Wide area networks: packet switching and congestion

Packet switching
ATM and Frame Relay
Congestion

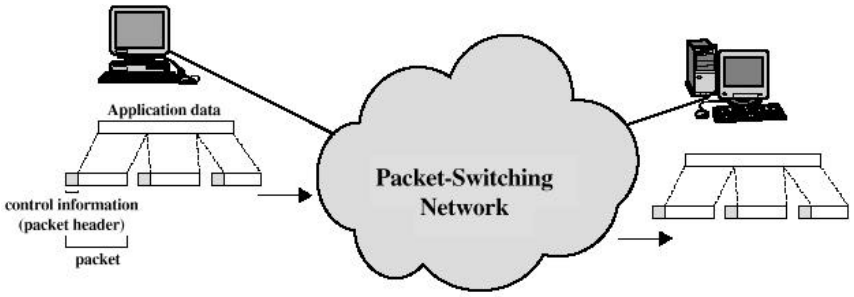
Circuit and Packet Switching

- Circuit switching designed for voice
  - Resources dedicated to a particular call
  - Much of the time a data connection is idle
  - Data rate is fixed
    - Both ends must operate at the same rate
- Packet Switching designed for data
  - resources allocated as required
  - idle time does not generate any overhead
  - data rate can vary

Basic Operation

- Data transmitted in small packets
  - Typically 1000 octets
  - Longer messages split into series of packets
  - Each packet contains a portion of user data plus some control info
- Control info
  - Routing (addressing) info
- Packets are received, stored briefly (buffered) and past on to the next node
  - Store and forward

Use of Packets



Advantages

- Line efficiency
  - Single node to node link can be shared by many packets over time
  - Packets queued and transmitted as fast as possible
- Data rate conversion
  - Each station connects to the local node at its own speed
  - Nodes buffer data if required to equalize rates
- Packets are accepted even when network is busy
  - Delivery may slow down
- Priorities can be used

Switching Technique

- Station breaks long message into packets
- Packets sent one at a time to the network
- Packets handled in two ways
  - Datagram
  - Virtual circuit

Datagram

- Each packet treated independently
- Packets can take any practical route
- Packets may arrive out of order
- Packets may go missing
- Up to receiver to re-order packets and recover from missing packets
- (implies end-to-end error correction)

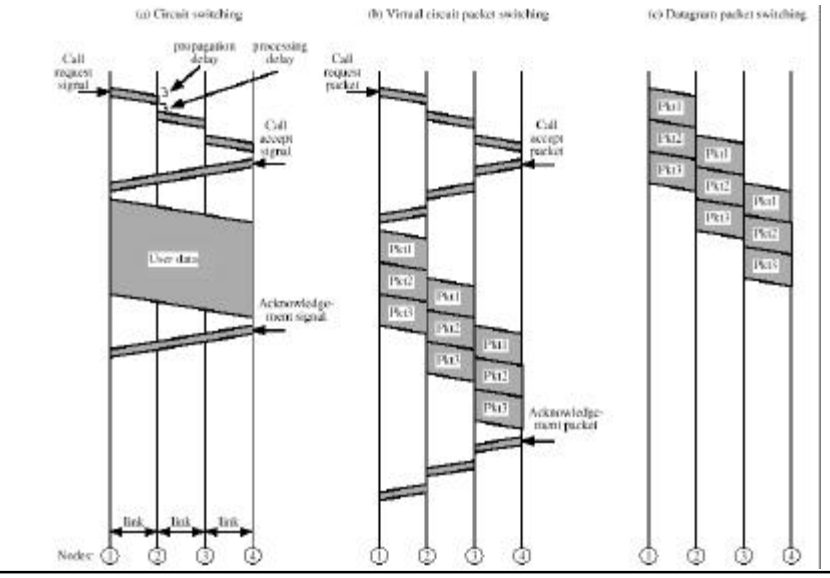
Virtual Circuit

- Preplanned route established before any packets sent
- Call request and call accept packets establish connection (handshake)
- Each packet contains a virtual circuit identifier instead of destination address
- No routing decisions required for each packet
- Clear request to drop circuit
- Not a dedicated path

Virtual Circuits v Datagram

- Virtual circuits
  - Network can provide sequencing and error control
  - Packets are forwarded more quickly
    - No routing decisions to make
  - Less reliable
    - Loss of a node loses all circuits through that node
- Datagram
  - No call setup phase
    - Better if few packets
  - More flexible
    - Routing can be used to avoid congested parts of the network

Event Timing



External and Internal Operation

- Packet switching - datagrams or virtual circuits
- Interface between station and network node
  - Connection oriented
    - Station requests logical connection (virtual circuit)
    - All packets identified as belonging to that connection & sequentially numbered
    - Network delivers packets in sequence
    - External virtual circuit service
      - e.g. X.25
    - Different from internal virtual circuit operation
  - Connectionless
    - Packets handled independently
    - External datagram service
    - Different from internal datagram operation

Combinations (1)

- External virtual circuit, internal virtual circuit
  - Dedicated route through network
- External virtual circuit, internal datagram
  - Network handles each packet separately
  - Different packets for the same external virtual circuit may take different internal routes
  - Network buffers at destination node for re-ordering

Combinations (2)

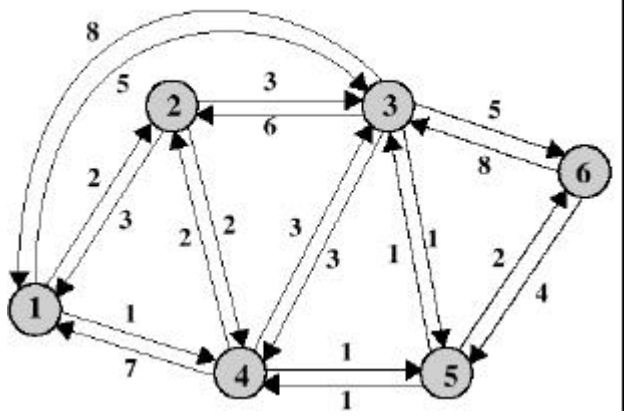
- External datagram, internal datagram
  - Packets treated independently by both network and user
- External datagram, internal virtual circuit
  - External user does not see any connections
  - External user sends one packet at a time
  - Network sets up logical connections

Routing

- Complex, crucial aspect of packet switched networks
- Characteristics required
  - Correctness
  - Simplicity
  - Robustness
  - Stability
  - Fairness
  - Optimality
  - Efficiency
- Rather a lot!

Costing of Routes

Link cost depends on
link speed (raw)
link latency
link queue size



When and where are routing decisions taken?

- When
  - On a Packet or virtual circuit basis
- Where
  - Distributed
    - Made by each node
  - Centralized
  - at Source

Network Information Source and Update Timing

- Routing decisions usually based on knowledge of network (not always)
- Distributed routing
  - Nodes use local knowledge
  - May collect info from adjacent nodes
  - May collect info from all nodes on a potential route
- Central routing
  - Collect info from all nodes
- Update timing
  - When is network info held by nodes updated
  - Fixed - never updated
  - Adaptive - regular updates