Lecture 19
Plan: Hierarchical routing, Broadcast routing, multicast routing

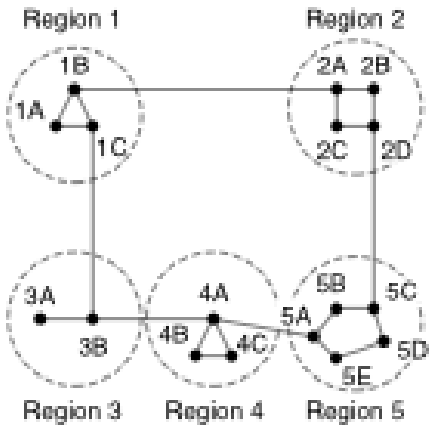
Review:
Flooding: extremely robust
Distance Vector Routing: local, adaptive (slow convergence)
Link State Routing: Global, adaptive (routers are loaded with many jobs)

Topic today: more routing algorithms
1. Hierarchical Routing
Problem: If the network (we mean a single protocol network) grows too big, it costs too much to use LS Routing
Q:/ Why?
A:/

- too many information to send among routers
- too big a graph to build
- too much time to use the D's algorithm

Q:/ How to solve this problem?
A:/ Decompose the network hierarchically so

- each router only needs to know every other router inside its region
- each router only needs to know how to get to other regions instead of every host in other regions



(a)

Full table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

(b)

Hierarchical table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

(c)

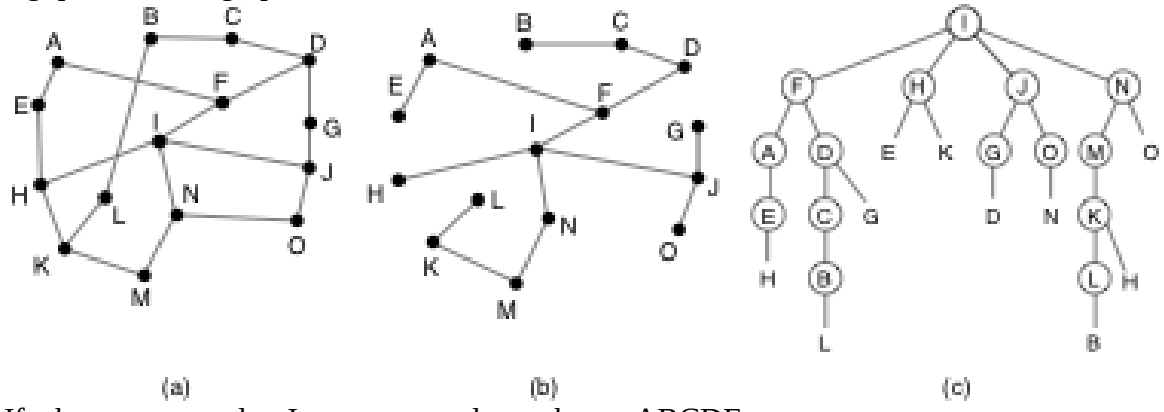
the table of router A decreased from 17 entries to 7 entries

Q:/ What is the catch?
A:/ may result in an increase in the mean routing distances. e.g. 1A to 5C now has a larger distance

2. Broadcast Routing
Scenario: a packet needs to be delivered to many or all other hosts in a network
Q:/ Do we need a special routing algorithm for this? Why not just send a packet to every host as a single message?
A:/ Wastes too much bandwidth

Q:/ What can we do?
A:/

1. Flooding→ again too much bandwidth
2. Multidestination routing
    a. packet knows a list of destination addresses
    b. When the packet arrives at a router, **the router determines a set of output ports** to forward the packet
    c. It basically partition the destination set at the output lines
    e.g. part a of the graph



If a host connected to I wants to send a packet to ABCDE

- I looks up its forwarding table ABCDE will all go through F
- I forward the packet to F
- F looks at its table and found that E will go through A and BC will go through D
- F generates a new copy of the packet addressing AE and forward it to A
- F generates another copy of the packet addressing BCD and forward it to D

3. Spanning tree

    a. Each router knows a spanning tree for the network
    b. when a packet arrives, the router sends it only on links which are part of the tree
    e.g. part b of the previous graph
    If I wants to send a packet to all other hosts

I → FHNJ
F→AD, J→GO, N→M
A→E, D→C, M→K
C→B, K→L
four hops and 14 extra packets

c. Pro: bandwidth efficient
Con: each router has to know the spanning tree (good for Link state, not for distance vector)

Q:/ Can routers do broadcast routing without knowing the spanning tree AND we don't have to put a list of destination addresses in our packets?
A:/ yes

4. Reverse path forwarding
   a. When a packet arrives from some source S, the router looks to see what its forwarding table indicates for packets **destined for S**
   b. If the packet arrives on that link, forward it to all other links
   c. Otherwise, discard it.
   e.g. part c of the previous figure
   Assume that the preferred path of a router follows the tree (for ease of illustration) for the tree as before
   If I has a packet to send to all other hosts
   I→ FHNJ
   Q:/ Does this packet from I come from the destined port to I on router F?
   A:/ Yes. → So this packet will be forwarded to all other ports of F
   Similarly for H, N and J
   F→AD, H→EK, N→MO, J→GO
   A→E, D→CG, M→K, O→N, G→D
   E→H, C→B, K→HL,
   B→L, L→B
   So 5 hops with 24 extra packets
   Pro: Easy to implement and no need to know the sink tree; also no need to use sequence numbers to stop looping

3. Multicast Routing

Q:/ What is the difference between multicast and broadcast?
A:/ broadcast means send a packet to all hosts. Multicast means send a packet to all members of a multicast group

Need a protocol for managing group membership
Can use a spanning tree or reverse path forwarding for each group
Can also use addresses (IP multicast) → later this chapter