Week 11

Circuit Switching
Packet Switching
Switching Networks

- Long distance transmission is typically done over a network of switched nodes
- Nodes not concerned with content of data
- End devices are stations
  - Computer, terminal, phone, etc.
- A collection of nodes and connections is a communications network
- Data routed by being switched from node to node
Nodes

- Nodes may connect to other nodes only, or to stations and other nodes
- Node to node links usually multiplexed
- Network is usually partially connected
  - Some redundant connections are desirable for reliability
- Transmission of switched nodes may be either…
  - Circuit switching
  - Packet switching
Simple Switched Network
Circuit Switching

- Dedicated communication path between two stations
- Three phases
  - Establish
  - Transfer
  - Disconnect
- Must have switching capacity and channel capacity to establish connection
- Must have “intelligence” to work out routing
Circuit Switching - Applications

- Inefficient
  - Channel capacity dedicated for duration of connection
  - If no data, capacity wasted
- Set up (connection) takes time
- Once connected, transfer is “transparent”
  - Transfer appears independent of the underlying network
- Developed for voice traffic (phone)
Public Circuit Switched Network

Consists of several (hierarchical) levels of switching between end nodes.
Telecomms Components

- **Subscriber**
  - Devices attached to network
- **Local Loop**
  - Subscriber loop
  - Connection to network
- **Exchange**
  - Switching centers
  - End office - supports subscribers
- **Trunks**
  - Branches between exchanges
  - Multiplexed
Circuit Switch Elements

- Generic switch elements:
  - duplex lines to devices
  - network interface
  - digital switching
  - control
Circuit Switching Concepts

- **Digital Switch**
  - Provide transparent signal path between devices

- **Network Interface**

- **Control Unit**
  - Establish connections
    - Generally on demand
    - Handle and acknowledge requests
    - Determine if destination is free
    - Construct path
  - Maintain connection
  - Disconnect
Blocking or Non-blocking

- A switch may be either blocking or non-blocking

- Blocking
  - A network is unable to connect stations because all paths are in use
  - A blocking network allows this
  - Used on voice systems
    - Short duration calls

- Non-blocking
  - Permits all stations to connect (in pairs) at once
  - Used for some data connections
Space Division Switching

- Developed for analog environment
- Separate physical paths
- Crossbar switch
  - Number of crosspoints grows as square of number of stations
  - Loss of crosspoint prevents connection
  - Inefficient use of crosspoints
    - All stations connected, only a few crosspoints in use
  - Non-blocking
Crossbar Matrix

Appropriate switch is activated to connect call.
Multistage Switch

- Reduced number of crosspoints
- More than one path through network
  - Increased reliability
- More complex control
- May be blocking
How many connections are required for the previous three stage switch compared to the crossbar matrix? How many calls can simultaneously be supported in each?
Time Division Switching

- Partition low speed bit stream into pieces that share higher speed stream
- e.g. TDM bus switching
  - based on synchronous time division multiplexing
  - Each station connects through controlled gates to high speed bus
  - Time slot allows small amount of data onto bus
  - Another line’s gate is enabled for output at the same time
Routing

- Many connections will need paths through more than one switch
- Need to find a route
  - Efficiency
  - Resilience
- Public telephone switches are a tree structure
  - Static routing uses the same approach all the time
- Dynamic routing allows for changes in routing depending on traffic
  - Uses a peer structure for nodes
Alternate Routing

- Possible routes between end offices predefined
- Originating switch selects appropriate route
- Routes listed in preference order
- Different sets of routes may be used at different times
Control Signaling Functions

- Audible communication with subscriber
- Transmission of dialled number
- Call cannot be completed indication
- Call ended indication
- Signal to ring phone
- Billing info
- Equipment and trunk status info
- Diagnostic info
- Control of specialist equipment
Switch to Switch Signaling

- Subscribers connected to different switches
- Originating switch seizes inter-switch trunk
- Send off hook signal on trunk, requesting digit register at target switch (for address)
- Terminating switch sends off hook followed by on hook (wink) to show register ready
- Originating switch sends address
Location of Signalling

- Subscriber to network
  - Depends on subscriber device and switch
- Within network
  - Management of subscriber calls and network
  - More complex
In Channel Signalling

- Use same channel for signalling and call
  - Requires no additional transmission facilities
- In-band
  - Uses same frequencies as voice signal
  - Can go anywhere a voice signal can
  - Impossible to set up a call on a faulty speech path
- Out of band
  - Voice signals do not use full 4kHz bandwidth
  - Narrow signal band within 4kHz used for control
  - Can be sent whether or not voice signals are present
  - Need extra electronics
  - Slower signal rate (narrow bandwidth)
Drawbacks of In Channel Signalling

- Limited transfer rate
- Delay between entering address (dialling) and connection
- Overcome by use of common channel signalling
Common Channel Signalling

- Control signals carried over paths independent of voice channel
- One control signal channel can carry signals for a number of subscriber channels
- Common control channel for these subscriber lines
- Associated Mode
  - Common channel closely tracks interswitch trunks
- Disassociated Mode
  - Additional nodes (signal transfer points)
  - Effectively two separate networks
Common v. In Channel Signalling

(a) Incannel

(b) Common channel

CCIS SIG: Common-channel interoffice signaling equipment
SIG: Per-trunk signaling equipment
Signalling Modes

(a) Associated

(b) Disassociated
Signalling System Number 7

- SS7
- Common channel signalling scheme
- ISDN
- Optimized for 64k digital channel network
- Call control, remote control, management and maintenance
- Reliable means of transfer of info in sequence
- Will operate over analog and below 64k
- Point to point terrestrial and satellite links
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
**Step 5: Connection Establishment**

- A Call Request Packet would be sent to the network. Routers would direct the CRP depending on the network conditions and configurations to another node or destination.

- Subsequently, a logical path would be established between the sender and the receiver.

- Receiver sends a Call Accept Packet back to Sender along the logical path if receiver is ready to accept the connection.
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
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 equalise 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
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 Circuit vs 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 looses 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
Data to be set in one large packet, with a small fixed header. First from X (source) to a

Then from a to b

And finally, from b to Y (destination)

But, with more (smaller) packets the data can be forwarded sooner, and this reduces transmission time. If the individual packets are too small, then the header size becomes significant, and the transmission takes longer.
Referring to the previous diagram, what is the optimum packet size to transmit 20kB of data over 2 intermediary nodes with 32 bits of header information?
Circuit vs Packet Switching

- Performance
  - Propagation delay
  - Transmission time
  - Node delay
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

- **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

- 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
(a) External virtual circuit. A logical connection is set up between two stations. Packets are labeled with a virtual circuit number and a sequence number. Packets arrive in sequence.

(b) External datagram. Each packet is transmitted independently. Packets are labeled with a destination address and may arrive out of sequence.
Internal Virtual Circuit and Datagram Operation

(a) Internal virtual circuit. A route for packets between two stations is defined and labeled. All packets for that virtual circuit follow the same route and arrive in the same sequence.

(b) Internal datagram. Each packet is treated independently by the network. Packets are labeled with a destination address and may arrive at the destination node out of sequence.
Virtual Circuit

Step 1: Connection Establishment

- A Call Request Packet would be sent to the network. Routers would direct the CRP depending on the network conditions and configurations, to another node or destination. Subsequently, a logical path would be established between the sender and the receiver.

- Receiver sends a Call Accept Packet back to Sender along the logical path if receiver is ready to accept the connection.
Each packet is treated independently. Packets, each with the same destination address, do not follow the same route.

It is possible that packets will be delivered to the destination in a different sequence from the one in which they were sent.
- Each packet is treated independently. Packets, each with the same destination address, do not follow the same route.
- It is possible the packets will be delivered to the destination in a different sequence from the one in which they were sent.