Electronics and Electrical
Communications Eng. dept.
Faculty of Engineering
Cairo University

قسم هندسة الالكترونيات والاتصالات الكهربية
كلية الهندسة
جامعة القاهره

Communications Engineering Part B

Unit 2: Telephone System

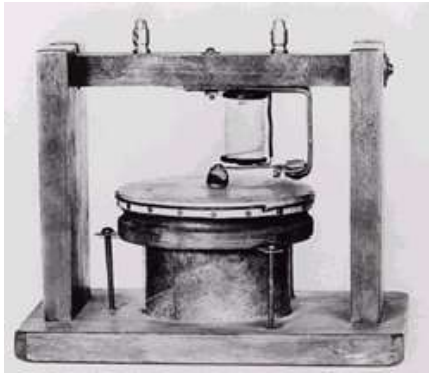
1

Module 1: Introduction to Public Switched Telephone Network (PSTN)

- History of PSTN
- Telephone Networks, Switching, and Signaling

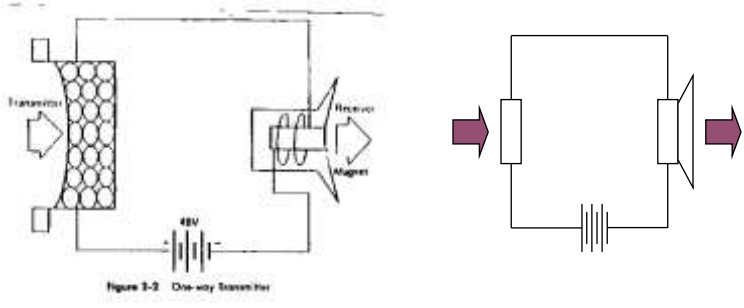
2

History of Public Switching Telephone Network (PSTN)



1876 A. G. Bell telephone patent

Bell's original system was single wire with earth return.



• Transmitter (originally a carbon particle microphone) varied the electrical energy inversely proportional to the sound energy. Receiver (transducer) recreated the sound.

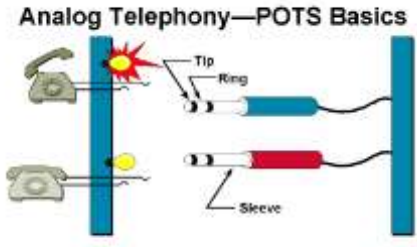
• Early systems used local batteries. Eventually a "common battery" model became prevalent.

Original PSTN

1878 The first exchange constructed in La Porte, the US that could connect any two of the 21 subscribers using manual switching (!)

Manual switching directly connected two *local loops*. Due to microphone technology, audio BW was 4 kHz

Manual switching



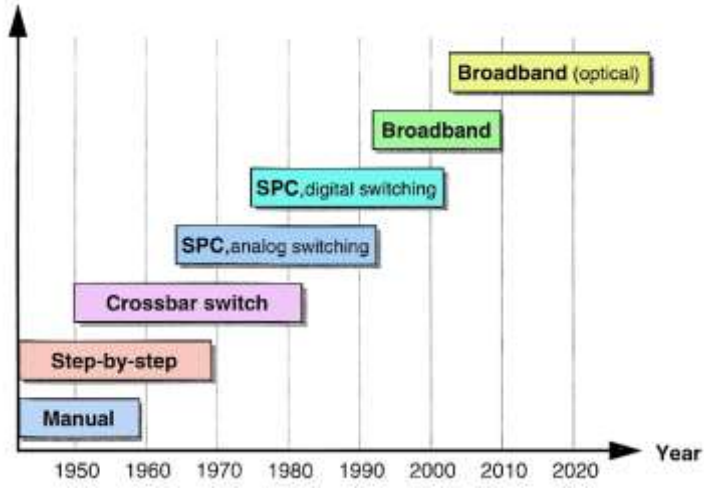
History of PSTN (1)

- **Telegraph systems**
  - 1837: Wheatstone and Morse
- **Telephone**
  - 1876: Alexander Graham Bell
- **Automatic Switching Exchanges**
  - 1891: Almon Brown Strowger patents first automatic exchange.
  - 1920: Register-controlled setup where asubscriber number is received by a register that controls all the remaining call setup stages
  - 1953: C.Clos develops theory of switch architectures

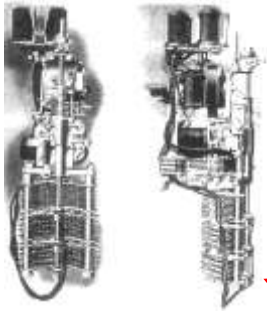
History of PSTN (2)

- **Traffic Theory**
  - 1902: C.E. Molina
  - 1915: K. D. Erlang
- **Digitization**
  - 1939: Alex Reeves invents PCM
  - leads to al digital networks (PDH, ISDN)
  - 1965, AT&T introduced the first electronic switching systems. Stored program control (SPC).
  - 1976: new type of electronic switch using time division switching was put into service

Switching Technology Evolution

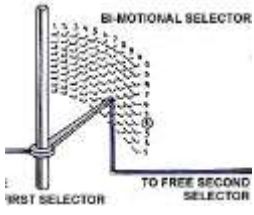


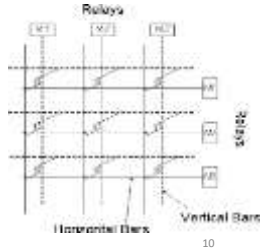
Early Exchanges



Crossbar Switch

Strowger two-motion selector

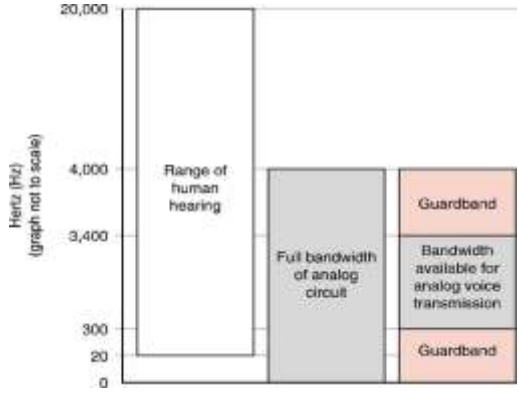




Evolution of Telephone Sets

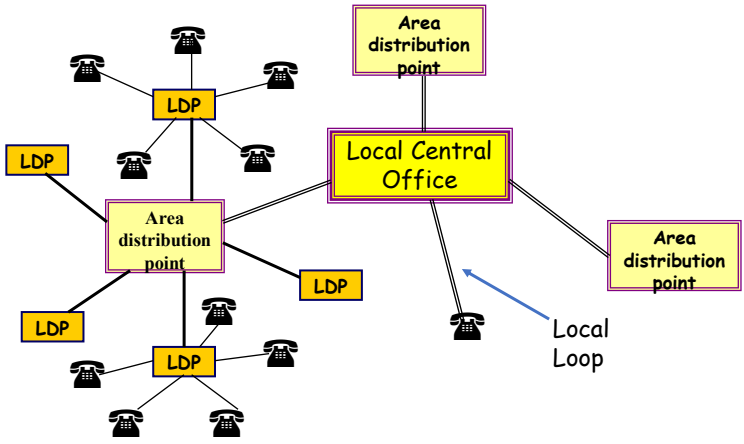
Telephone Networks, LAN, Switching, and Signalling

Voice Channel



Actual telephone voice bandwidth is 3400 Hz, which is narrow than the bandwidth of the connecting wires.

Local Network Network (LAN) Architecture

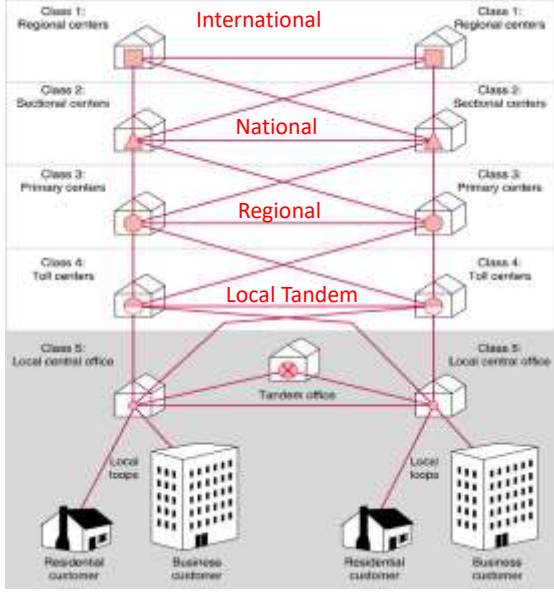


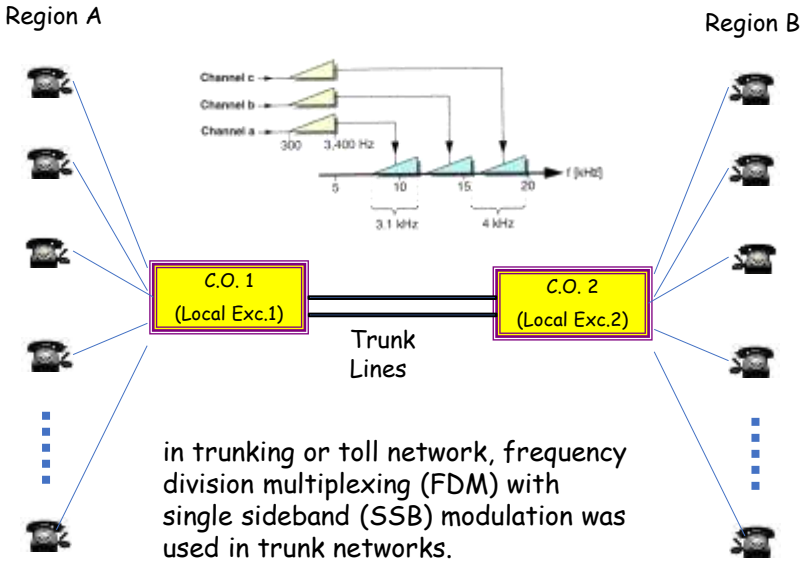
The circuit between the central office and customer is called the ***local loop***
The local loop is the only remaining analog.

Network Hierarchy

Original AT&T network hierarchy was organized in a 5 class hierarchy

Hint: Office or exchange..

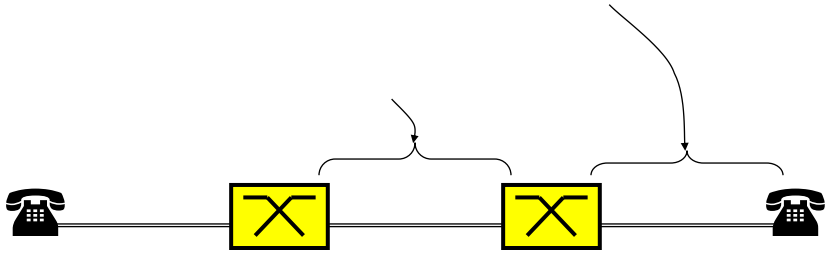




Switching

To enable automatic switching, the telephone system must feature the following essential components:

- Addressing.
- Communications between a subscriber and a switch.
- Communications between switches.



Addressing in PSTN

- Each subscriber is assigned a unique number. It comprises:

International prefix	+	Country code	+	Area code	+	Subscriber number

e.g., 00202 35678847

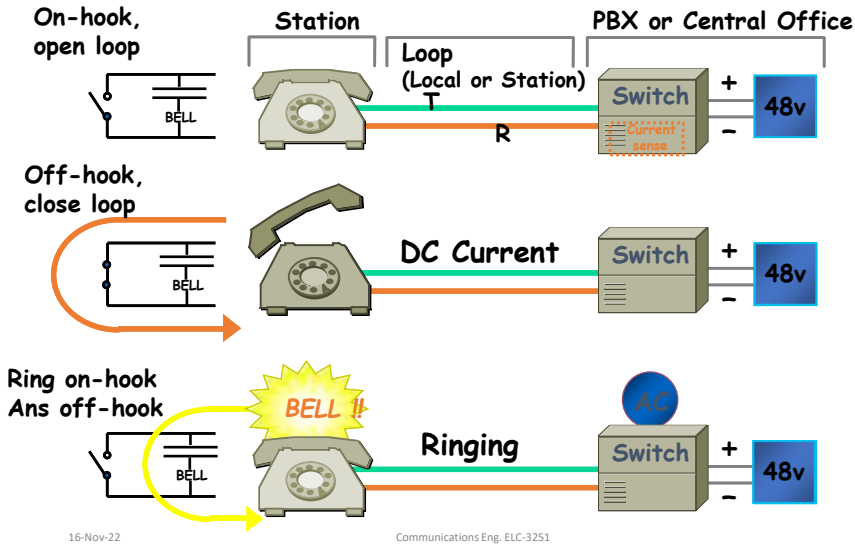
- *A **calling party*** enters the number of the ***called party*** to allow the PSTN to establish a path for the call.
- Some special numbers may be created for a specific purpose. For example: Hunting number.

Signaling: Subscriber ↔ Switch

- Communications between a subscriber and a switch is done by "in-band" signaling (except ISDN).
- In-band signaling uses the same channel to perform message exchanges between two devices. The same telephone channel is used to:
  - transmit dial digits (in the form of pulse signals or Dual Tone Multi Frequency tones) from a subscriber to a local switch.
  - transmit dial tone, ringing tone, etc… from a local switch to a subscriber.

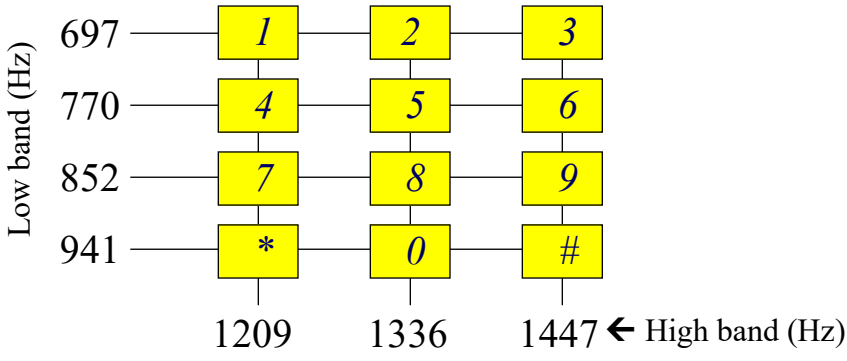
Hint: ISDN stands for Integrated service digital network

Examples of Signaling: Loop Start Signaling

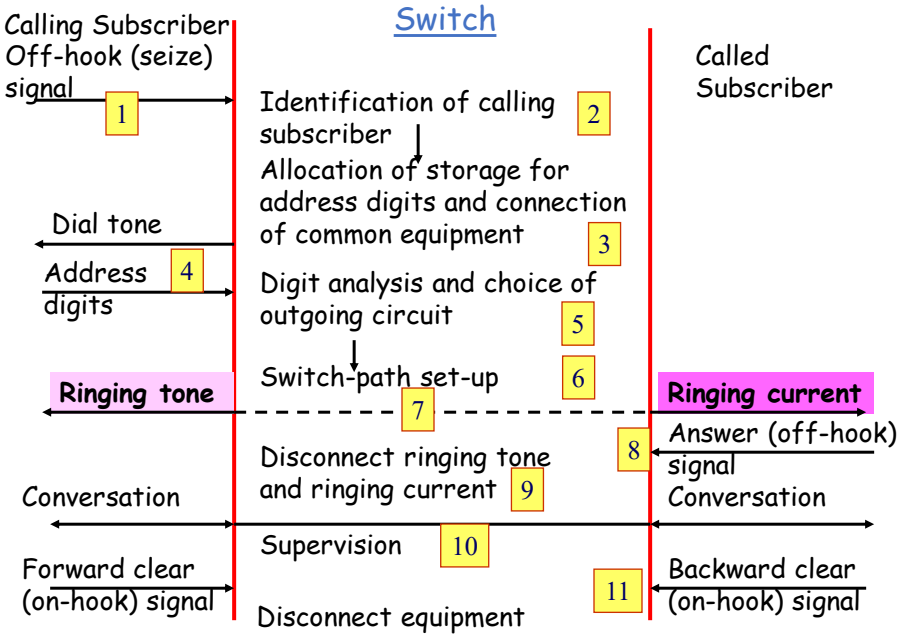


Dial Signals: DTMF Tones

Dual Tone Multi Frequency (DTMF) tones: a combination of two different frequencies representing each dialed digit.



To summarize, the Signal Sequence in a call Set up (Subscriber ↔ Switch) will be as follows:



In Channel Signaling

- Use same channel for signaling 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
  - Narrow signal band within 4kHz used for control
- **Out of band**
  - Voice signals do not use full 4kHz bandwidth
  - Can be sent whether or not voice signals are present
  - Need extra electronics
  - Slower signal rate (narrow bandwidth)

Drawbacks of In Channel Signaling

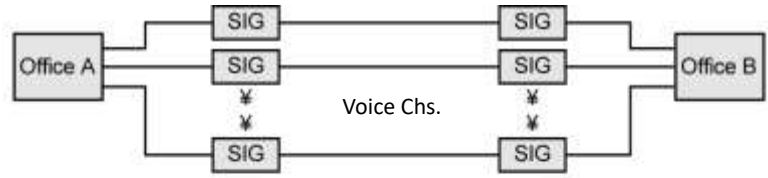
- Limited transfer rate
- Delay between entering address (dialing) and connection

All these can be overcome by use of ***common channel signaling (CCS)***.

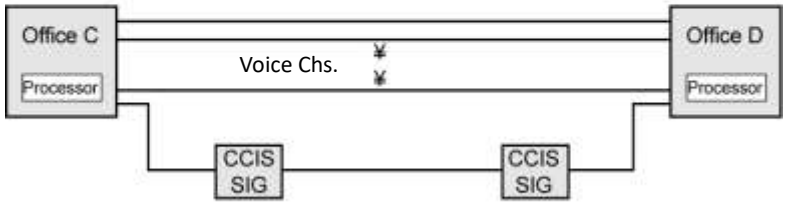
Common Channel Signaling

- Control signals are carried over paths independent of voice channels.
- One control signal channel can carry signals for a number of subscriber channels.

Common verses In Channel Signaling



In channel Signalling



Common Channel Signaling

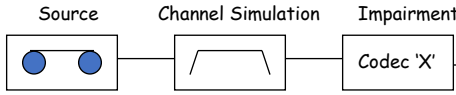
CCIS SIG: Common-channel interoffice signaling equipment
SIG: Per-trunk signaling equipment

Signaling System Number 7or SS7

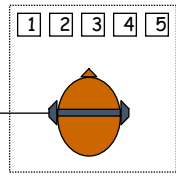
- Common channel signaling scheme
- Optimized for 64k digital channel network
- Call control, remote control, management and maintenance
- Reliable means of transfer of info in sequence
- Operate over analog and below 64k

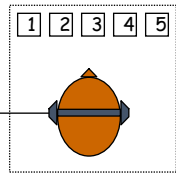
Quality Measurement

Mean Opinion Score (MOS)



Rating	Speech Quality	Level of Distortion
5	Excellent	Imperceptible
4	Good	Just perceptible but not annoying
3	Fair	Perceptible and slightly annoying
2	Poor	Annoying but not objectionable
1	Unsatisfactory	Very annoying and objectionable





MOS of 4.0 = Toll Quality

Unit 2: Telephone System

Module 2: Switching Techniques

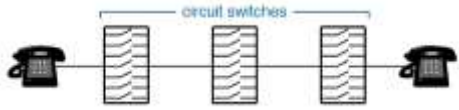
Switching Networks

- Long distance transmission is typically done over a network of switched nodes
- Nodes are 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 another.

Techniques Used in Switched Networks

- Circuit switching
- Packet switching

Circuit Switching



Dedicated communications path between two stations. This includes:

Circuit establishment
An end to end circuit is established through switching nodes

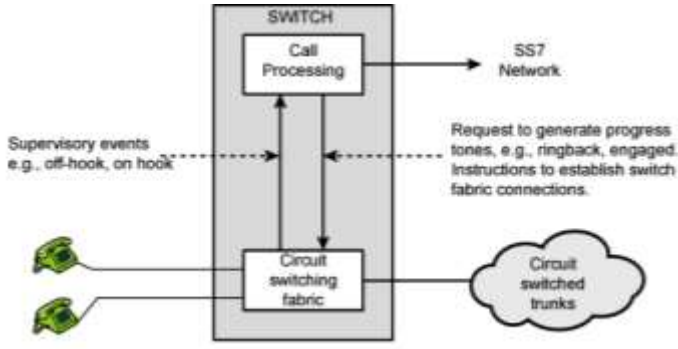
Information Transfer
Information transmitted through the network
Data may be analog voice, digitized voice, or binary data

Circuit disconnect
Circuit is terminated
Each node de-allocates dedicated resources

Characteristics of Circuit Switching

- Can be inefficient
  - Channel capacity dedicated for duration of connection
  - Utilization not 100%
  - Delay prior to signal transfer for establishment
- Once established, network is transparent to users
- Information transmitted at fixed data rate with only propagation delay

Traditional Circuit Switching



In electronic exchanges; there are two types of software (firmware):
System software (to deal with Control of timing, scheduling, interrupt handling, inter-process communications, input/output control, storage management, and human machine communication)
Application software (to deal with call processing , and maintenance)

Packet switching

- Messages split into series of blocks that is transmitted in small packets, typically 1000 bytes.
- Each packet contains a portion of user data plus some control info such as 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 equalize rates
- **Packets are accepted even when network is busy**
  - Delivery may slow down
- **Priorities can be used**

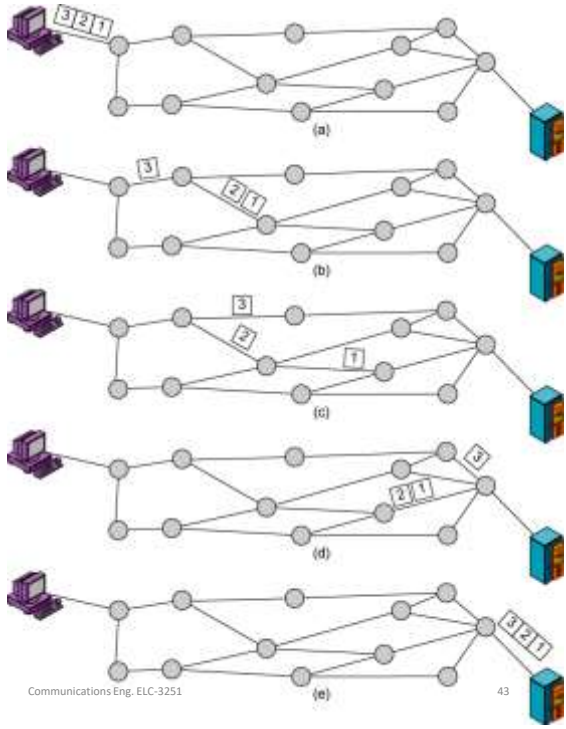
Packet Switching Techniques:

- 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

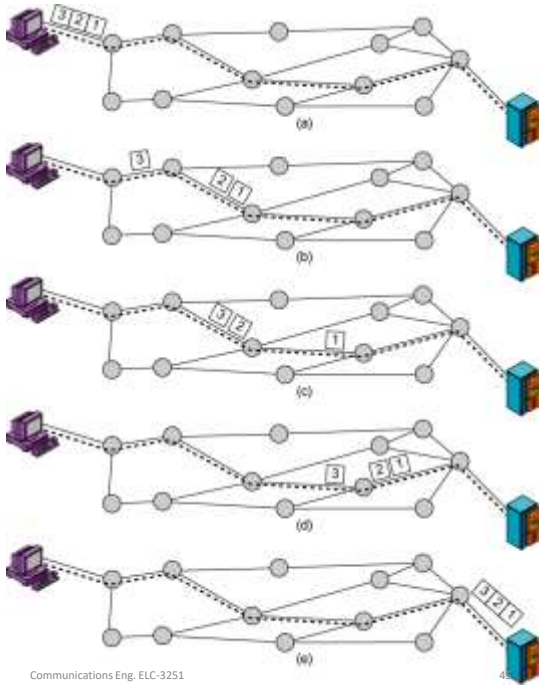
Datagram Diagram



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

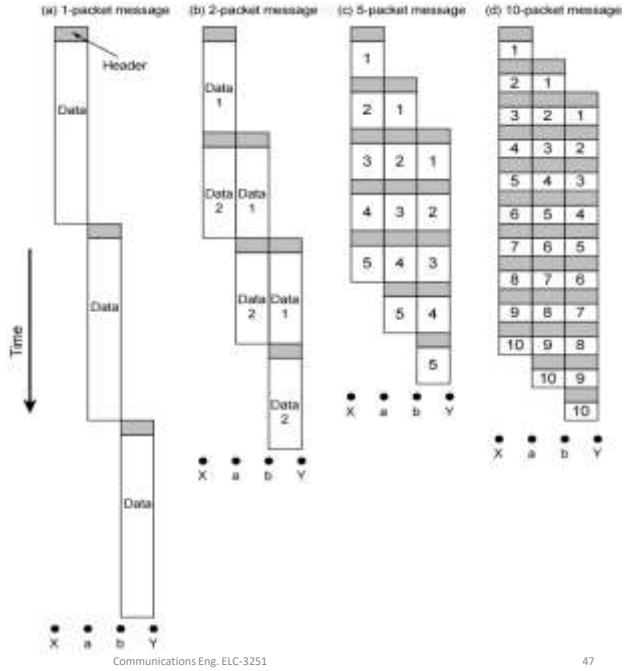
Virtual Circuit Diagram



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

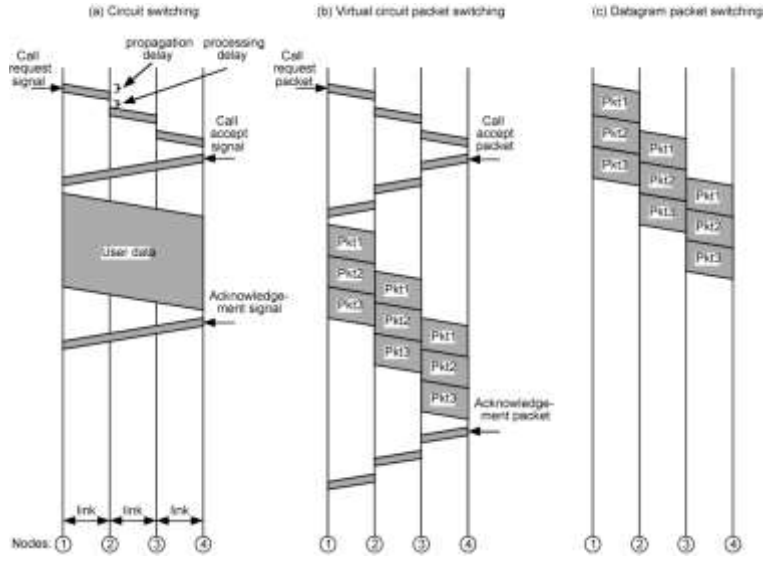
Packet Size



Circuit verse Packet Switching

- Performance
  - Propagation delay
  - Transmission time
  - Node delay

Event Timing



Soft switch
Architecture

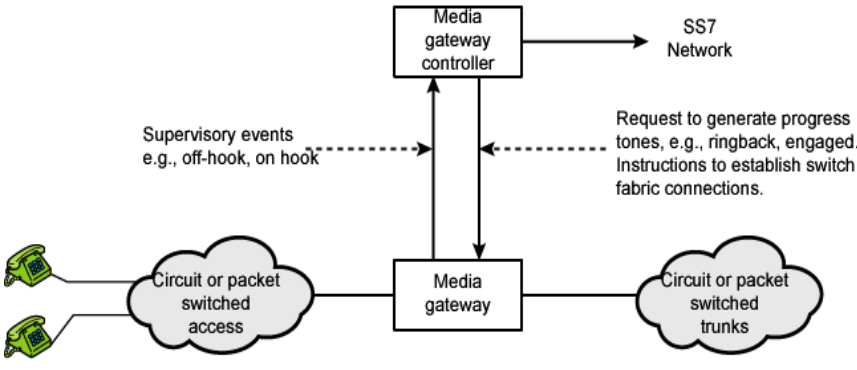
- The most complex part of telephone network switch is the software controlling call process which includes :
  - Call routing
  - Call processing logic

Hint: This is typically running on proprietary processor

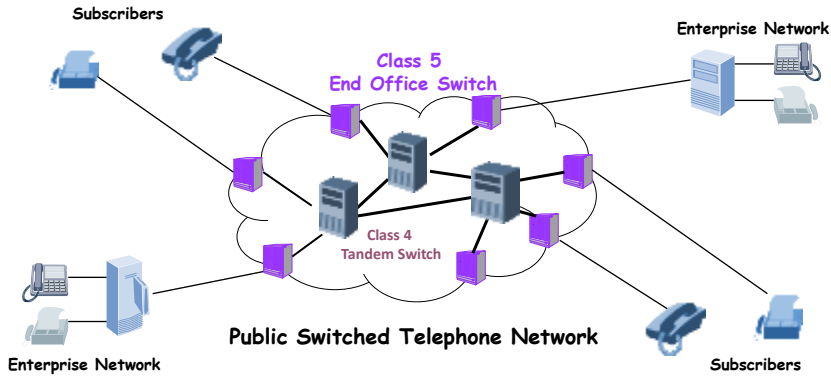
- Any general purpose computer can run software to make it a smart phone switch (assuming digitized voice) with:
  - Lower costs
  - Greater functionality

- In soft switching,
  - call processing is separated from hardware function of switch,
  - physical switching done by media gateway, and
  - call processing done by media gateway controller

Softswitch

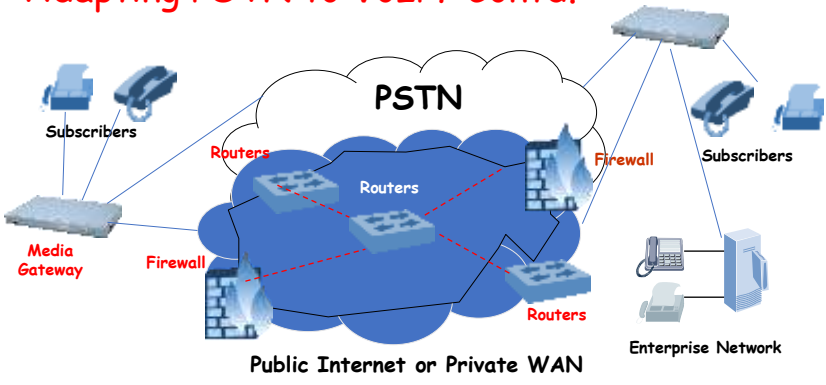


Adapting PSTN to VoIP?



All Routing Logic is managed by the Service Provider's Network .

Adapting PSTN to VoIP? Contd.



In most cases, IP Routing Logic is still managed by a Service Provider's Network.
VoIP Communication Protocols, such as SIP & H.323, allow control of communication routing without interfering with the Service Providers Network.

VoIP Media Gateways?

VoIP Media Gateways provide the bridge between PSTN Systems and VoIP