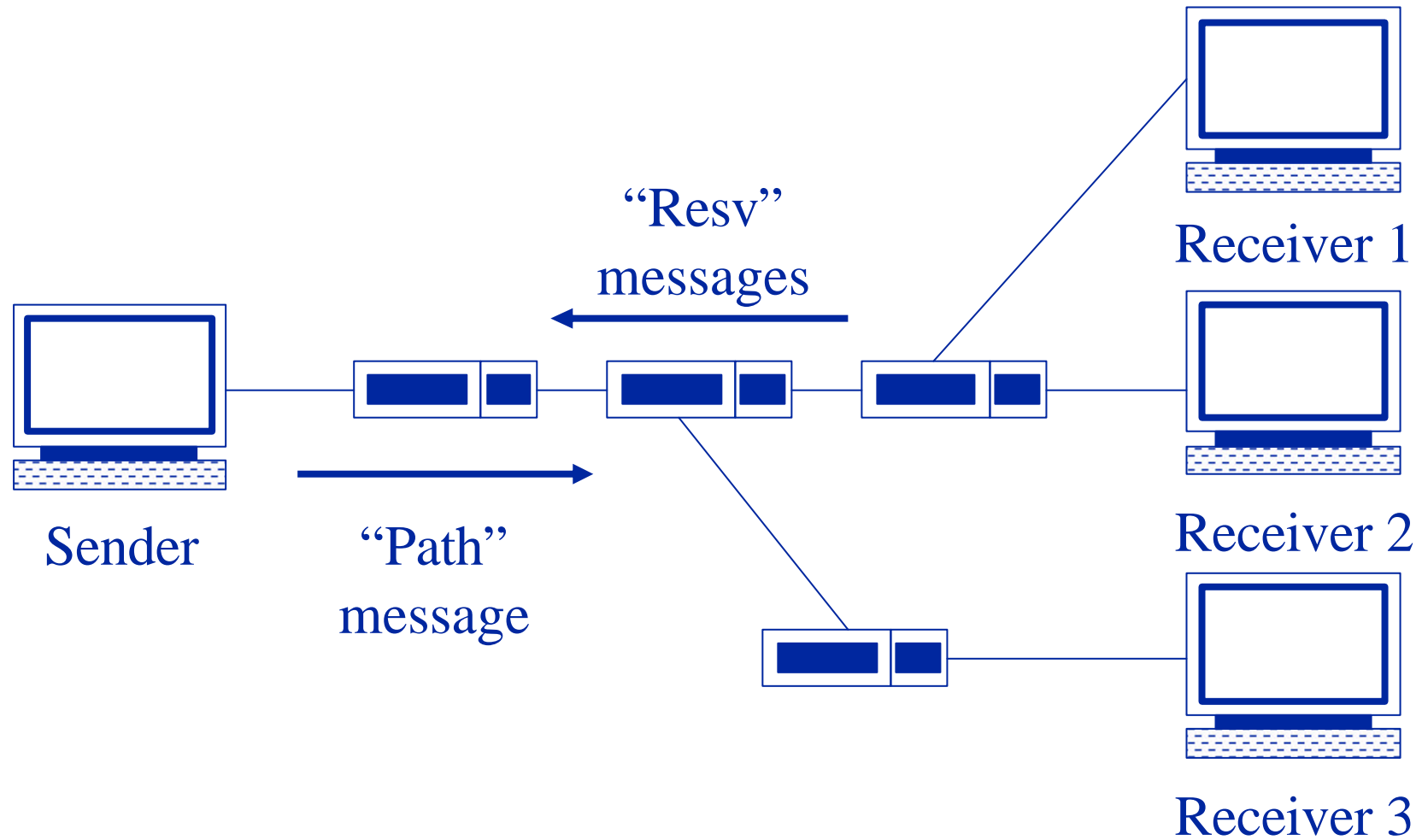
RSVP

- 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



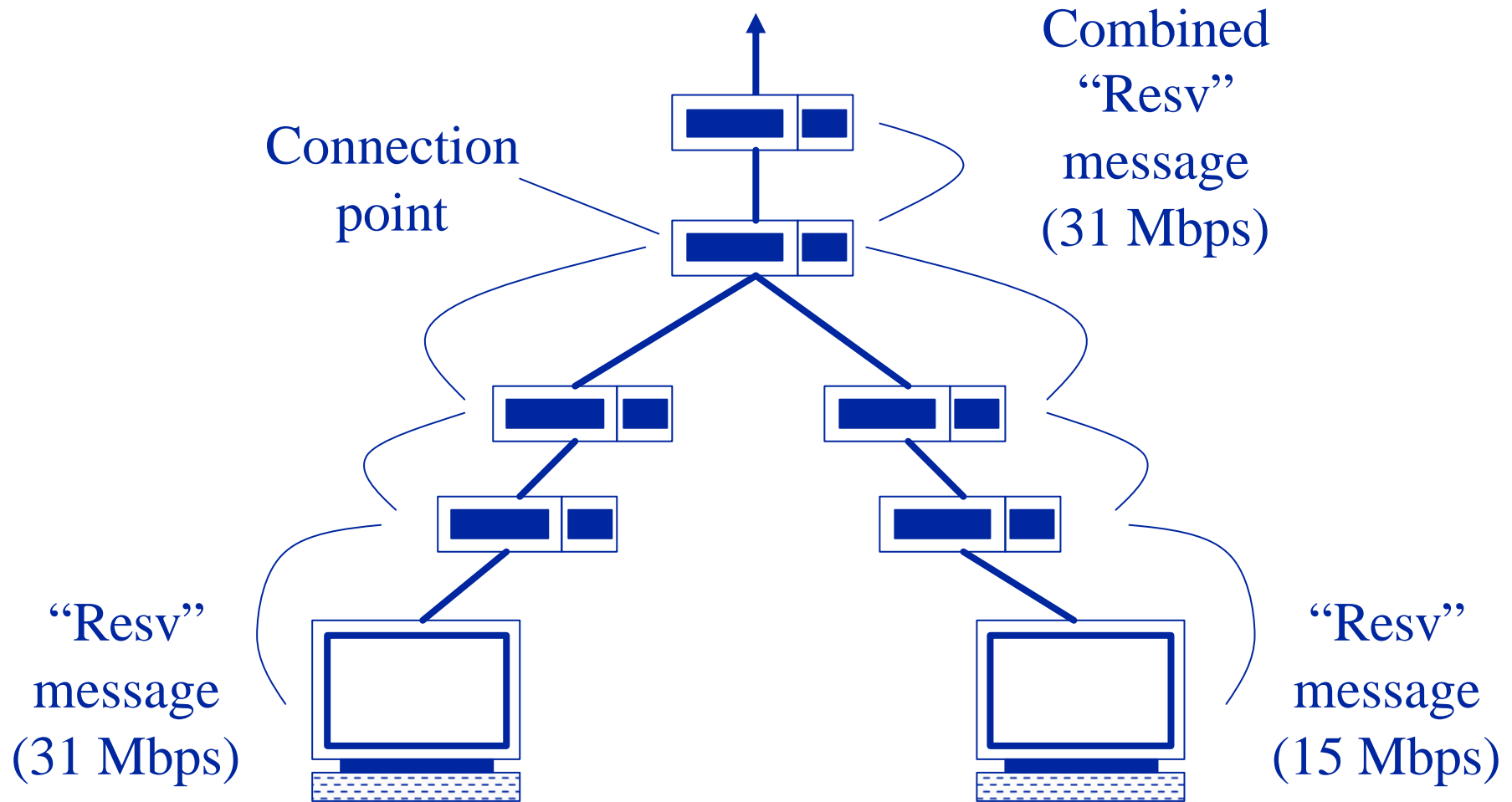
Soft state

- 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



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

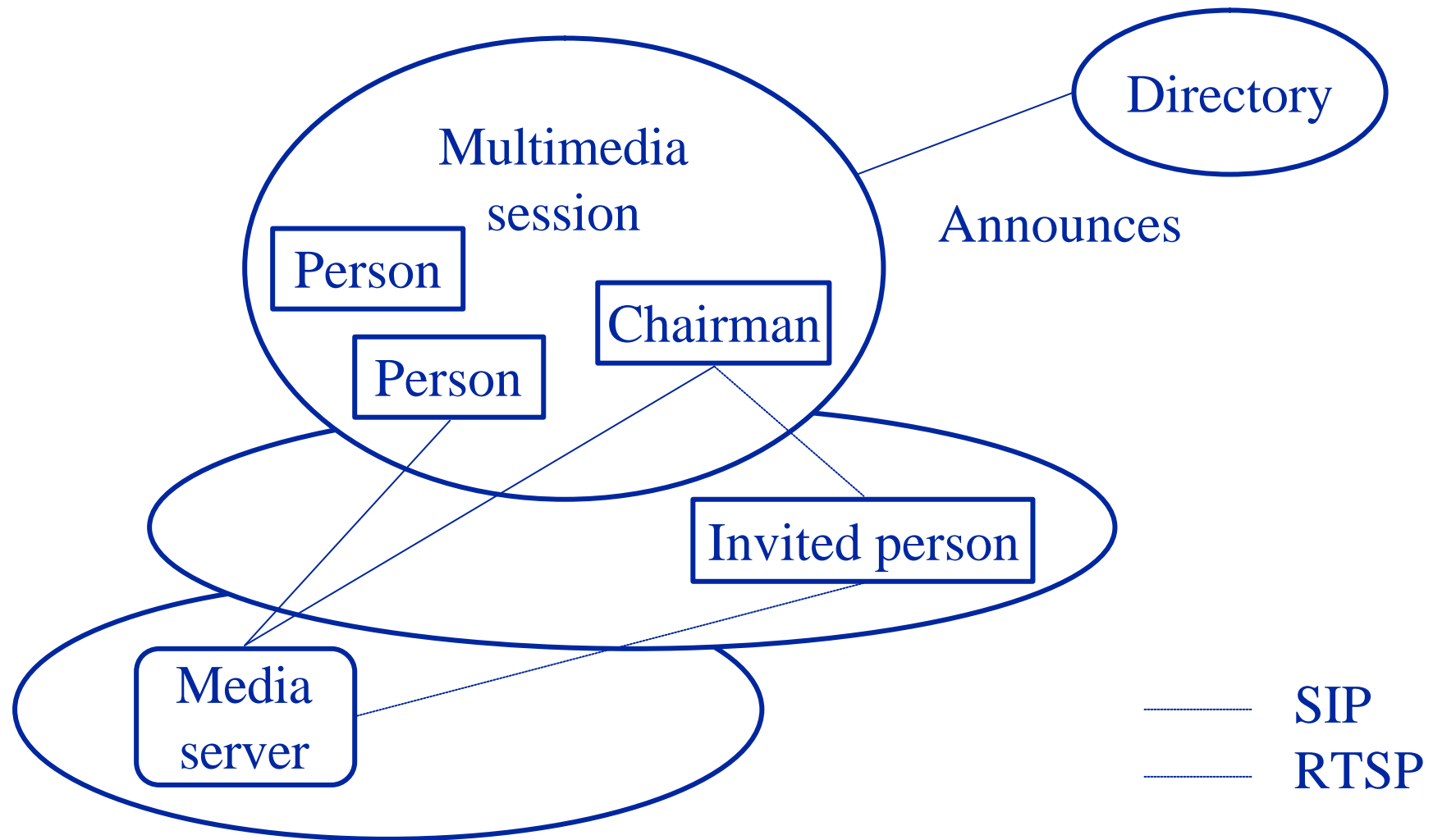
SAP

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

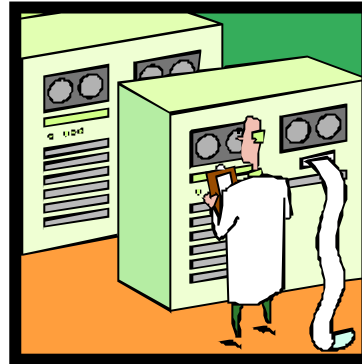
SIP

- 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

Robots



Person search



`cz@cs.tu-berlin-de`

2. `henning`

3. `hgs@play`

`hgs@play`



1. Call `henning@cs.columbia.edu`

6. 200 OK



4. Call `hgs@play`

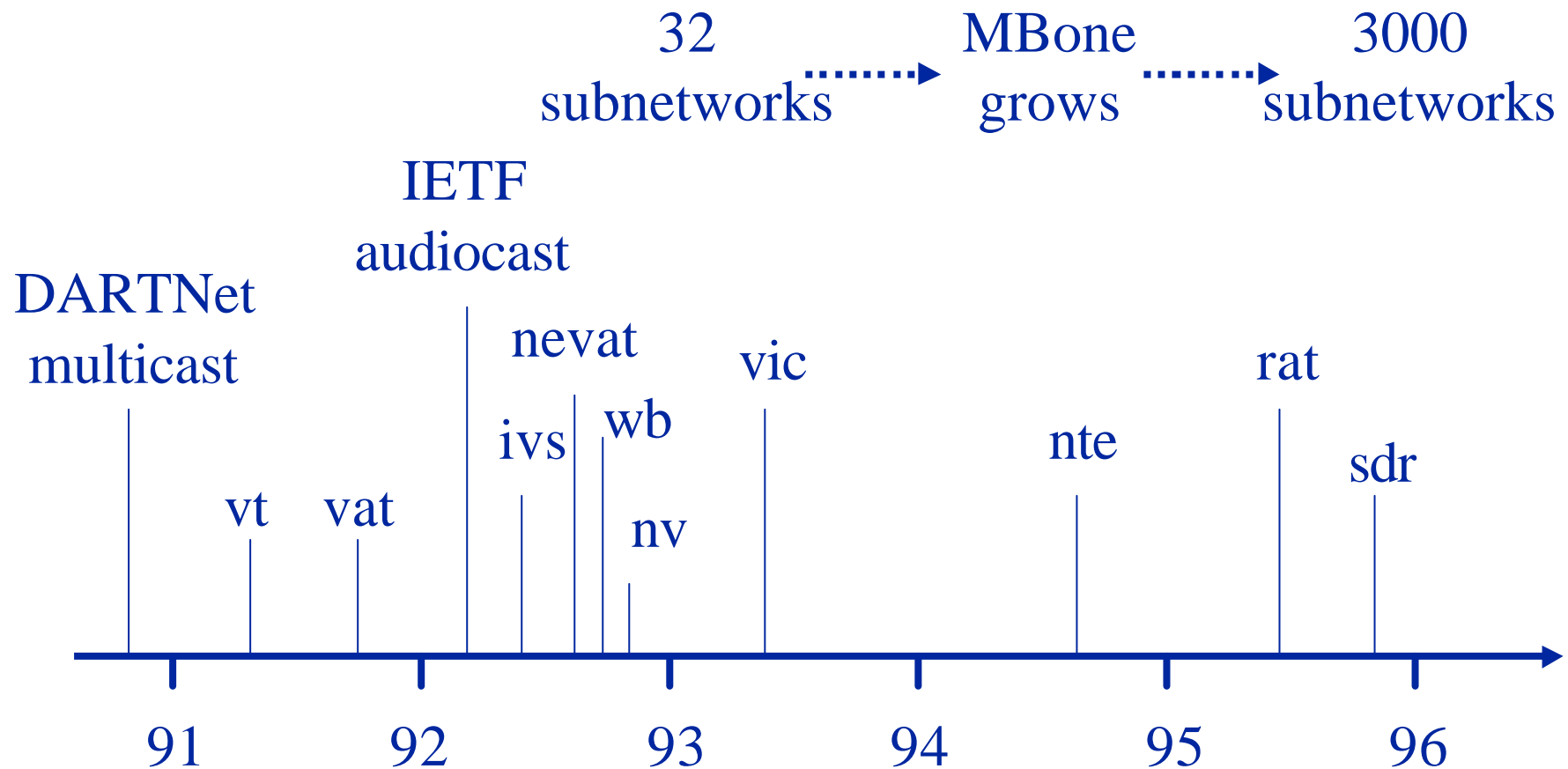
5. 200 OK



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



Mbone archives

- Merit Networks
 - + www.merit.edu/~mbone/index/titles.html
- Henning Schulzrinne
 - + www.cs.columbia.edu/~hgs/rtp/
- Mbone FAQ
 - + www.cs.columbia.edu/~hgs/internet/mbone-faq.html