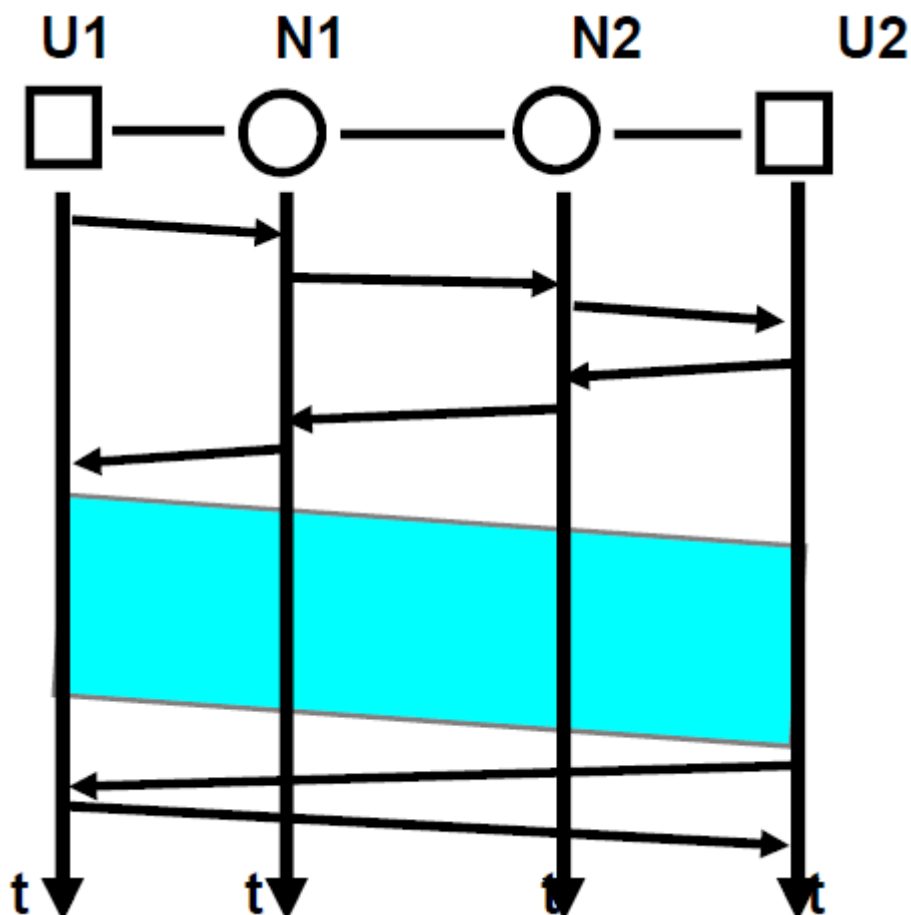# 4. Telephone network

4.1 Switching techniques

4.1.1 Circuit switching (commutazione, smistamento)

- Resources allocated uniquely to a circuit
- Connection oriented ⟶ Need to open and close the circuit to transmit
- Address used only when opening the circuit
- Data unit identified by position
- Routing performed only when opening the circuit
- Data forwarding

4.1.2 Packet switching
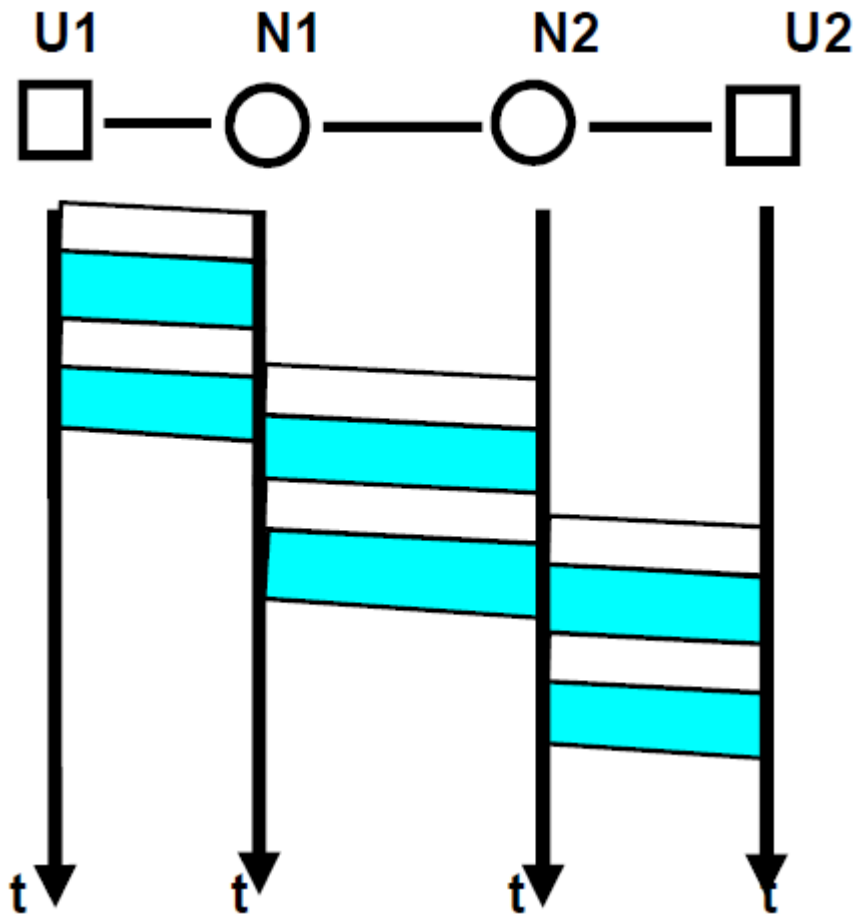
- Shared resources

- Connectionless

- Each packet must carry the destination (and source) address

- Data unit identified through source and destination addresses

- Routing and forwarding performed independently over each packet
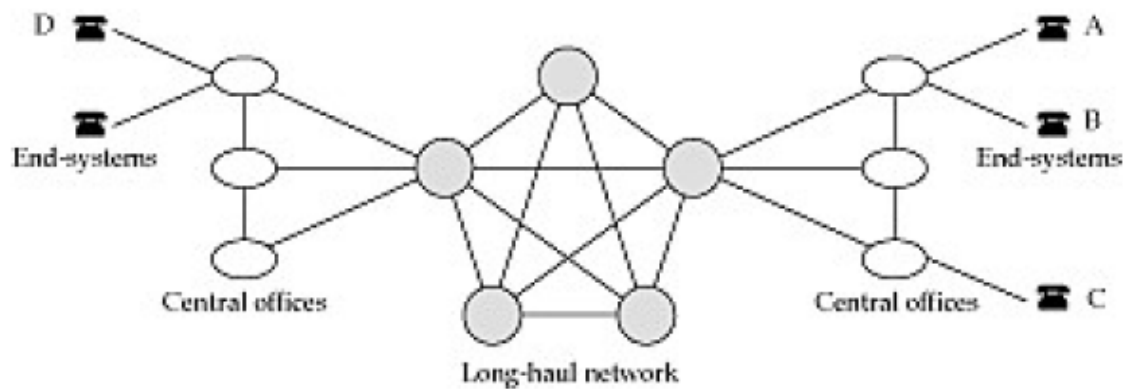
4.2 Telephone network

Specialized for voice, but also telemetry, fax, video, modem calls; uses digital samples

- **Basic service: Two-way voice**

low delay, guarantee of completion, connection through a circuit, full duplex signals, reserved bandwidth and buffer resources
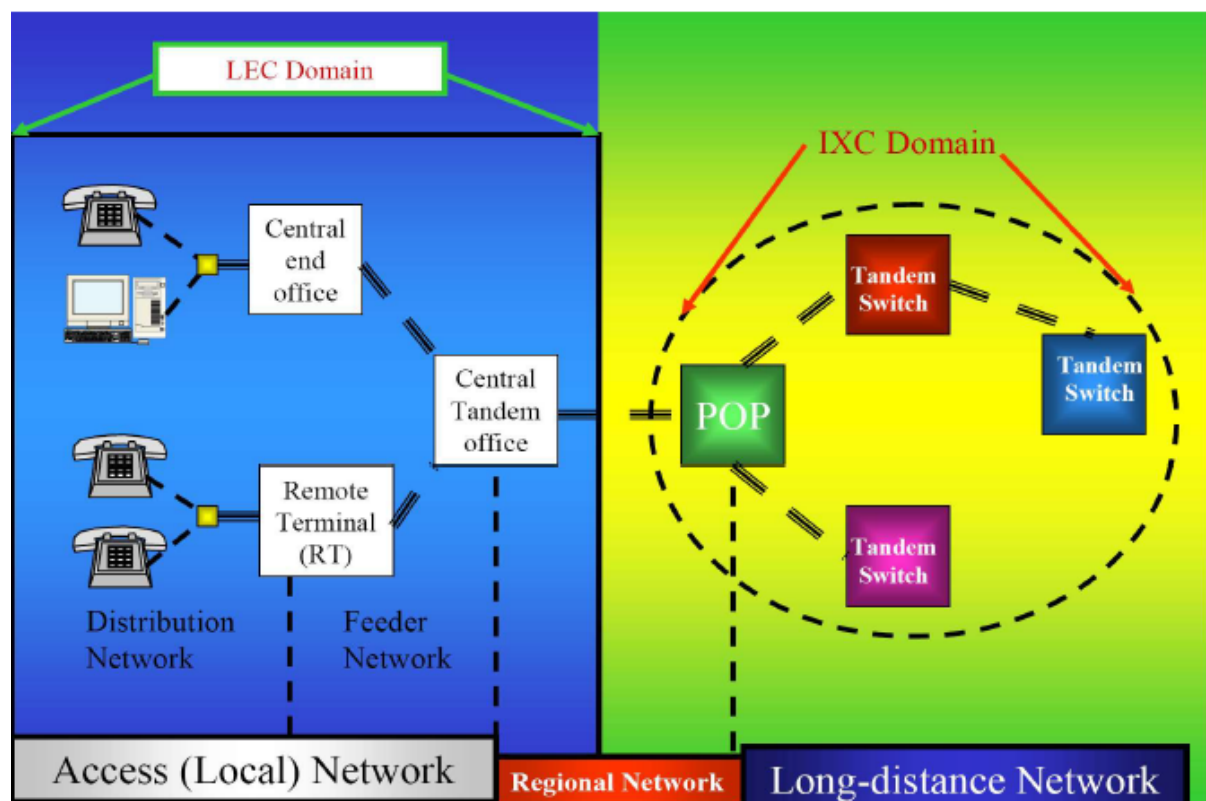
- **Design**

Hierarchy:

-Local office switches that connects directly to the customer

-Tandem office serves a cluster of local office

-Toll office switches traffic over long-distance

4.2 PSTN Arch. (Public Switched Telephone Network)

- **Local Exchange Carriers (LECs)**

provide local service, short-haul, long distance, centrex, voice mail etc.

- **Local access transport areas (LATA)**

Services offered by carriers (LECs) inside a LATA are called Intra-LATA services
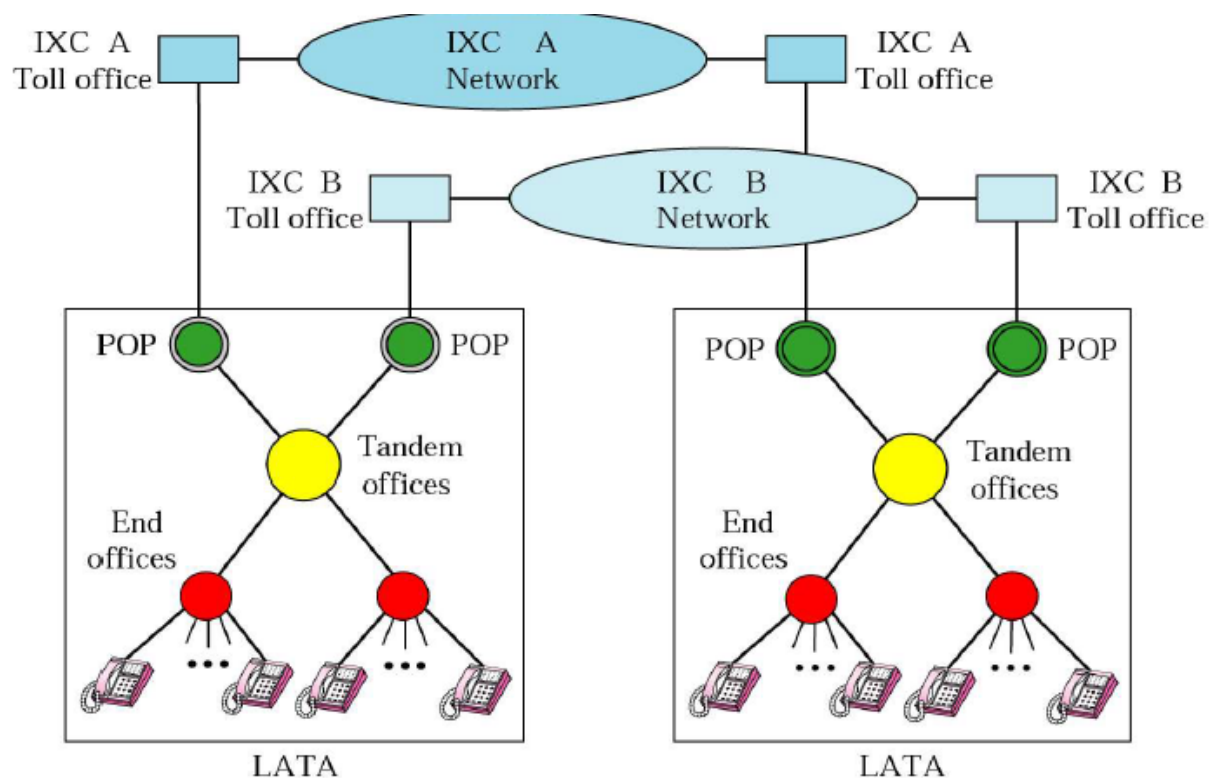
- **Competitive LEC (CLEC)**

Just business stuff

- **InterExchange Carriers (IXC or IEC)**

IXCs are responsible for connection across LATA and provide inter-LATA services

IXCs are connected to LECs through a POP (Point of presence) (a tandem switch)

A telephone call going through an IXC is normally digitized, with the carriers using several types of networks to provide service.

- **Point of Presence (POP)**

In telephone systems, POPs was a location where carriers terminate services and provide connection.

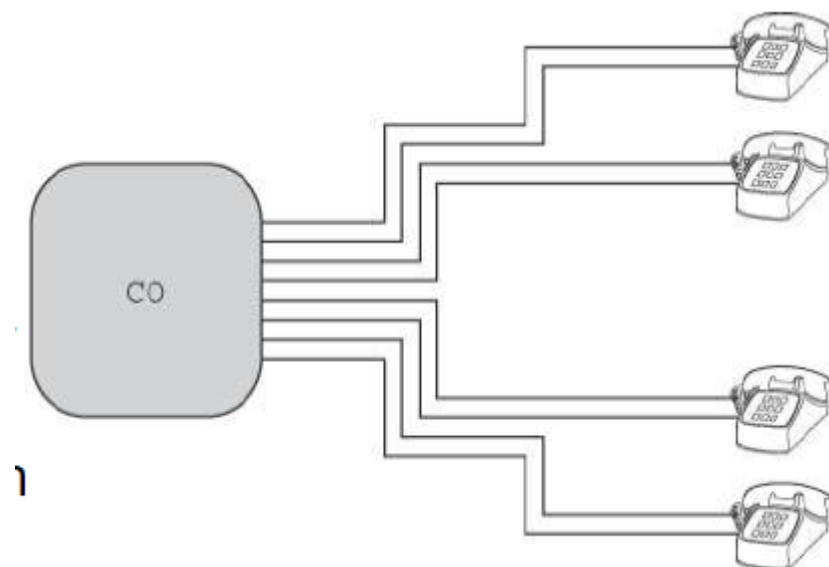Instead, an internet POP is a physical access point

Last mile transmission noises:

-Bridged-tap noise

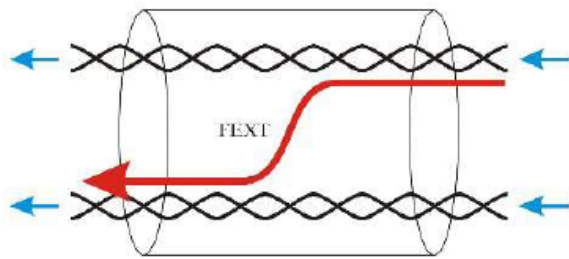-Crosstalk

-Ham radio

-AM broadcast

- **2-wire vs 4-wire**
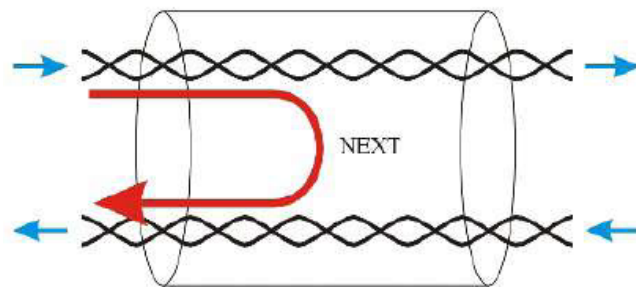
Trans & rec. need 2 wires

Reverse effect: received signal bounces back to CO: echo, to solve it: balance circuit + echo-cancellation circuit

- **Cross-talk noise**

- <u>Far-end cross-talk (FEXT)</u> is the cross-talk between a transmitter and a receiver placed on opposite sides of the cable

<u>Near-end cross-talk (NEXT)</u> is the cross-talk between a transmitter and a receiver placed on the same side of the cable

- **Dialing**

-Pulse: sends a pulse per digit to the Central Office

-Tone: key press sends a pair of tone = digit (Dual Tone multifrequency - DTMF)

-CO bring the ringing

4.3 Transmission Multiplexing

Send many calls on the same wire
– Multiplexing (Sharing)

- Analog: band-limit to 3.4 KHz, high frequency, obsolete

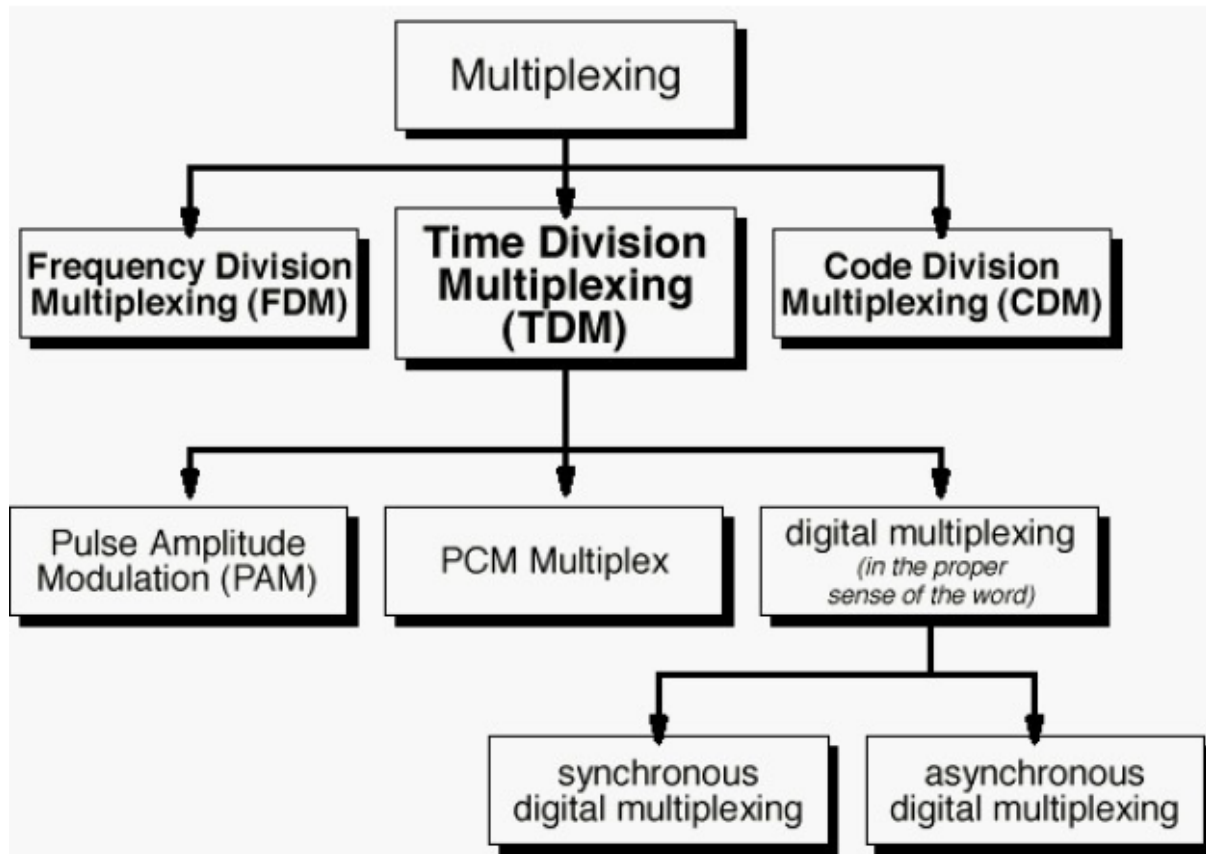- Digital: convert voice to samples → 1 sample = 8 bits → 8000 samples/sec

There are 256 quantization logarithmically spaced levels, the value is the amplitude of nearest quantization level.
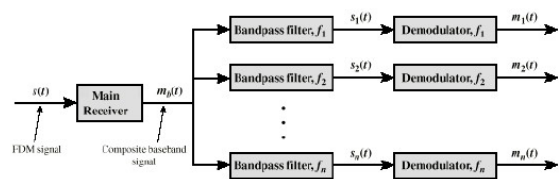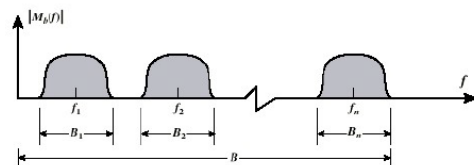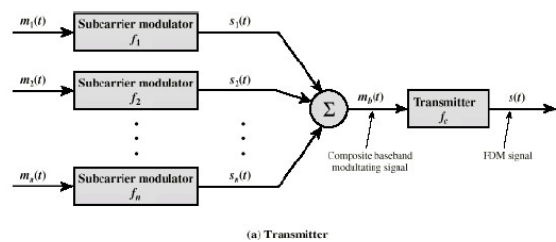
Two choices of levels:
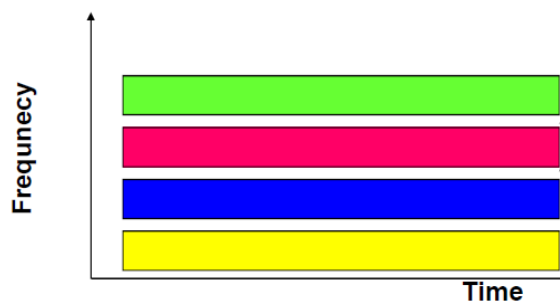
1) mu law (US/Japan) = 256

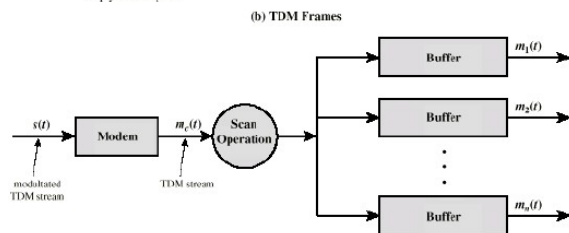2) A law (Europe) = 87.6
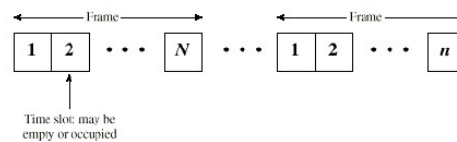
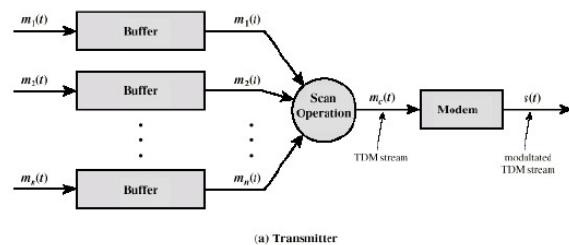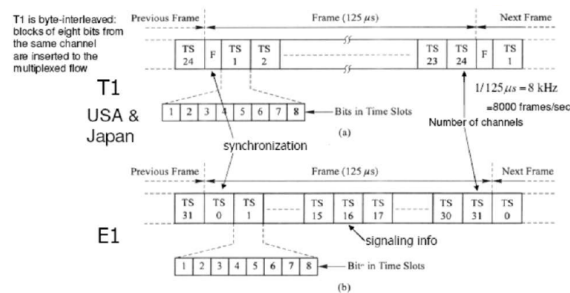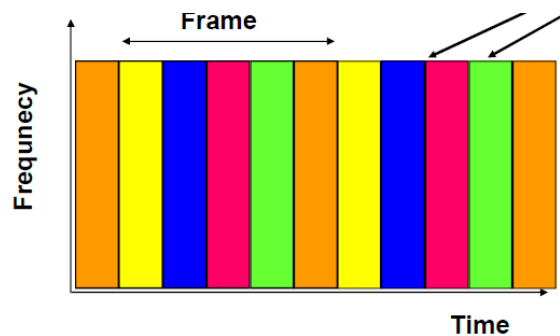## 4.4 Multiplexing techniques

4.4.1 FDM

Divide the spectrum into smaller bands, wastes spectrum

Ex.: In the ADSL: the modem divides the available bandwidth on the copper line

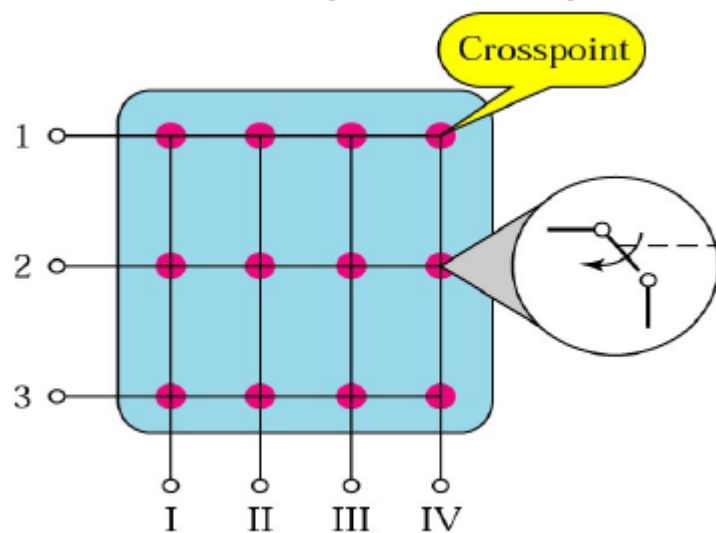## 4.4.2 TDM

Use the entire spectrum in slot of time

4.5 Switching

Switches establish temporary circuits: switch and switch controller

4.5.1 Space-Division Switch

Paths separated spatially; crossbar switch connects n inputs to m outputs
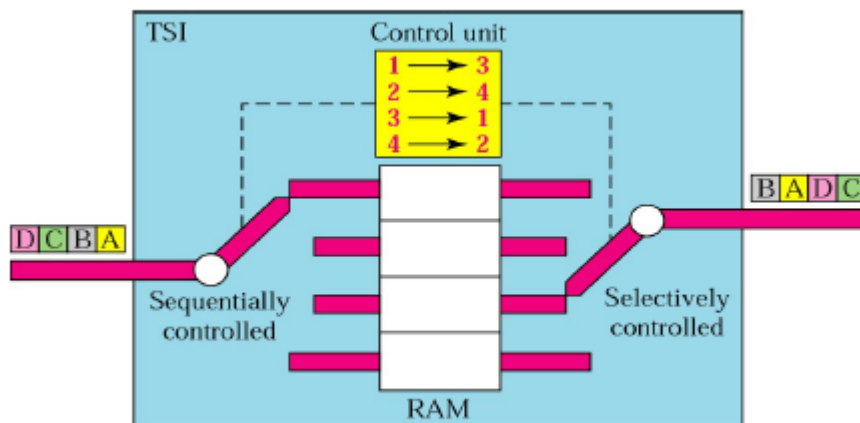
Crosspoint

1 2 3

I II III IV

4.5.2 Time-Division Switch

Uses TDM; Time-slot interchange changes the order of the slots based on the desired connection

a. No switching

b. Switching
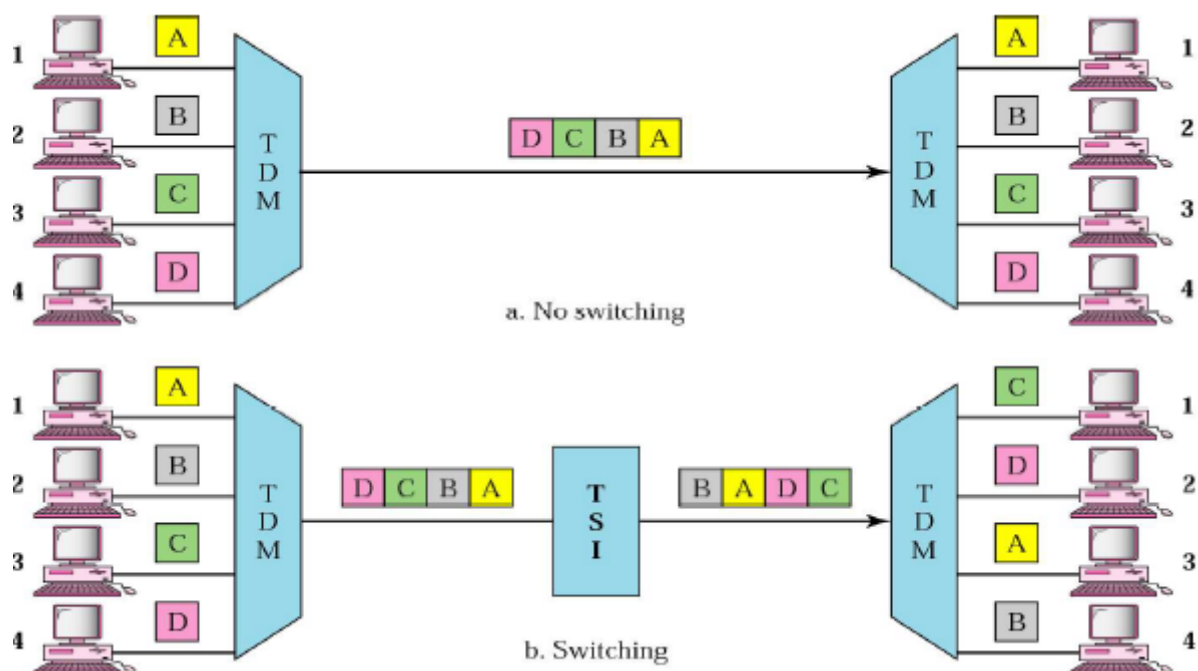
TSI consists of RAM with locations. #locations = #inputs. Data are sent based on the decisions of a control unit.

4.6 Signaling

Switches are linked by their internal computer network: Common Channel Interoffice Signaling (CCIS) network; messages here are conform to Signaling System 7 (SS7).

- **Channel Associated Signaling (CAS)**

The timeslot 16 of E1 transpost CAS.

When CAS is used, ITU recommendation G.732 describes a "MultiFrame" format for E1; 16 frames, Frame 0: alignment

For each channel, there is a frame where half of its TS16 is dedicated for that channel signaling. When bit aren't used for signal should be: 2nd and 4th = 1 and 3rd = 0

- **Common Channel Signaling System No.7 (SS7)**

-Data communications network standard

-Used ad a control and management network

-provides call management, DB query, routing, controls.

-designed to support ISDN
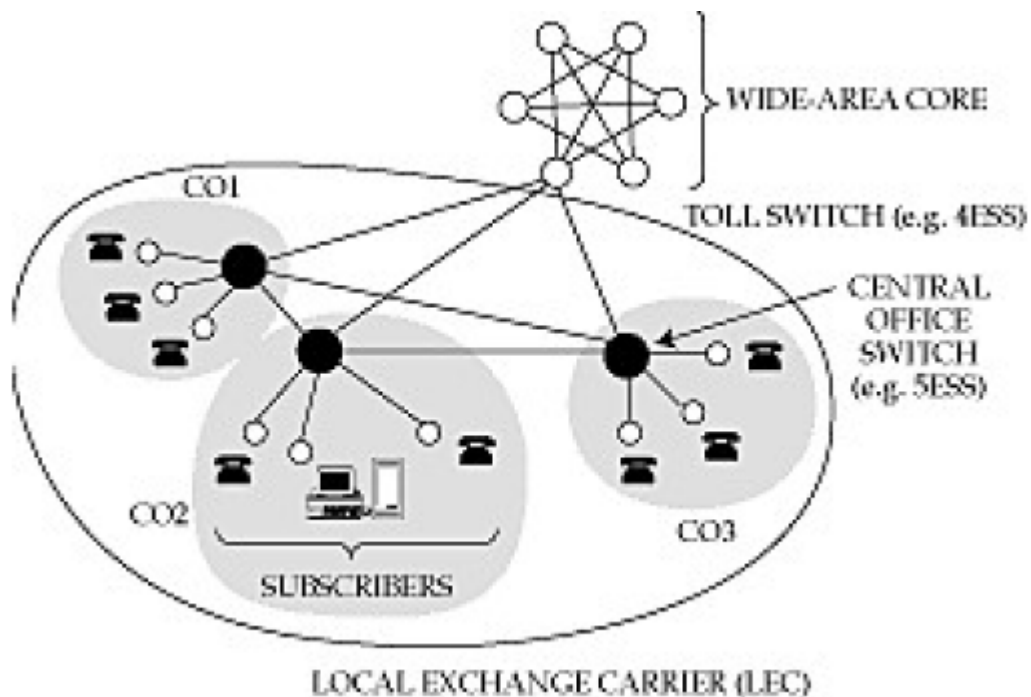
- **Telephony routing algorithm**

-Directly connect if same CO

-COs in same LEC → one-hop path

-Otherwise send call to core

-Only major decision is at toll switch

Essence: use two-hop if one-hop is full

- **Features of telephone routing**

-Resource reservation aspects: path reservation, stable load

-Technology and economic aspects: extremely reliable

-Simplified topology

-Organizational aspects: single controls entire core, affordable, global interactions.