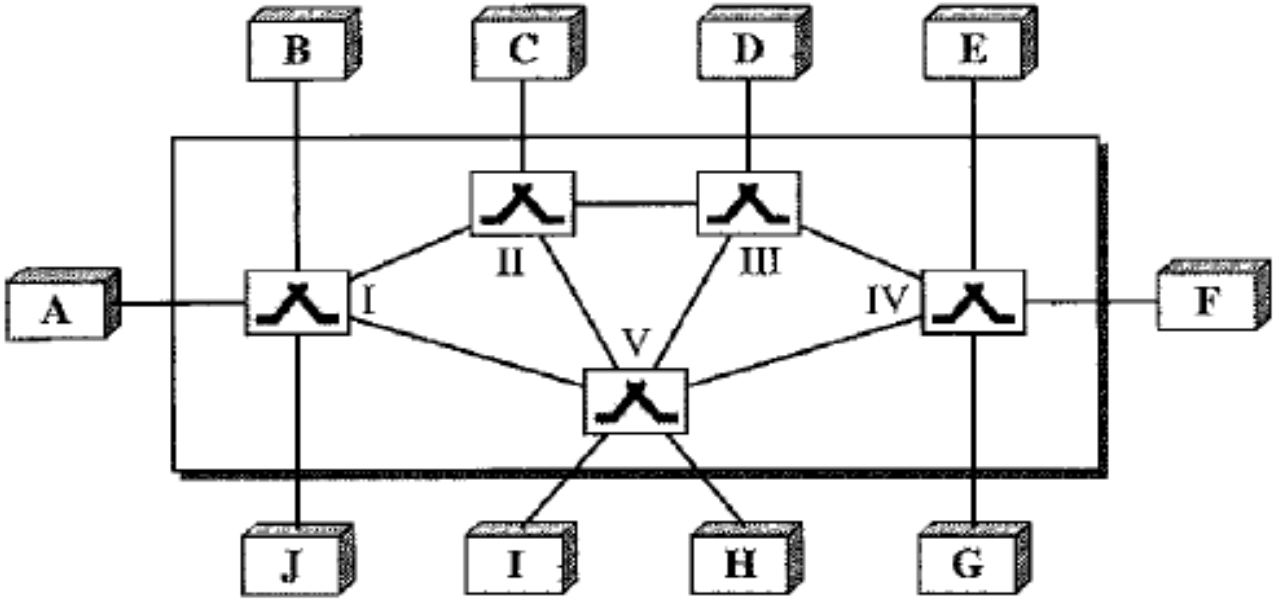
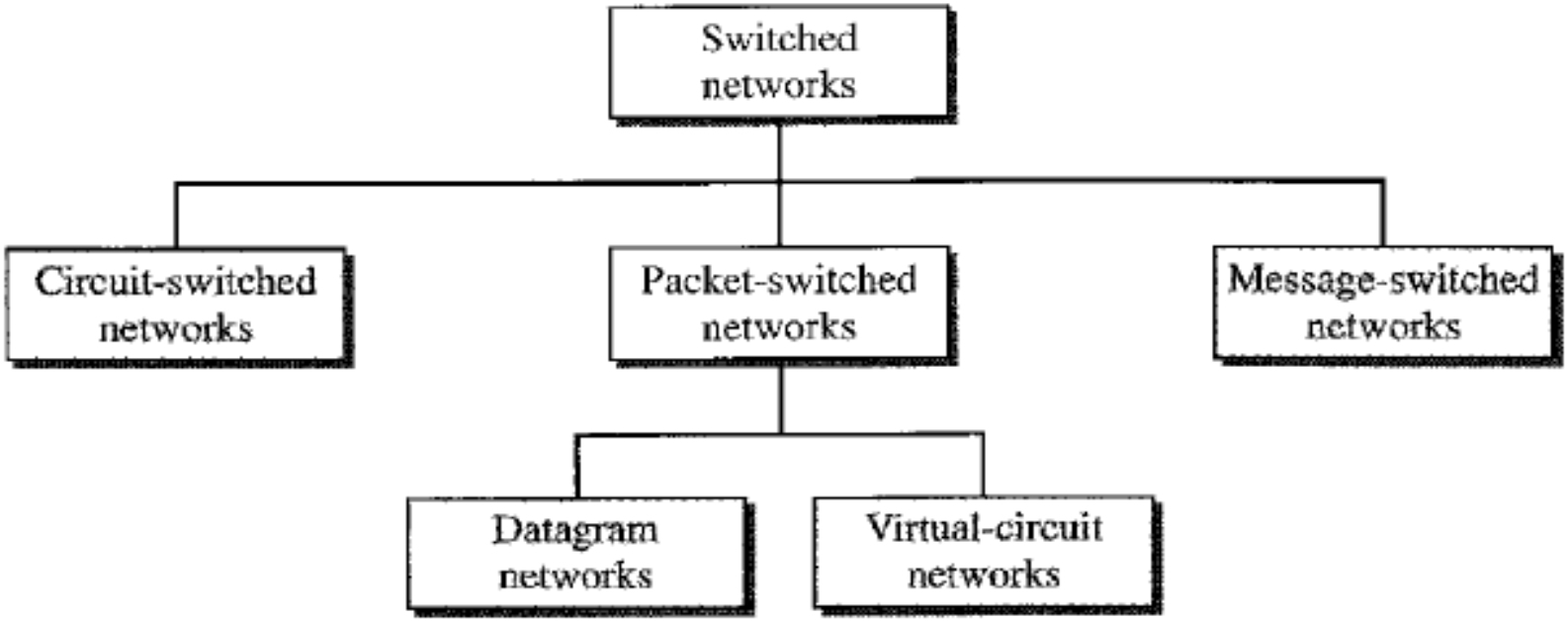
Switching

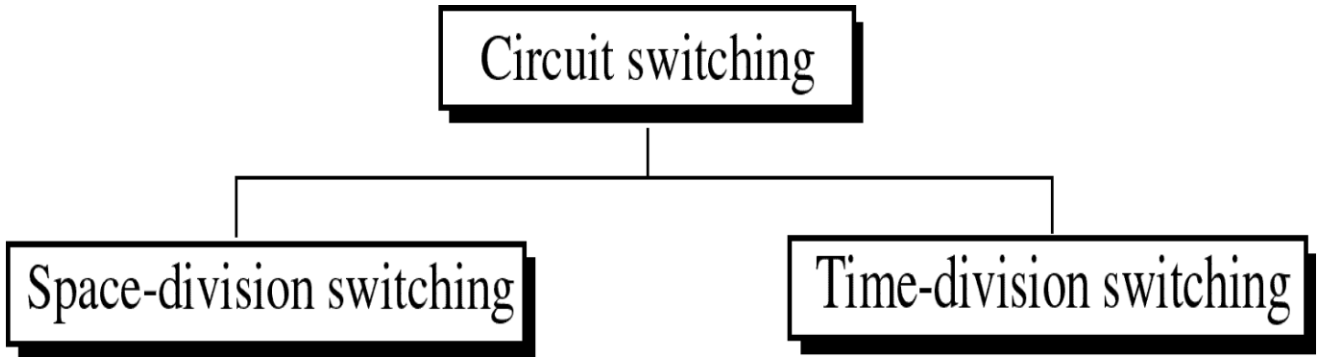
Switched Network



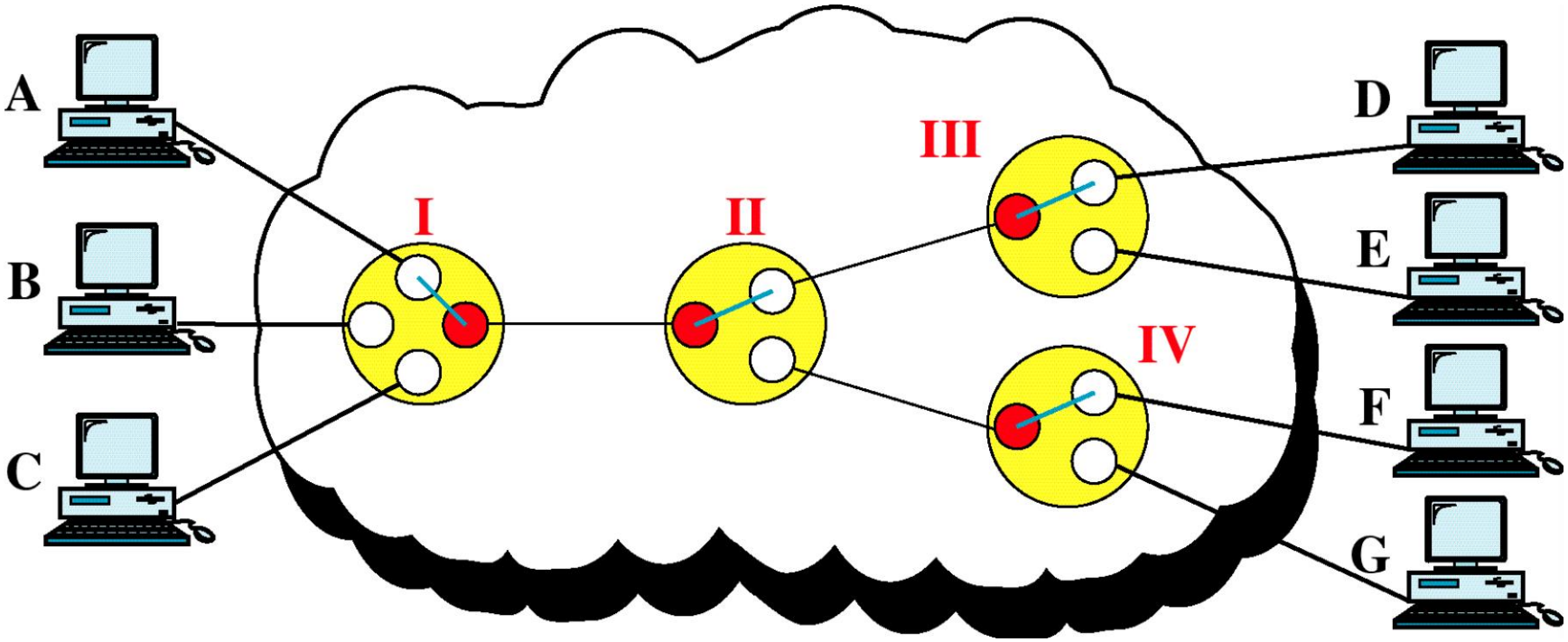
- Cost-efficient infrastructure
- Interlinked nodes/switches creating temporary connections
- Switches connected to end-system (telephones or personal computers)

Switched Network





Circuit Switching

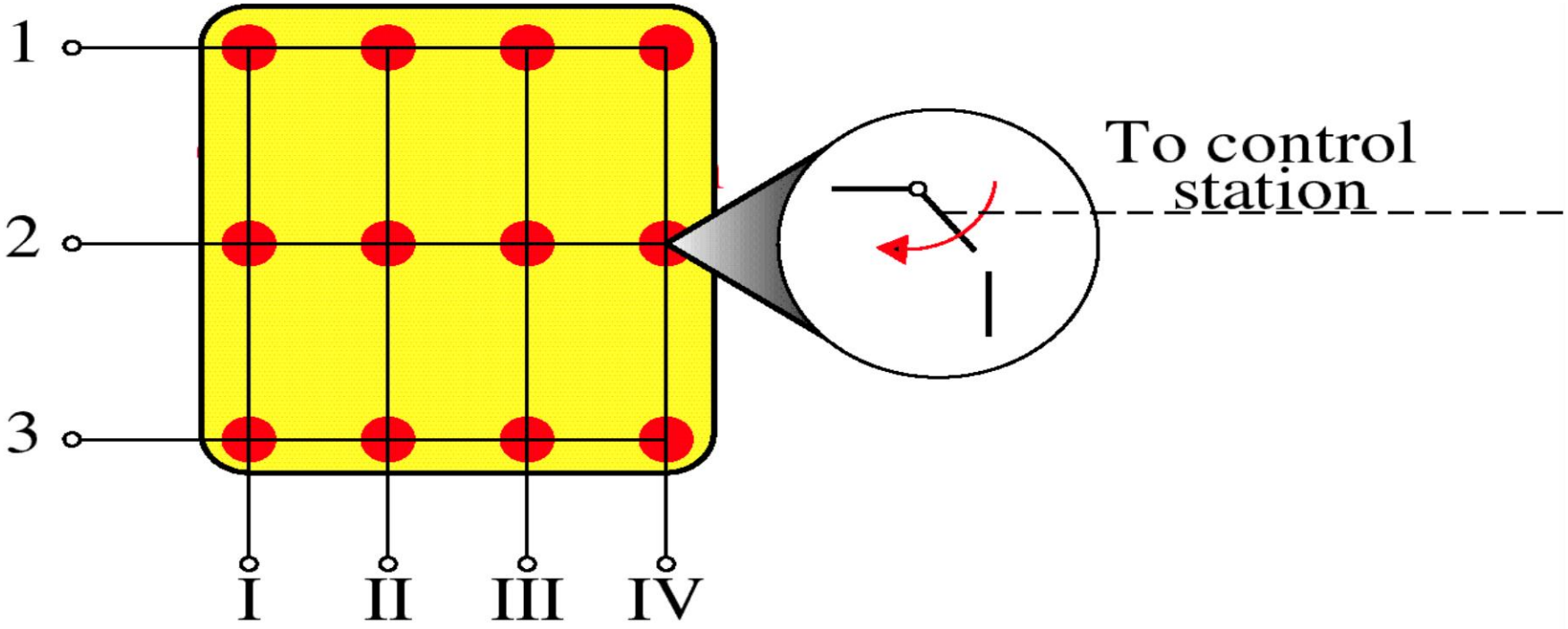


- 3 phases: setup, data transfer and tear down
- Resources reserved during setup phase
- Resources remain dedicated until teardown phase.
- No addressing; routing as per occupied band (FDM) or time slot (TDM)

Space-division switching

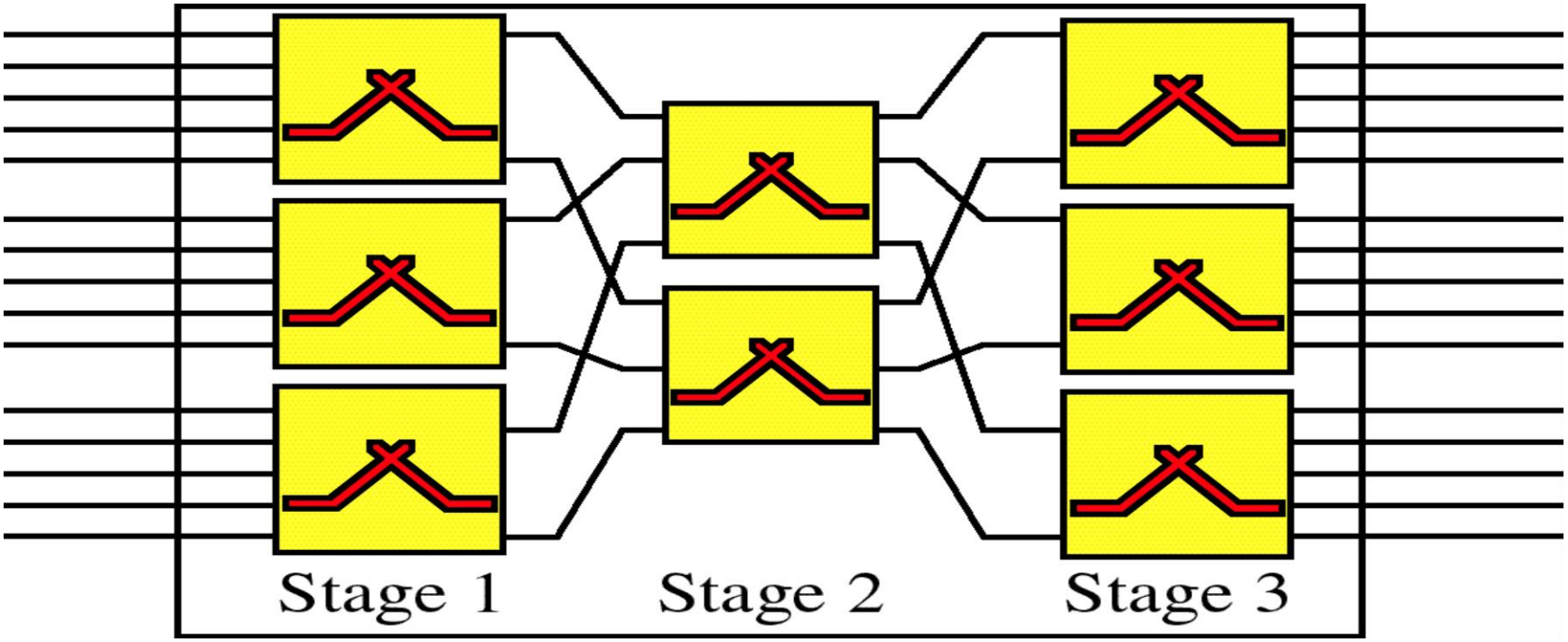
- Paths in the circuit are separated from one another spatially
- Originally designed for analog networks
- Currently used in both analog and digital networks.
- Implementations: Crossbar & Multistage switches
- Merit: it is instantaneous.
- Demerit: too many crosspoints required for practical applications.

Crossbar Switch



- Electronic microswitches (transistors) at each crosspoint.
- Limitation: too many crosspoints required to connect m inputs to n outputs.
- Few crosspoints use at any time. Remaining stay idle.

Multistage Switch

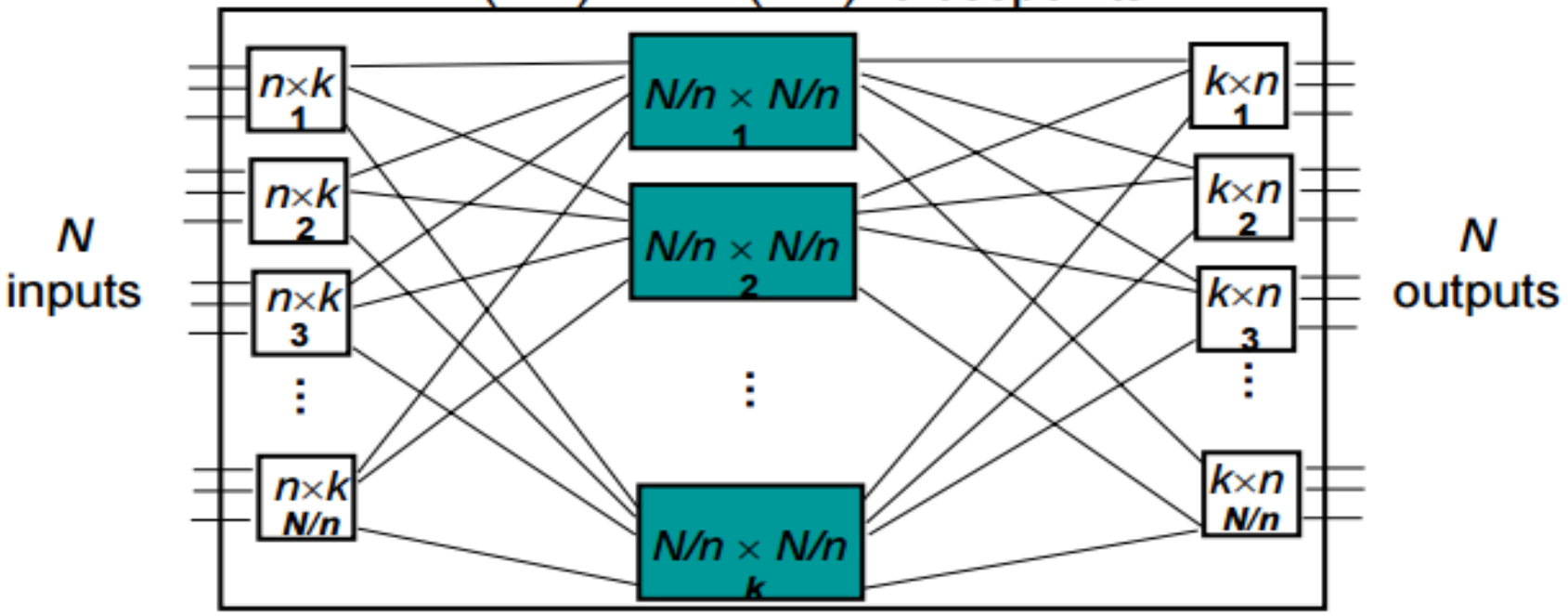


- **To decrease the number of crosspoints and hence complexity of the switch, a new design idea is to use multiple stages.**

Multistage switches

- First stage: *N/n nxk* switches
- Intermediate stage: *k N/n x N/n* switches
- Third stage: *N/n kxn* switches
- If *k<n*, obviously, the switch is not non-blocking (in fact, if *k<2n-1*, not non-blocking)

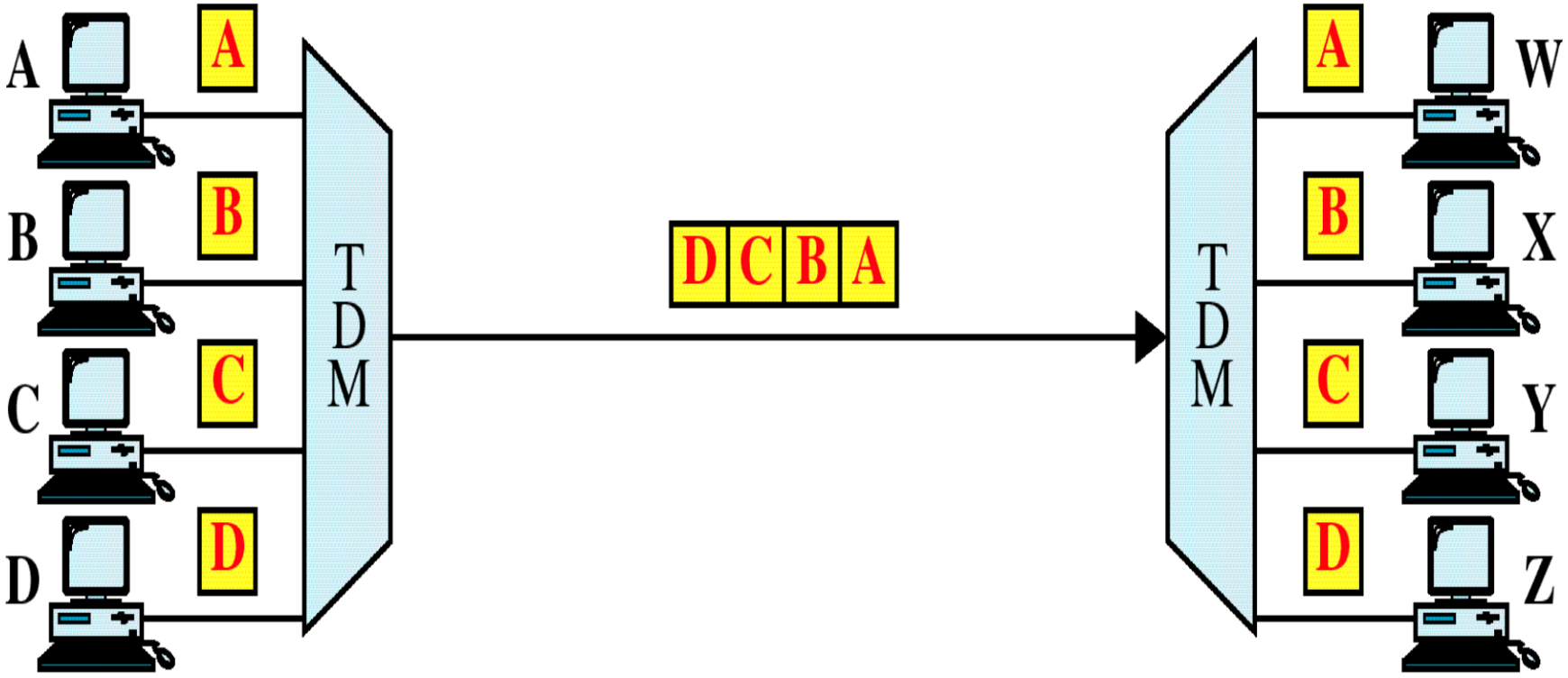
$2(N/n)nk + k\,(N/n)^2$ crosspoints



Time Division Switch

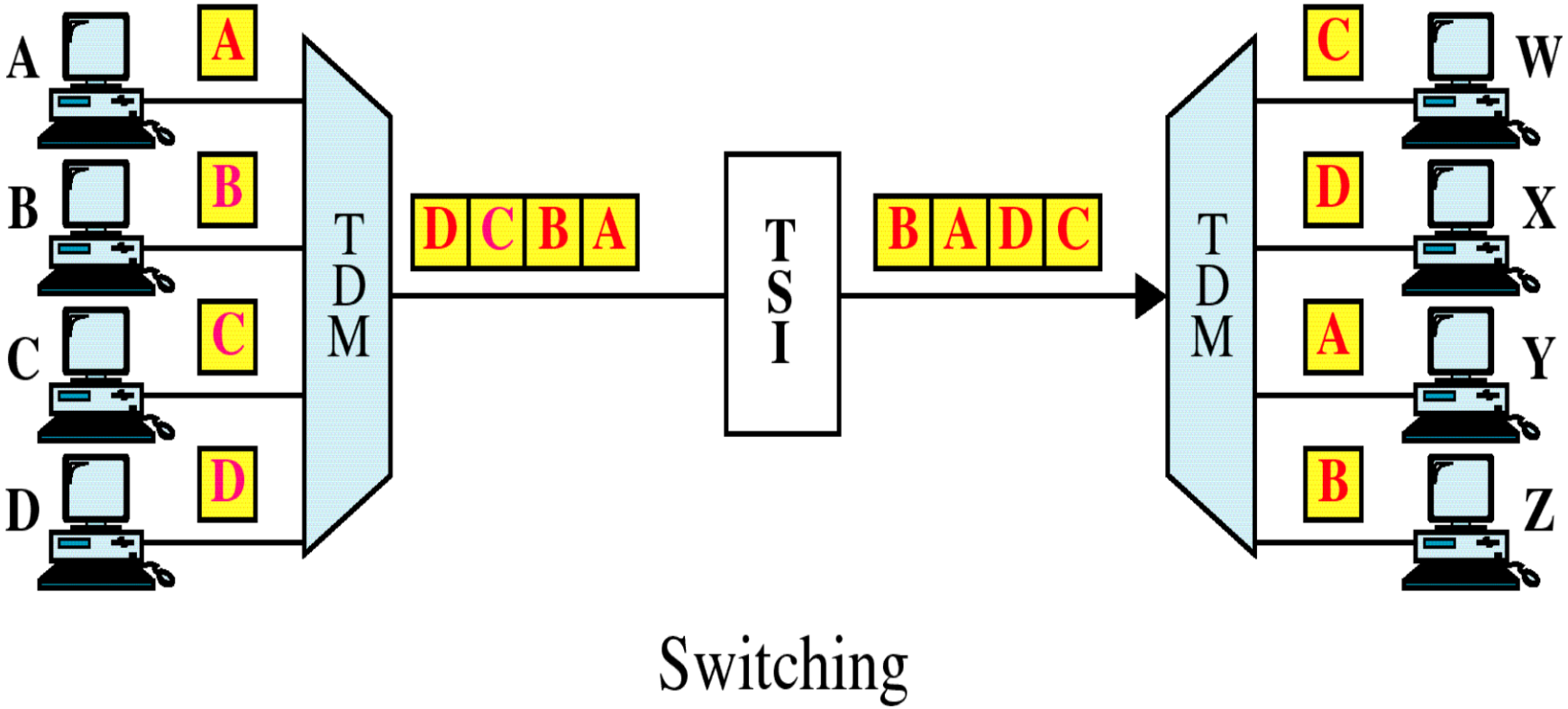
- Uses time-division multiplexing (TDM) inside a switch.
- Two popular technologies: Time Slot Interchange (TSI) & TDM Bus.
- Merit: needs no crosspoints.
- Demerit: for TSI, processing each connection creates delays. Each time slot stored by the RAM, then retrieved and passed on.

TDM without TSI



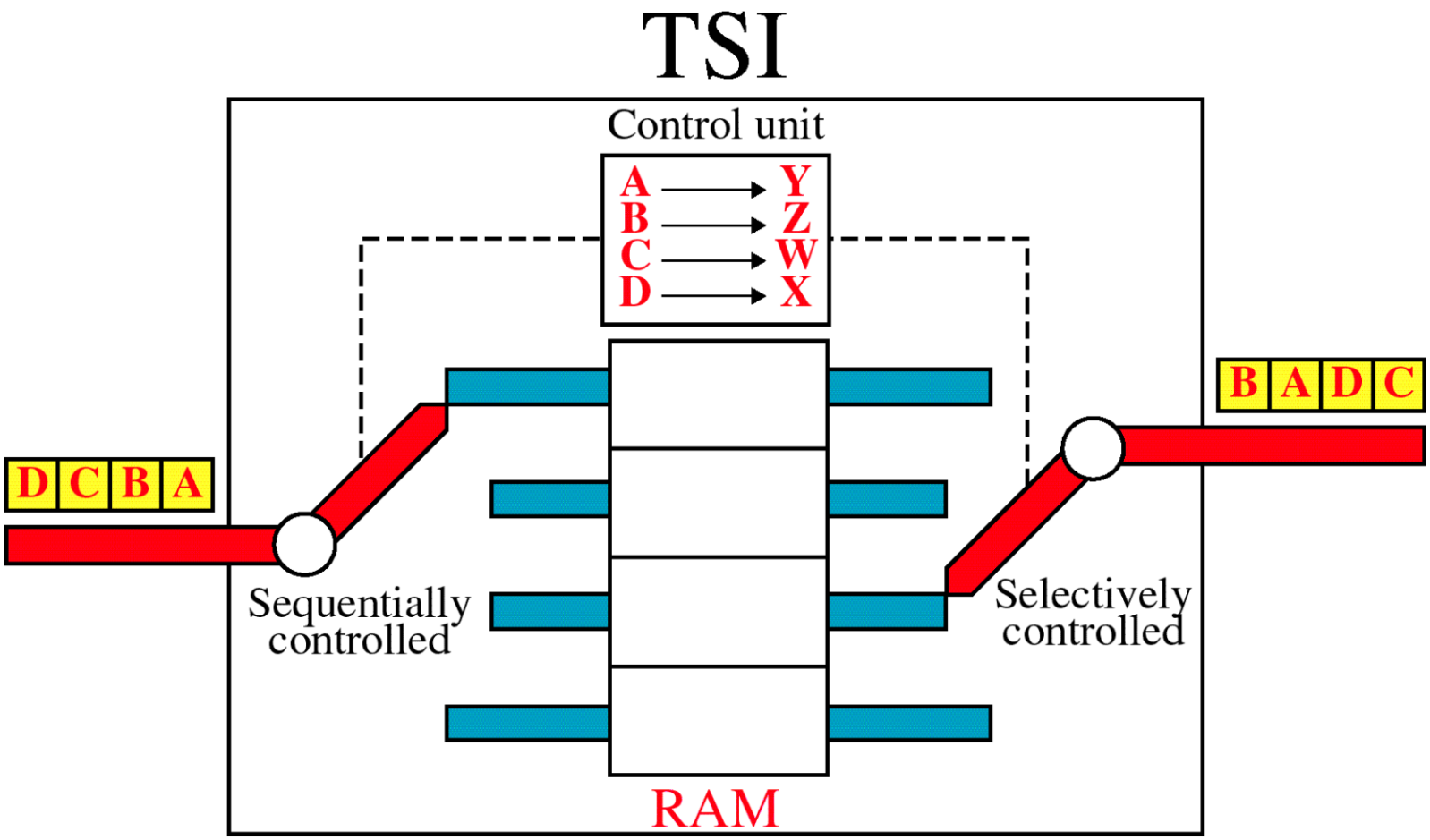
No switching

TDM with TSI



Switching

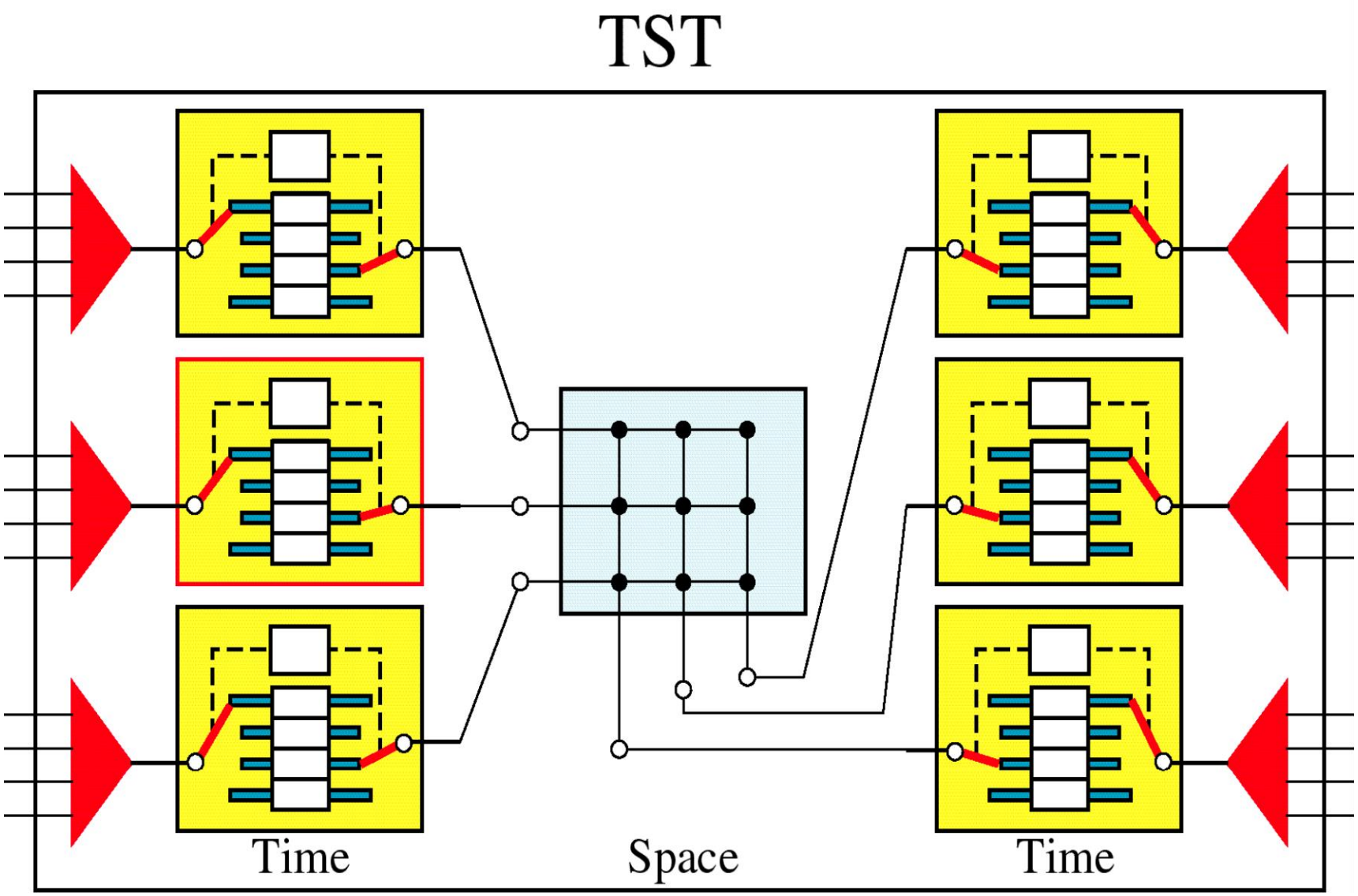
Time-Slot Interchange



TST switch

- Combine space-division and time-division technologies
- Resultant switch optimized physically (the number of crosspoints) and temporally (the amount of delay).

TST switch



TDM Bus

- Several input and outputs connected to a high-speed bus.
- During a time slot only one particular output switch is closed, so only one connection at a particular instant of time is possible.

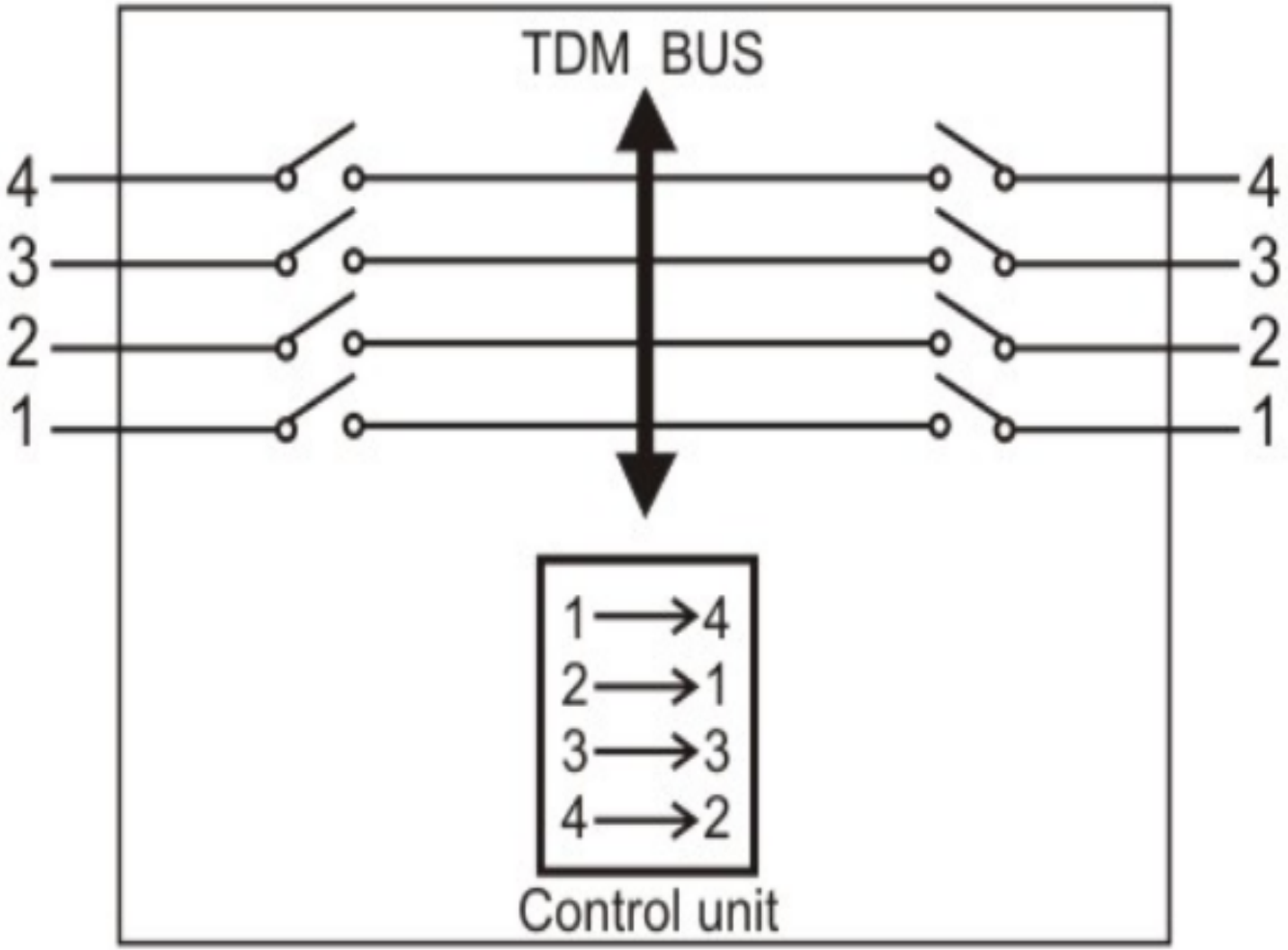
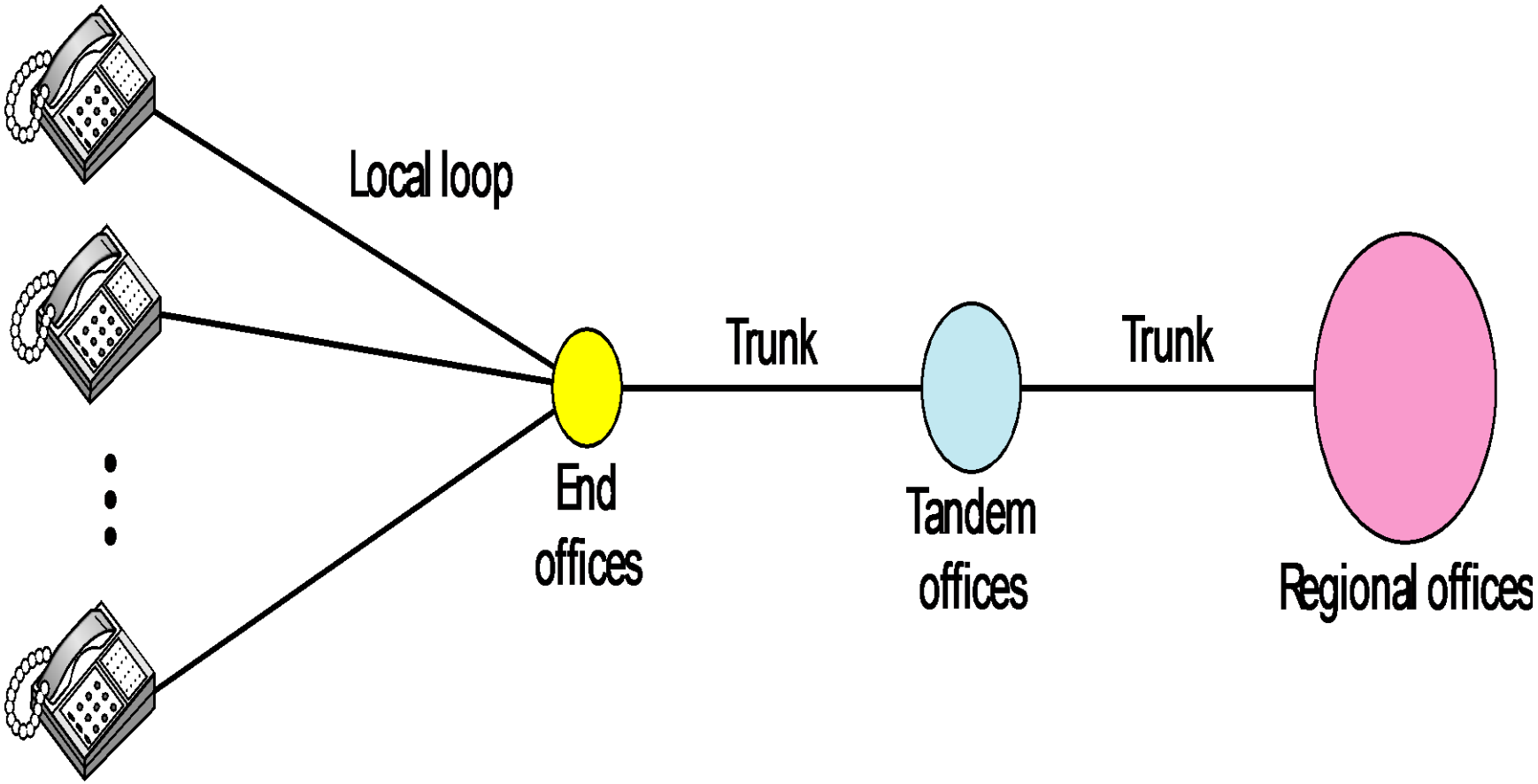


Figure TDM bus switching

Telephone Network

- Uses circuit switching
- POTS or plain old telephone system was originally an analog system using analog signals to transmit voice.
- Telephone network components:
  - Local Loops
  - Trunks
  - Switching Offices (levels: end offices, tandem offices & regional offices)



A telephone system

Local Loops

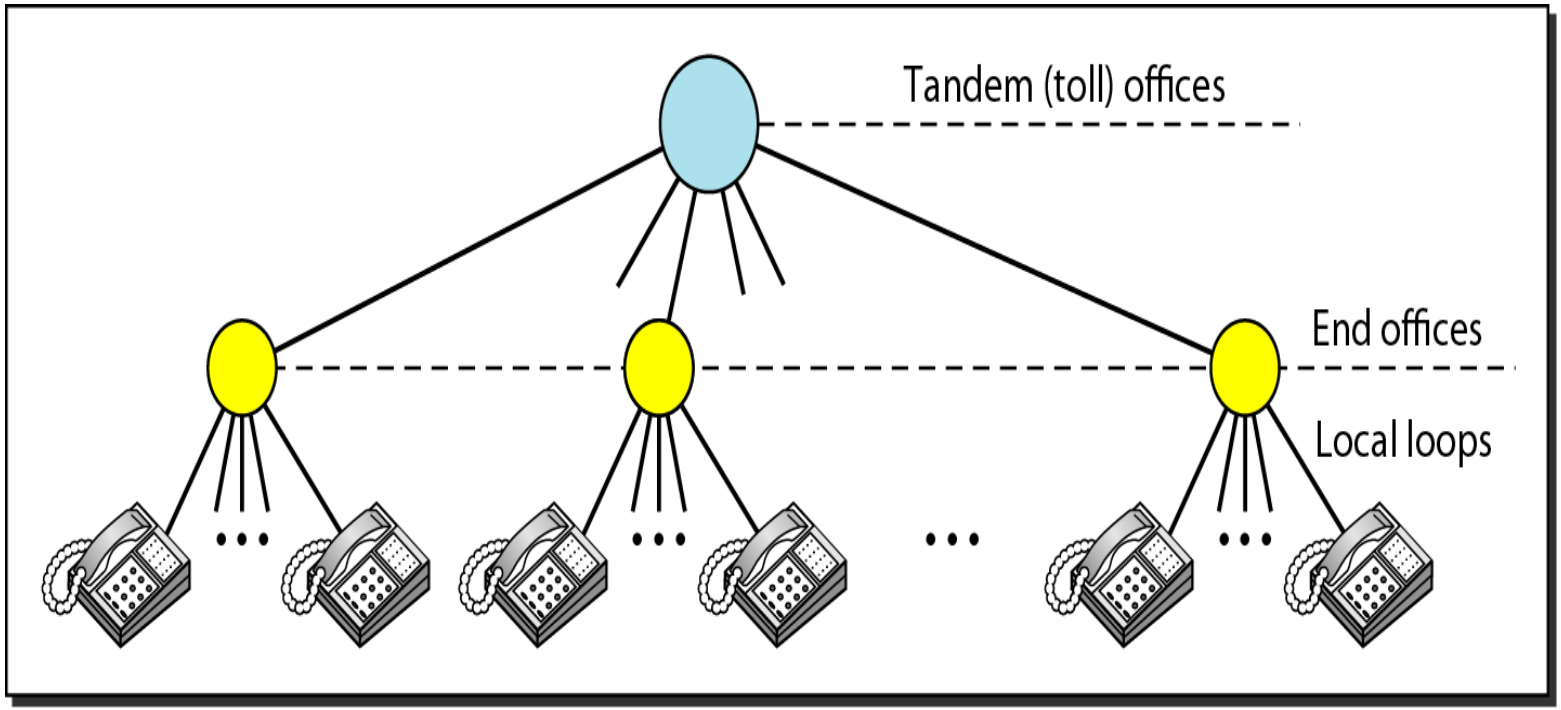
- A twisted-pair cable connecting the subscriber telephone to the nearest end office or local central office
- When used for voice, has a bandwidth of 4000 Hz (4 kHz).
- Telephone number is associated with each local loop.
  - first three digits define the office, and the next four digits define the local loop number.

Trunks

- Trunk is the transmission media that handle the communication between offices.
- Normally handles hundreds or thousands of connections through multiplexing.
- Transmission is usually through optical fibers or satellite links.

Switching Offices

- Telephone company has switches located in a switching office.
- A switch connects several local loops or trunks
- So, no need for permanent physical link between any two subscribers



Local Access Transport Area (LATA)

- LATA is a small or large metropolitan area.
  - Small state has single LATA
  - Large state has many LATAs
  - LATA boundary can overlap state boundary
  - Single LATA can have parts in different states
- Intra-LATA services are provided by local exchange carriers (LEC).
- Two types of LECs: incumbent local exchange carriers and competitive local exchange carriers

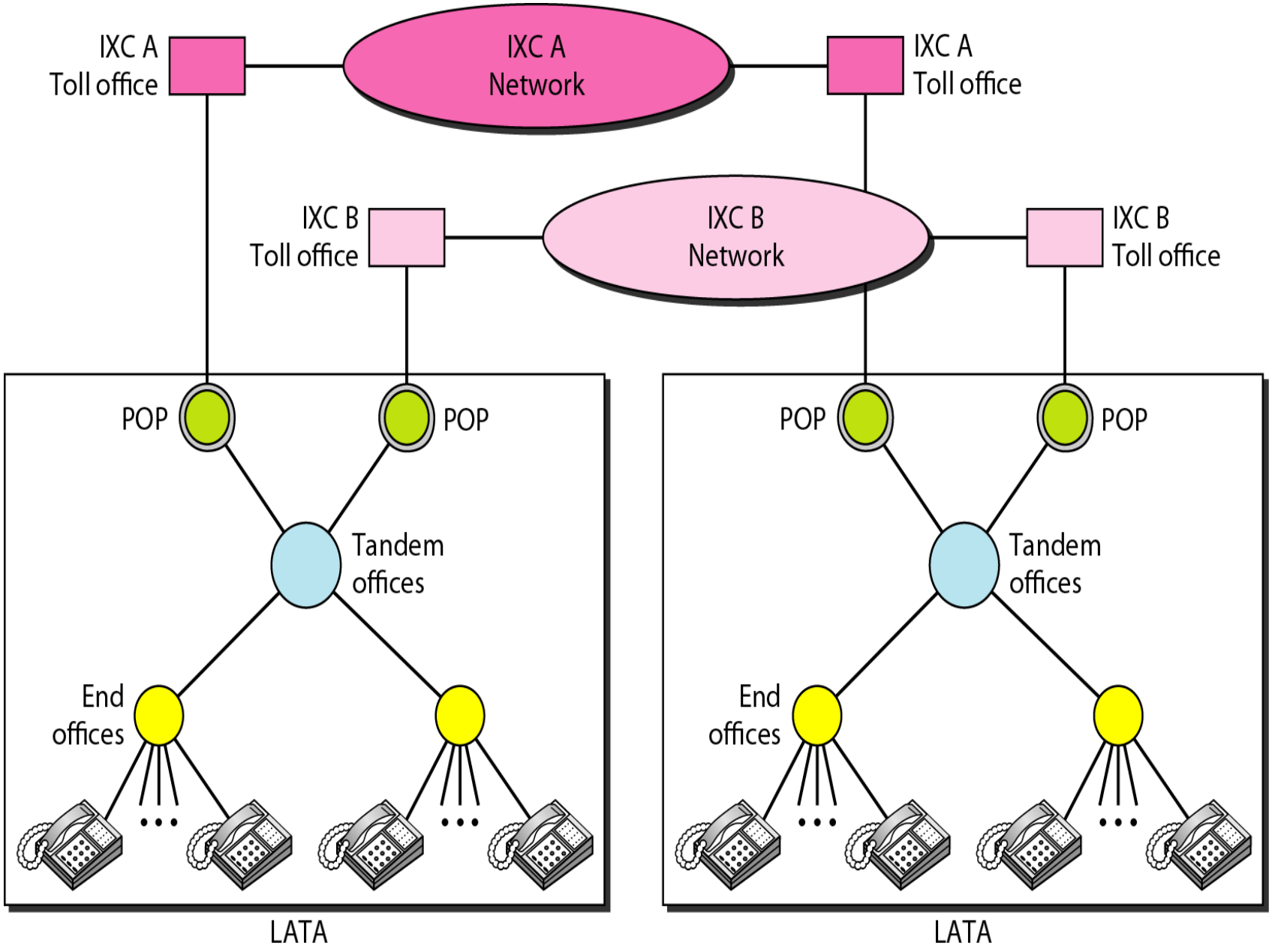
LATA (contd.)

- Communication inside a LATA handled by end switches and tandem switches
- Toll free call: Calls that can be completed using end offices only
- Calls going through tandem office (intra-LATA toll office) is charged
- Services between LATAs are handled by interexchange carriers (IXCs).
- IXCs are long-distance carriers, provide general data communications services including telephone service.
- Call going through an IXC is normally digitized, with the carriers using several types of networks to provide service.
- IXCs: AT&T, MCI, WorldCom, Sprint, and Verizon.

Point **O**f **P**resence **(POP)**

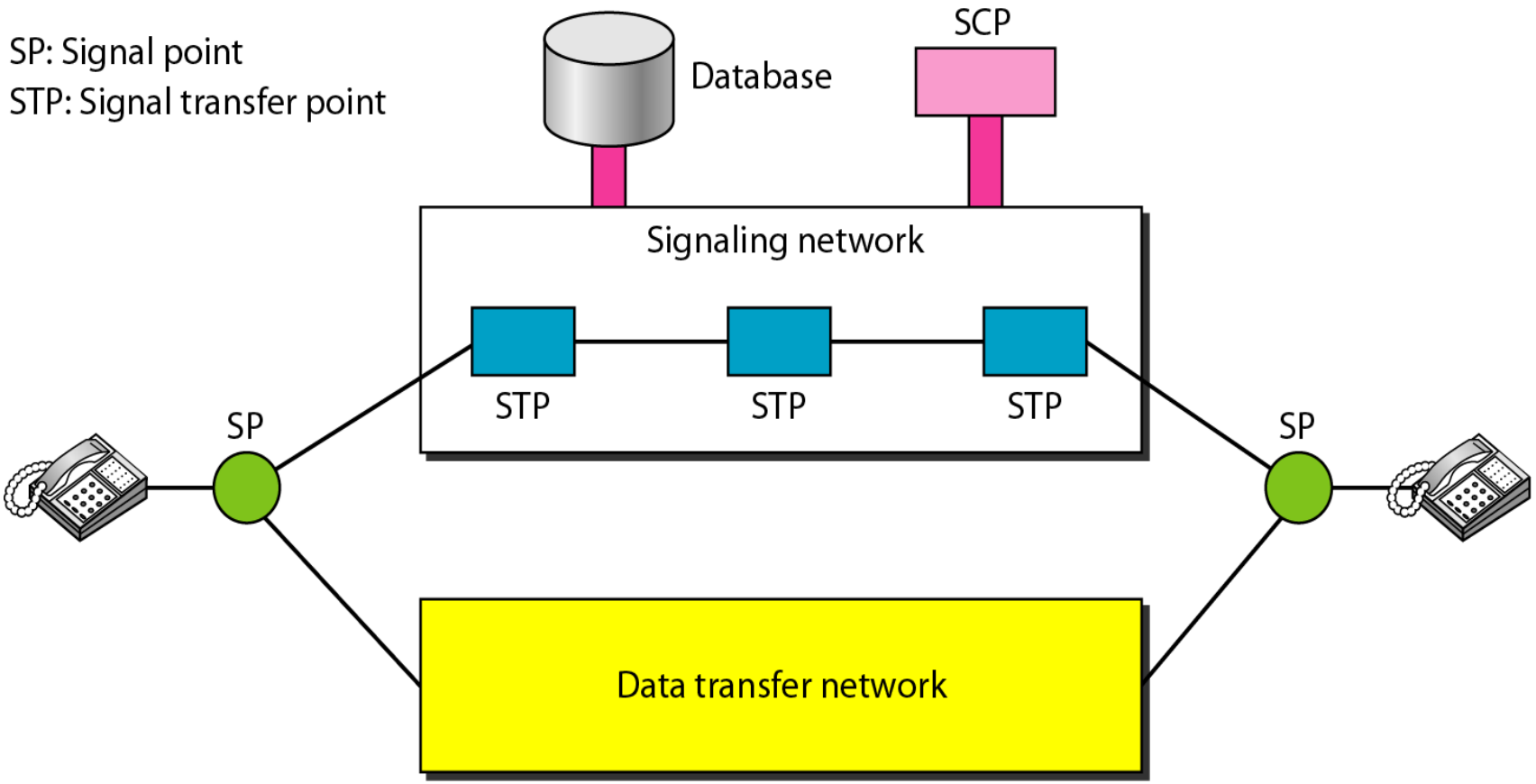
- Interaction between **LEC**s & **IXC**s via **POP**
- **POP is a** switching office
- LECs that provide services inside a LATA must provide connections so that every subscriber can have access to all POPs *

*__NOTE:__ A subscriber who needs to make a connection with another subscriber is connected first to an end switch and then, either directly or through a tandem switch, to a POP. The call now goes from the POP of an IXC (the one the subscriber has chosen) in the source LATA to the POP of the same IXC in the destination LATA. The call is passed through the toll office of the IXC and is carried through the network provided by the IXC.


IXC A
Toll office
IXC A
Network
IXC A
Toll office
IXC B
Toll office
IXC B
Network
IXC B
Toll office
POP
POP
Tandem
offices
End
offices
LATA
POP
POP
Tandem
offices
End
offices
LATA

Signal & Data Transfer in Telephone System

The tasks of data transfer and signaling are separated in modern telephone networks: data transfer is done by one network, signaling by another.



Data Transfer Network

- Circuit-switched, or packet-switched network
- Follows the same type of protocols and model as other networks
- Can also carry multimedia information

Signaling Network

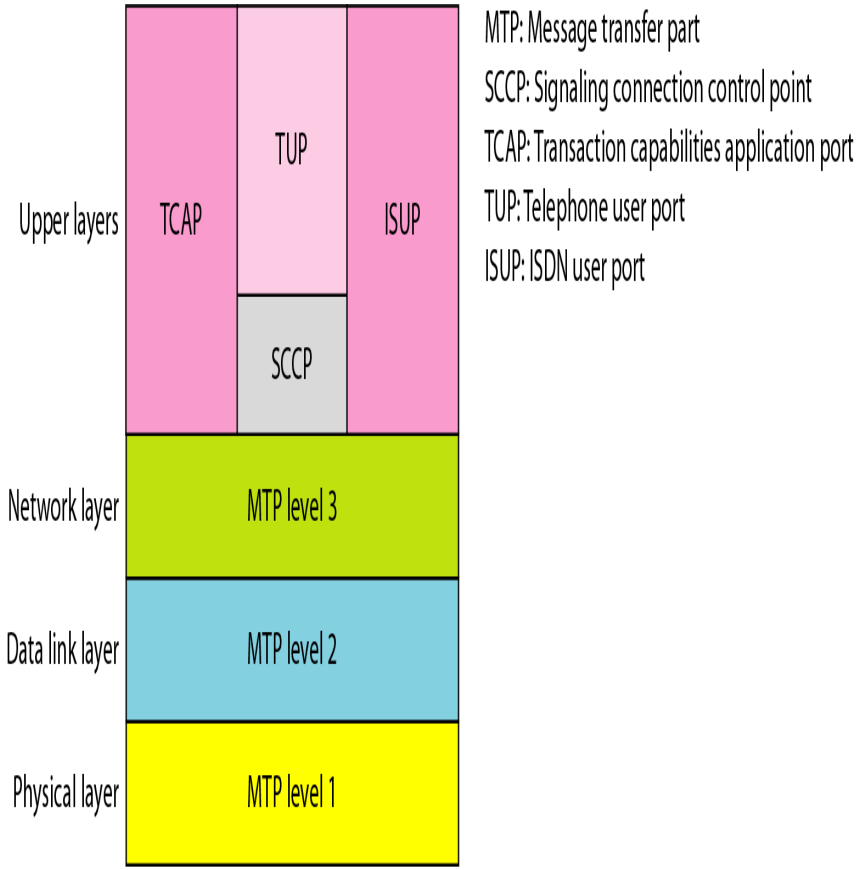
- Packet-switched network involving the layers similar to those in the OSI model or Internet model
- User telephone or computer is connected to the Signal Points (SPs)
- Signaling network uses nodes called Signal Transport Ports (STPs) that receive and forward signaling messages.
- Signaling network also includes a Service Control Point (SCP) to control the whole operation of the network.
- Other systems e.g. database center to provide stored information about the entire signaling network.

Signaling Network (contd.)

Functions:

- Providing dial tone, ring tone, and busy tone
- Transferring telephone numbers between offices
- Maintaining and monitoring the call
- Keeping billing information
- Maintaining and monitoring the status of the telephone network equipment
- Providing other functions such as caller ID, voice mail, and so on

Signaling System Seven (SS7)



- MTP Level 1: uses several physical layer specifications
- MTP Level 2: packetizing, address in headers, error checking
- MTP Level 3: end-to-end connectivity (routing)
- Transport Layer: SCCP- extended routing, flow control
- Upper Layers: voice calls, ISDN services

Telephone Network Services

- Analog Services
  - Analog Switched Services
  - Analog Leased Service
- Digital Services
  - Switched/56 Service
  - Digital Data Service

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