

Introduction to Networks and the Internet

CMPE 80N

Winter 2004

Lecture 12



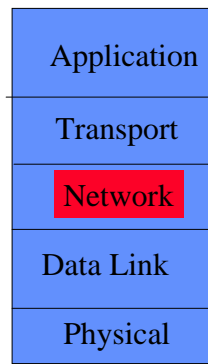
Announcements

- *Third quiz scheduled for 02.13.*
- *Library presentation on 03.03.*
- *Lecture notes “dilemma”.*



The Network Layer

TCP/IP



Network Layer

- *Main functions: routing and forwarding.*
 - *What’s routing?*
 - *What’s forwarding?*



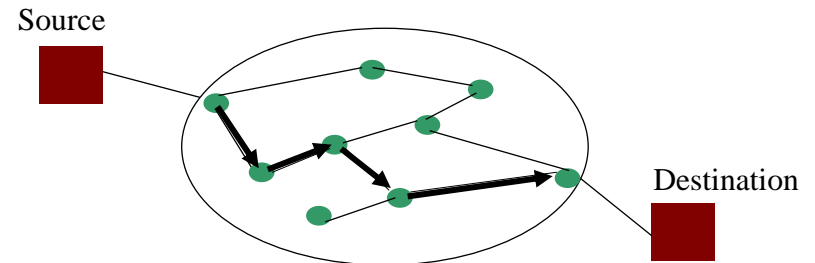
Routing

- Find path (route) between source and destination.
- Analogy: air travel.
 - To go from San Francisco to NY.
 - Go from SFO to Denver.
 - From Denver to Chicago.
 - From Chicago to NY.
- Main idea: at every hop, get closer to destination.



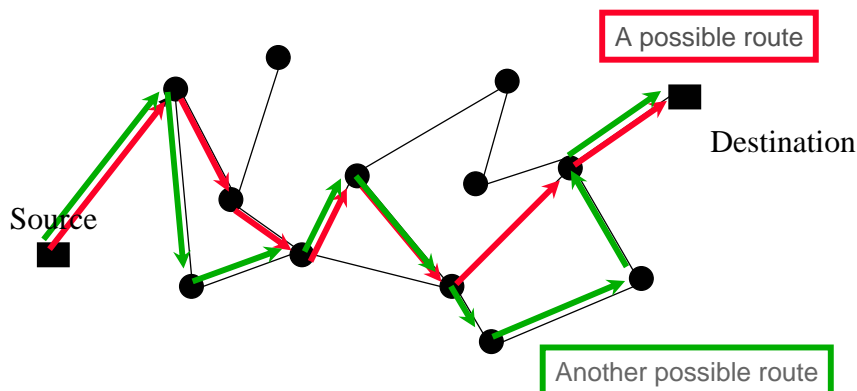
Routing

- Find path (route) between source and destination.



Routing (cont'd)

- **Routing** means finding a suitable path for a packet from sender to destination



Routing (cont'd)

- A router may need to choose between two or more paths that lead to destination.
 - Choosing the “shortest” path.
- Typically, there are multiple hops to make the journey.
 - Unless hosts are on the same network.
- The **routing algorithm** is the part of a network layer software responsible for deciding which output line data should be transmitted on



Forwarding

- *When data is received, forward it in toward the destination.*



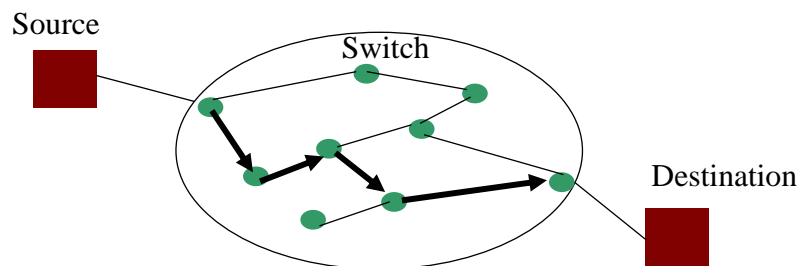
Who? How?

- *Who performs network layer functions?*
 - **Switches/routers.**
- *How these functions are carried out?*
 - *Later...*



Switches or Routers

- *Switches, or routers, receive data on one side and forward it on the other side.*
- *Like telephone switches.*



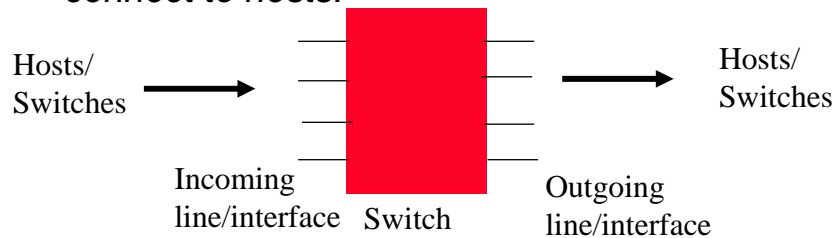
Wide-Area Network

- *One possibility: connect every host using dedicated line.*
 - *Problem?*



Wide-Area Network

- *One possibility: connect every host using dedicated line.*
 - Problem?
- *Another possibility: use interconnected switches which are interconnected and connect to hosts.*



Switch Internals

- *Early WANs used general purpose machines dedicated to the task of switching.*
- *Modern WAN switches use special purpose hardware optimized for the switching task.*



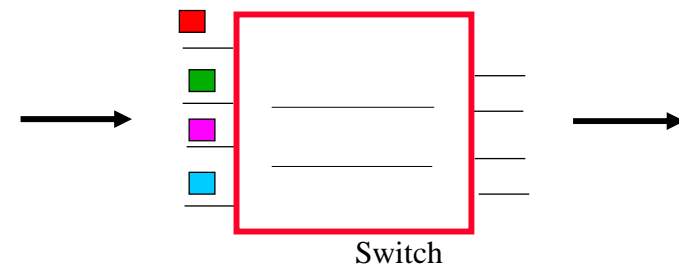
Store and Forward

- *How switches operate.*
- *Shared LANs: only 1 pair of hosts can exchange a frame at a time.*
- *WANs: many hosts can send simultaneously.*
- *Switch stores data they receive in memory; next switch examines data, determines which interface to send it, and forwards data on.*



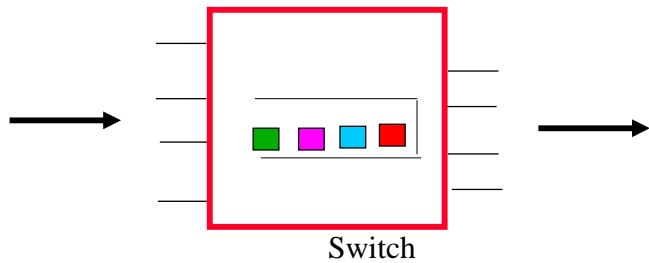
Queuing

- *If multiple data items arrive for the same outgoing interface, they are queued waiting to be transmitted.*



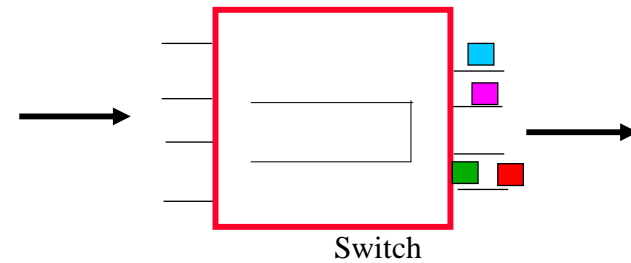
Queuing (cont'd)

- If multiple data items arrive for the same outgoing interface, they are queued waiting to be transmitted.



Queuing (cont'd)

- If multiple data items arrive for the same outgoing interface, they are queued waiting to be transmitted.



Next-Hop Forwarding

- Air travel analogy: SF ->NY
 - You want to go from SF->NY.
 - Go to SF airport; go to airline ticketing; ask for cheapest ticket from SF to NY.
 - Get ticket from SF -> Denver.
 - At Denver airport, get cheapest ticket to go to NY.
 - Get ticket from Denver->Chicago, etc.



Next-Hop Forwarding (cont'd)

- If data not destined to directly connected host, switch forwards it to the cheapest next hop toward destination.
- Next hop does not depend on source, not on the path traveled so far.
- Advantage: switch need only examine destination address.



Routing Table

- Switches need to know where to forward data they receive.
 - Essentially, destination address -> next hop.
- Table containing destination and associated next-hop information.

Switch 2

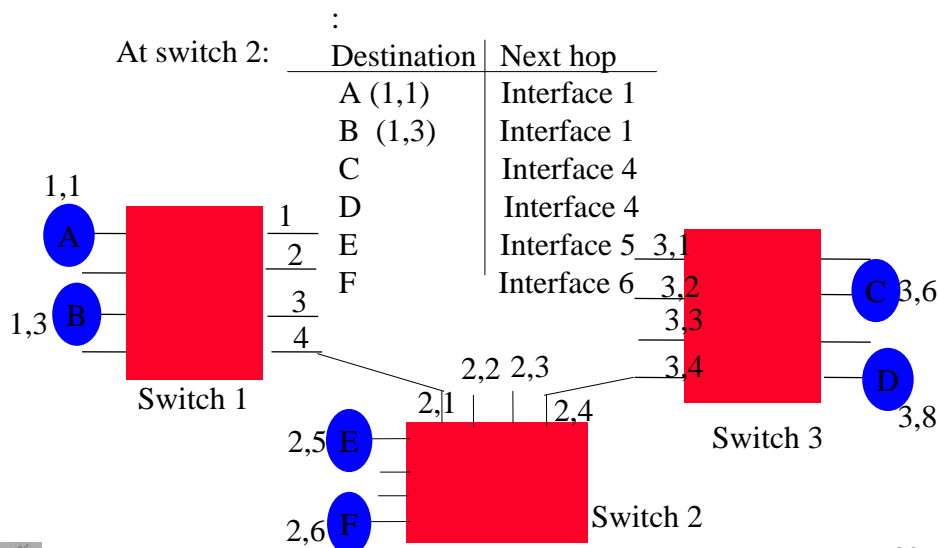


Routing Table

- Air travel analogy:
 - At each airport there is a table showing the cheapest next hop to every destination.
 - The source does not matter!
 - Example: at Denver airport,
 - NY go to Chicago
 - DC go to Chicago
 - Miami go to Houston
 - Houston go to Houston
 - Los Angeles go to Los Angeles
 - San Diego go to Los Angeles



Routing Table: Example



More Routing Table

- Each router stores information about forwarding in a **routing table**.
 - Initialized at system initialization.
 - Must be updated as network topology changes.
- Routing table contains a list of destination and next **hop** for each destination.
- Routing table is built by routing protocol.



Routing and Hierarchical Addresses

- *Hierarchical addresses allow routing tables to be smaller and more concise.*

At switch 2:

Destination	Next hop	Destination	Next Hop
1,1	Interface 1	1, any	Interface 1
1,3	Interface 1		
3,6	Interface 4		
3,8	Interface 4	3, any	Interface 4
2,5	Interface 5	2, any	Local
2,6	Interface 6		

