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Advanced Networks

(EENGM4211)

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Slides courtesy: Prof. Reza Nejabati and Slides from Ross's Book

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Unit Outline

1. Introduction
2. Internet Routing and Switching
3. IP Multicast
4. Networking for Realtime Applications
5. Routing in Wireless Networks
6. Quality of Service

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Part 3:
IP Multicast

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Topics

- What is multicast
  - why it is different from other ‘casts’?
  - what applications use it
  - how is it implemented (layering)
- What does it mean for
  - addressing
  - routing
  - protocols
- Multicast Routing

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ILOs

- Demonstrate knowledge of multicast
- Differentiate between unicast, multicast, and broadcast
- Understand and demonstrate the knowledge about multicast routing and strategies

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The Many Uses of Multicasting

- Applications
  - Teleconferencing
  - Distributed Games
  - Software/File Distribution
  - Video Distribution
  - Replicated Database Updates
  - Auto-configuration
  - ….
- Why use it?
  - To reduce time to send data to a (large) set of receivers (e.g. online games)
  - To minimise the network capacity required for this.
- Who benefits mostly?
  - Users that source information (e.g. content providers)
  - Network transport service providers (ISPs, carriers – i.e. operators)

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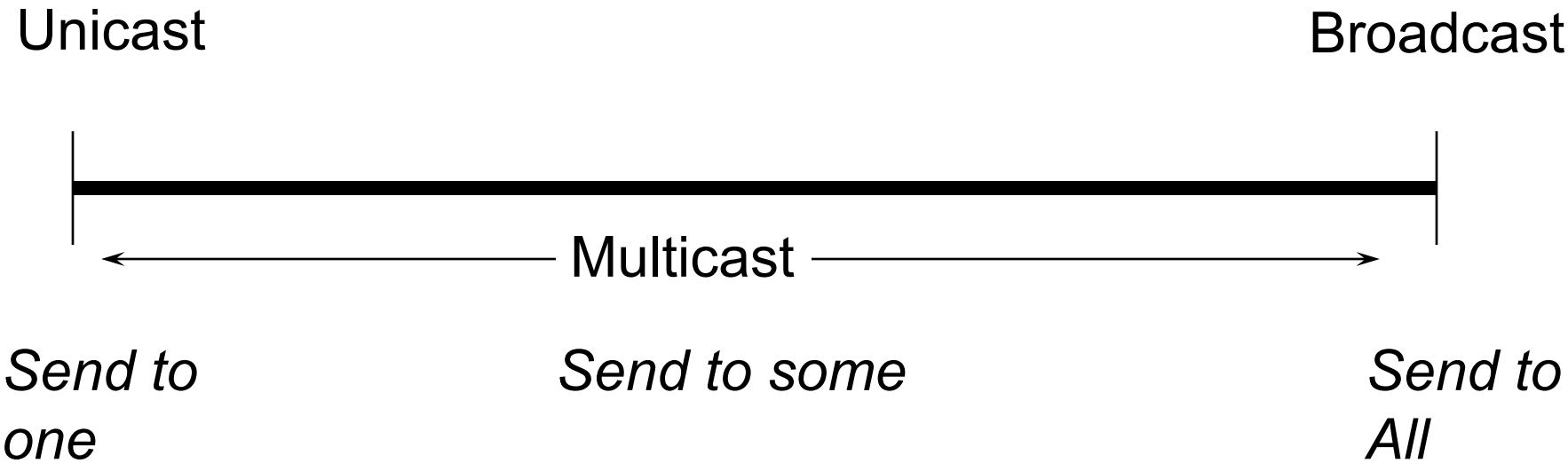
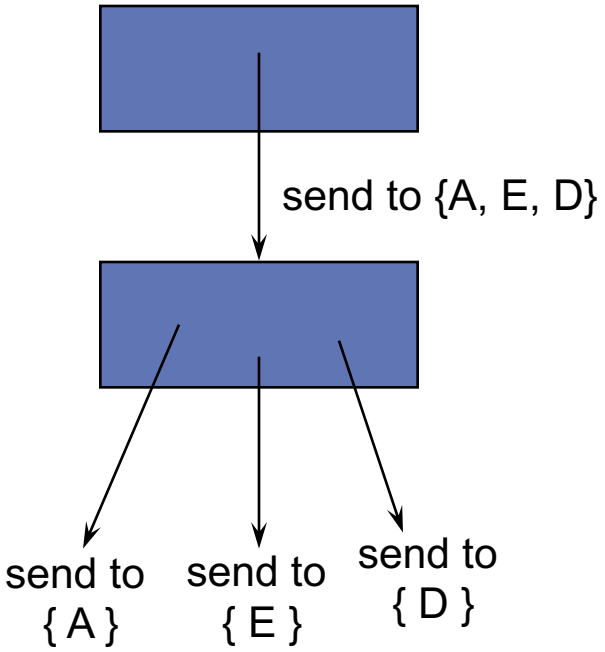
Definition

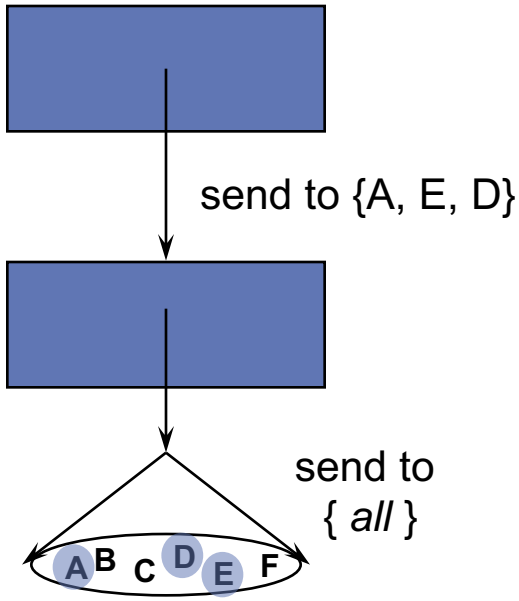
- Sending a message to multiple receivers using a single local "transmit" operation



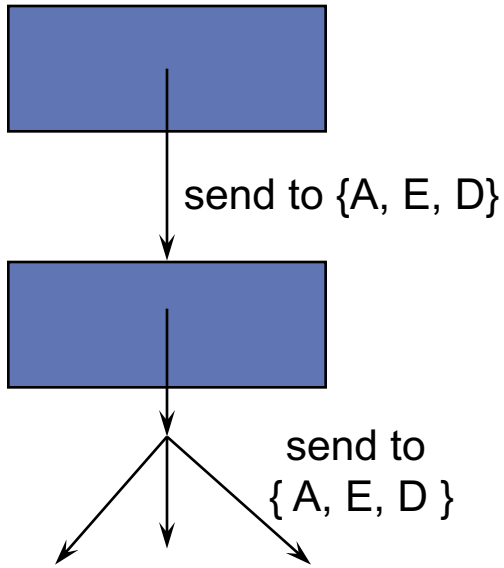
Layering and Multicast



Multicast by Unicast



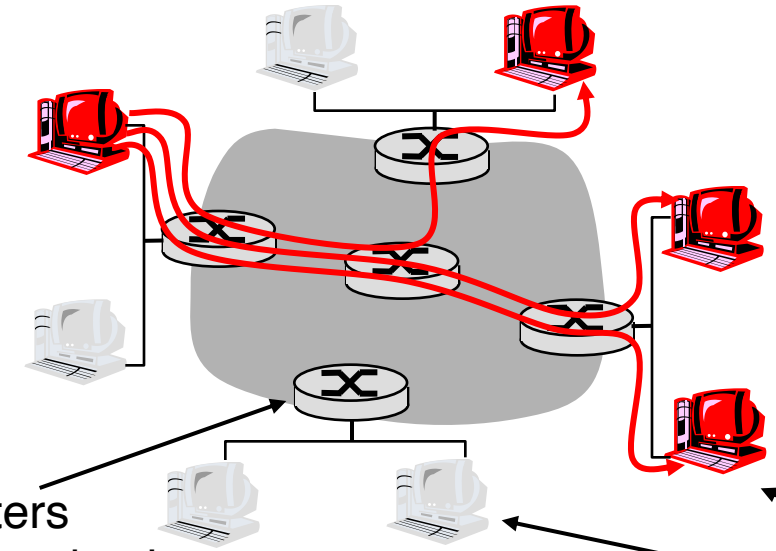
Multicast by Broadcast



Multicast by Multicast

Multicast: One to Many

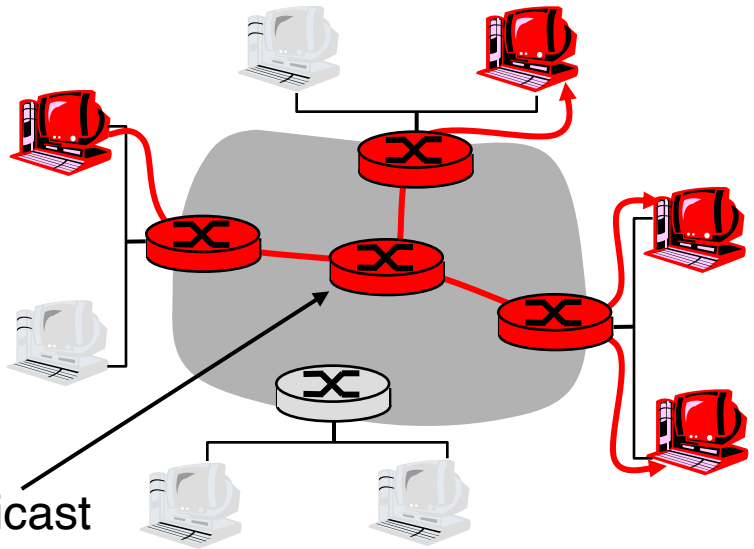
- Multicast: act of sending datagram to multiple receivers with single "transmit" operation
  - analogy: one teacher to many students
- Question: how to achieve multicast



Multicast via unicast

- source sends N unicast datagrams, one addressed to each of N receivers

Multicast: One to Many

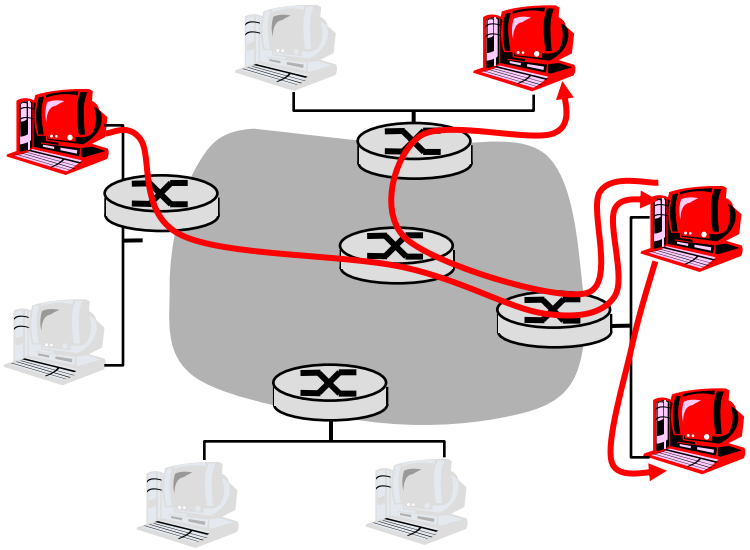


Multicast routers (red) duplicate and forward multicast datagrams

Network multicast

- Router actively participate in multicast, making copies of packets as needed and forwarding towards multicast receivers

Multicast: One to Many



Application-layer multicast

- end systems involved in multicast copy and forward unicast datagrams among themselves

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Multicast Application Models (classification)

- Number of sources:
  - Point-to-Multipoint:
    - Single Source, Multiple Receivers
  - Multipoint-to-Multipoint:
    - Multiple Sources, Multiple Receivers
- Source multicast membership:
  - Sources are receivers
    - e.g. teleconferencing
  - Sources are not receivers
    - e.g. webcast
- Who's in control?
  - SENDER-oriented multicast
  - Receiver-oriented multicast

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Sender-Oriented Multicast

- Source sets up one-to-many multicast group
- Each source responsible for its own group
- Good for connection-oriented services
- Discourages dynamic groups
- Centralised
  - not always a bad thing!
- Not scalable

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Receiver-Oriented Multicast

- Senders need not be members
- Groups may be of any size → scalable
- No topological restrictions on membership
- Membership is dynamic and autonomous
  - everyone is free to come and go – as viewed from the network!
- Host groups may be transient or permanent

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Principles of Multicast Routing

- Addressing
  - List Addressing (all destinations)
    - Not Scalable
  - Group Addressing (single address, hosts accept datagrams on that address)
    - Less Control
- Reuse of unicast routing infrastructure
  - desirable
  - too constraining
    - unicast network is optimised for every packet
- Multicast routing overhead
  - needs to be minimized (e.g. to limit redundant traffic)

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IP Multicast

- Network-level; same packet format as unicast, different address class
- Routers do all of the work
- Class D IPv4 addresses:
  224.0.0.0 - 239.255.255.255
  - Some are reserved for pre-determined groups, e.g. 224.0.0.1 is all-routers
- 28 bits => 268 million groups
  - may be reused
- TTL (hop count) value limits distribution, i.e. controls the scope of the group

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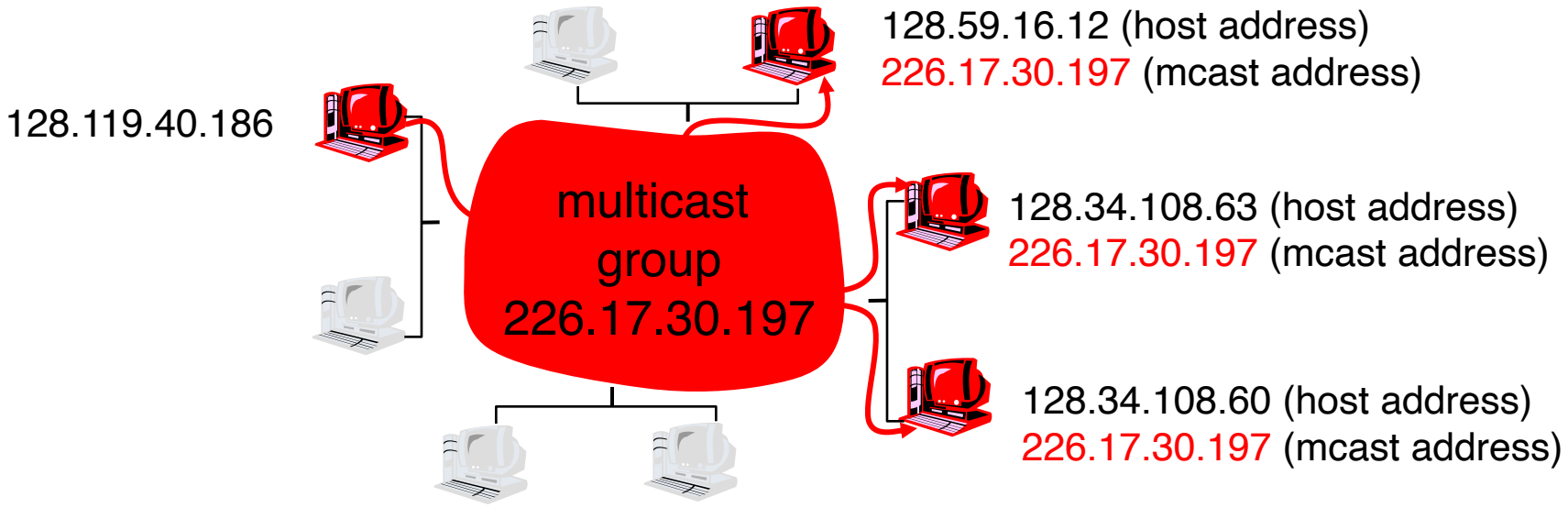
Internet Multicast Routing: Components

- Multicast management based on two protocol functions
  - Group Management
    - How does a host tell the network it is a member of a multicast group?
      - IGMP (Internet Group Management Protocol)
  - Route Establishment
    - How does the network deliver the multicast packets to the group members?
      - DVMRP, MOSPF, CBT, PIM
- Group Addressing
  - Class D IP addresses (224.0.0.0 – 239.255.255.255)

Internet Multicast Service Model

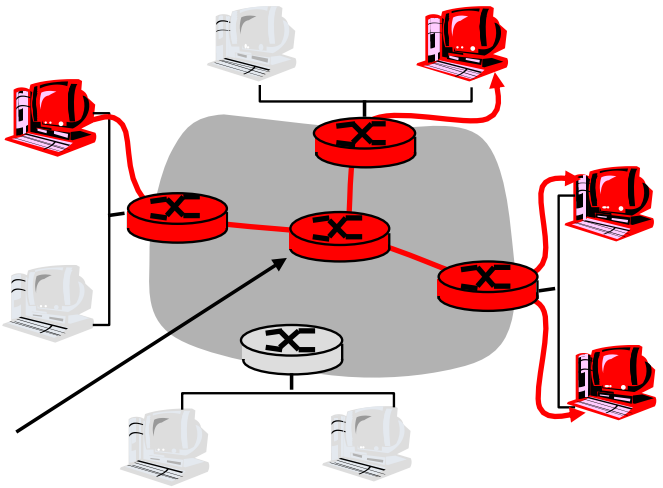


- hosts addresses IP datagram to multicast group
- routers forward multicast datagrams to hosts that have "joined" that multicast group

Multicast groups

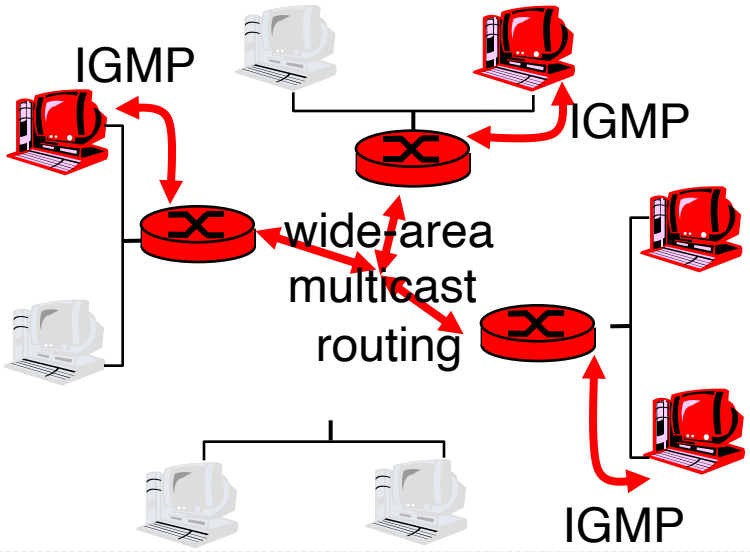
- Class D Internet addresses (IPv4) reserved for multicast:

- Host group semantics:
  - anyone can "join" (receive) multicast group
  - anyone can send to multicast group
  - no network-layer identification of members to hosts
- Needed: infrastructure to deliver mcast-addressed datagrams to all hosts that have joined that multicast group



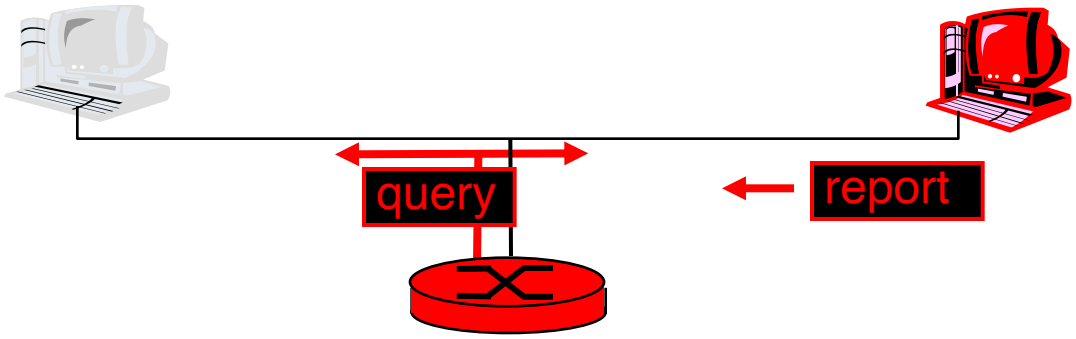
Joining a mcast group: two-step process

- *local:* host informs local mcast router of desire to join group: IGMP (Internet Group Management Protocol)
- *wide area:* local router interacts with other routers to receive mcast datagram flow
  - many protocols (e.g., DVMRP, MOSPF, PIM)



IGMP: Roles

- *host:* sends IGMP report when application joins mcast group
- *router:* sends IGMP query at regular intervals
  - host belonging to a mcast group must reply to query



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IGMP - Internet Group Management Protocol

- Used by end-system to declare membership in particular multicast group to nearest router(s)
- Several versions:
  - Version 1: Timed-out Leave (RFC-1112)
  - Version 2: Fast (Explicit Leave)
  - Version 3: Per-Source Join

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IGMPv1 – Principles

- Router periodically polls hosts on subnet using IGMP Query
  - Joining host send IGMP Report
  - Leaving host does nothing
- Hosts respond to Query in a randomized fashion
  - Why is this necessary?

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IGMPv1 – Principles

Operation

- An IGMP-capable router periodically broadcasts Membership Query in the subnet.
- Host-Membership Report is sent by the member hosts in the subnet.
- When is it sent?
  - A random timer is activated by each member host when a query is received
    - Why?

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IGMPv2 (RFC 2236)

- Adds:
  - Group Specific Queries
  - Leave Group Message
- Host sends Leave Group message if it was the one to respond to most recent query
  - The logic being that it may be the only one group member remaining in the subnet.
- Router receiving Leave Group message queries group.

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IGMPv3 (RFC 3376)

- Adds:
  - Group-Source Specific Queries, Reports and Leaves
- Inclusion/Exclusion of sources
  - because sources may or may not be receivers (group members).

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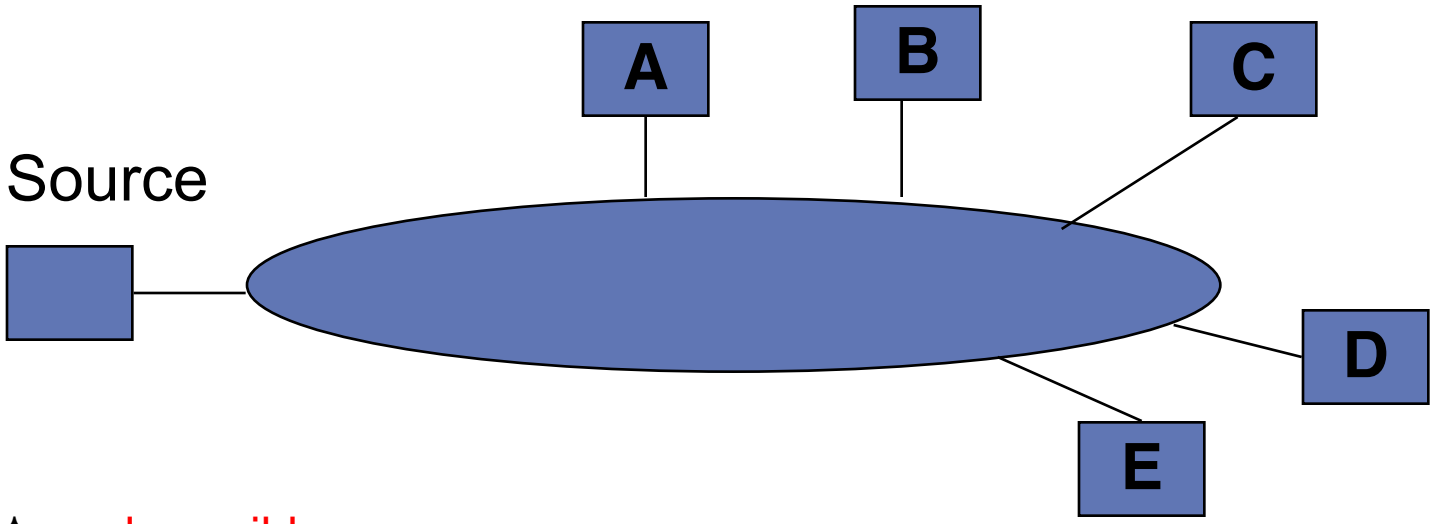
Principles of Multicast Routing

- Metrics for evaluation
  - bandwidth usage
  - delay -- average, maximum, variance
  - concentration – density of multicast tree
  - router/switch overhead

Basic Multicast Routing Protocols (1)

- Problem:
  - Given a source and a set of destinations,
  - Route the same packet to at least (or exactly) this set of destinations



✦ and possibly:

- Optimise routes from source to receivers
- Maintain loop-free routes
- Distribute multicast load fairly/equally between all possible links (do not create hot spots)

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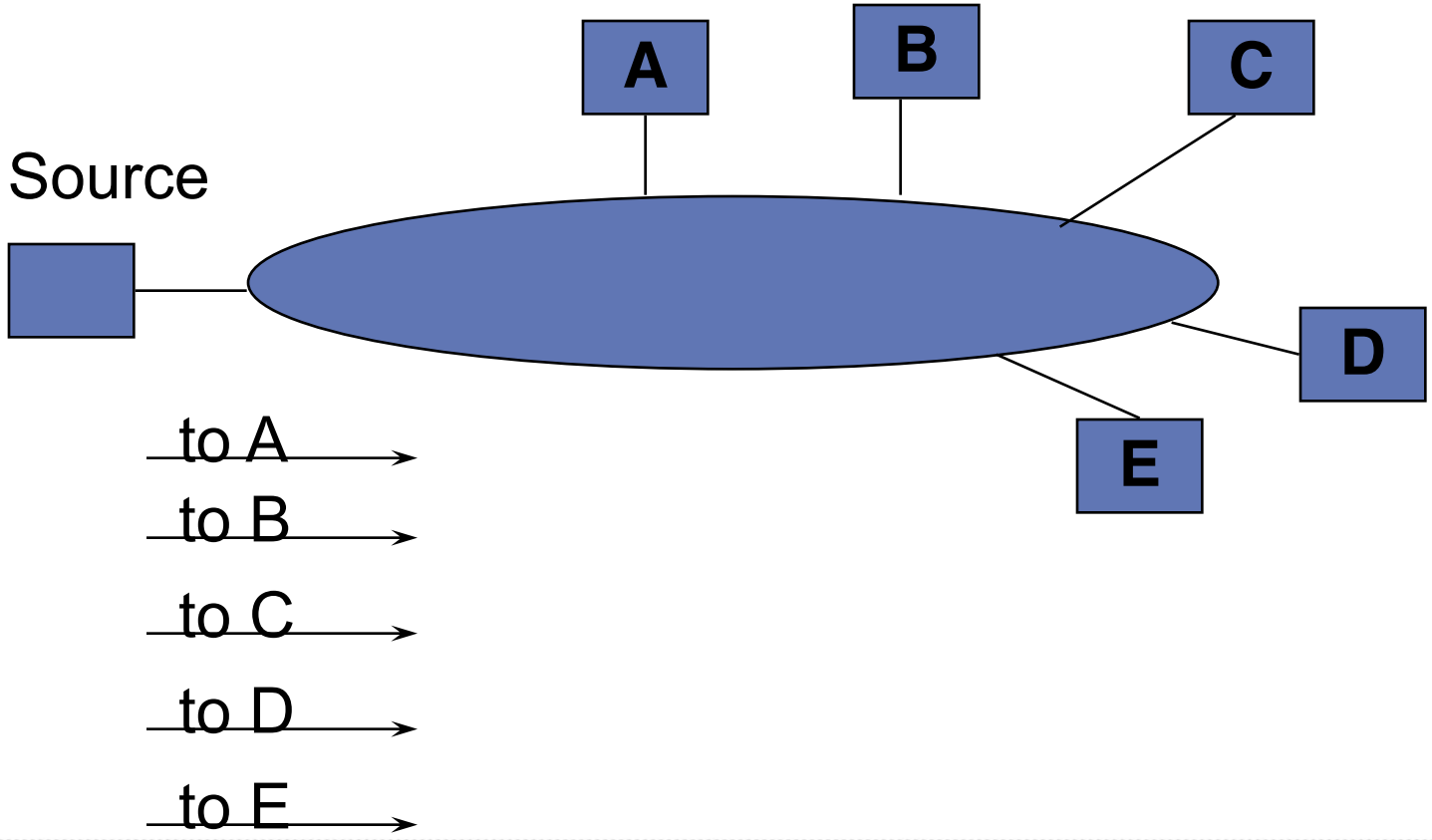
Basic Multicast Routing Protocols (2)

- Multicast by Broadcast (flooding)
- ***How?***
  - Filter above network layer
    - Natural in broadcast networks (satellite, bridged LANs)
    - Use flooding in packet switched networks
- Issues:
  - Bandwidth inefficient
  - Security concerns
    - Though these are endemic in the multicast open model

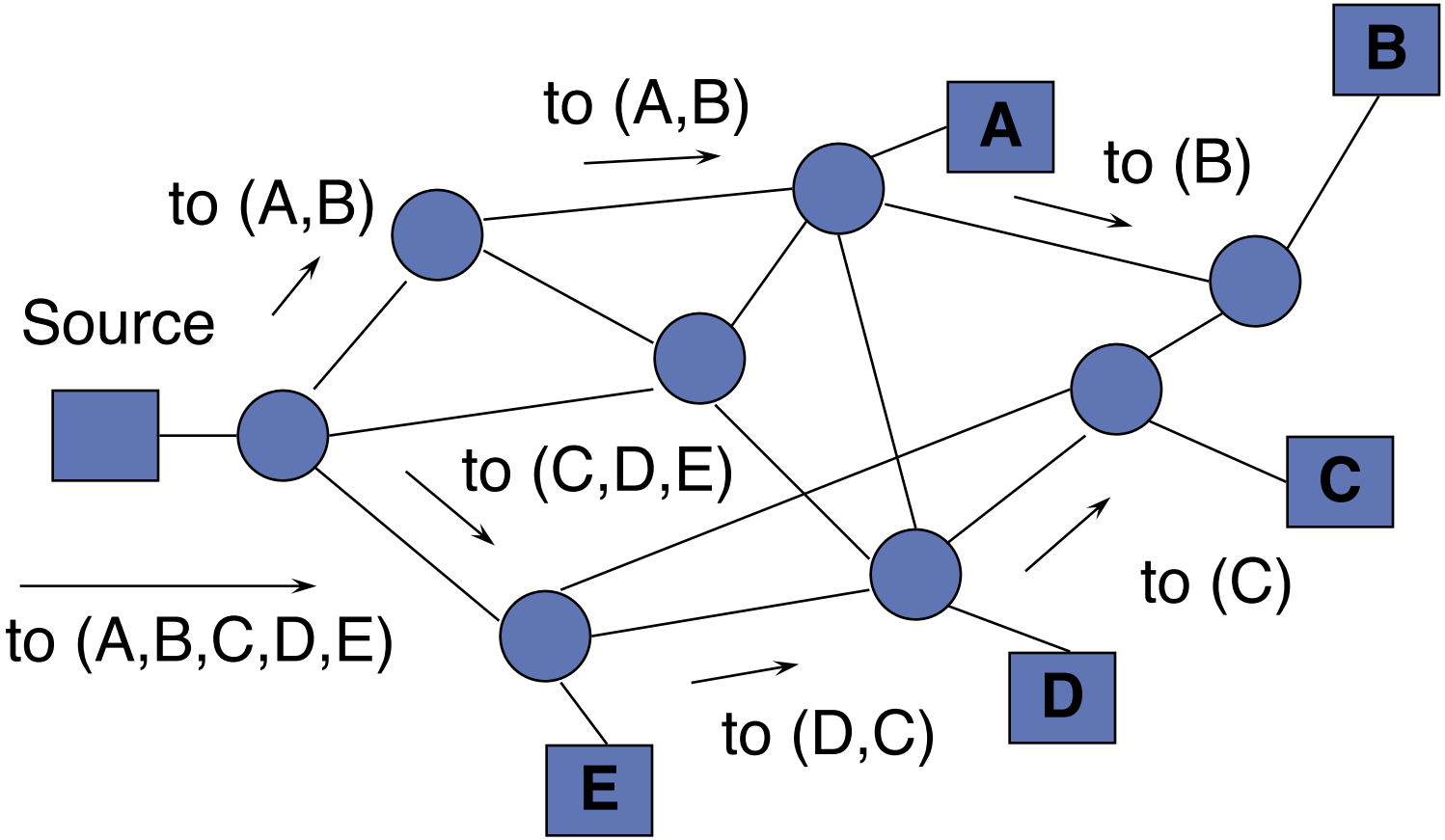
Basic Multicast Routing Protocols (3)

- Separately addressed packets



Basic Multicast Routing Protocols (4)

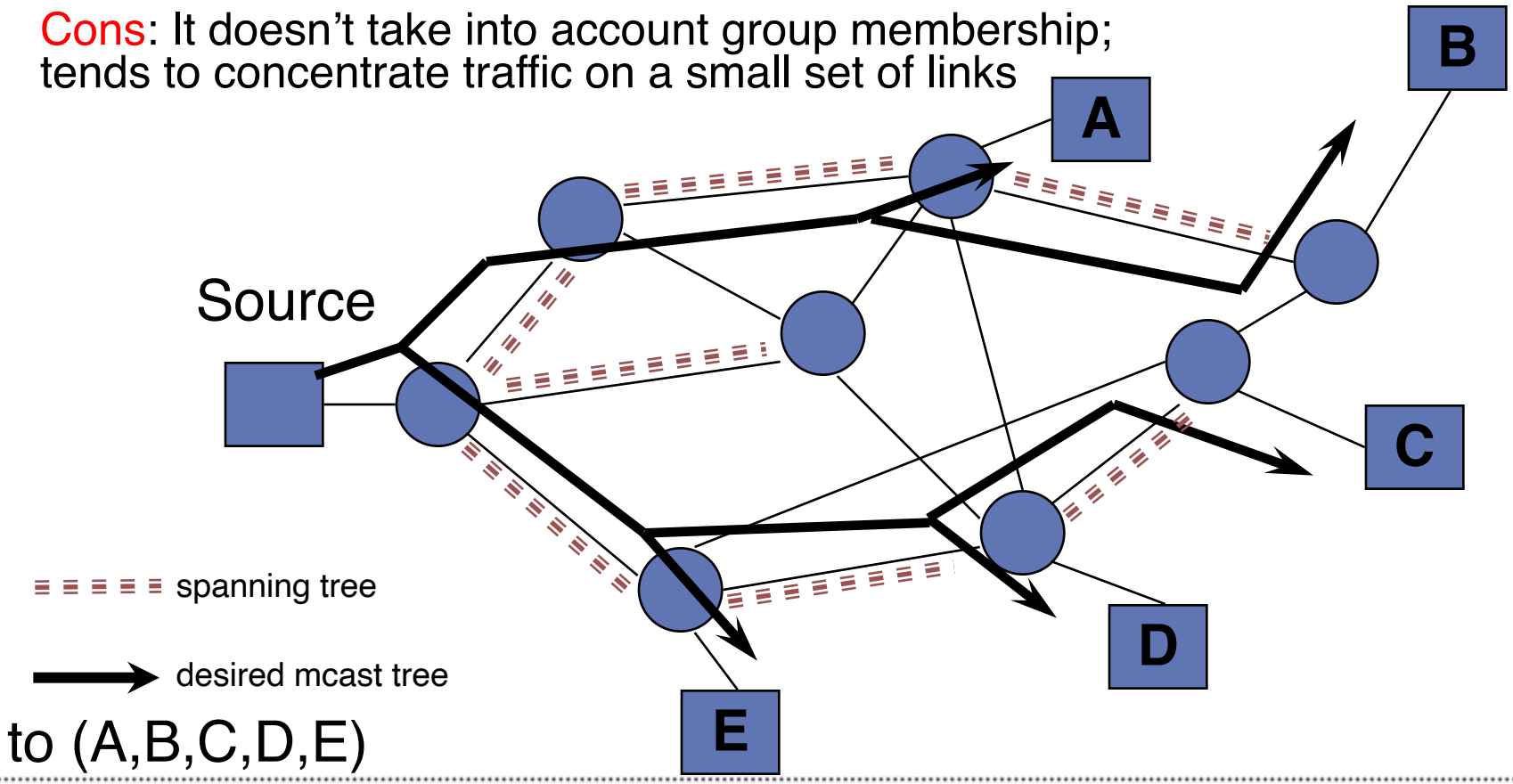
Multidestination Addressing



Basic Multicast Routing Protocols (5)

Spanning tree forwarding

- Pros: most efficient in minimising unnecessary traffic; robust; low memory requirement
- Cons: It doesn't take into account group membership; tends to concentrate traffic on a small set of links



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Conclusions

- Multicast routing protocols
  - structure and overhead
- Purpose and benefits of multicast
- Many approaches
- Only discussed the simple issues!

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References

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