Chapter 10
Circuit Switching and 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
- Two different switching technologies
  - 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
- Developed for voice traffic (phone)
Public Circuit Switched Network

End Office

Subscriber Loop

Connecting Trunk

Long-distance office

Intercity Trunk

Long-distance office

Connecting Trunk

Digital PBX
Telecomms Components

- Subscriber
  - Devices attached to network

- Subscriber line
  - Local Loop
  - Subscriber loop
  - Connection to network
  - Few km up to few tens of km

- Exchange
  - Switching centers
  - End office - supports subscribers

- Trunks
  - Branches between exchanges
  - Multiplexed
Circuit Establishment

a

b

End office

 Intermediate exchange

Trunk

Trunk

c

d

End office
Circuit Switch Elements
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

- **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
Space Division Switch
Multistage Switch

- Reduced number of crosspoints
- More than one path through network
  - Increased reliability
- More complex control
- May be blocking
Three Stage Space Division Switch

FIRST STAGE

SECOND STAGE

THIRD STAGE

1

2

5 → 2 switch

2 → 2 switch

2 → 5 switch

1

2

3

4

5

6

7

8

9

10

6

7

8

9

10
Time Division Switching

- Modern digital systems rely on intelligent control of space and time division elements
- Use digital time division techniques to set up and maintain virtual circuits
- Partition low speed bit stream into pieces that share higher speed stream
Control Signaling Functions

- Audible communication with subscriber
- Transmission of dialed number
- Call can not be completed indication
- Call ended indication
- Signal to ring phone
- Billing info
- Equipment and trunk status info
- Diagnostic info
- Control of specialist equipment
Control Signal Sequence

- Both phones on hook
- Subscriber lifts receiver (off hook)
- End office switch signaled
- Switch responds with dial tone
- Caller dials number
- If target not busy, send ringer signal to target subscriber
- Feedback to caller
  - Ringing tone, engaged tone, unobtainable
- Target accepts call by lifting receiver
- Switch terminates ringing signal and ringing tone
- Switch establishes connection
- Connection release when Source subscriber hangs up
Switch to Switch Signaling

- Subscribers connected to different switches
- Originating switch seizes interswitch 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 Signaling

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

- Use same channel for signaling and call
  - Requires no additional transmission facilities
- Inband
  - 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 Signaling

- Limited transfer rate
- Delay between entering address (dialing) and connection
- Overcome by use of common channel signaling
Common Channel Signaling

• 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 Signaling

(a) Inchannel

Office A ─────────── Office B
✦ SIG

Office C ─────────── Office D
✦ SIG
✦ Processor
✦ CCIS SIG
✦ Processor
✦ CCIS SIG

(b) Common channel

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

(a) Associated

(b) Disassociated
Signaling System Number 7

- SS7
- Common channel signaling 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
SS7
Signaling Network Elements

• Signaling point (SP)
  — Any point in the network capable of handling SS7 control message

• Signal transfer point (STP)
  — A signaling point capable of routing control messages

• Control plane
  — Responsible for establishing and managing connections

• Information plane
  — Once a connection is set up, info is transferred in the information plane
Transfer Points

STP = Signaling transfer point
SP = Signaling point
TC = Transit center
LE = Local Exchange
Signaling Network Structures

- STP capacities
  - Number of signaling links that can be handled
  - Message transfer time
  - Throughput capacity

- Network performance
  - Number of SPs
  - Signaling delays

- Availability and reliability
  - Ability of network to provide services in the face of STP failures
Softswitch Architecture

- General purpose computer running software to make it a smart phone switch
- Lower costs
- Greater functionality
  - Packetizing of digitized voice data
  - Allowing voice over IP
- Most complex part of telephone network switch is software controlling call process
  - Call routing
  - Call processing logic
  - Typically running on proprietary processor
- Separate call processing from hardware function of switch
- Physical switching done by media gateway
- Call processing done by media gateway controller
Traditional Circuit Switching

- Call Processing
- Circuit switching fabric
- SS7 Network

Supervisory events e.g., off-hook, on hook

Request to generate progress tones, e.g., ringback, engaged. Instructions to establish switch fabric connections.

Circuit switched trunks
Supervisory events e.g., off-hook, on hook

Request to generate progress tones, e.g., ringback, engaged. Instructions to establish switch fabric connections.

Circuit or packet switched access

Media gateway

Media gateway controller

SS7 Network

Circuit or packet switched trunks
Packet Switching Principles

• 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
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
Datagram Diagram

(a)

(b)

(c)

(d)

(e)
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 Diagram
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 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
Packet Size
Circuit v Packet Switching

- Performance
  - Propagation delay
  - Transmission time
  - Node delay
Event Timing

(a) Circuit switching
(b) Virtual circuit packet switching
(c) Datagram packet switching