Introduction to Networks and the Internet

CMPE 80N

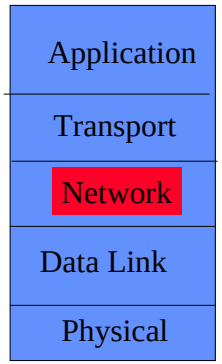
Winter 2004

Lecture 13

Announcements

The Network Layer

TCP/IP



Main Functions

- **Routing.**
  - *Find path (route) between source and destination.*
- **Forwarding.**
  - *When data is received, forward it toward the destination based on routing information.*
- *Who performs these function?*
  - **Routers/switches.**

How routers operate?

- *Store and forward.*
  - *Switch stores data they receive in memory; next switch examines data, determines which interface to send it, and forwards data on.*
- *Next-hop forwarding.*
  - *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.*

Routing Table

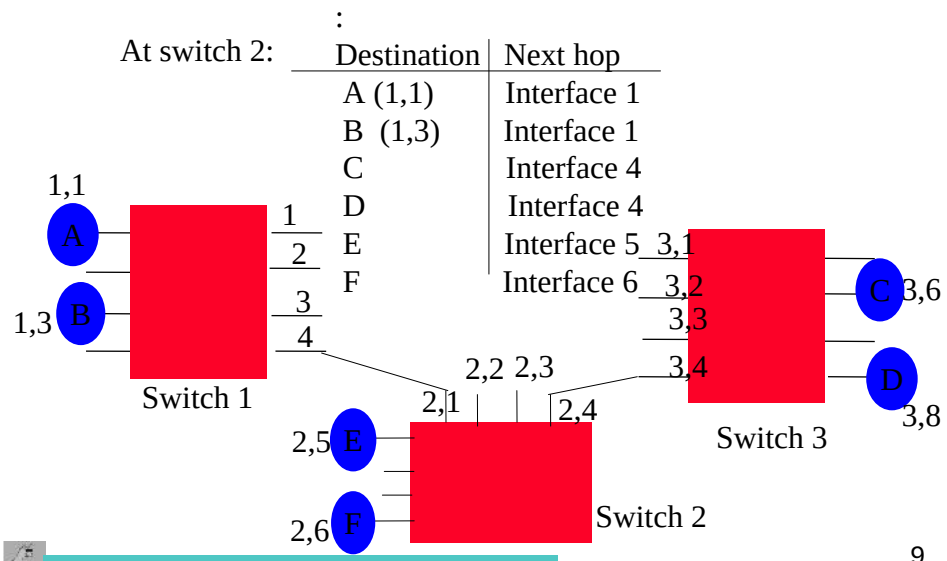
Routing Table

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

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
1,1	Interface 1
1,3	Interface 1
3,6	Interface 4
3,8	Interface 4
2,5	Interface 5
2,6	Interface 6

Destination	Next Hop
1, any	Interface 1
3, any	Interface 4
2, any	Local

Network Layer: Implementation and Services

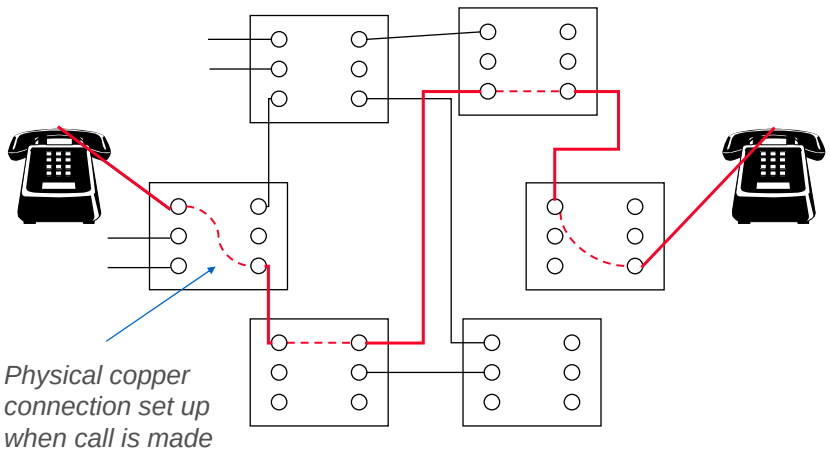
Network Layer: Implementation and Services

- *Circuit switching versus packet switching.*

Circuit Switching

- *Old telephone technology*
- *For each connection, physical switches are set in the telephone network to create a **physical "circuit"***
  - *That's the job of the switching office*

Circuit Switching - Example



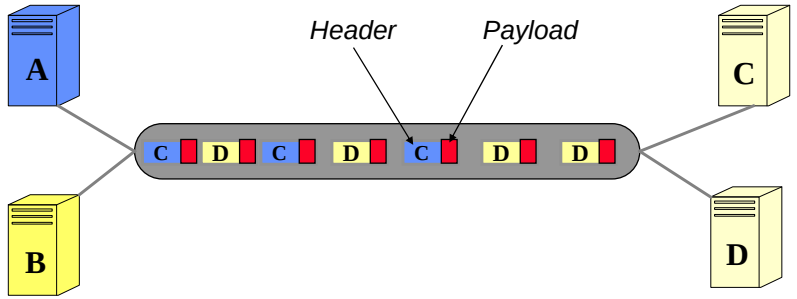
Circuit Switching (cont'd)

- *Switches are set up at the beginning of the connection and maintained throughout the connection*
- *Network resources **reserved** and **dedicated** from sender to receiver*
- *Not a very efficient strategy*
  - *A connection "holds" a physical line even during "silence" periods (when there is nothing to transmit)*

Packet Switching

- *Sharing by taking turns.*
  - *Analogy: conveyor belt in a warehouse.*
  - *Items are picked from the storage room and placed on the conveyor belt every time a customer makes an order.*
  - *Different customers may request a different number of items.*
  - *Different users' items may be interspersed on the conveyor belt (they are "multiplexed").*
- *Networks use a similar idea*
  - ***Packet Switching***
    - ***Packetize*** *data to transfer.*
    - ***Multiplex*** *it onto the wire.*
  - *Packets from different connections share the same link.*

Packet Switching Example



Packet Switching

- *Each packet is composed by the* ***payload*** *(the data we want to transmit) and a* ***header.***
  - *The header contains information useful for network layer functions.*
  - *Contains:*
    - *Source (sender's) address*
    - *Destination (recipient's) address*
    - *Packet size*
    - *Sequence number*
    - *Error checking information*

Packet Switching (cont'd)

- *The header introduces* ***overhead****, that is, additional bits to be sent.*
  - *Therefore, it is not wise to have packets that are too small.*
    - *What happens if the payload is just 1 bit?*
- ***Addresses***
  - *Each computer attached to a network is assigned a unique* ***number*** *(called* ***address****).*
  - *A packet contains the address of the sender and the receiver.*

Packet Switching (cont'd)

- *In general, packets need not be of the same size*
  - *Maximum transmission unit (MTU)*
  - *No minimum size*
    - *But, header size is fixed (e.g., 20 bytes for TCP/IP).*
- *Original data chopped up into packets.*
  - *The application (e.g., email) does not know that the data to be transmitted is packetized.*
  - *When packets are received, they are put together before the application accesses the data*

Packet Switching (cont'd)

- *What kind of **delay** should we expect?*
  - *Time-division multiplexing: **constant delay.***
  - *Packet switching multiplexing: **variable delay** (it depends on the **traffic** on the line).*
    - *Conveyor belt example: if there are many customers before you, you may have to wait more.*

Circuit Switching vs Packet Switching

Circuit switching

- *Must set up a connection (initial delay)*
- *Connection is reliable*
- *Resources are dedicated*
  - *Therefore they are used inefficiently!*

Packet switching

- *Very small set-up delay*
- *Efficient shared use of resources*
- *Possible congestion and consequent packet dropping*