Introduction to Switching Techniques

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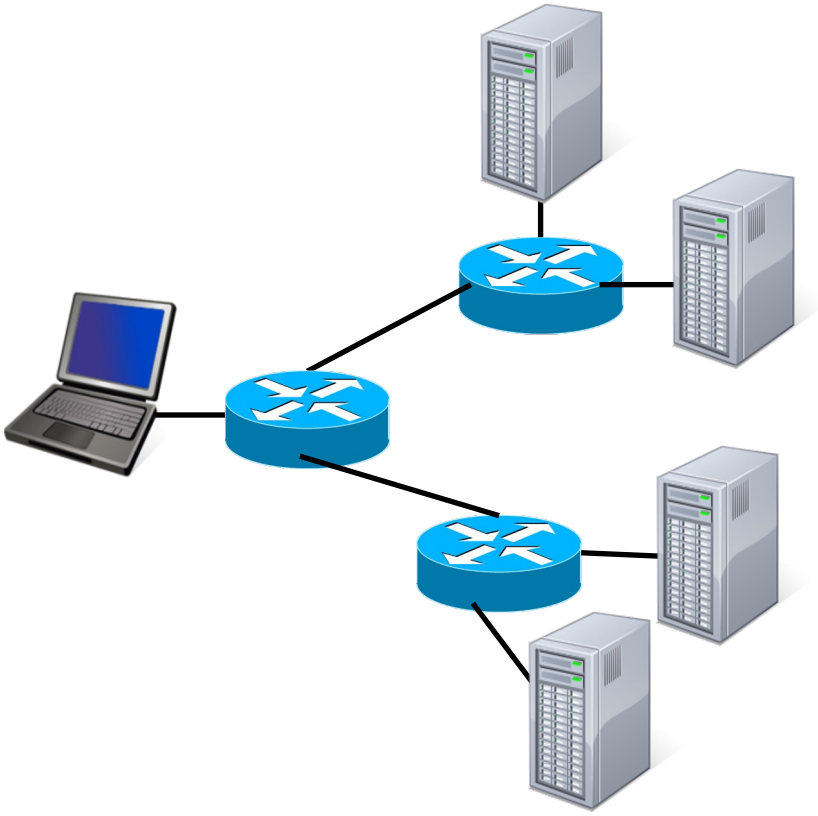
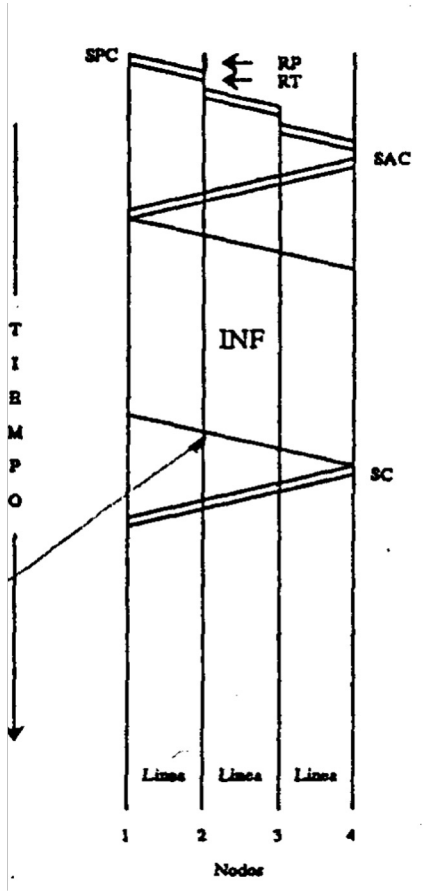
Why switching ?

- Direct links (full mesh) among all end systems does not scale to a large number of nodes (number of links grows with $O(N^2)$).
- Solution: we introduce intermediate devices called switches that allow to share the capacity of links by multiple data transfers.
- Switches forward "data" -- in the past, a signal -- from the source end-system to destination end system(s).
    - Normally: spatial switching
- End-systems and switches make up a Switched Network



Circuit Switching (1)

- In a CSN, links and switches are designed to deal with discrete capacity chunks called **channels**. Channels are stitched together by means of switches to create an end-to-end channel called **circuit**. The **capacity of the circuit is exclusively allocated** to the call even if unused.
- **A signalling protocol sets up and releases the circuit.**
- **Stages**
  - **Circuit set-up.** Call routing according to dialed end-system address or E164 number (hierarchical routing with backup paths to the backbone).
  - **Information transfer.**
  - **Circuit release.**



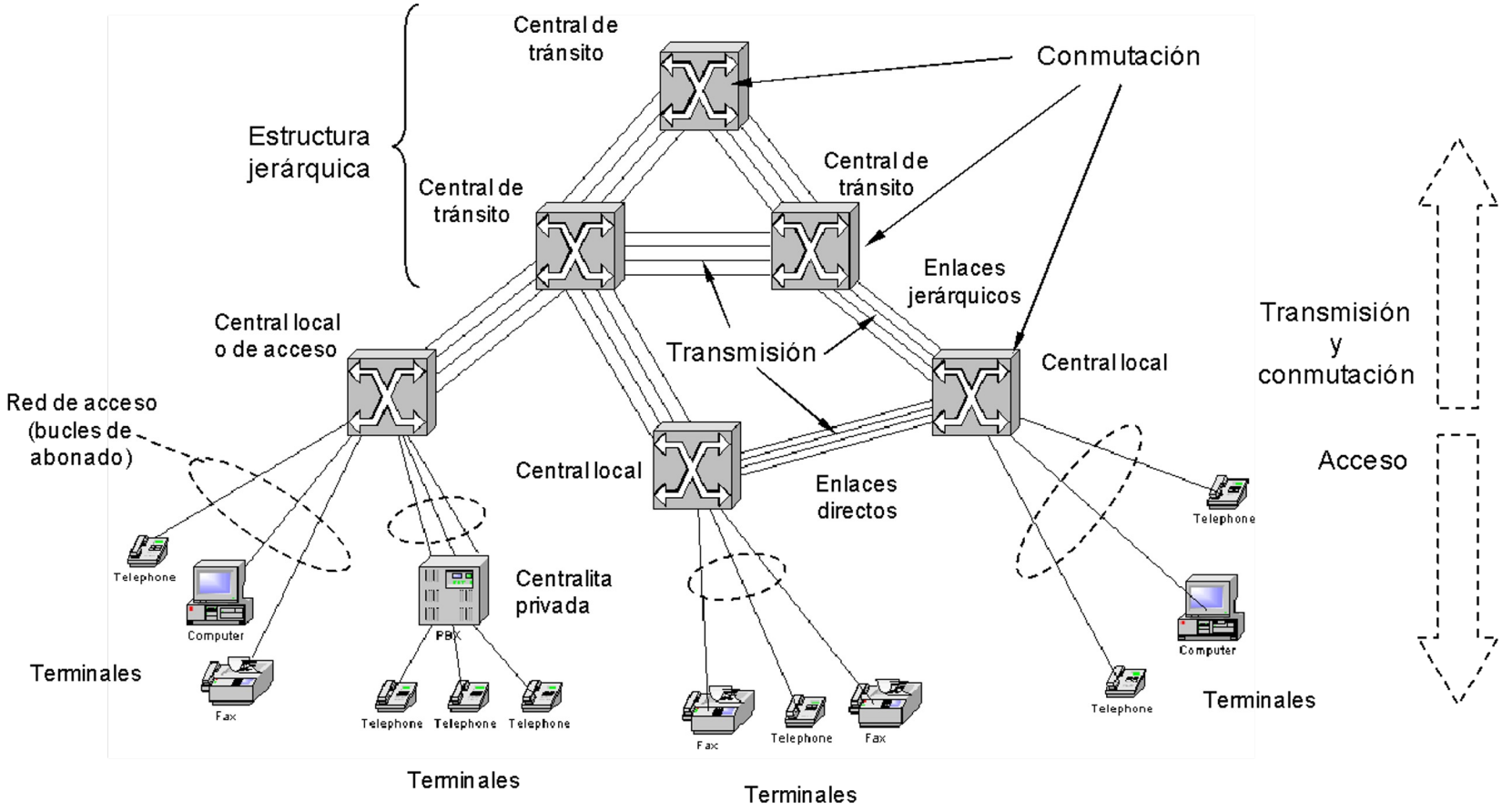
Circuit Switching (2)

- **Advantages:**
  - Traffic contract and QoS guarantees
    - Constant small delay, guaranteed rate
- **Disadvantages:**
  - Inefficient use of resources during inactivity periods
  - Blocking: If all circuits are occupied no more service requests are accepted
    - Hard service degradation: some users get a circuit, others are blocked
  - Requires a constant bit rate circuit allocated throughout the network
    - Links are structured into channels, exploited as channels and switches allocate buffers for channel-to-channel interconnection
    - Synchronous operation, complex expensive electronics to MUX and DEMUX channels

Circuit Switching Networks (3)

- **Examples:**
  - **Telephony (PSTN): originally analog circuit switching, nowadays digital (Narrowband Integrated Services Digital Networks NB-ISDN)**
    - Channel = 64Kb/s TDM, Circuit = 64Kb/s TDM, Switching Unit: voice sample (8 bits)
    - Circuit: spans subscriber - local exchange - primary exchange (sector) - secondary exchange (national) - terciary exchange (nodal)..
  - **IMPORTANT: The Telephony service is being replaced by packet-switched IP telephony progressively**
  - **PDH, SDH/SONET:**
    - **Circuits: nx64Kb/s TDM, nx2Mb/s, nx155Mb/s TDM.**
  - **Optical Transport Networks:**
    - **Circuits: nx2.5Gb/s TDM. Switching unit: byte**
    - **Circuits: lambda (Wavelength Routed Networks). Switching unit: a carrier.**
      - CS is the only technique that supports analog signal switching

CS example: Telephone Network



Packet Switching (1)

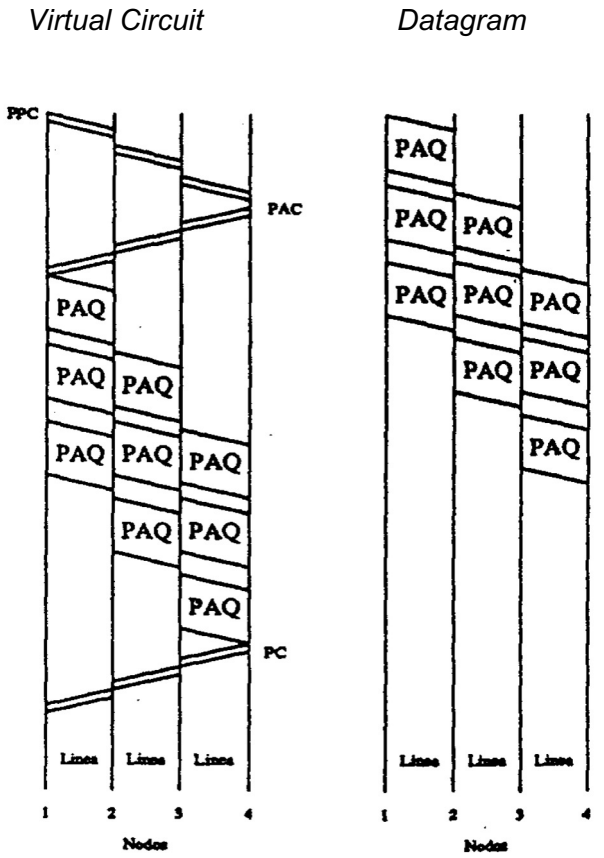
- **Main features:**
  - Messages are split into numbered chunks called packets
  - Packets wait on queues until they get the link
  - All link capacity is allocated to the packet once packet transmission starts.
  - Link capacity is shared by many users.
  - The original message is reassembled at the destination node.

Packet Switching (1)

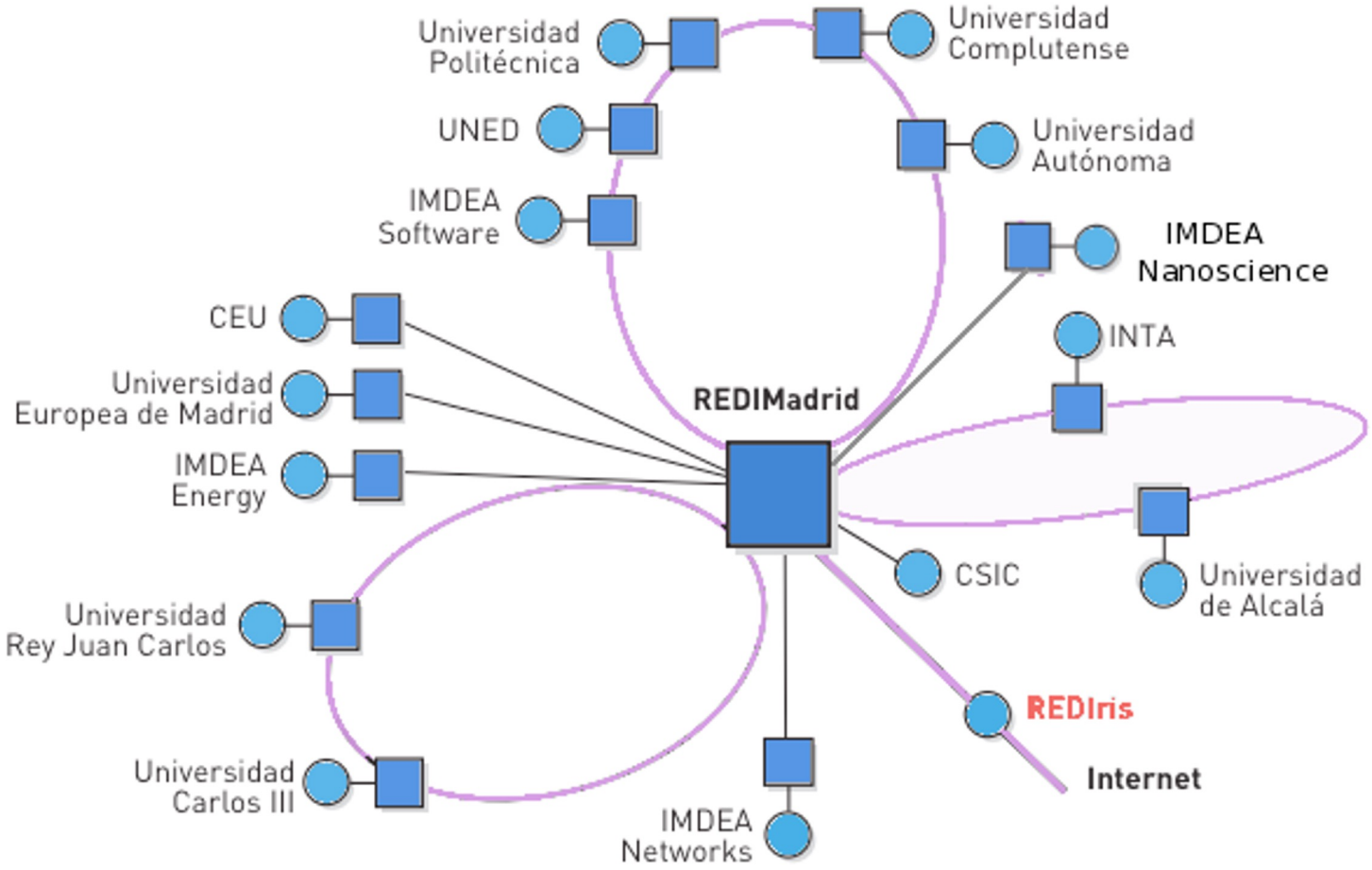
- **Advantages:**
  - High Resource Utilization thanks to statistical multiplexing of links and buffers
  - Soft degradation with load
  - Lower Cost: simpler cheaper equipment, more users served at the same time
  - Reduced signalling
- **Disadvantages:**
  - No QoS and no traffic contract guarantee (unless QoS mechanisms are configured)
  - Variable end-to-end delay
  - No rate guarantee
  - Packet loss
  - Flow and congestion control mechanisms
  - Traffic conditioning

Packet Switching (2)

- **Two sub-types:**
  - **Datagram:**
    - Packets forwarding based on the destination address.
    - Datagrams may follow different paths to destination
    - Packet order not guaranteed
    - No signalling required to set up a path for datagrams
    - Examples: IP , IPv6, ethernet, Fiber Channel, …
  - **Virtual circuits:**
    - A path (a virtual circuit) is previously established before transmitting packets.
    - Packet forwarding based on labels with a link-scope meaning.
    - Types: "switched" (SVC), permanent (PVC)
    - Phases for SVC:
      - SET UP
      - DATA TRANSMISSION
      - VC RELEASE
    - Examples: X.25 (obsolete), Frame Relay (obsolete), ATM (fixed-size packets called cells), MPLS.



PS example: REDIMadrid Network



Summary of switching techniques and technologies

Technique	subtype	Switching unit (granularity)	Technology under exploitation
Circuit Switching	TDM	Timeslot (TDM channel)	CS Telephony*, SDH*, OTN (ODU switching)
	FDM	wavelength	OTN (lambda switching)
Packet Switching	Datagrams	Packet (L3) Frame (L2)	IP, ethernet, FiberChannel, Infiniband, PCIExpress
	VC	Frame, cell	MPLS, ATM*

* Obsolete legacy systems, no vendor making products for these ones

Exercise: comparing PS and CS

- Comparing PS and CS on a simple scenario
- Try to understand
  - how data is handled by switches in an ideal scenario:
    - PS: “per-packet”
    - TDM CS: “per-byte” switching
  - Implications of store & forward and queueing
    - TDM CS: ?
    - PS: ?
  - Implications on max concurrently-served users
    - TDM CS: ?
    - PS: ?
  - Concept of bottleneck and best-effort delivery
    - TDM CS: ?
    - PS: ?

Exercise: comparing PS and CS