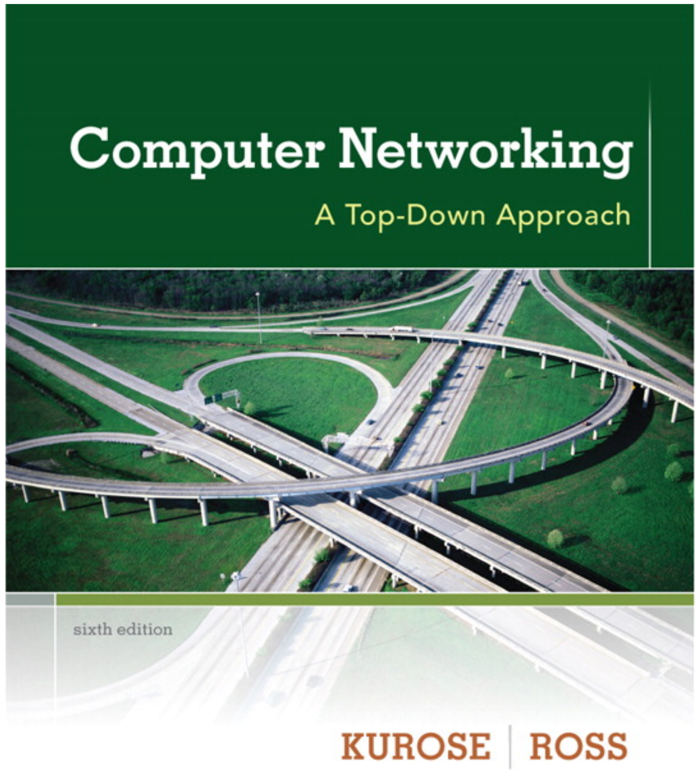
CN-Advanced
L46

Broadcast and Multicast

Dr. Ram P Rustagi
rprustagi@ksit.edu.in
http://www.rprustagi.com
https://www.youtube.com/rprustagi

Chapter 4 Wireless and Mobile Networks



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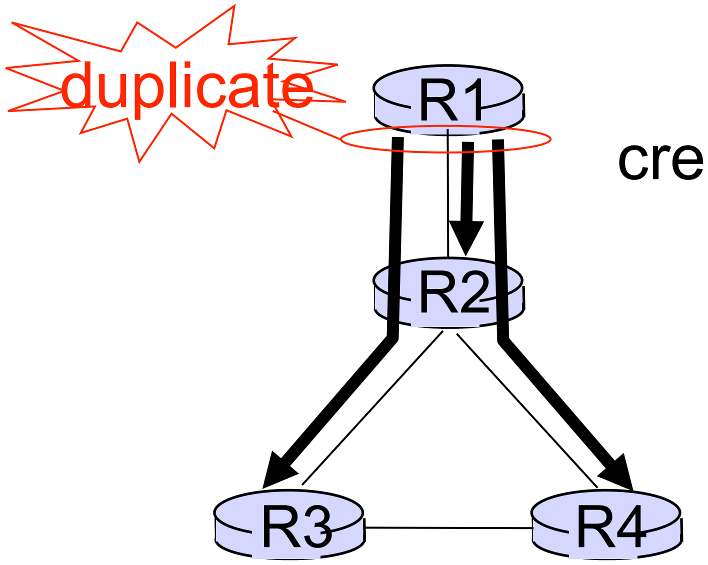
Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
March 2012

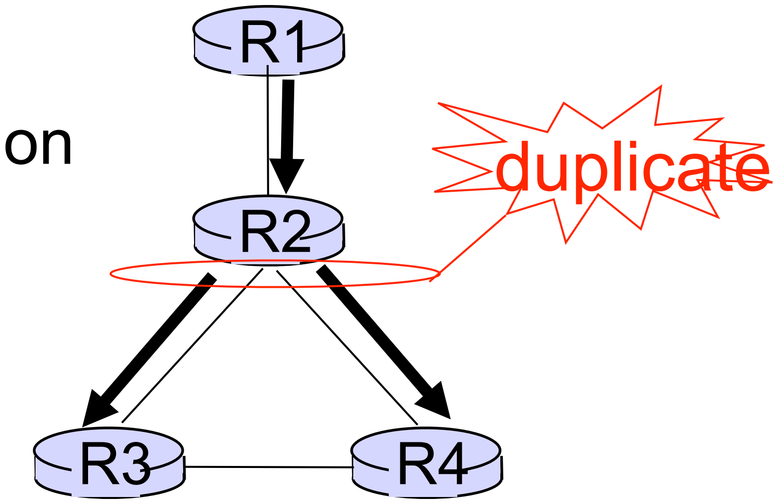
Broadcast routing

- deliver packets from source to all other (N) nodes
- source duplication is inefficient:
- source duplication: how does source determine recipient addresses?



duplicate creation/transmission

source duplication



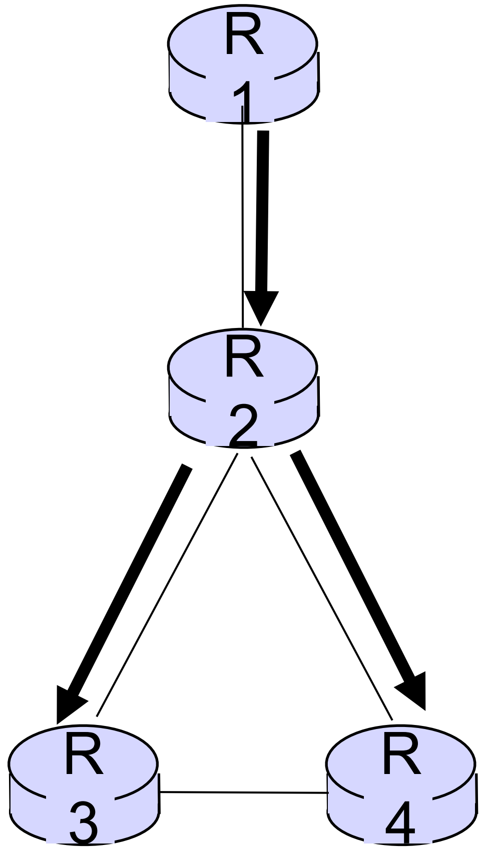
in-network duplication

Broadcast routing: N-Way Unicast issues

- Src needs to know all (unicast) addresses of recipients
  - how?
  - run some protocols to discover
    - other overheads
- to know all recipients require some kind of broadcast
  - which is used for discovering unicasts
  - broadcast is being implemented as unicasts
  - A fine subtle anomaly?
- Approaches:
  - **Flooding, Controlled Flooding, Spanning Tree**

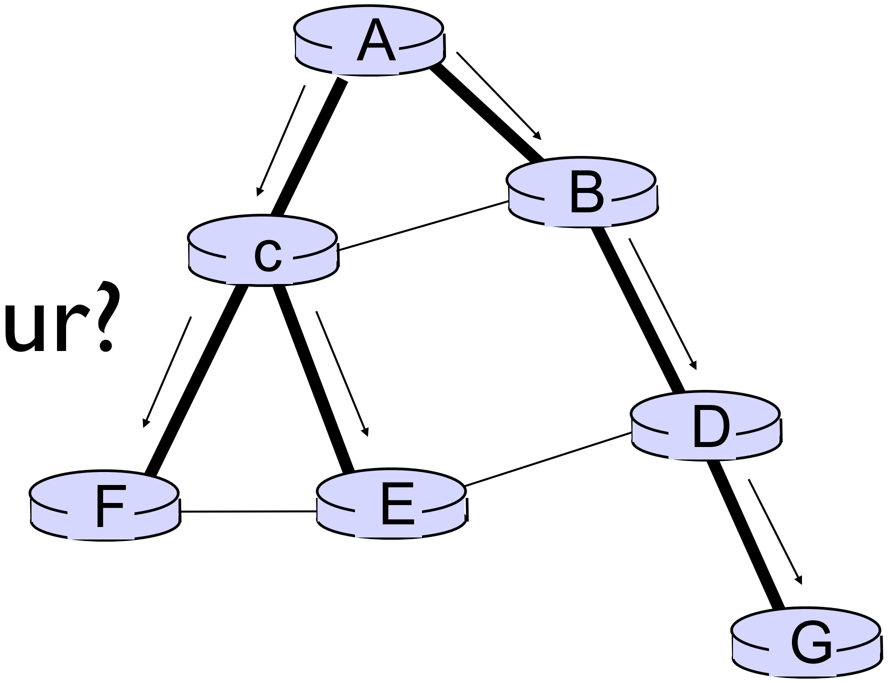
In-network duplication

- *flooding:* when node receives broadcast packet, sends copy to all neighbors
- problem 1 - cycles
    - R2 ->R3 ->R4
    - R2 ->R4->R3
- Problem 2 - broadcast storm
    - assume each R2,R3,R4 is connected to more than 2 nodes
    - each node will create multiple copies of packets
        - result: endless multiplication



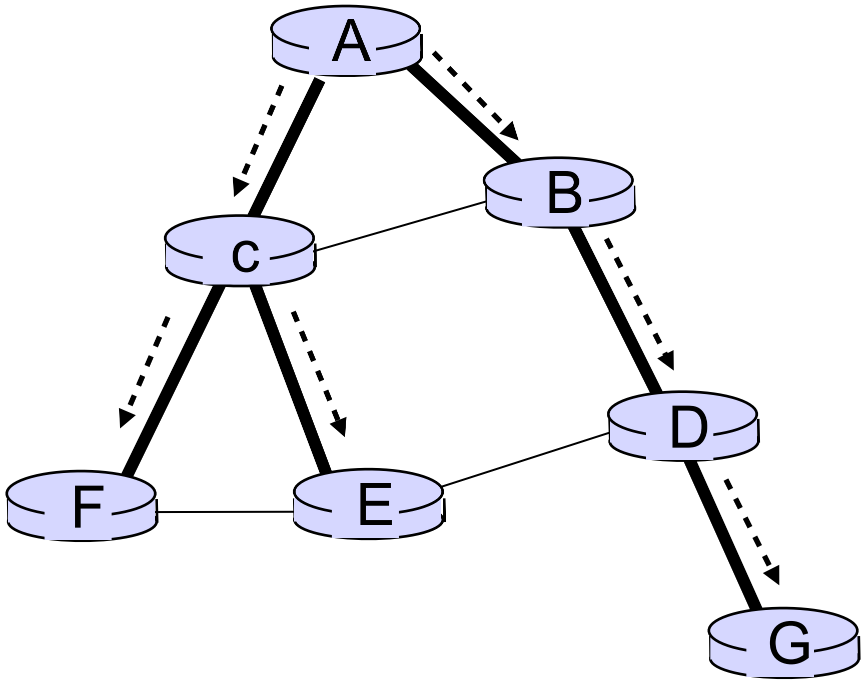
In-network duplication

- *controlled flooding:* node only broadcasts pkt if it hasn't broadcast same packet before
- Node keeps track of packet ids already broadcasted
  - Using **source address** and **pkt seq** number
  - *Gnutella* protocol uses this algorithm
- Reverse path forwarding (RPF):
  - forward packet if it arrived on shortest path
    - between node and source
  - else discards the packet
  - Will looping, or broadcast storms occur?
- Issues with RPF
  - a node still receives multiple packets

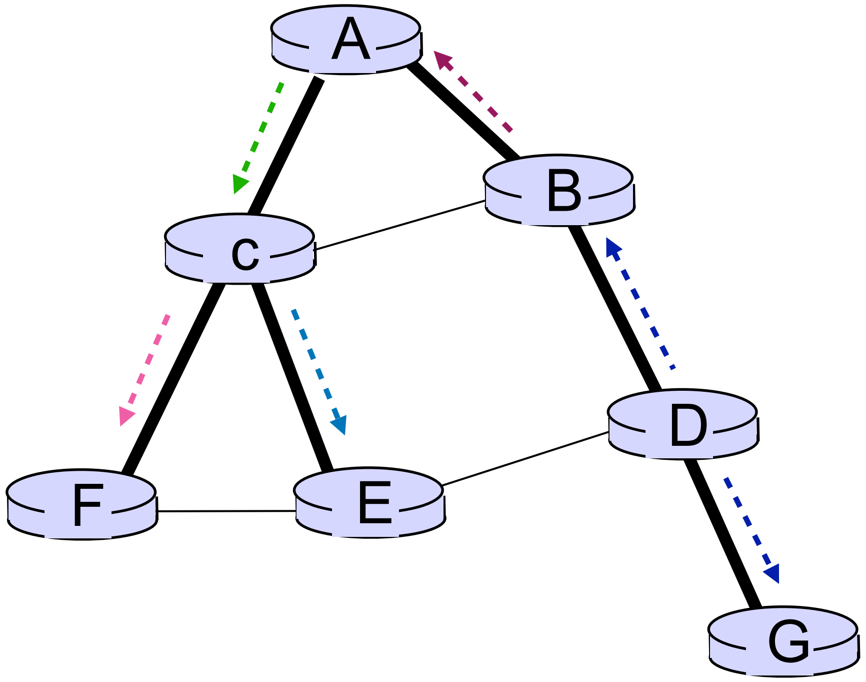


Spanning tree

- No redundant packet received by any node
- first construct a spanning tree
- nodes then forward/make copies only along spanning tree



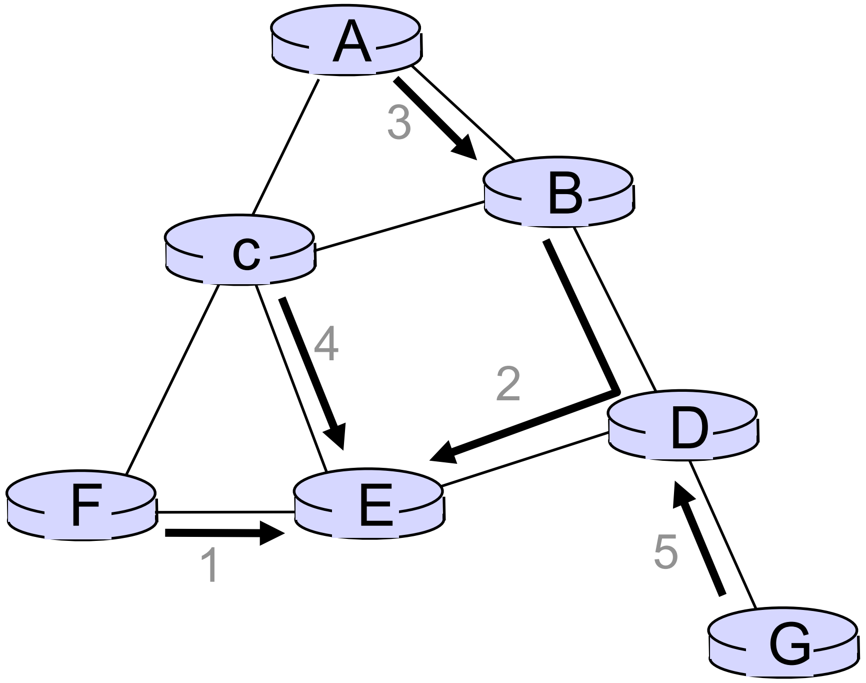
(a) broadcast initiated at A



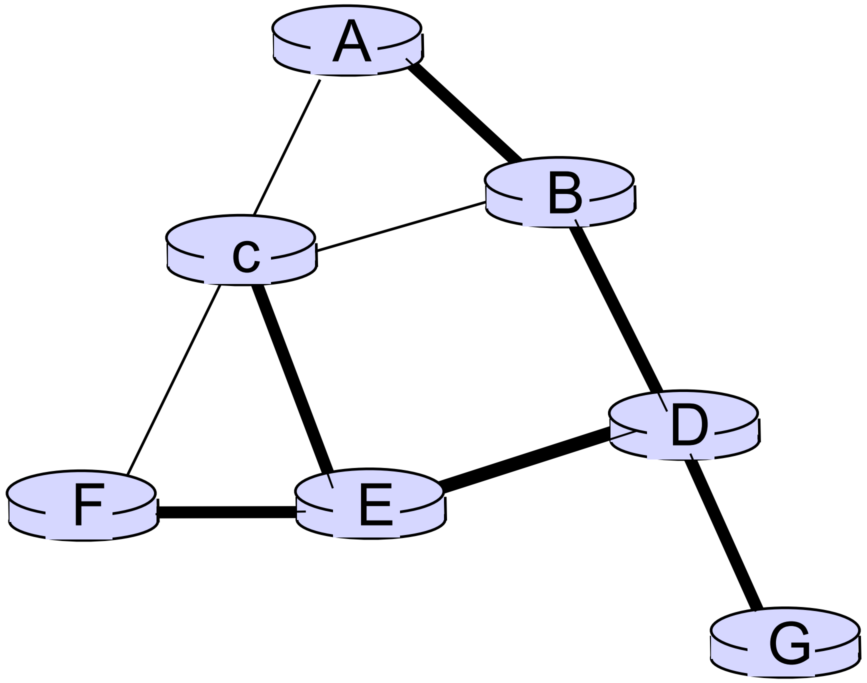
(b) broadcast initiated at D

Spanning tree: creation

- center node
- each node sends unicast join message to center node as per its forwarding table
  - message forwarded until it arrives at a node already belonging to spanning tree



(a)stepwise construction of spanning tree (center: E)



(b) constructed spanning tree

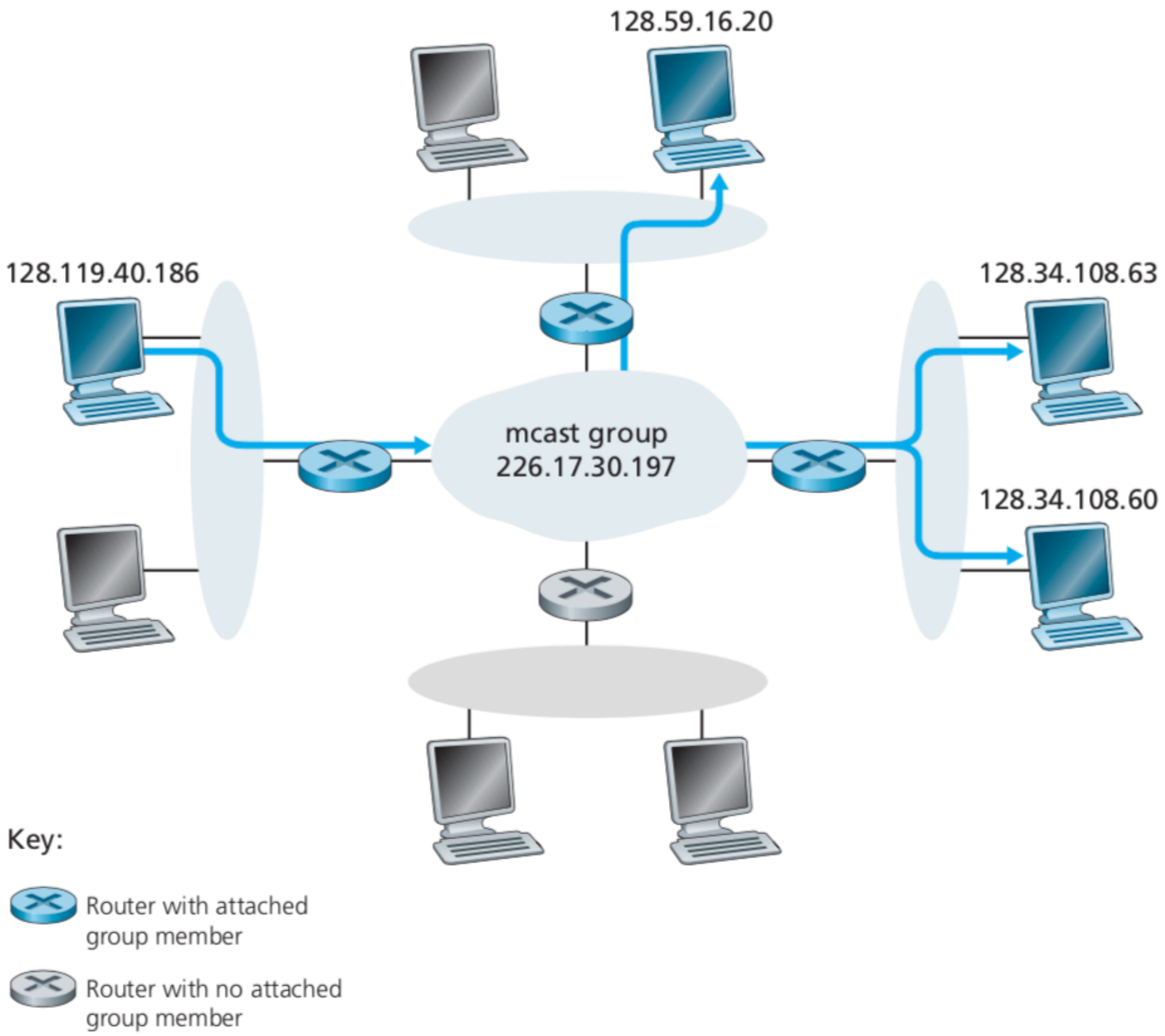
Broadcast Routing - in Practice

- OSPF Link State Advertisements
  - uses 32 bit sequence numbers
  - uses 16 bit age field (like TTL)
    - starts from 0, increases with time and hop
- Looks Simple but complex
  - Incorrect handling of LSA by two routers brought down ARPANet (RFC 789)

Multicast

- Delivery to only a subset of network nodes
- Applications
  - bulk data transfer, software upgrade
  - stream continuous media
  - shared data applications e.g. whiteboard
- Two challenges to deal with
  - identify receivers which are part of multicast group
  - how to address a packet sent to these receivers
- Options
  - have unicast address of each receiver node
    - not scalable

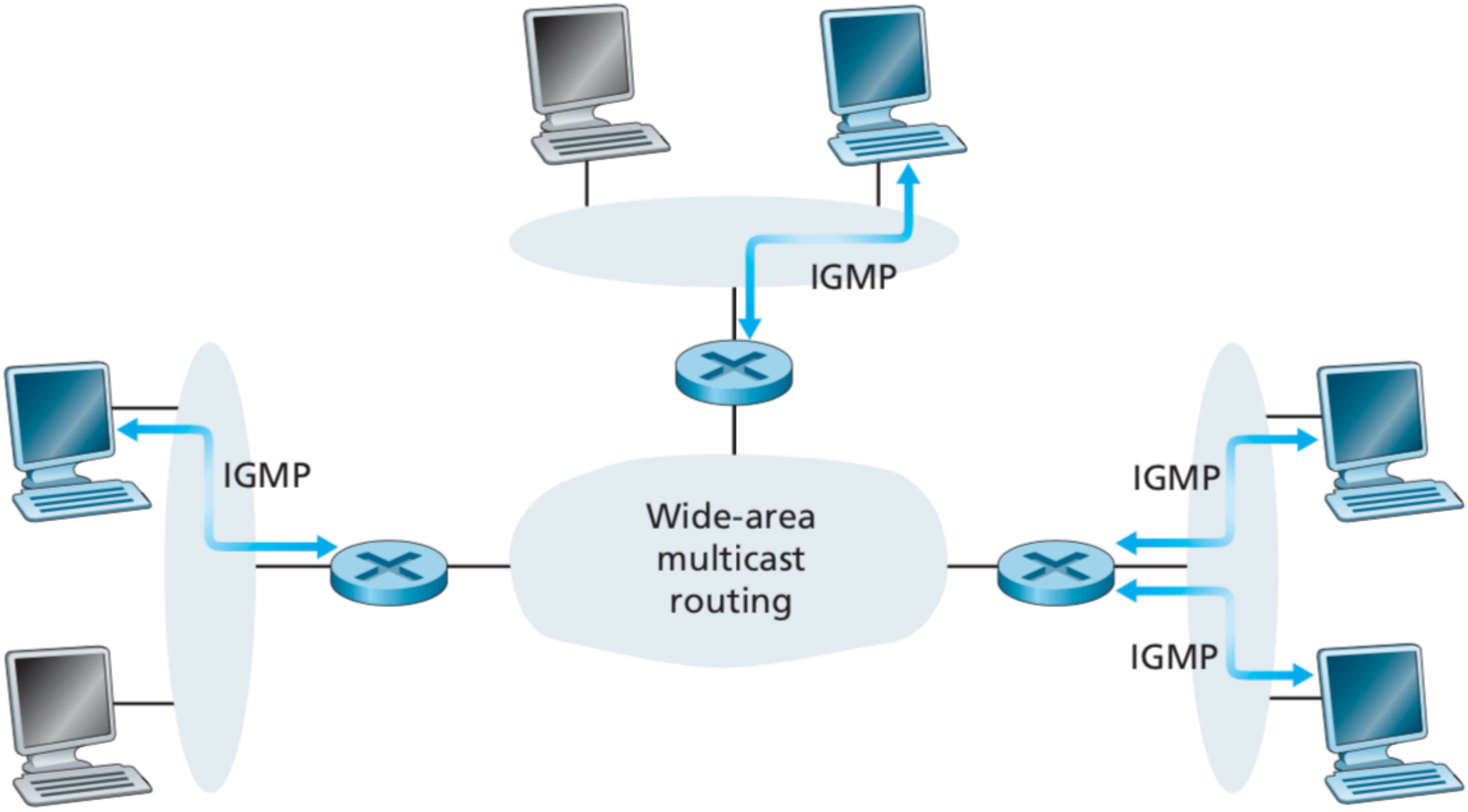
Multicast Group (226.17.30.197)



Multicast

- Implementation in Internet
  - Using address redirection
    - a single identifier is used for group of receivers
    - IP Addressing uses Class D (multicast group)
- Questions that arises from this abstraction
  - how does a group start/terminate?
  - how is the group address chosen?
  - how are hosts added to group as senders/receivers?
  - Is group membership open or restricted?
  - How does network routers work to deliver multicast?
- Answer: IGMP - Internet Group Management Protocol
  - RFC 3376

IGMP and MultiCast Routing

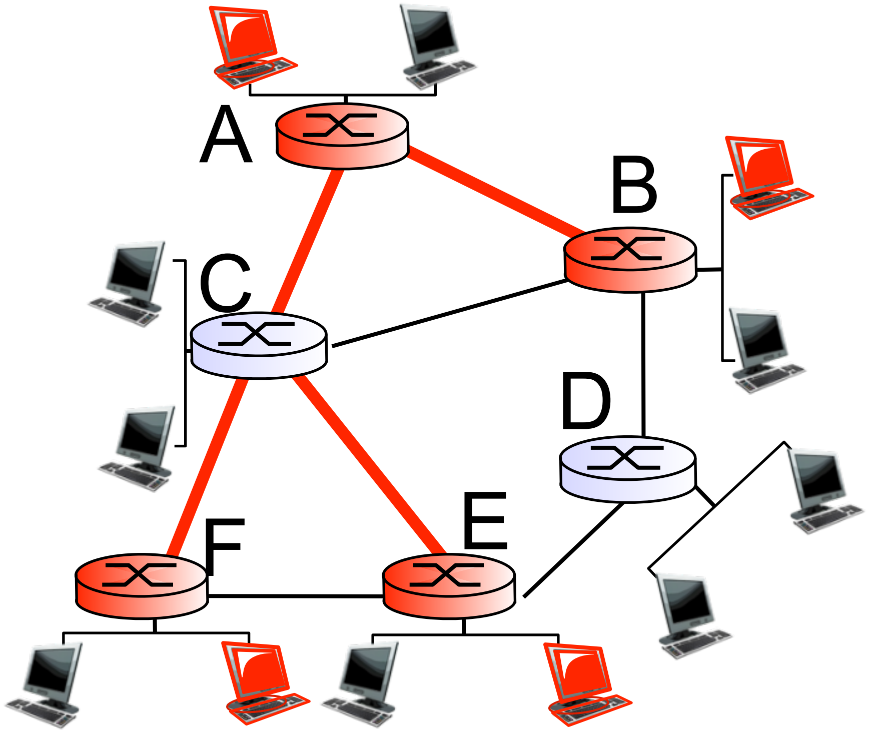


3 First hop connected multicast routers

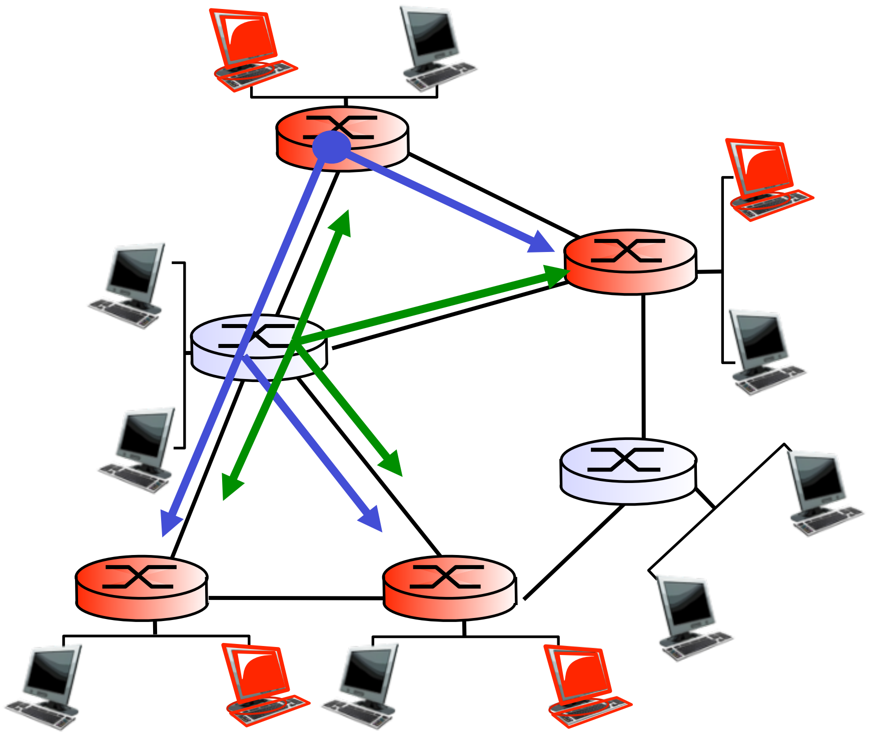
Multicast routing: problem statement

goal: find a tree (or trees) connecting routers having local mcast group members

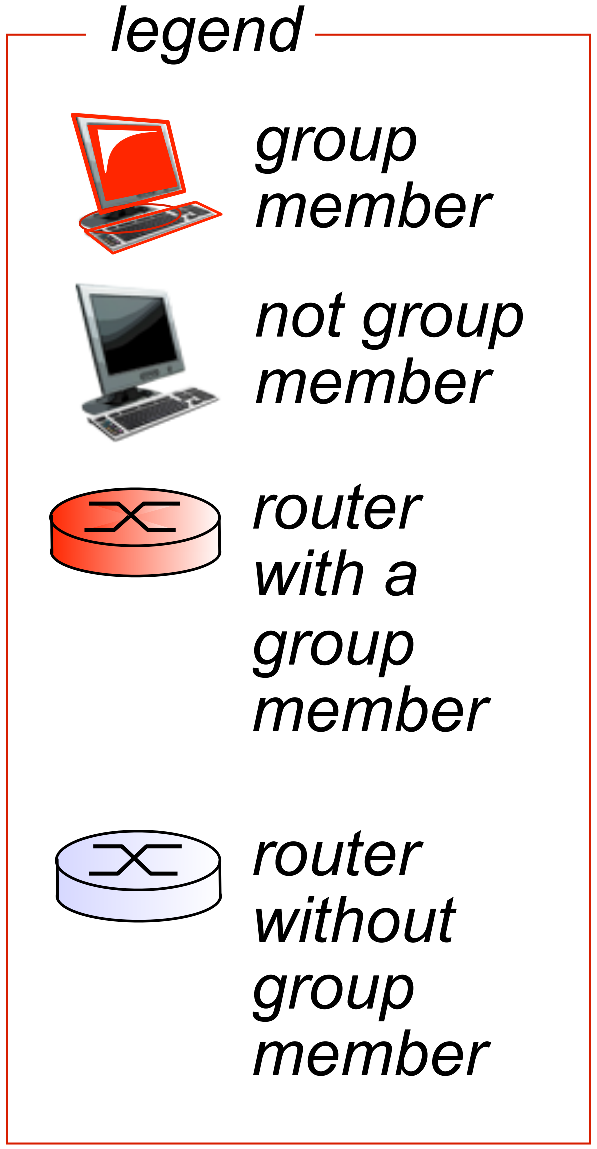
- *tree:* not all paths between routers used
- *shared-tree:* same tree used by all group members
- *source-based:* different tree from each sender to rcvrs



shared tree



source-based trees



Approaches for building mcast trees

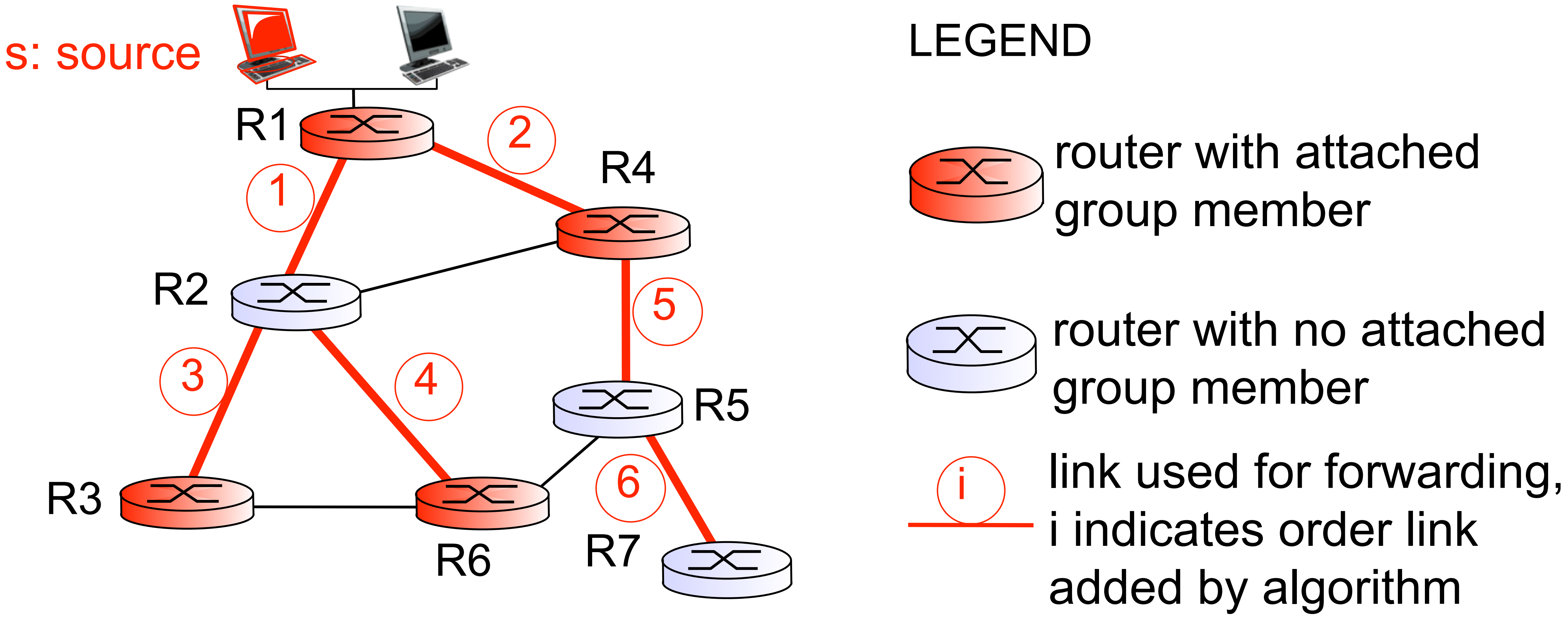
approaches:

- *source-based tree:* one tree per source
  - shortest path trees
  - reverse path forwarding
- *group-shared tree:* group uses one tree
  - minimal spanning (Steiner)
  - center-based trees

…we first look at basic approaches, then specific protocols adopting these approaches

Shortest path tree

- mcast forwarding tree: tree of shortest path routes from source to all receivers
  - Dijkstra's algorithm



LEGEND

router with attached group member

router with no attached group member

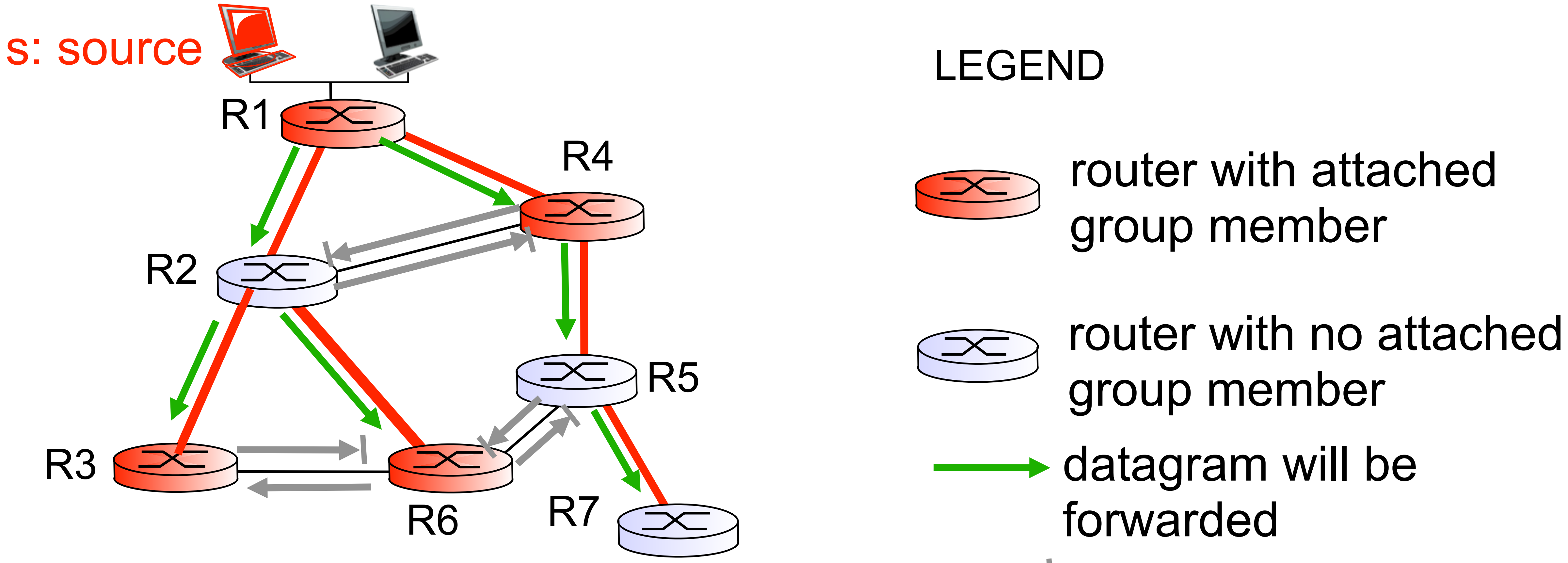
link used for forwarding, i indicates order link added by algorithm

Reverse path forwarding

- rely on router’s knowledge of unicast shortest path from it to sender
- each router has simple forwarding behavior:

```
if (mcast datagram received on incoming link
    on shortest path back to center)
  then flood datagram onto all outgoing links
  else ignore datagram
```

Reverse path forwarding: example



LEGEND

router with attached group member

router with no attached group member

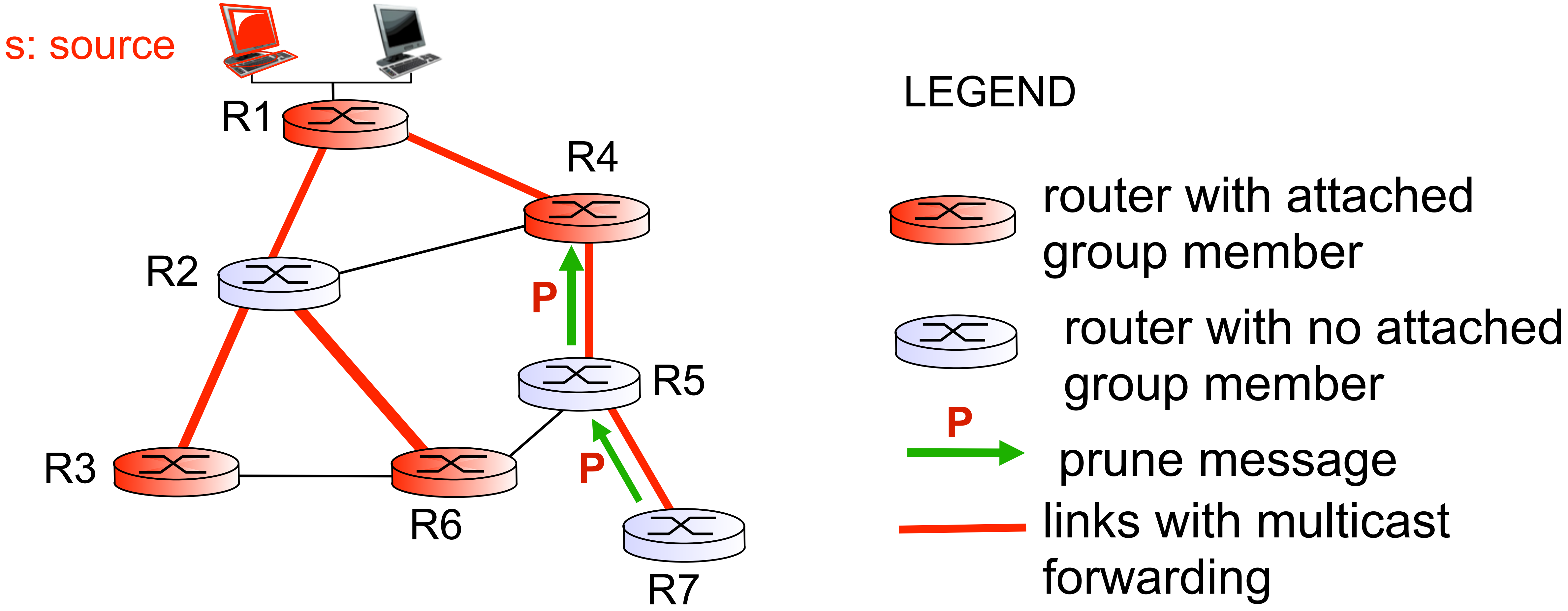
datagram will be forwarded

datagram will not be forwarded

- result is a source-specific *reverse* SPT
- may be a bad choice with asymmetric links

Reverse path forwarding: pruning

- forwarding tree contains subtrees with no mcast group members
  - no need to forward datagrams down subtree
  - "prune" msgs sent upstream by router with no downstream group members

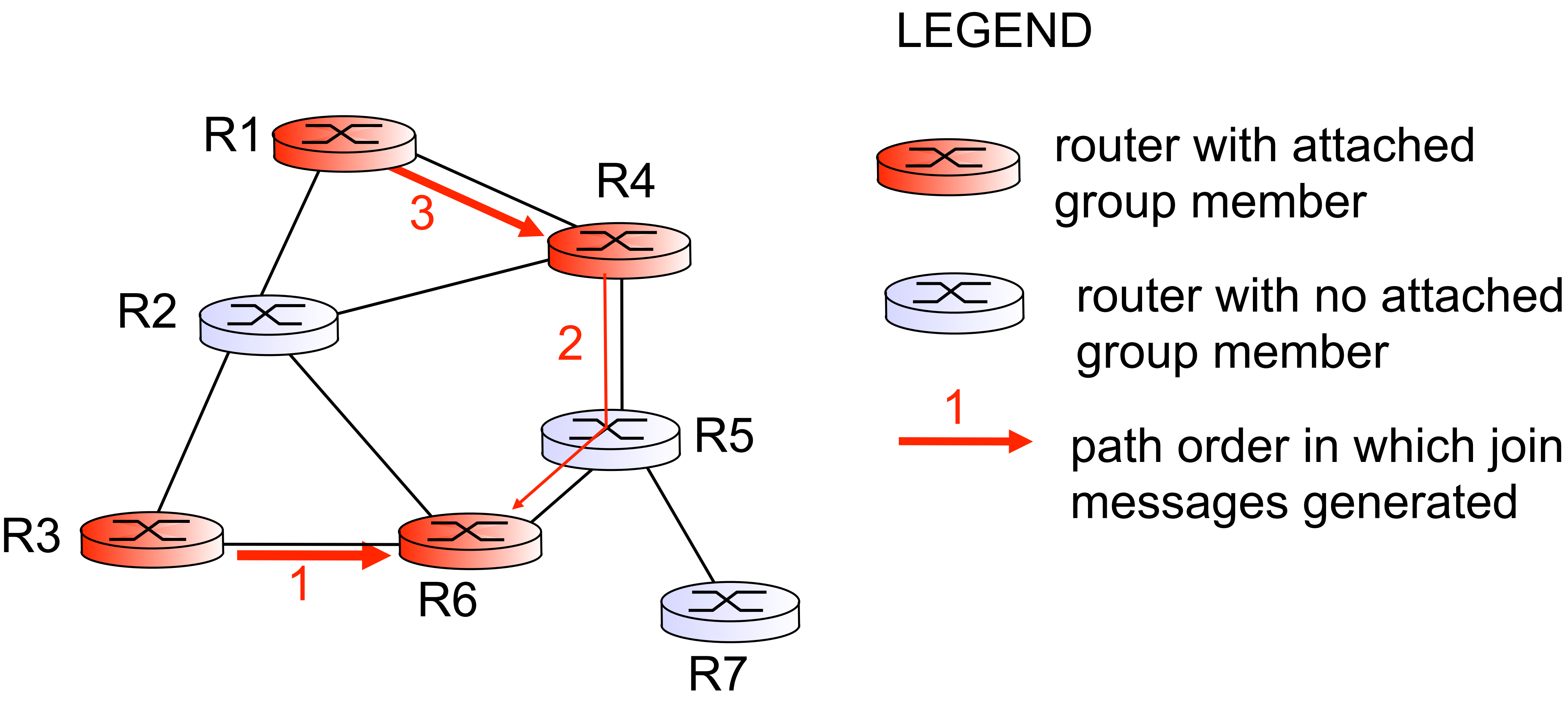

s: source
R1
R4
R2
R5
R3
R6
R7
P
P
LEGEND
router with attached group member
router with no attached group member
P
prune message
links with multicast forwarding

Center-based trees

- single delivery tree shared by all
- one router identified as *"center"* of tree
- to join:
  - edge router sends unicast *join-msg* addressed to center router
  - *join-msg* "processed" by intermediate routers and forwarded towards center
  - *join-msg* either hits existing tree branch for this center, or arrives at center
  - path taken by *join-msg* becomes new branch of tree for this router

Center-based trees: example

suppose R6 chosen as center:



LEGEND

🟥 router with attached group member

⬜ router with no attached group member

1 → path order in which join messages generated

Multicast Routing in Internet

- DVMRP (Distance Vector multicast routing)
    - First multicast routing protocol
    - Implements Source Based Tree with
        - Reverse Path Forwarding and Pruning
- PIM (Protocol Independent Multicast routing)
    - Dense mode
        - Most of the routers in an area are involved
        - Uses Flood and Prune Reverse Path Forwarding
    - Sparse mode
        - Very few routers are involved
        - Only a single sender is allowed to send traffic to Mcast Tree

Summary

- Broadcast and Multicast routing
  - Reverse Path Forwarding
  - Spanning Tree
  - Shared tree and Source based Tree
- DVMRP and PIM

Summary: Network Layer

- Forwarding and Routing
- Router architecture
- IP addressing
- IP packet structure
- IPv6
- Routing algorithm
  - Distance vector, Link State and Path Vector
- Routing
  - RIP, OSPF, BGP
- Broadcast and Multicast routing
  - Reverse Path Forwarding
  - Spanning Tree
  - Shared tree and Source based Tree
- DVMRP and PIM