# Switching

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# **Recap**

- Two node network (Point-to-point link)

  - PHY layer: Encoding

  - Link Layer: Framing, Error Recovery, Reliable Transfer

- Network with few hundred nodes                    1024
                                                    250

  - Links Layer: Topology and MAC

- Network with thousands of nodes?

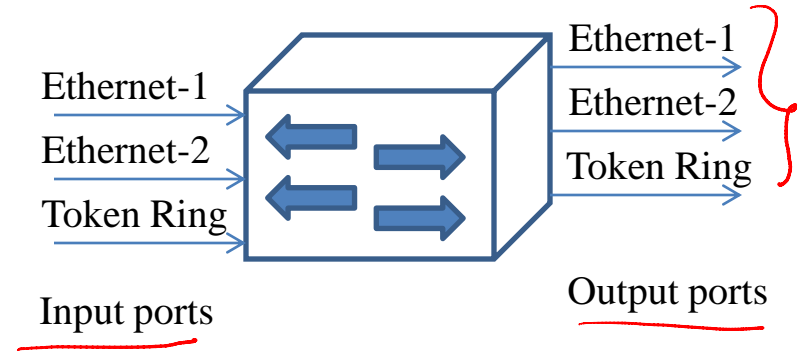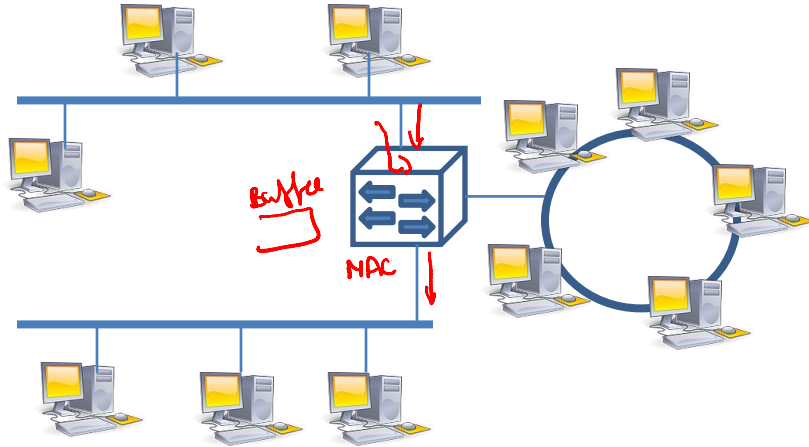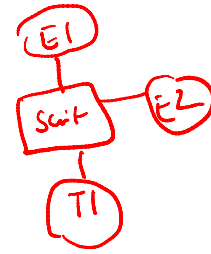  - Solution: Switching

# Outline

- Switching Concept

- Circuit Switching

- Packet Switching

- Types of packet switching covered elsewhere

# Switch Characteristics

- A multi-input multi-output device

- Main Function: Transfer packets from an input to one or more outputs

- Provides star topology → more scalable

- Runs appropriate data link protocols on each link

# Switching



**Important Functionality: Which port to forward incoming packets?**

# Note

- Switching is a concept

  - Different types of switching: Circuit and Packet

- Packet switching:  Possible at link-layer as well as network layer

  - Devices at link-layer are called bridges, switches (layer-2)
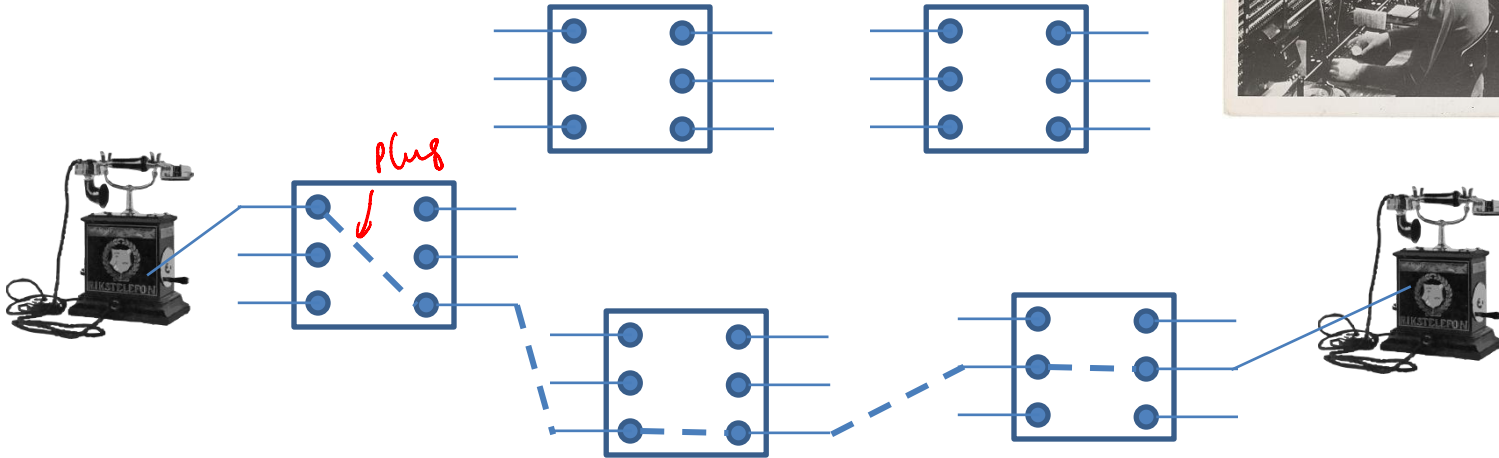
  - Devices at network-layer are called routers

# Circuit Switching

- Origins in Telephone Network *1890's*
  - Manual to automatic *Strowger*
  - Electromagnetic to electronic

# Circuit Switching

- Transmission involves two phases

- First Phase: Configuration of state along path from source to destination

- Second Phase: Information flow along set path
  - Frames carry no information on route to take

# **Multiplexing**

- Multiplex many conversations onto single physical link

- Choices: FDM, WDM (optical fiber), TDM

  *wavelength*

- E.g. TDM

  *given conversation*

| T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
|----|----|----|----|----|----|----|----|

  Frame

  - Number of nodes N, Capacity = R        $R/N$

  - Each user gets R/N bps

- How is forwarding done?

  - Map incoming port, time slot to outgoing port, time slot (mapping set up during call set up)

# Pros and Cons

- Pro: Assured resources once call established

    – Works well for CBR traffic ← voice telephone

- Con:

    – Wastage of resources

        • Unused slots are wasted in case of bursty, variable bit rate traffic

    – Per-connection state

# Packet Switching

- Emerged in 1960's

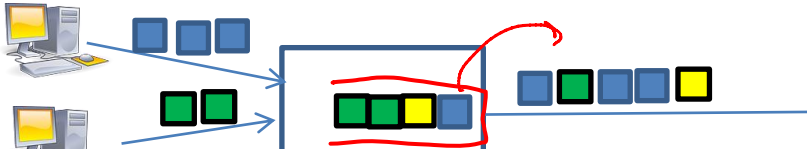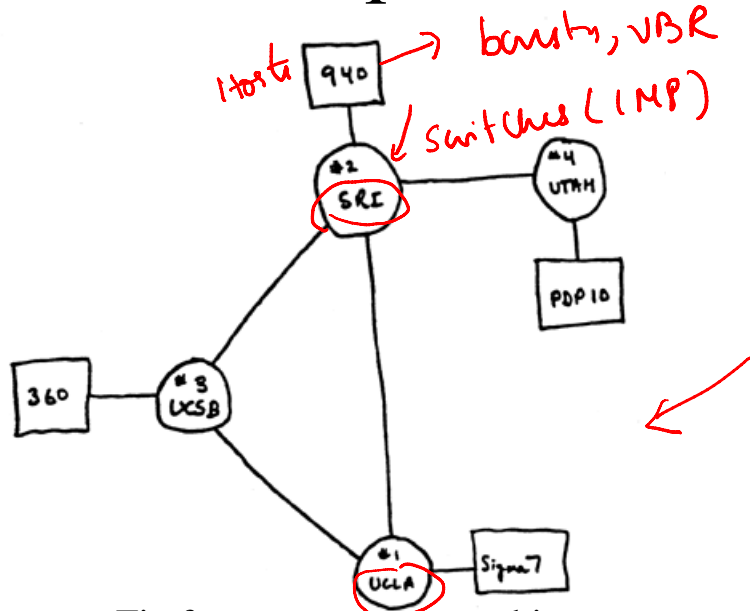- World's first packet switched network : ARPANET



Fig from www.computerhistory.org

First ARPANET IMP log

# Statistical Multiplexing

- Physical link is shared among users

- Sharing is on demand and not fixed

  - Fairness handled by limiting amount of data (**packets**)  → upper limit

  - **Store and forward** mode of operation

  - Packets from different flows are interleaved

    - Packets served predominantly in a FIFO basis

    - Potential of packet loss
      (Buffer overflow)
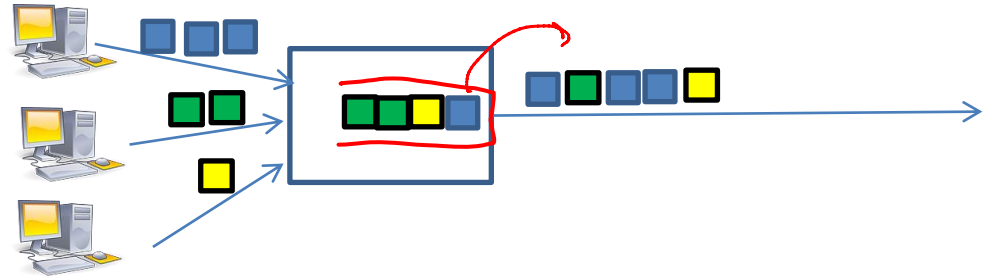
# **Forwarding**

- How are packets forwarded to the right port?

  - Packets carry information (in headers)

- Different types of packet switching

  - Datagram

  - Virtual Circuit

  - Source Routing

# Pros and Cons

- Pros

  - Less wastage of resources

  - No call set-up delay and per-connection state maintenance (first packet can be sent right-away). Virtual Circuit is an exception

  - Highly fault-tolerant

- Cons:

  - No guarantee for resources

  - Out of order delivery

  - Per packet overhead → information

  - Store and forward introduces delay and losses (per packet)

# Example

\* A user alternates between periods of
   activity & inactivity

\* Active 10/ of the time (90/. inactive)

\* Requires 100KBPS during active
   time

Circuit Switching

What should the link capacity be?

Assume (10 users)

$10 \times 100 \text{Kbps} = 1 \text{Mbps}$

Packet switching

Suppose (35 users,

Prob (11 or more
   active at any time)

$= 0.0004$

0.9996     10 or less
           user active

$10 \times 100 \text{Kbps}$

$1 \text{Mbps}$

# Summary

- Switching helps interconnect hosts/networks in a scalable fashion

- Two Types: Circuit and Packet Switching

  - Tradeoffs involved

  - Internet employs packet switching

- Ahead: Types of packet switching