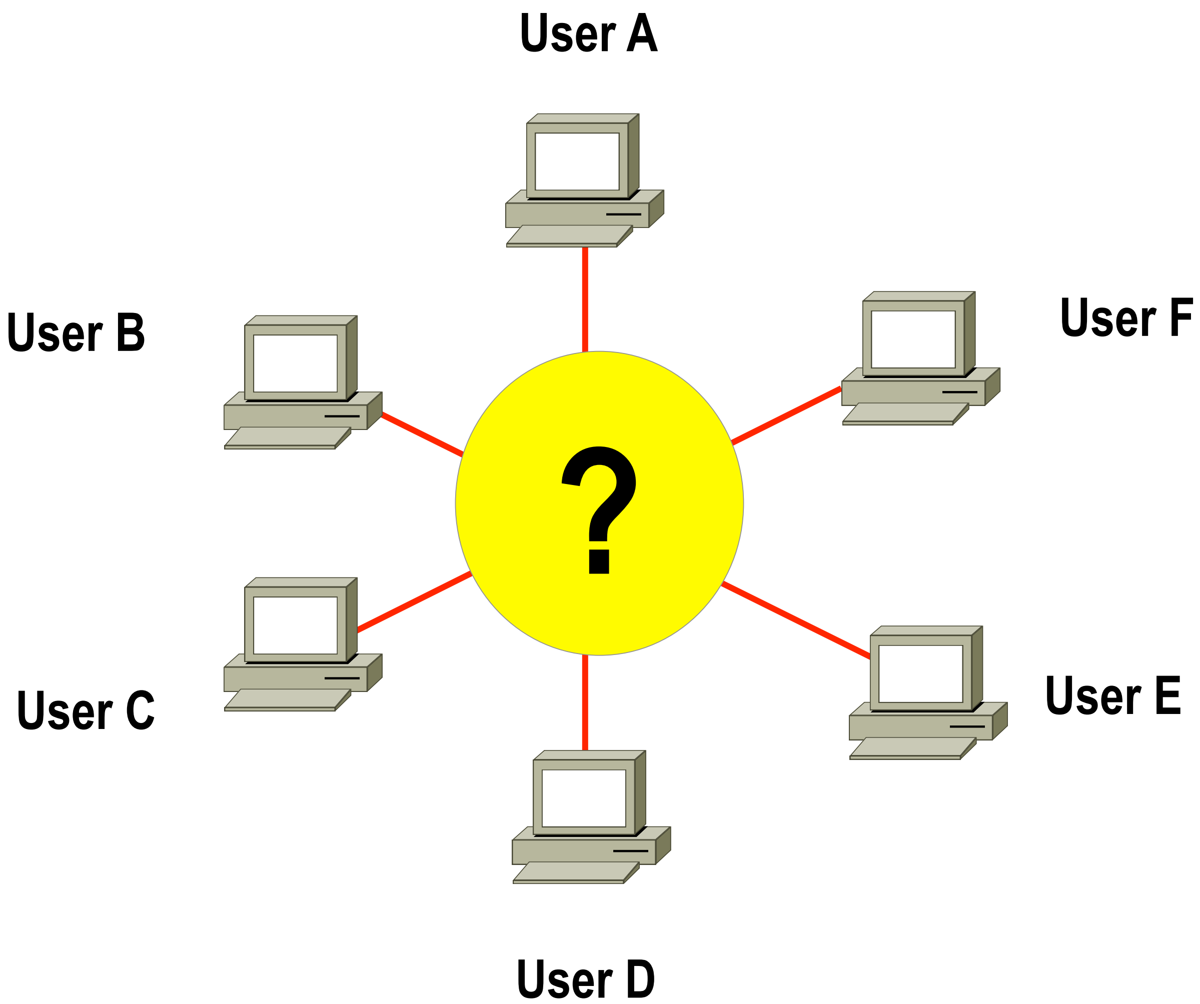
Network Principles

Circuit Switching, Packet Switching,
Datagram versus Virtual Call Service
OSI Model

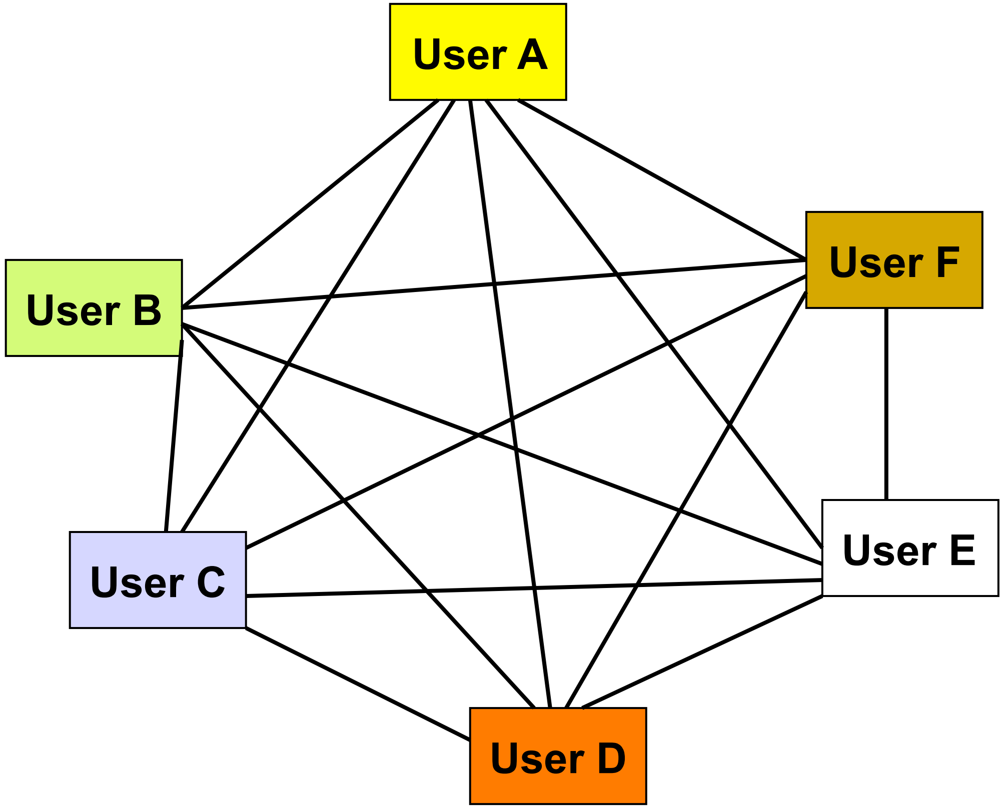
Agenda

- <u>**Introduction**</u>
- **Circuit Switching**
- **Packet Switching**
  - Principles
  - Datagram Service
  - Virtual Call Service
- **OSI Reference Model**
- **Summary of Network Methods**

How To Connect All Locations?

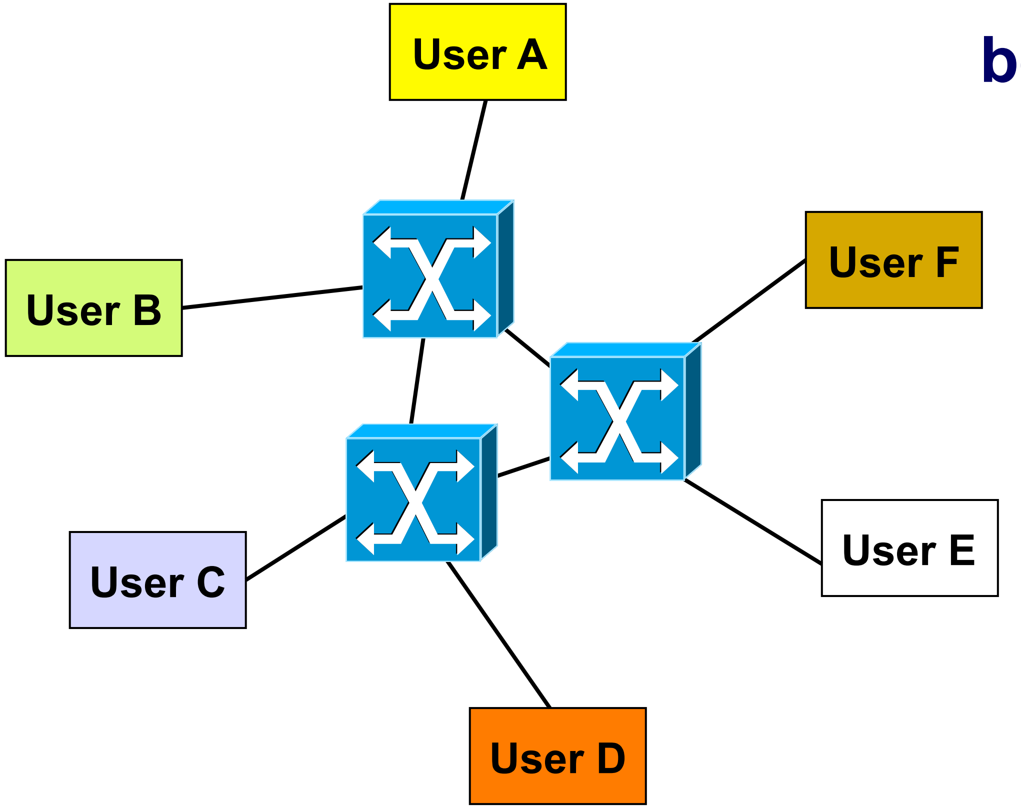


Networking: Fully Meshed



- Metcalfe's Law: n(n-1)/2 links
- Good fault tolerance
- Expensive

Networking: Switching



Network switches could be based on:

Synchronous TDM

- **Circuit Switching**

or

Asynchronous TDM

- **Packet Switching**

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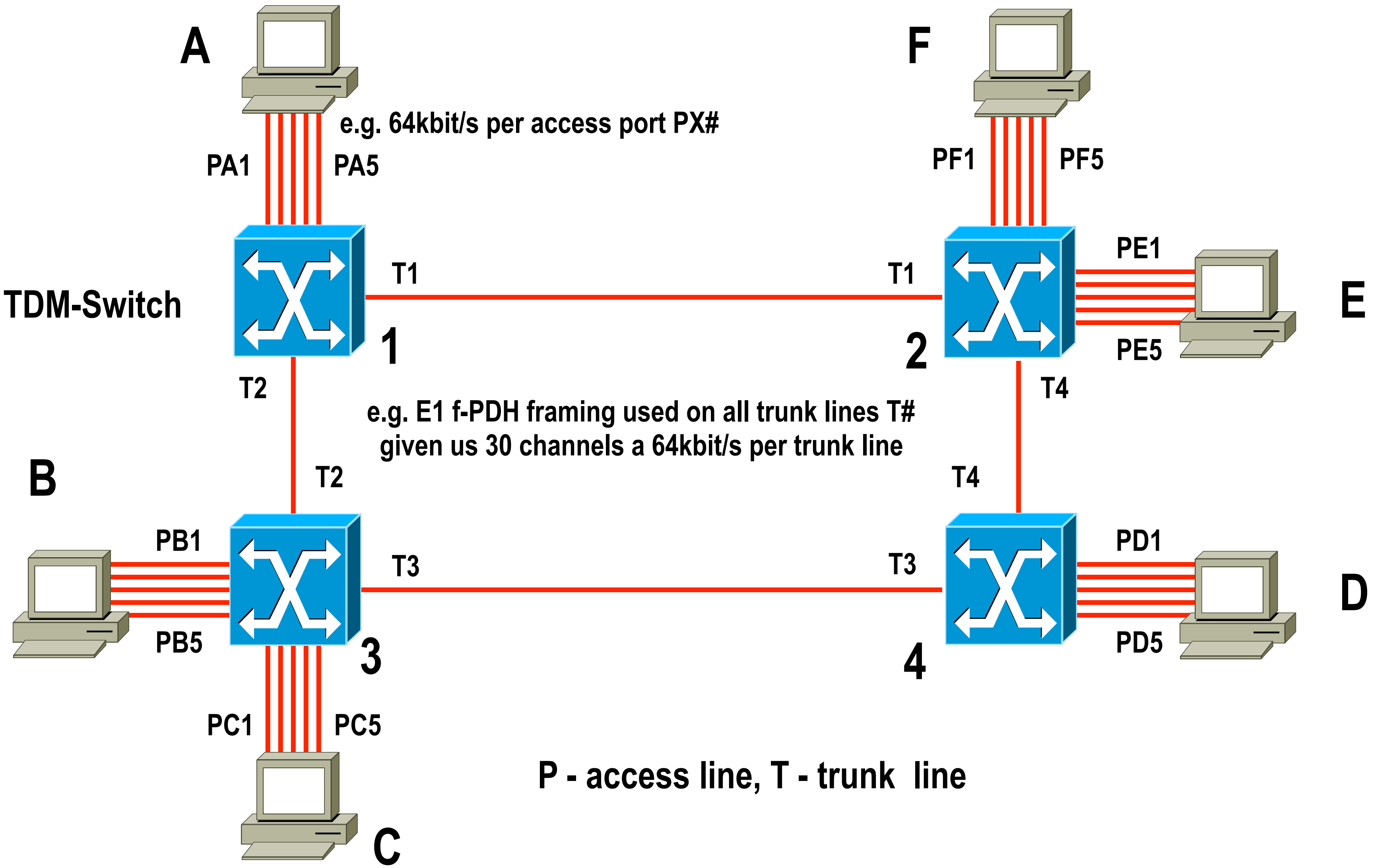
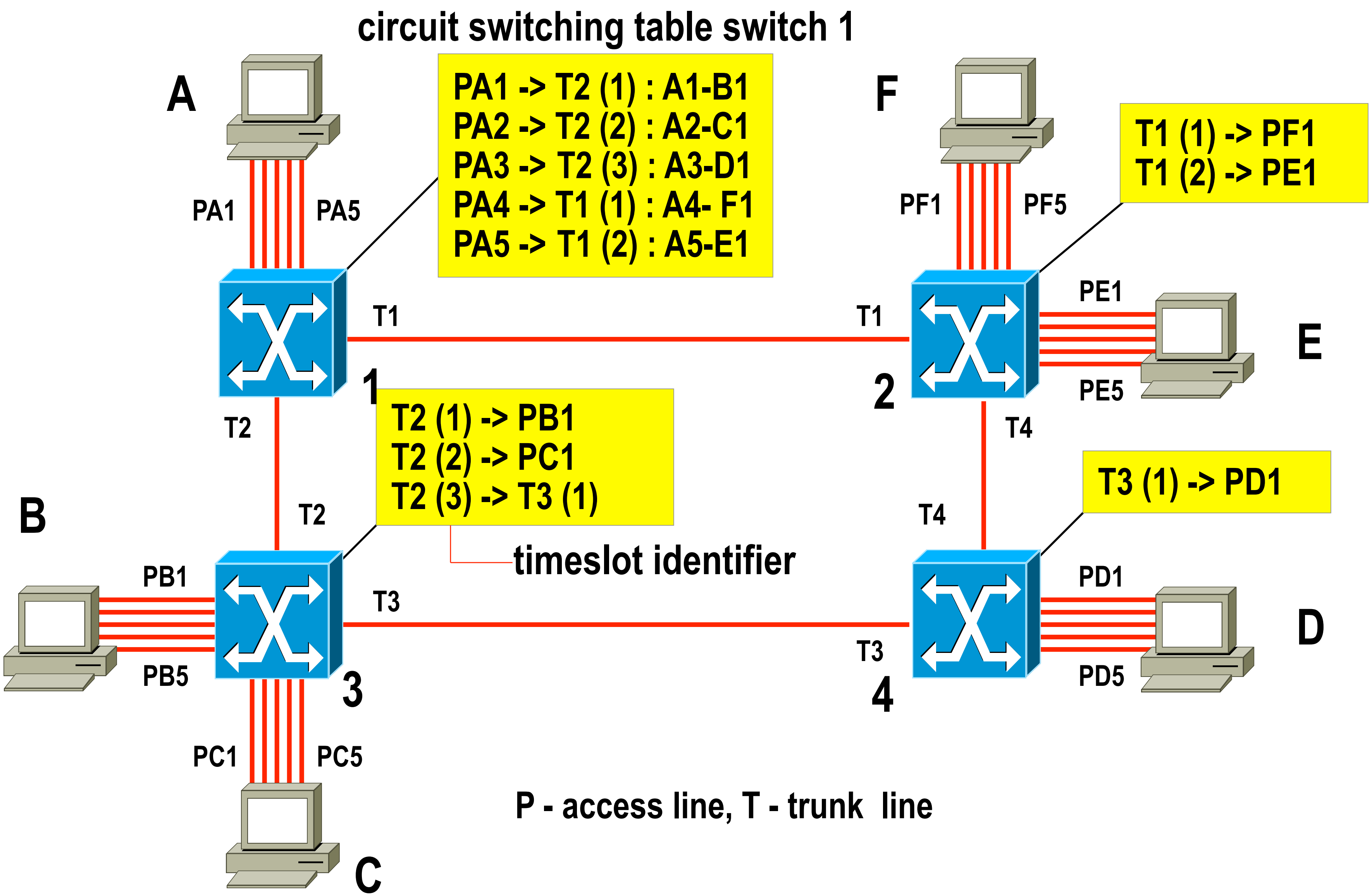
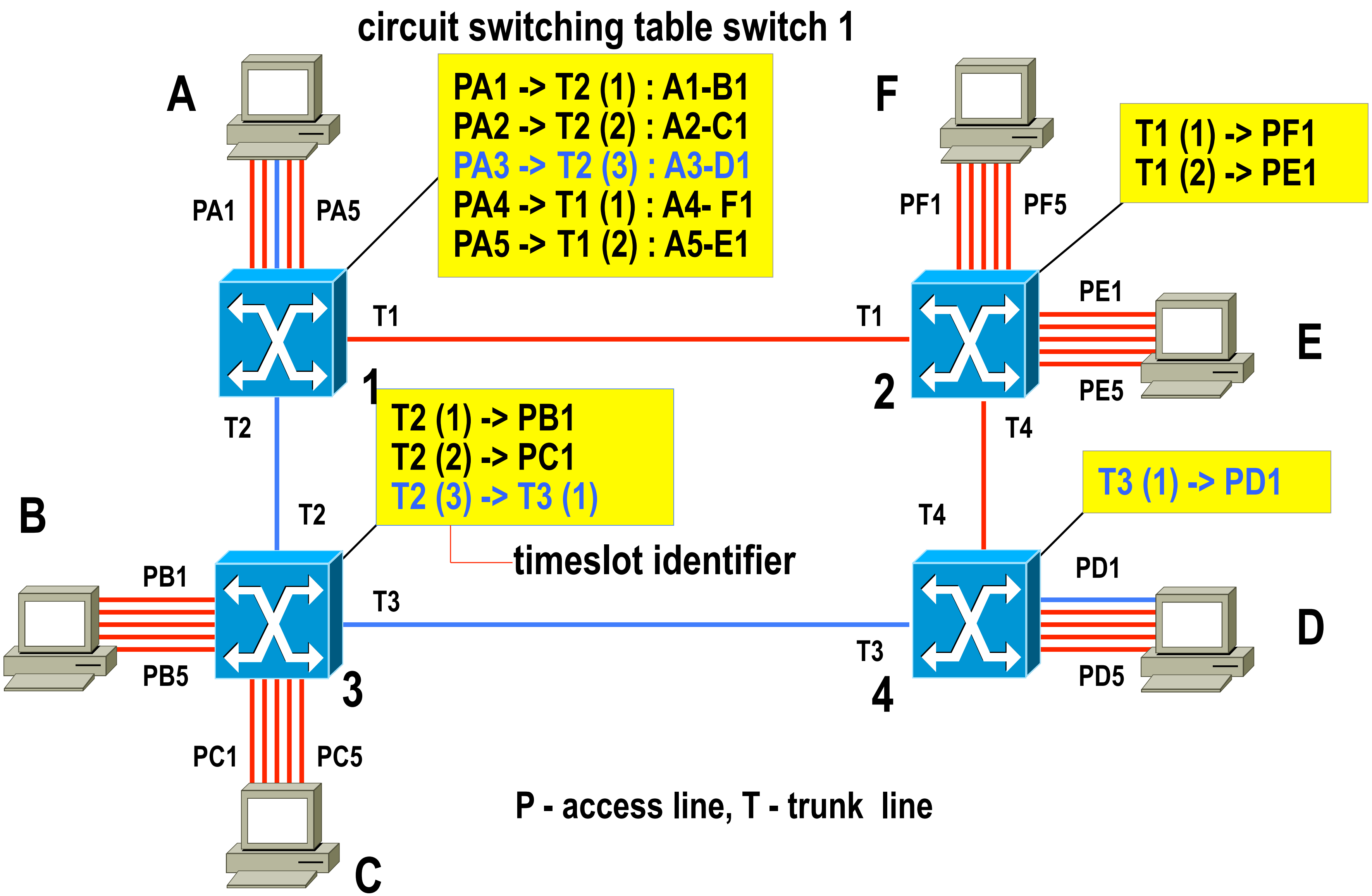
Circuit Switching



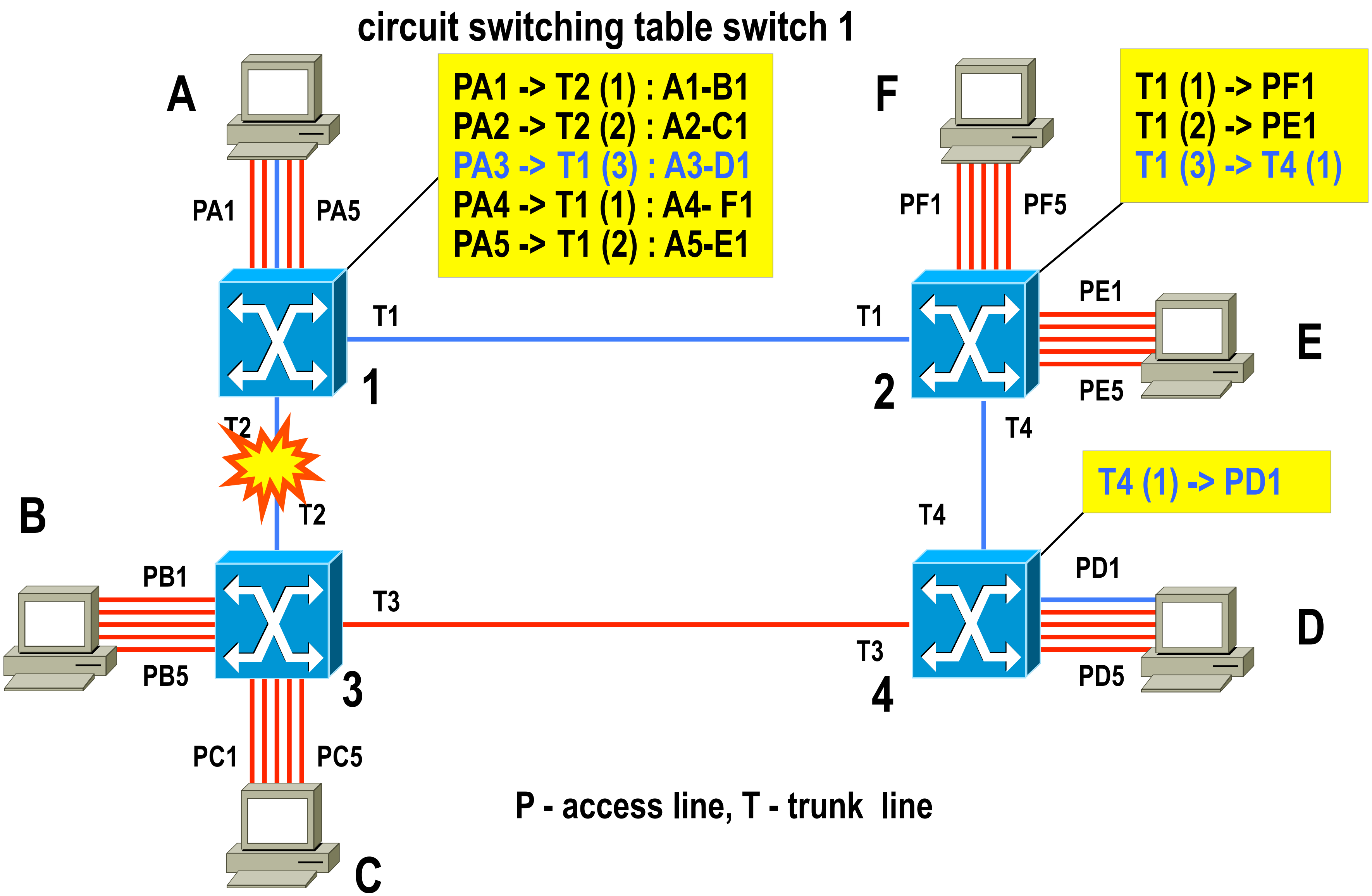
Connections of Device A



Connections of Device A
Circuit Path PA3 (A) - PD1 (D)



Connections of Device A
Circuit Path PA3 (A) - PD1 (D) Restoration

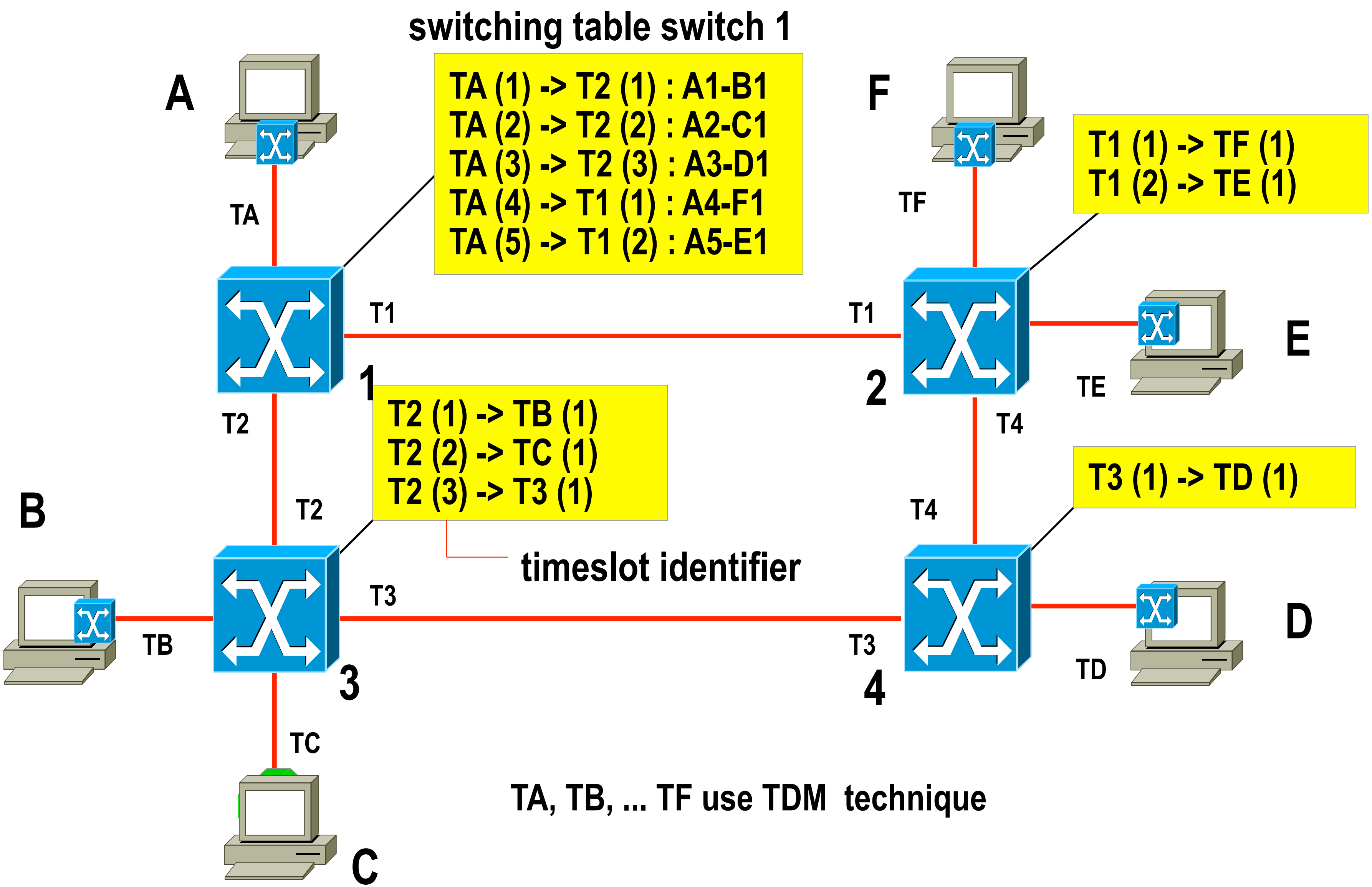


Circuit Switching – Facts

- **Based on synchronous (deterministic) TDM**
  - Minimal and constant delay
  - Protocol transparent
  - High bit rate on trunk lines
    - Sum of I access links traversing a given trunk
  - Possibly bad utilization
    - Idle pattern in timeslots if no data present
  - Good for isochronous traffic (voice)

- **Switching table entries**
  - Static (manually configured)
  - Dynamic (signaling protocol)
  - Scales with number of connections!

TDM lines to Devices



Handling Of Circuit Switching Table

- **Static**
  - Entries are configured by TDM network administrator
  - **Permanent circuit service**
- **Dynamic (fail-safe)**
  - Entries are changed automatically by TDM network management protocol to switch over to a redundant path in case a trunk line breaks
  - **Soft permanent circuit service**
- **Dynamic (on demand)**
  - End-systems use a signaling protocol to local TDM switch in order to transport setup or tear down requests
  - TDM switches establish path (corresponding entries in circuit switching tables) using their own signaling protocols
  - **Switched circuit service**

Circuit Switching Data Networks

- **Network providers offer permanent circuit services**
  - With permanent entries in circuit switching tables
  - Optional with fast automatic switchover (50ms) in case of trunk failure
  - **Leased line**

- **Network providers offer switched circuit services**
  - With dynamic entries in circuit switching tables generated on demand
  - Today implementations are based on **ISDN** only
  - **Integrated Services Digital Network**
  - Outband signaling via D-channel) between ISDN end system (ISDN-TE) and ISDN-LE (Local Exchange) = that is the local TDM switch
  - Communication between ISDN-LEs is based on Signaling System 7 (SS7)
- **Base is PDH or SDH transmission infrastructure**

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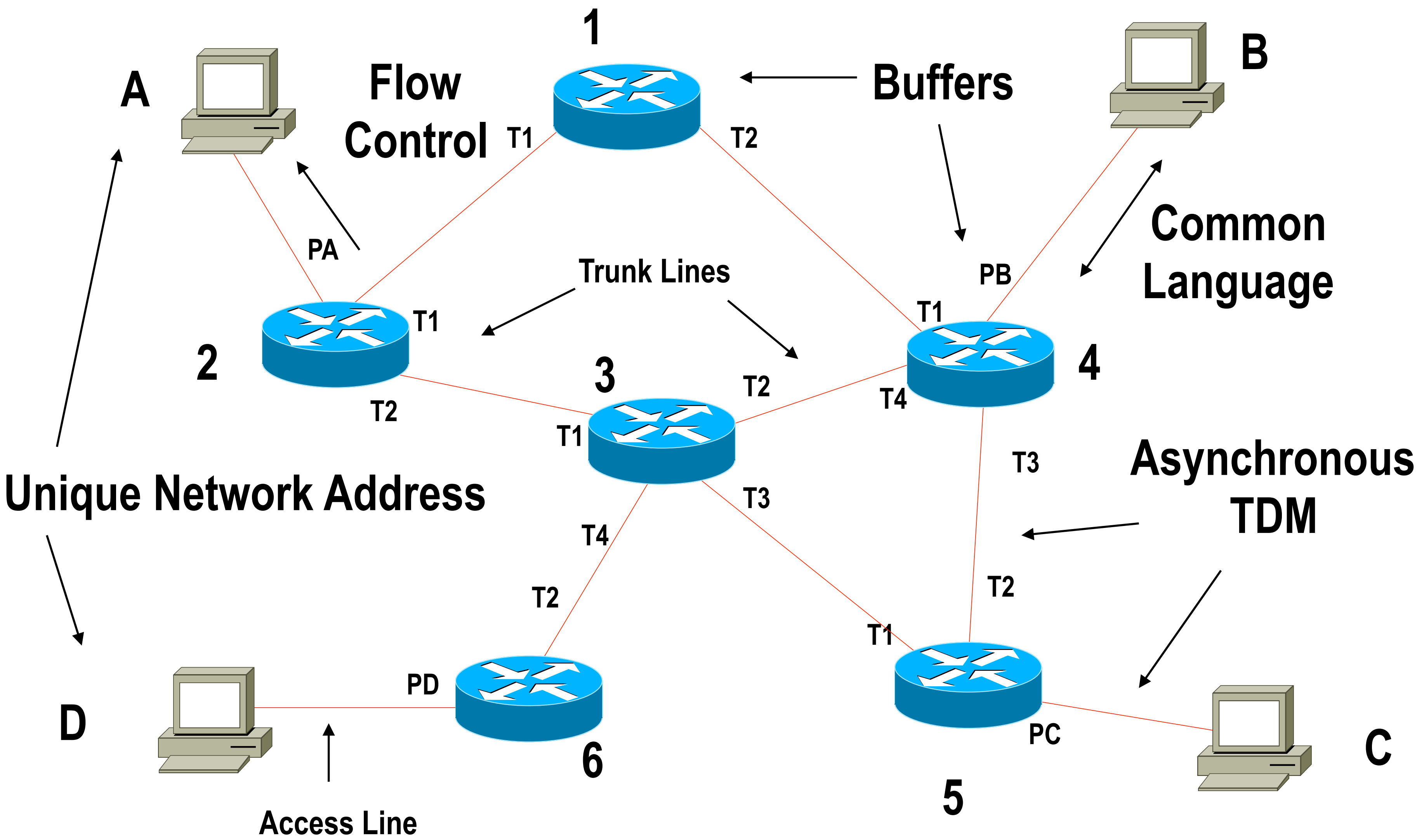
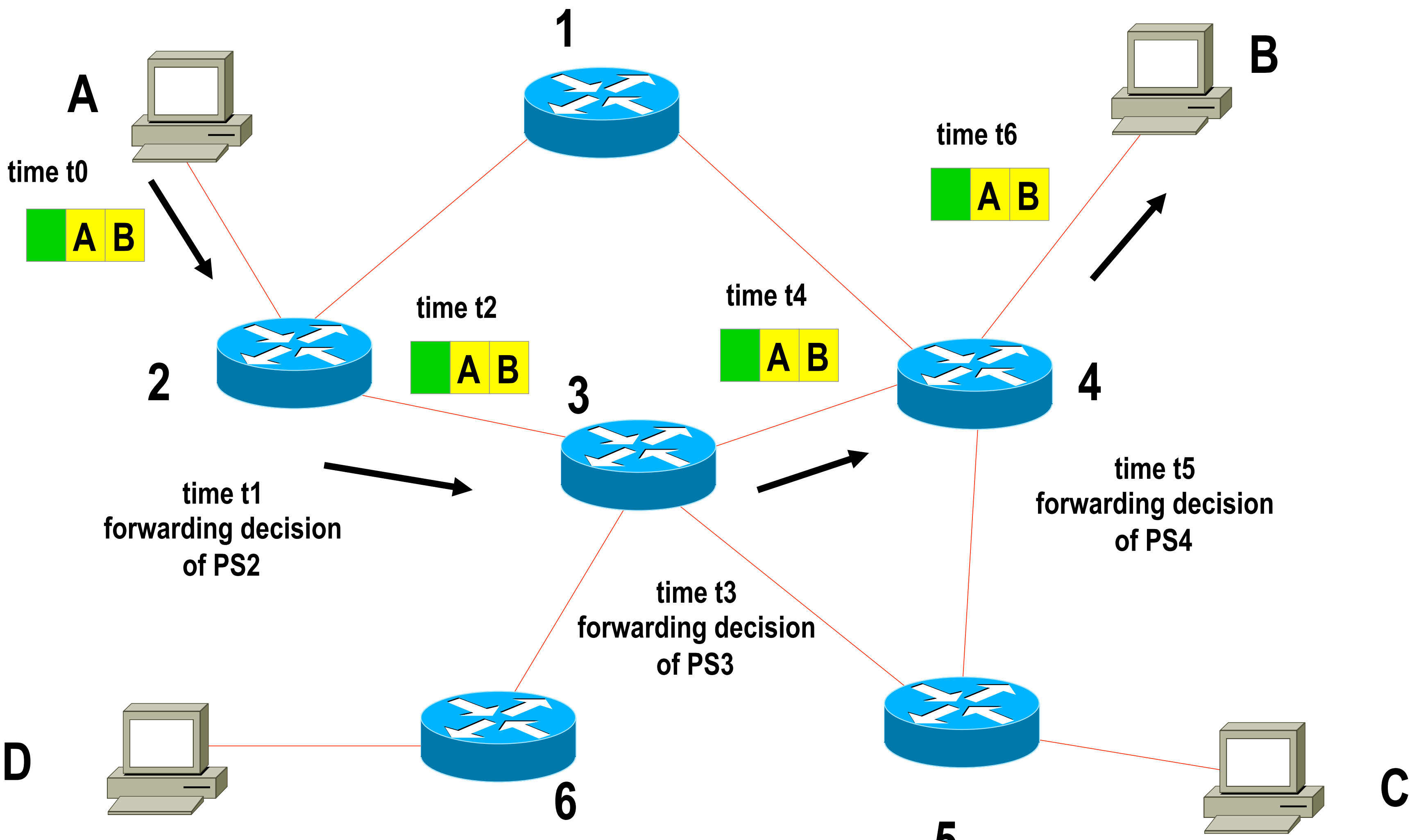
Packet Switching Topology



Packet Forwarding Principle (Store and Forward)



... Packet payload

A B ... Source Address / Destination Address

Packet Forwarding is based on Tables

- Tables contains
  - Information how to reach destinations
  - Mapping between destination address or local connection identifier and outgoing trunk or access port
  - "**Signposts**"

- Two types of tables
  - Depending on the actual implementation of packet switching technology
  - **Routing tables**
  - **Switching tables**

Routing - Addressing

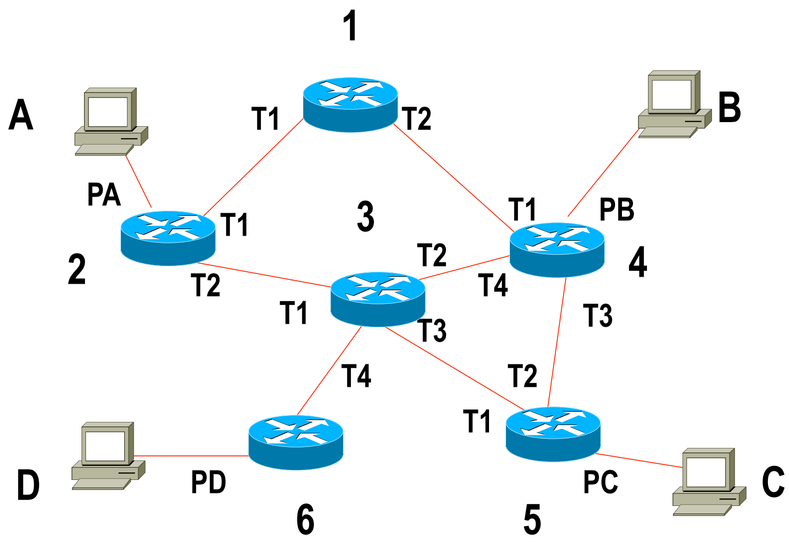
- **Routing in packet switched networks**
  - Process of path selection in order to forward a packet to a given destination
  - Selection based on (destination) address
- **Address specifies the location of end system**
  - Contains topology information
  - Address must be unique within the network in order to enable routing based on signposts
- **Protocol using unique <u>and</u> structured addresses**
  - Is called <u>**routed**</u> or <u>**routable protocol**</u>

Routing Types

- **Static routing**
  - Routing table entries are static
  - Based on preconfigured routing tables
  - Configuration done by the network administrator
  - Non-responsive to network topology changes
- **Dynamic routing**
  - Routing table entries are variable (dynamic)
  - Changes done by **routing protocols**
    - Communication protocol used between packet switches to find out the network topology and to calculate the best path to any given destination
  - Responsive to any network topology changes

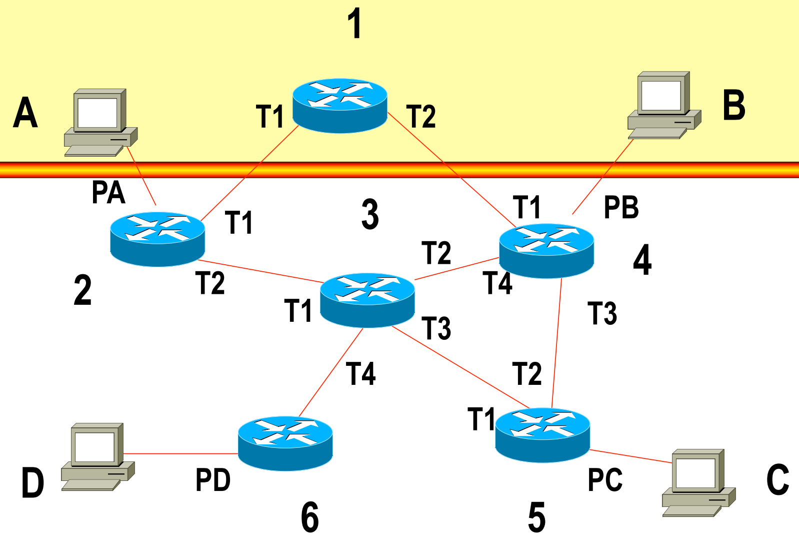
Routing Table

- **Example of a static routing table of packet switch 2**



Address of destination	*incoming line*	outgoing line	next PS
B	*PA, T1*	T2	PS 3
D	*PA,T1*	T2	PS 3
C	*PA, T1*	T2	PS 3
A	*T1 or T2*	PA	local

Routing Table



- **Example of a static routing table of packet switch 3**

Address of destination	*incoming line*	outgoing line	next PS
B	*T1*	T2	PS 4
C	*T1*	T3	PS 5
D	*T1*	T4	PS 6
B	*T2*	kill	- - -
B	*T3*	T2	- - -
B	*T4*	T2	- - -
C	*T2*	T3	PS 5
C	*T3*	kill	- - -
…..	*…..*	…..	…..

Routing Table Usage / Type of Service

- **Routing tables are differently used**
  - Depending on the type of service of the packet switching network
- **Packet switched networks based on**
  - Connectionless Service (CL) - Datagram service
    - Routing tables are used to forward all kind of packets
  - Connection-oriented Service (CO) – Virtual Call service
    - Routing tables are used to forward control packets for connection establishment
    - These control packets generate entries in switching tables
    - After connection establishment, only the switching tables are used to forward data packets

Technology Differences - Summary

- **Datagram Principle**
  - Global and routable addresses
  - Connectionless
  - Routing table for forwarding of packets

- **Virtual Call Principle**
  - Local addresses
  - Connection-oriented
  - Routing table for setup of connections
  - Switching table for forwarding of packets

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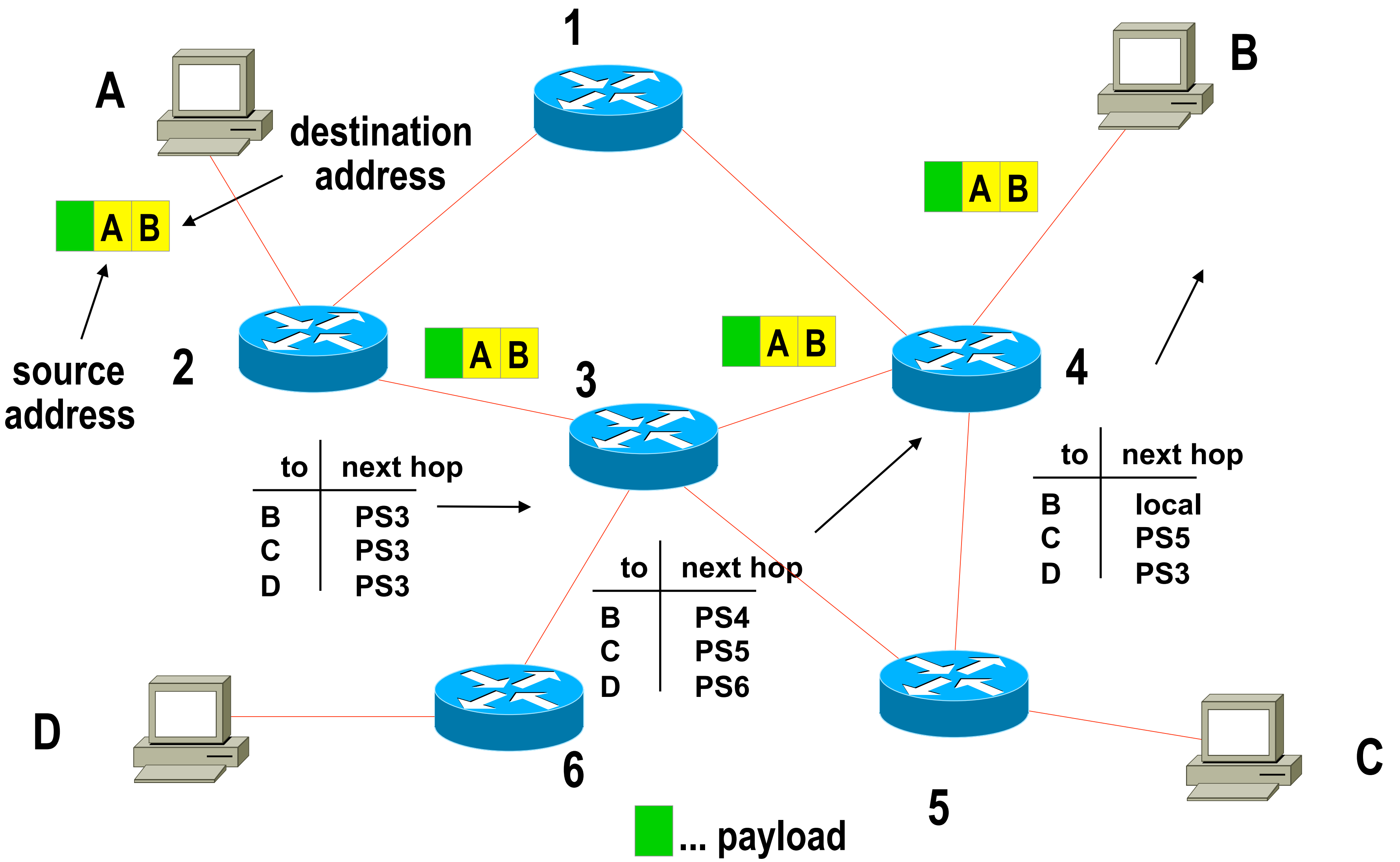
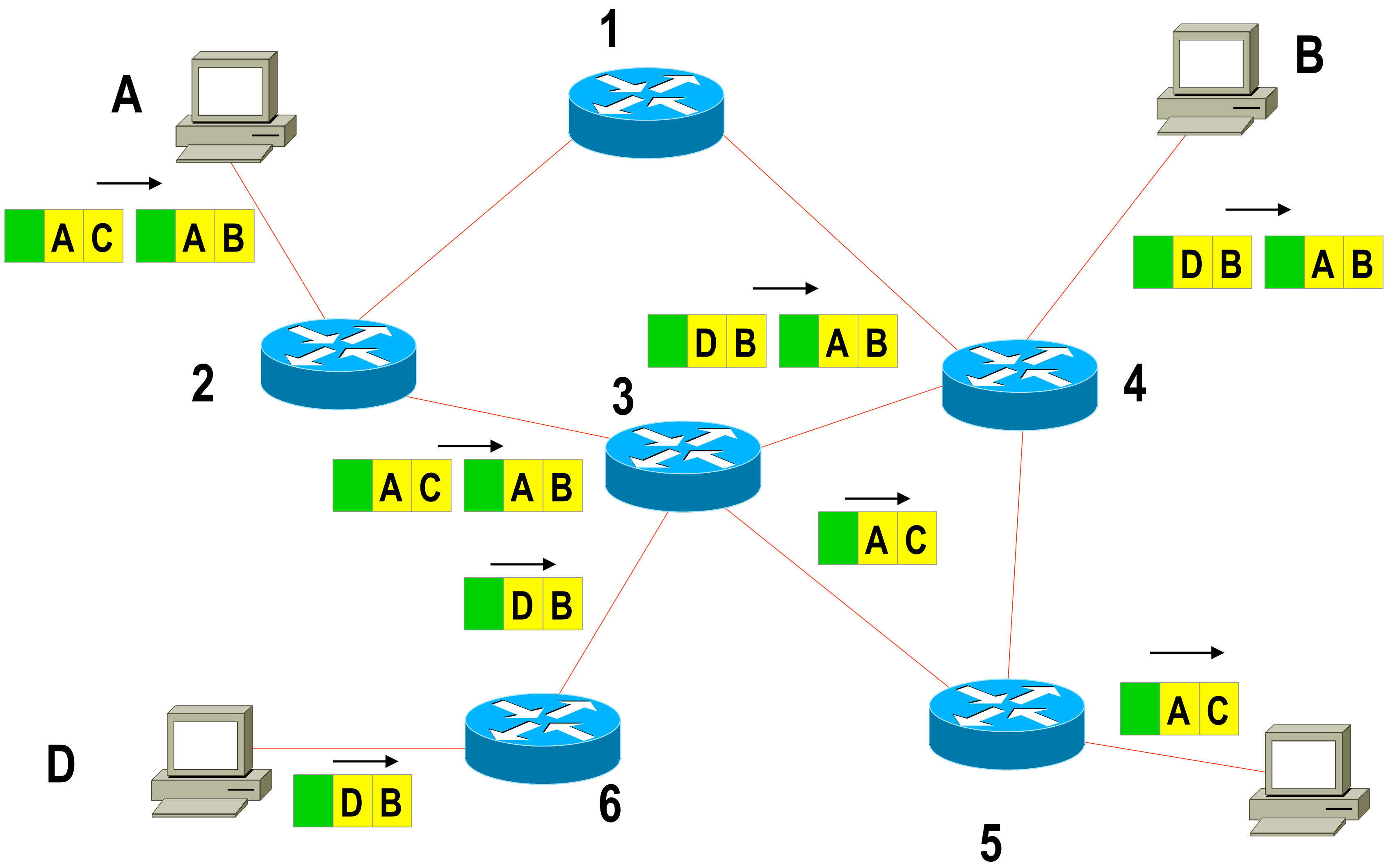
Datagram Service Principles

- **Connectionless service**
  - Packets can be sent without establishing a logical connection between end systems in advance
  - Packets have no sequence numbers
  - They are called **"Datagrams"**
- **Every incoming datagram**
  - Is processed independently regarding to all other datagrams by the packet switches
- **The forwarding decision for incoming packets**
  - Depends on the current state of the routing table
- **Each packet contains**
  - Complete address information (source and destination)

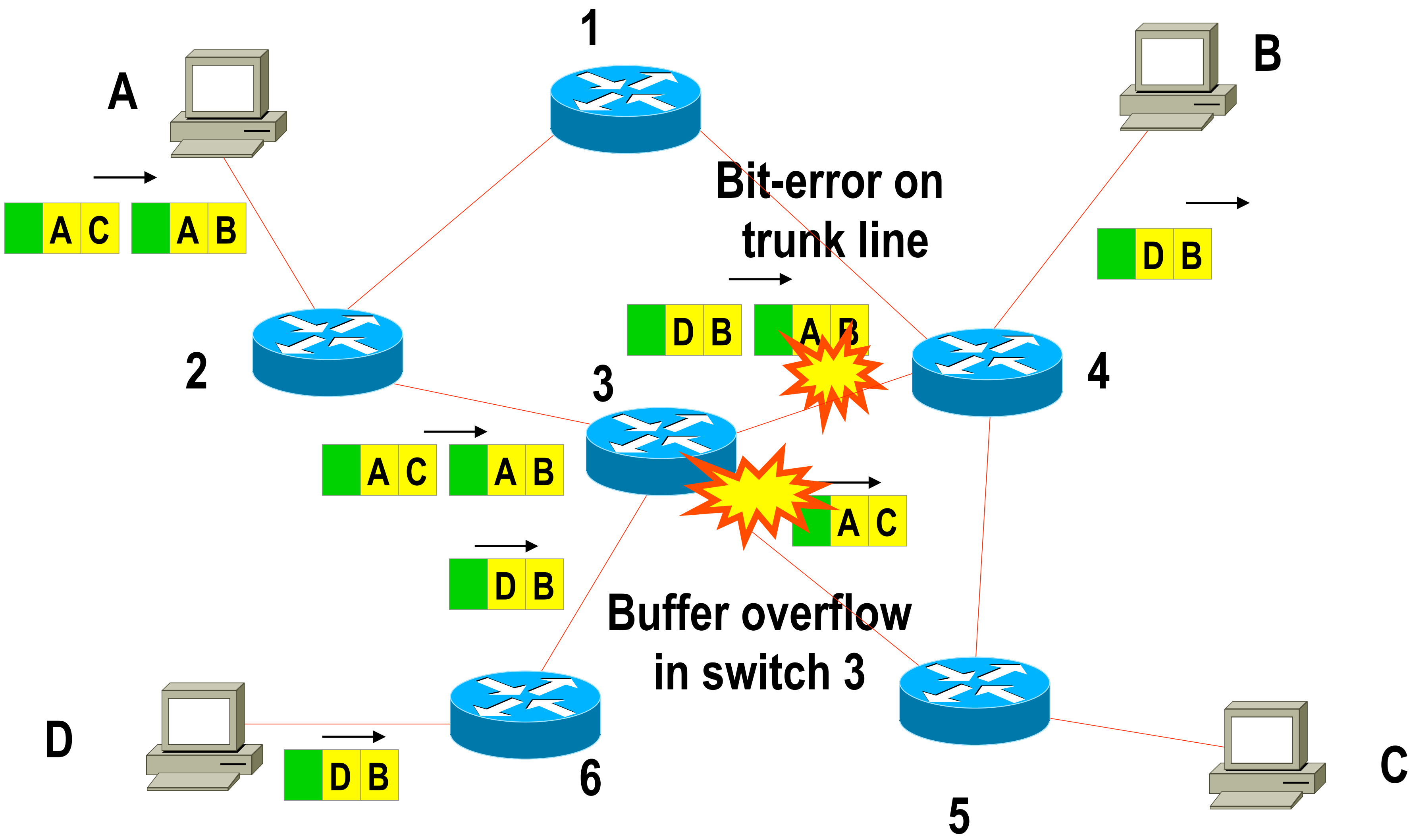
Packet forwarding (CL) is based on routing tables only
(Datagram Service, Best-Effort Service)



Datagrams are forwarded completely independent from each other based on current state of routing tables



Best-Effort Service



Datagram Service Facts (1)

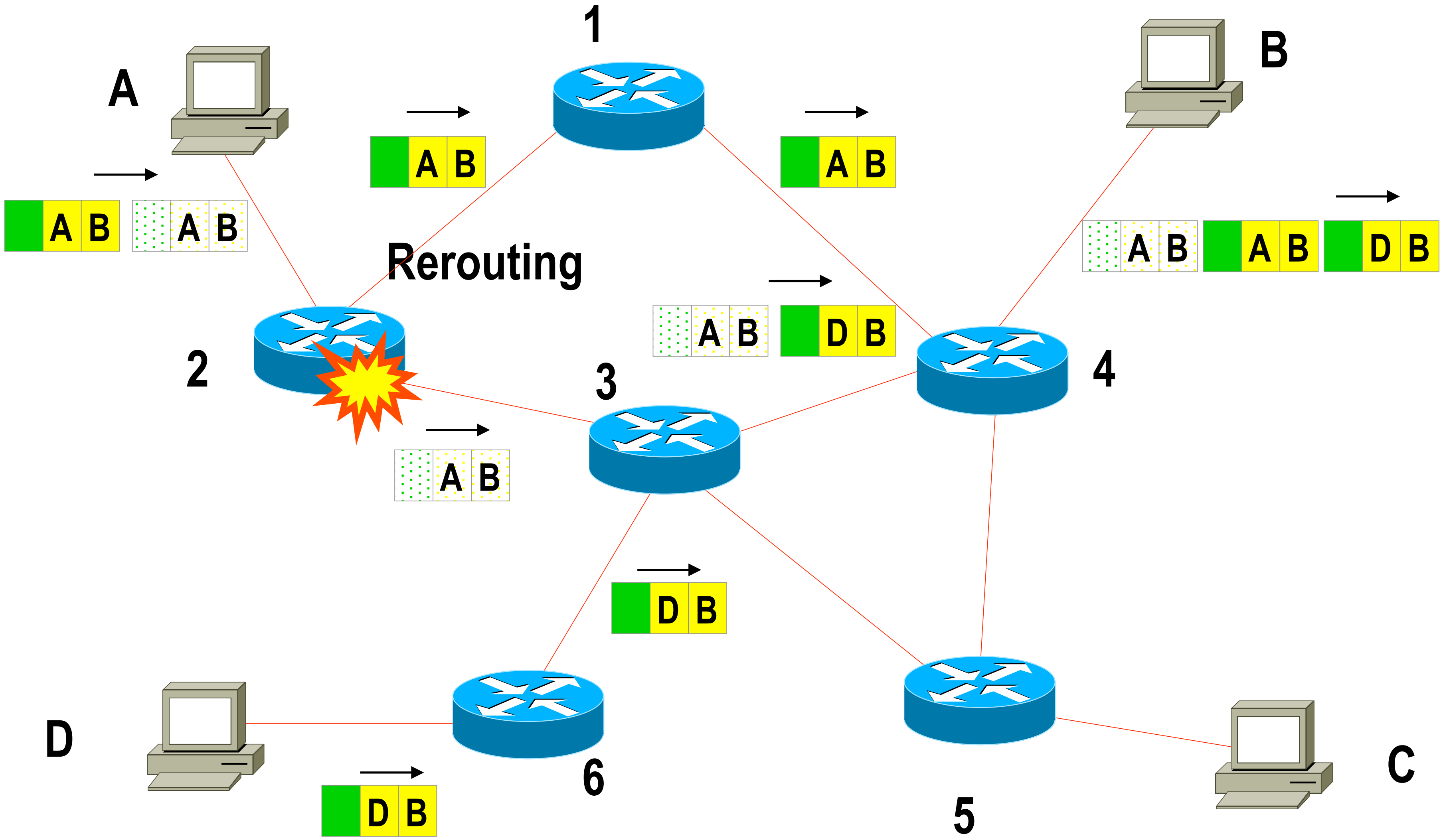
- **Packets may be discarded / dropped by packet switches**
  - In case of network congestion
  - In case of transmission errors

- **Best effort service**
  - Transport of packets depends on available resources

- **The end systems may take responsibility**
  - For error recovery (retransmission of dropped or corrupted packets)
  - For sequencing and handling of duplicates

- **Reliable data transport requires good transport layer**
  - "Dumb network, smart hosts"

Rerouting – Sequencing Not Guaranteed !

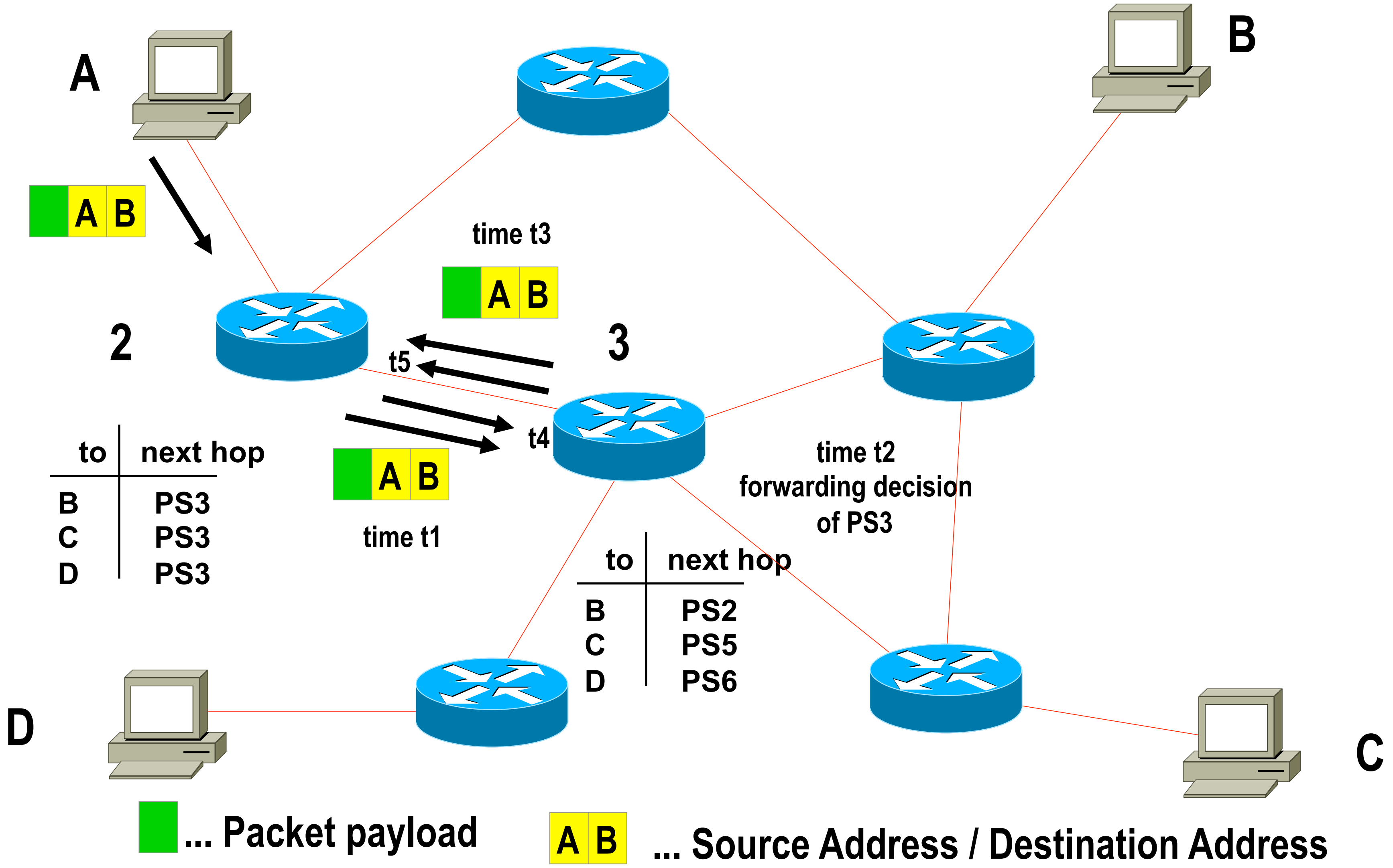


Datagram Service Facts (2)

- **Rerouting in case of topology changes or load balancing means**
  - Packets with the same address information can take different paths to destination
  - Packets may arrive out of sequence

- **Sequence not guaranteed**
  - Rerouting on topology change
  - Load sharing on redundant paths
  - End stations must care

Datagram forwarding needs a kill-mechanism to overcome inconsistent routing tables



Datagram Service Facts (3)

- **Connectionless behavior**
  - Faster delivery of first data
  - No resource reservation is possible
    - e.g. bandwidth on trunk line for a certain communication between end systems
    - e.g. buffer memory on packet switches
  - Bad "**Quality of Service**" (QoS)
  - Flow control between packet-switch and end-system
    - Would help in case of congestion if proactively performed
    - But lack of trust makes it impossible to implement it

Datagram Service Facts (4)

- **Advantages**
  - Small protocol overhead (easy to implement in end systems and packet switches)
  - Fastest delivery of data between end systems because no connection must be established in advance
- **Disadvantage**
  - Delivery of packets is not guaranteed by the network, must be handled by end systems using higher layer protocol
  - Proactive flow control between end-system and packet switch is not possible

Network Technologies based on Datagram Method

- **IP**
  - Packet is called IP datagram
  - End system is called IP host
  - Packet switch is called IP router
- **IPX (Novell)**
- **XNS**
- **Appletalk**
- **Decnet Phase IV**
- **OSI CNLP**

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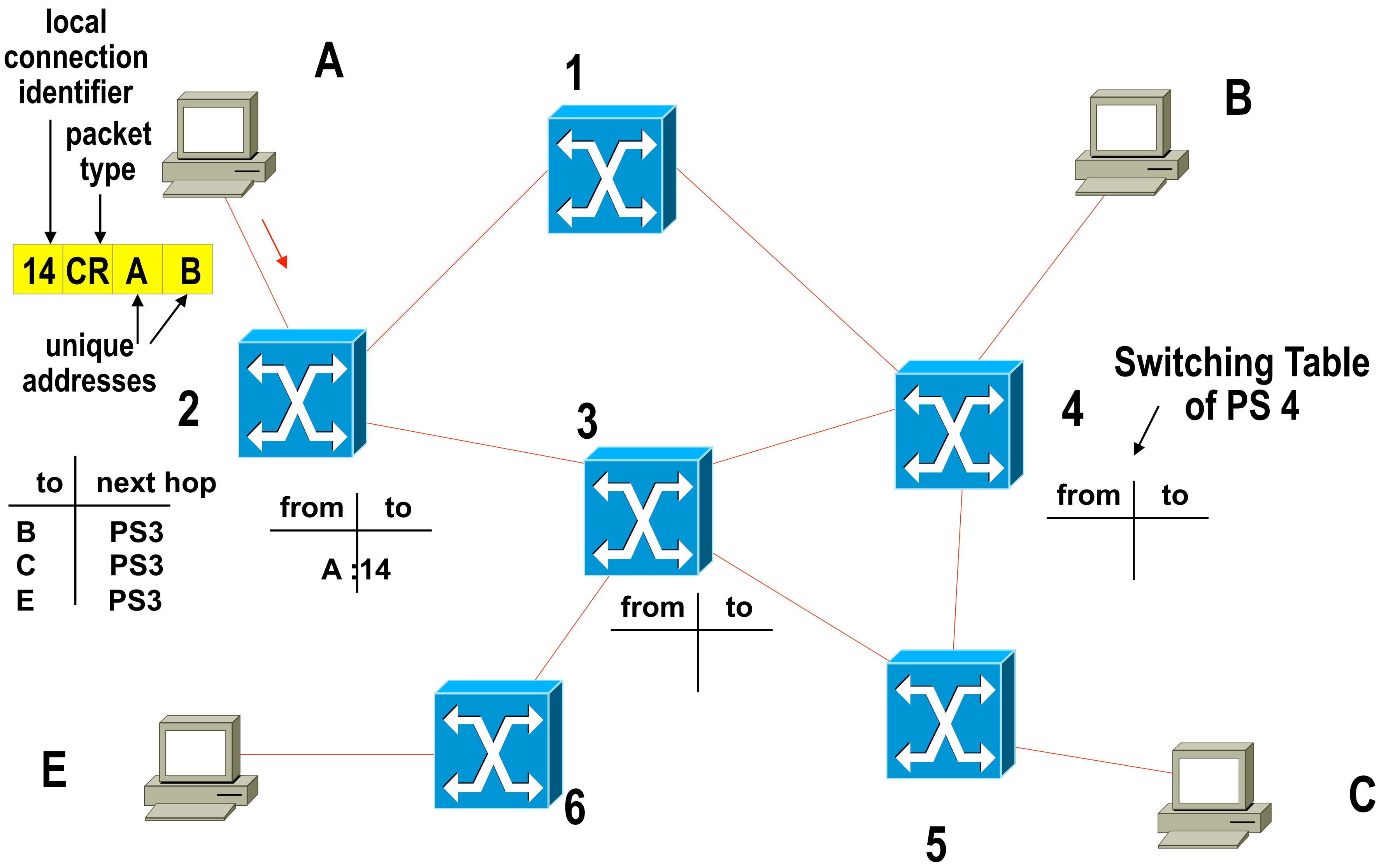
Virtual Call Principles

- **Connection-oriented service**
  - Special control packets (call setup packets) establish a logical (virtual) point-to-point connection between end systems first
  - We call that connection a **Virtual Circuit**
  - After connection is established
    - Data packets can be transmitted across that virtual circuit
    - Typically virtual circuit will be closed after data transfer is finished

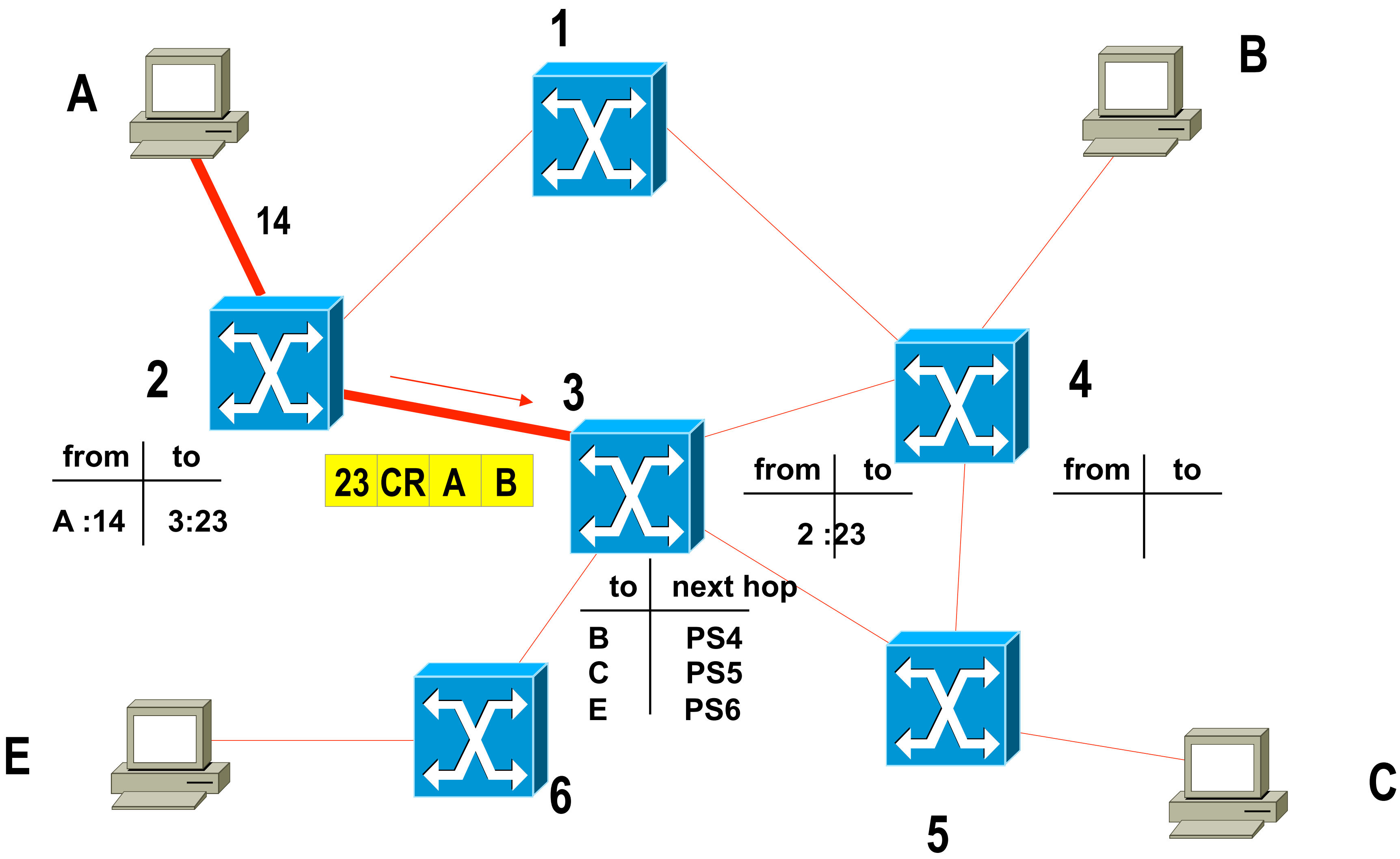
- **Different methods are possible**
  - To establish a virtual call service

Packet forwarding (CO) is based on special switching tables but call-setup still uses conventional routing tables (Virtual Call Setup 1)



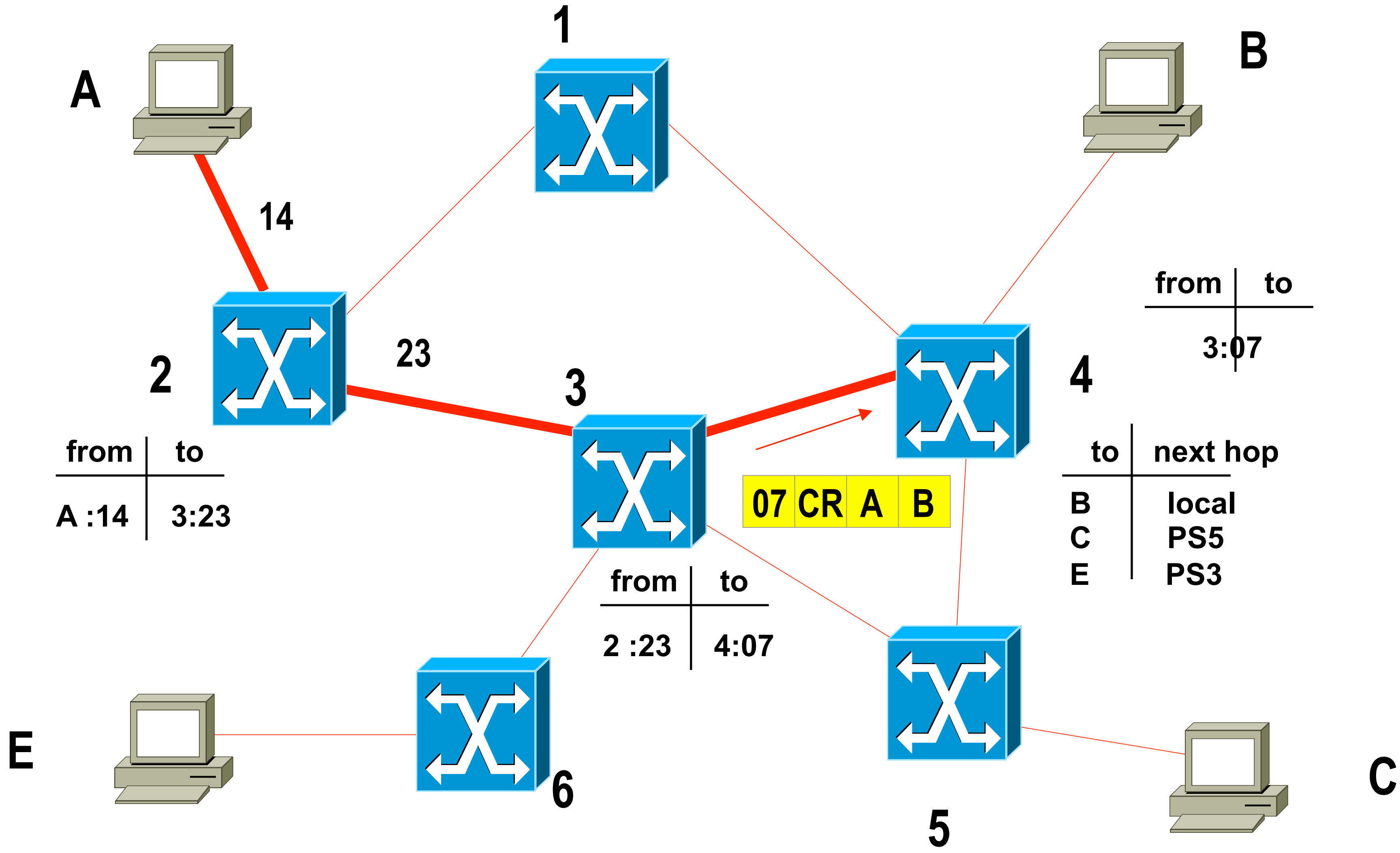
CR ... Call Request

Virtual Call Setup 2



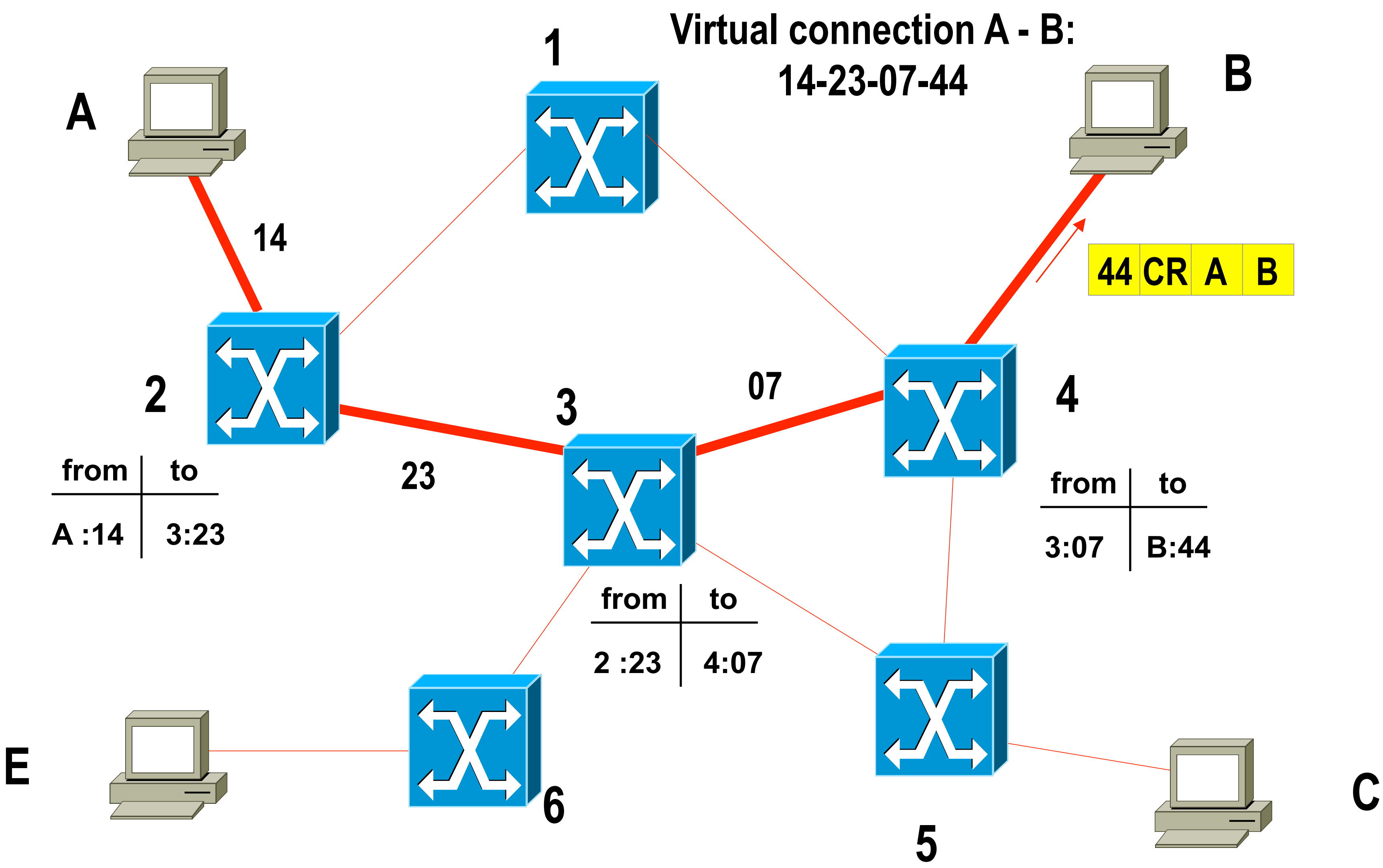
CR ... Call Request

Virtual Call Setup 3



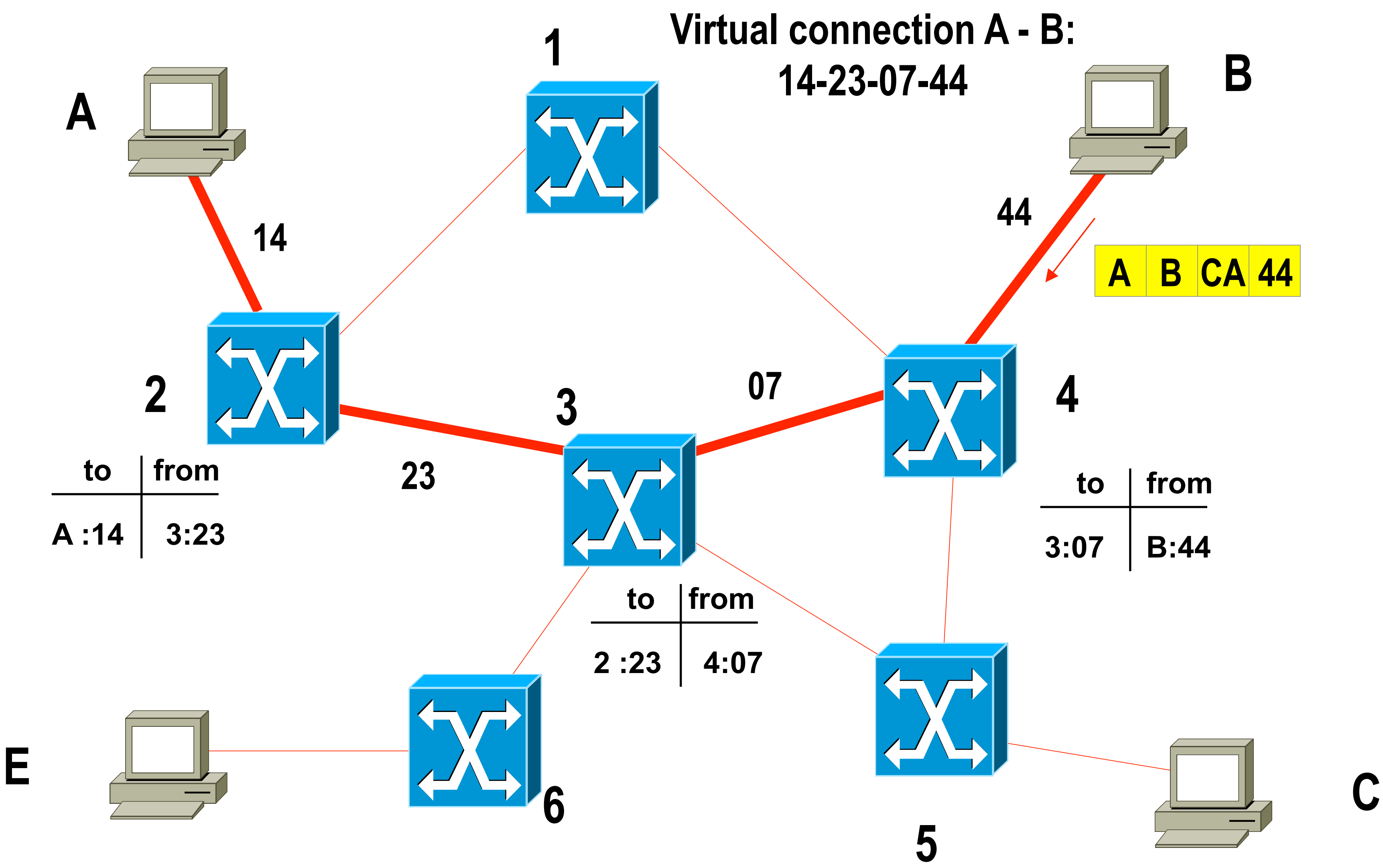
CR ... Call Request

Virtual Call Setup 4



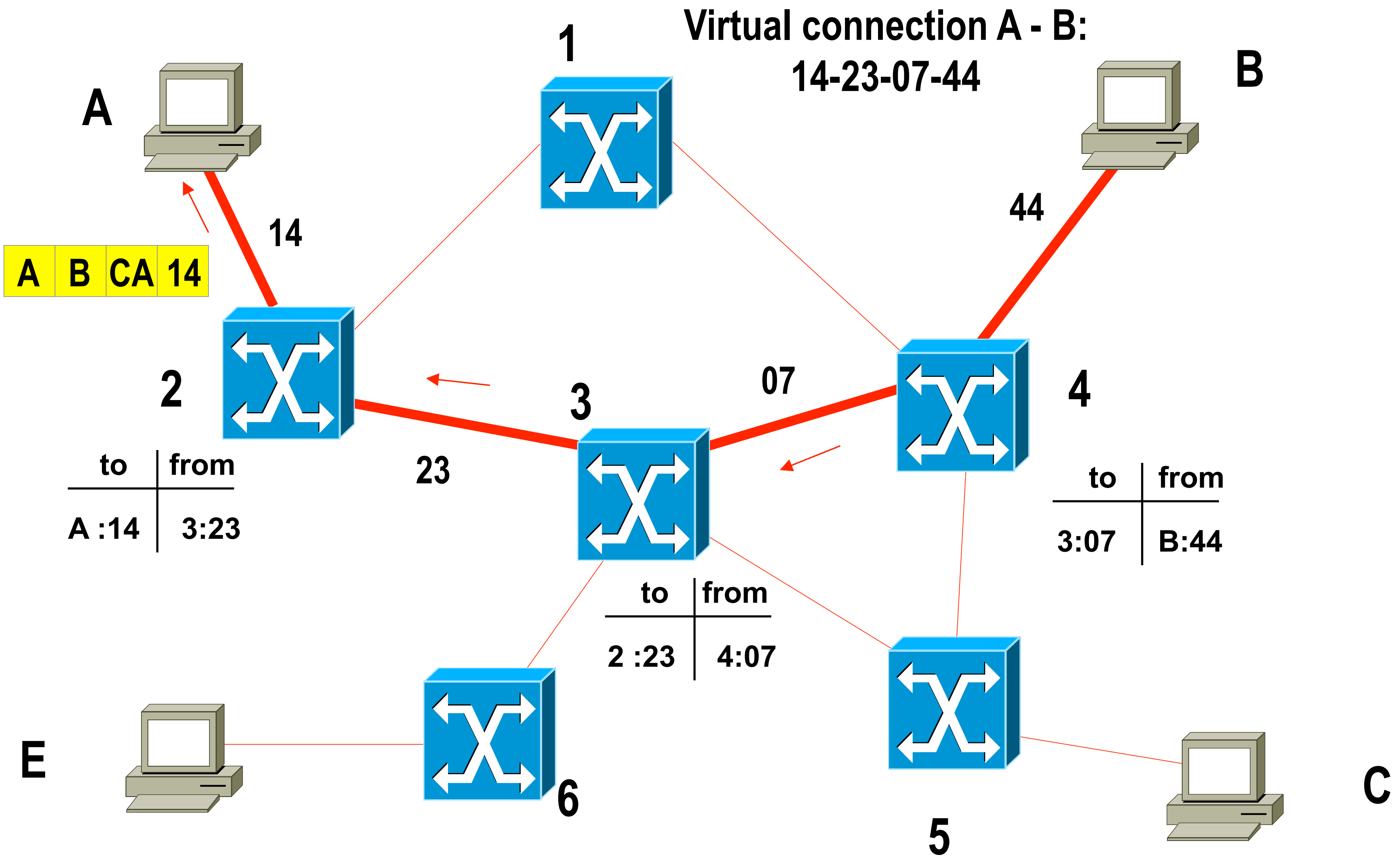
CR ... Call Request

Virtual Call Setup 5



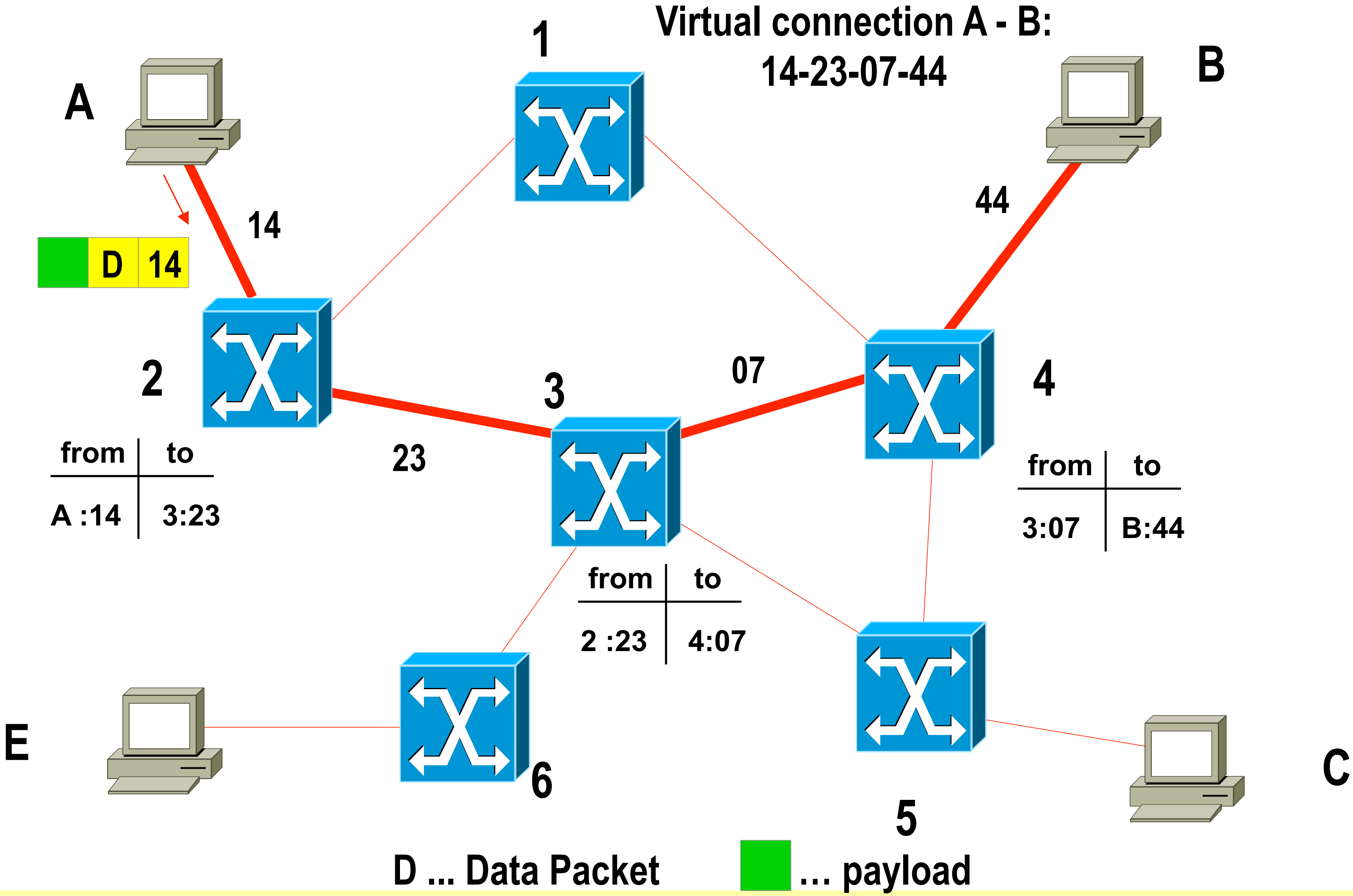
CA ... Call Accepted

Virtual Call Setup 6

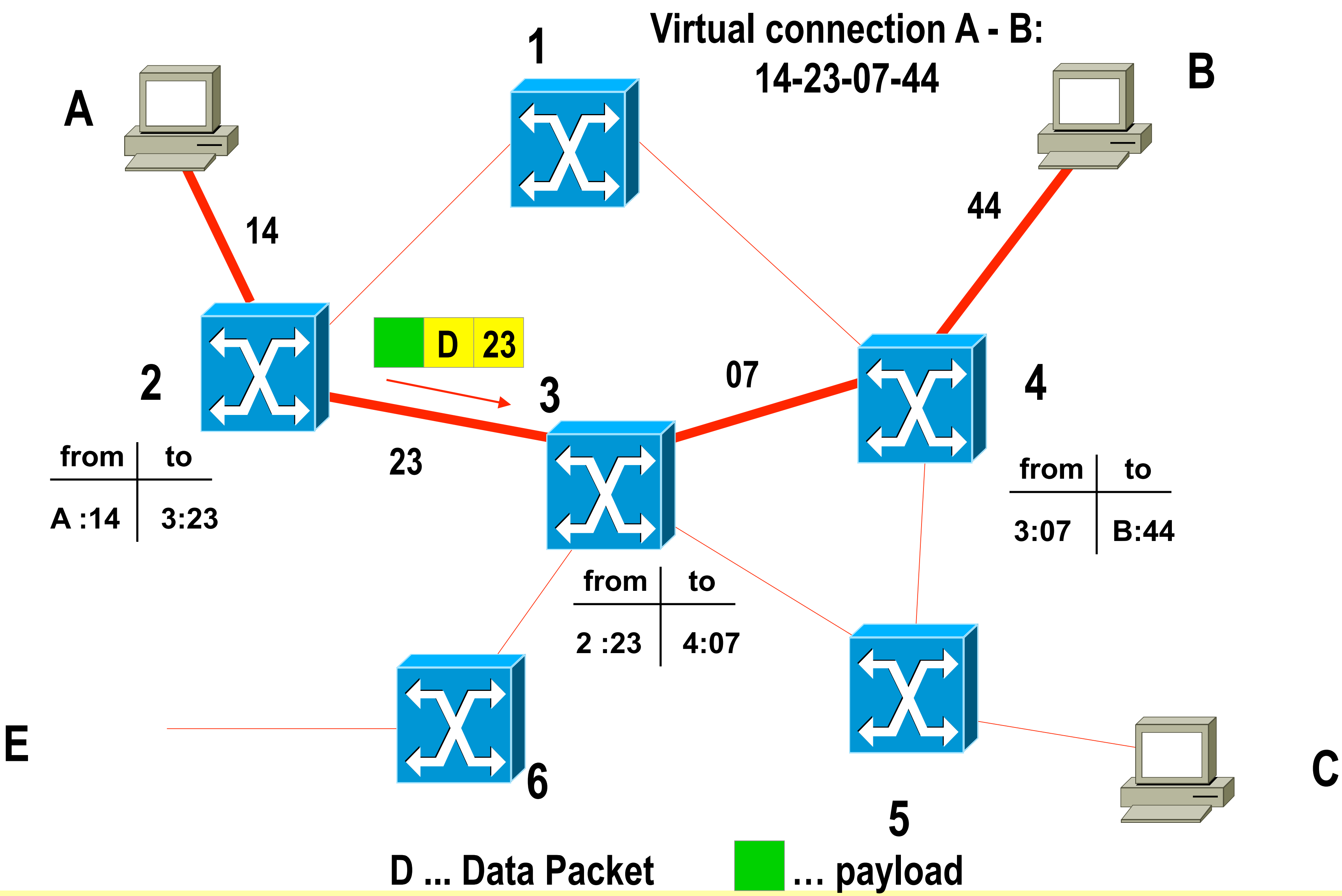


CA ... Call Accepted

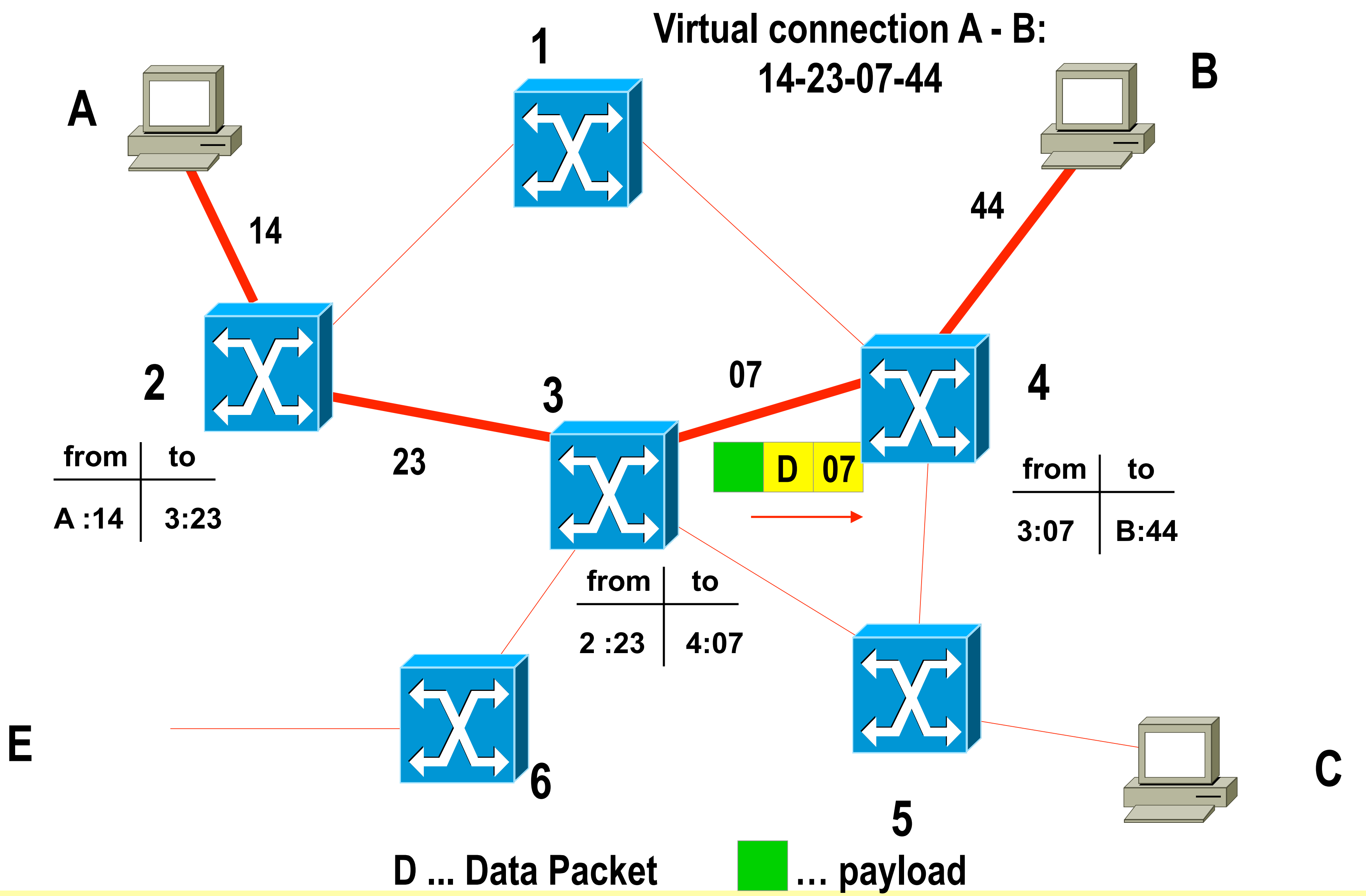
Data Forwarding 1



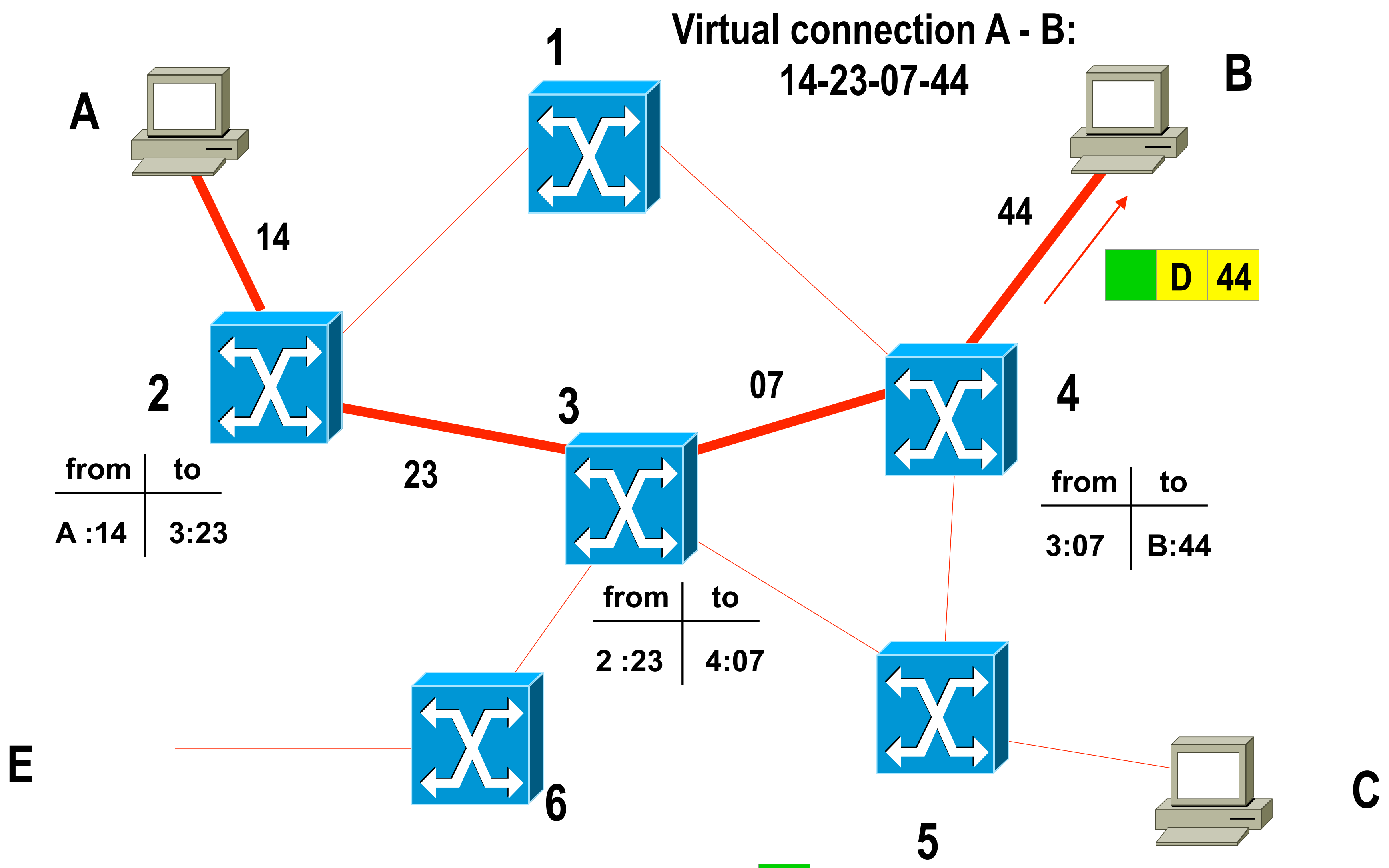
Data Forwarding 2



Data Forwarding 3

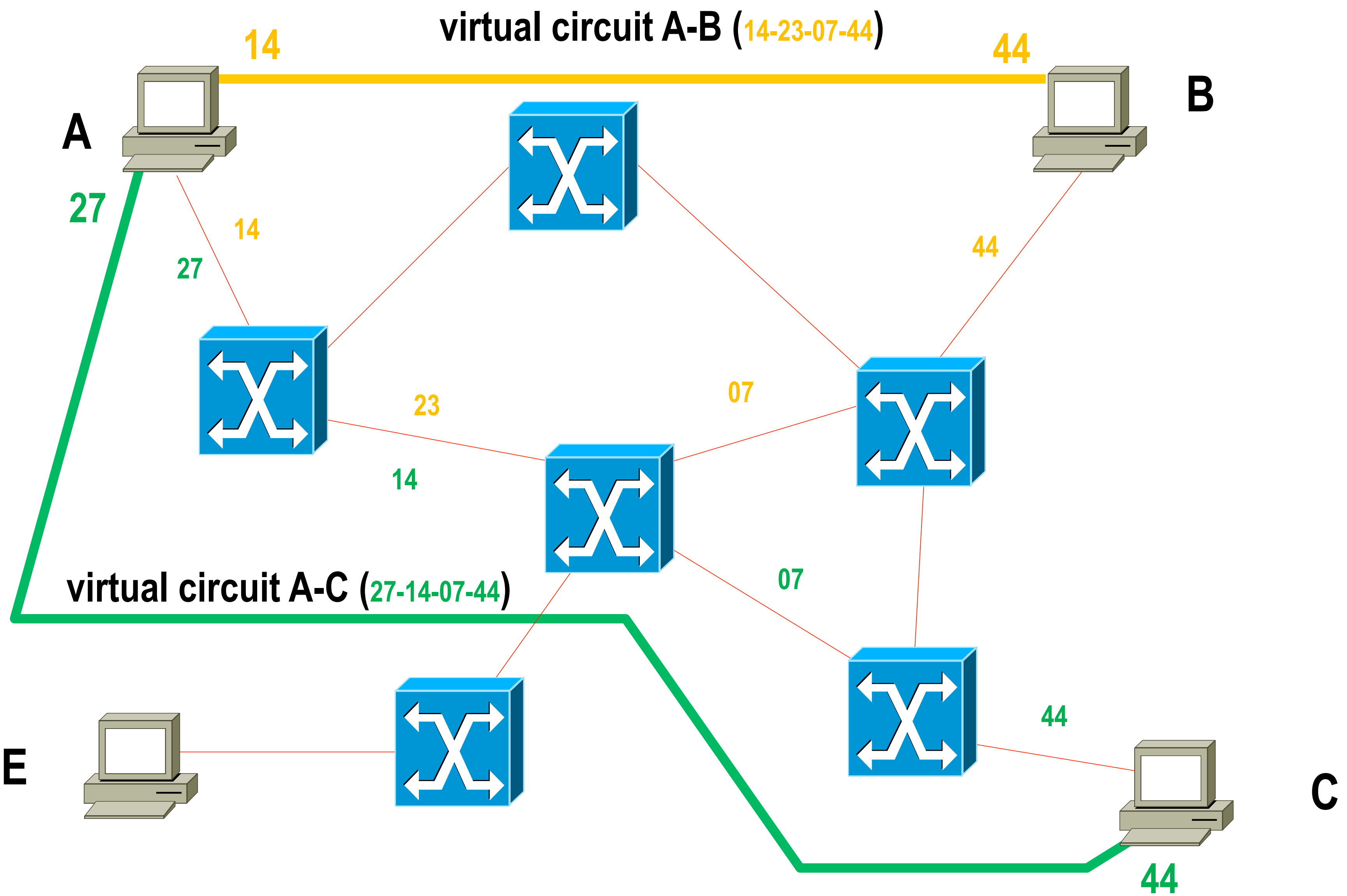


Data Forwarding 4



D ... Data Packet ... payload

Multiplexing of Virtual Circuits



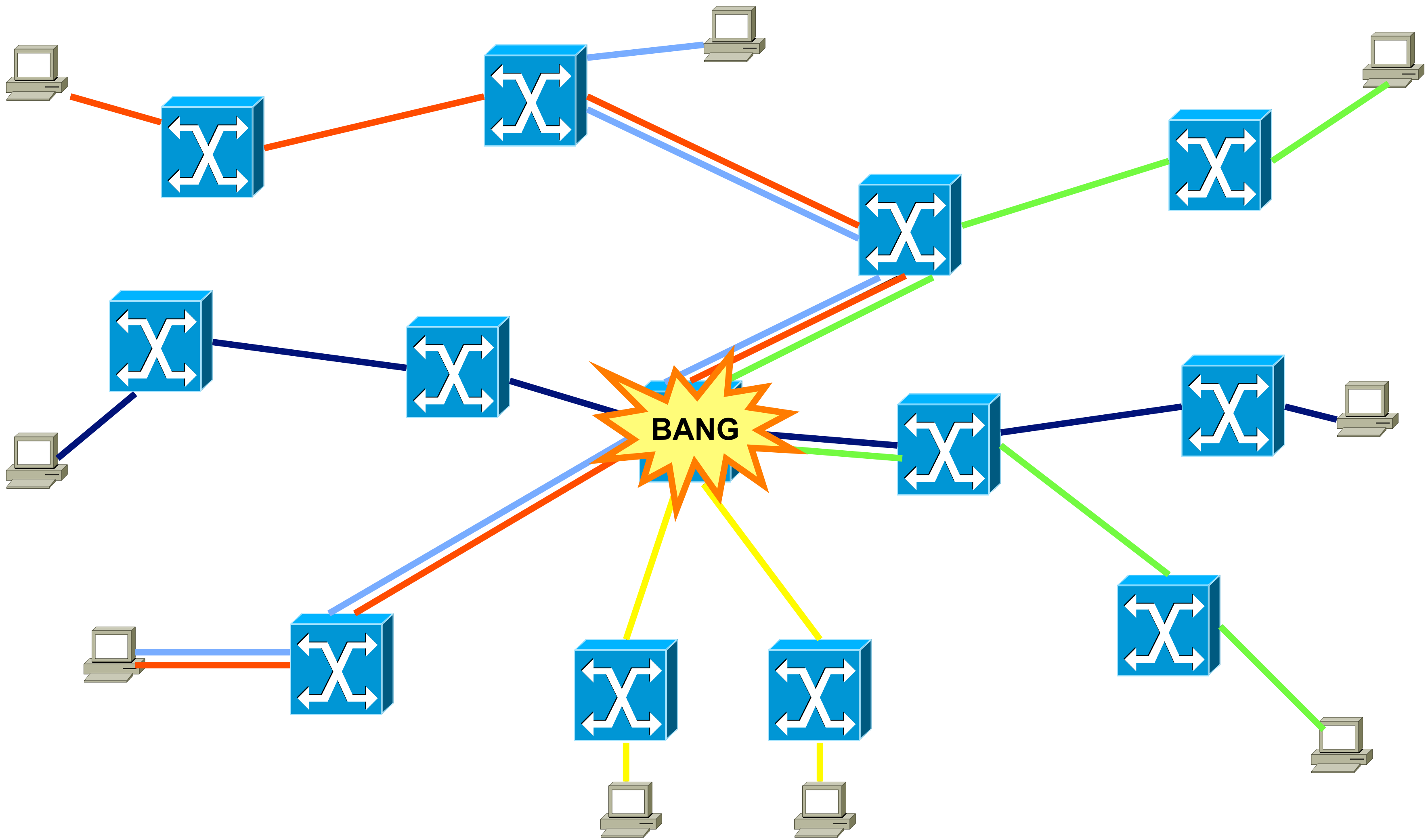
Two Service Types

- **Switched Virtual Circuit (SVC)**
  - Dynamic establishment as shown
  - At the end a proper disconnection procedure is necessary
  - Virtual circuits require establishing and clearing
- **Permanent Virtual Circuit (PVC)**
  - No establishment and disconnection procedures are necessary
  - Switching tables preconfigured by administrator
  - Circuits are permanently available for data transfer

Virtual Call Service Facts (1)

- **The sequence of data packets is guaranteed by the network**
  - Packets can use the established path only
- **Path selection is done during connection setup**
  - Afterwards, entries of routing table are not used
- **In case of trunk line or packet switch failure**
  - Virtual circuits will be closed and must be reestablished again by end systems using call setup packets
  - If there is at least one redundant path, packet switches can establish a new virtual circuit taking the redundant path

Example



Virtual Call Service Facts (2)

- **Connection-oriented packet switching**
  - Allows flow control procedures between end system and packet switch because of connection-oriented approach
    - In connectionless packet switching networks flow control is not possible or only poorly implemented
  - Flow control procedures can avoid buffer overflow and hence network congestion
  - Allows reservation of resources
    - Capacity, buffers, cpu time, etc.
  - Can offer Quality of Service (QoS)
  - Call setup can be denied by network if QoS can not be guaranteed

Virtual Call Service Facts (3)

- **Advantages**
  - Required resources of packet switches can be reserved during call setup and hence QoS could be provided
  - End system view of the network
    - Reliable point-to-point transport pipe based on network internal error recovery, flow control and sequencing procedures (X.25)
    - Higher protocol layers can rely on network services (X.25)
  - Readiness for receipt is tested in advance
    - Call setup of SVC service
- **Disadvantages**
  - Call setup takes time
  - More complex protocols for end systems and packet switches than datagram service

Virtual Call Service Facts (4)

- **Packet switching like that was much faster than packet forwarding of IP routers in the past**
  - Routing process is complex, typically implemented in software
  - Switching is simple, typically implemented in hardware
- **Nowadays high speed packet forwarding of IP routers**
  - Is done in a more optimized way which allows support in hardware
  - e.g. Cisco's cef-switching

Virtual Call – Summary (1)

- **Connection establishment**
  - Through routing process (!)
  - Globally unique topology-related addresses necessary
  - Creates entries in switching tables
  - Can reserve switching resources (QoS)
- **Packet forwarding relies on local identifiers**
  - Not topology related
  - Only unique per port
  - Swapping of local identifiers (labels) according to the switching table

Virtual Call – Summary (2)

- **Connection can be regarded as virtual pipe**
  - Sequence is guaranteed
  - Resources can be guaranteed
- **Virtual call multiplex**
  - Multiple virtual pipes per switch and interface possible
  - Pipes are locally distinguished through connection identifier
- **Network failures disrupt pipe**
  - Connection re-establishment necessary
  - Datagram networks are more robust

Network Technologies based on Virtual Call Method

- **X.25**
  - Reliable transport pipe because of protocol inherent error recovery and flow control
  - Local identifier = LCN
  - In-band signaling
- **Frame Relay**
  - Virtual circuit technique but no error recovery
  - Congestion indication instead of flow control
  - Local identifier = DLCI
  - Out-band signaling
- **ATM (Asynchronous Transfer Mode)**
  - Same as Frame Relay but packets with fixed length
  - Hence called cell switching
  - Local identifier = VPI/VCI
  - Out-band signaling

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“The good thing about standards is that there are so many to choose from”

Andrew S. Tanenbaum

Standards

- **We need networking standards**
  - Ensure interoperability
  - Large market, lower cost (mass production)
- **Vendors need standards**
  - Good for marketing
- **Vendors create standards**
  - Bad for competitors, hard to catch up
- **But: Slow standardization processes freeze technology...**

Who Defines Standards?

- **ISO - Anything**
  - International Standards Organization (ISO)
  - International agency for the development of standards in many areas, founded 1946, currently 89 member countries
- **IETF - Internet**
- **ITU-T (former CCITT) – Telco Technologies**
- **CEPT - PTT Technologies**
- **ETSI - European Standards**
- **ANSI - North American Standards**
- **ATM-Forum, Frame Relay Forum, MPLS Forum**
- **IEEE - LAN Protocols**
- **DIN, ÖNORM - National Standards**

Standards Types

- **De facto standards**
  - Anyone can create them
  - E.g. Internet RFCs
- **De jure standards**
  - Created by a standardization organization
  - E.g. ISO/OSI, ITU-T

Note

Standardization is applied to *network layers* and *interfaces* between them

Idea of Layering and Services

- **Because communication between systems can be a very complex task**
  - Divide task of communication in multiple sub-tasks
    - So called layers
  - Hence every layer implements only a part of the overall communication systems
- **Hierarchically organized**
  - Each layer *receives* services from the layer below
  - Each layer *serves* for the layer above
- **Good for interoperability**
  - Capsulated entities and interfaces
- **But increases complexity / overhead**

Where to Define Layers? Why to define Layers?

- **Where:**
  - Group functions (services) together
  - When changes in technology occur
  - To expose services
- **Why:**
  - To allow changes in protocol and HW
  - To utilize existing protocols and HW

The ISO/OSI Model

- **International Standards Organization (ISO)**
  - International agency for the development of standards in many areas
  - Founded 1946
  - Currently 89 member countries
  - More than 5000 standards until today
  - Network standardization is just one part of it

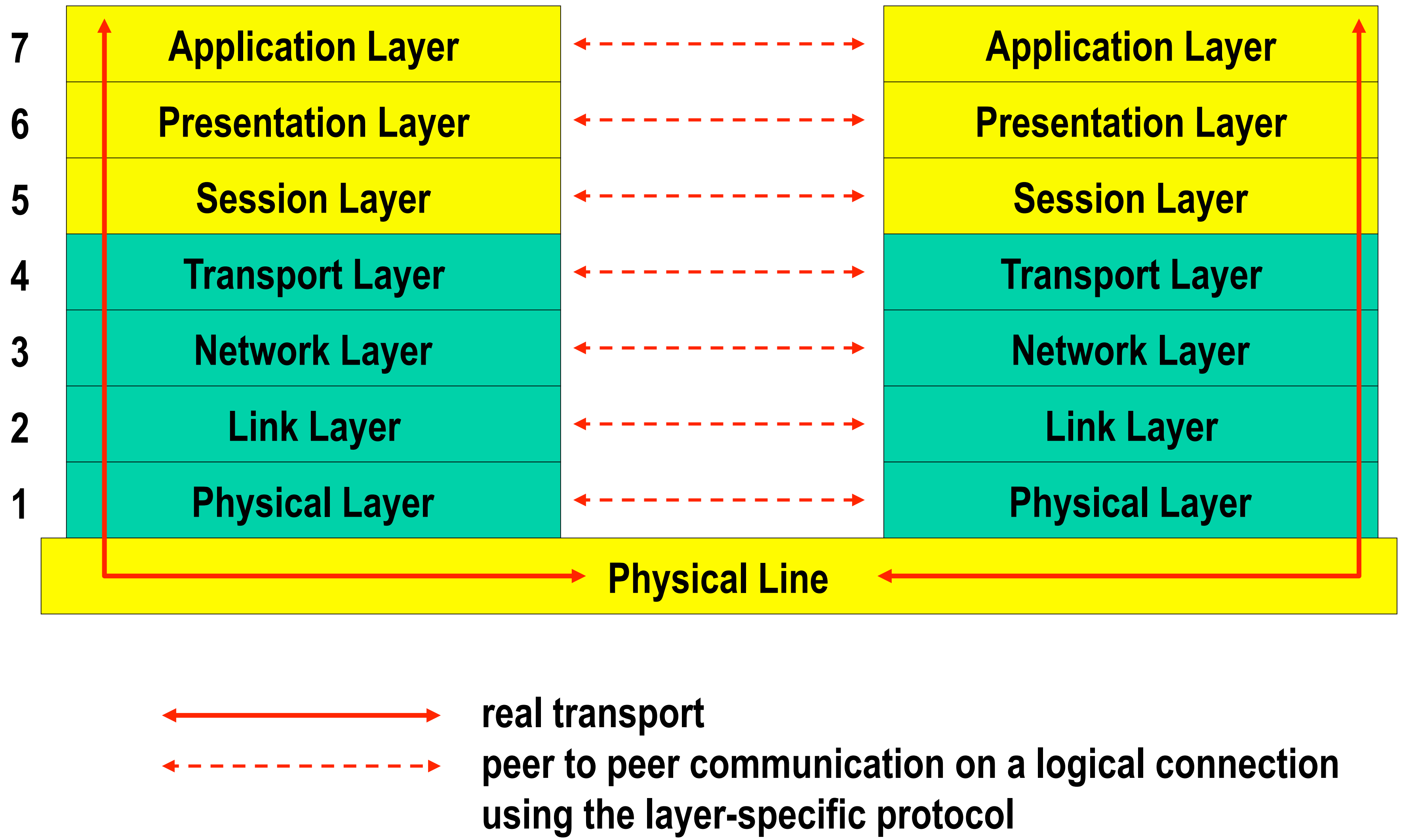
- **OSI (Open Systems Interconnection) Reference Model**
  - Defines tasks and interactions of seven layers
  - Framework for development of communication standards
  - System-internal implementation is out of the scope
  - Only external behavior of a system is defined by open standards

- **1988 US Government OSI Profile (GOSIP)**
  - Requires Government products to support OSI layering

Basic Idea of the OSI Model

- **Each layer depends on services of the layer below in order to provide its own services to the upper layer**
  - **Service specification standards**
- **Representation of a layer within a system**
  - Is called entity (e.g. a particular task or subroutine)
- **In order to fulfill the task of a layer**
  - Entities use their own system internal resources as well as peer-to-peer communication based on layer specific protocol
  - **Protocol specification standards**

The 7 OSI Layers



Purpose

- **OSI model *describes* communication *services* and *protocols***
- **No assumption about**
  - Operating system
  - Programming Language
- **Practically, the OSI model**
  - Organizes knowledge
  - Provides a common discussion base

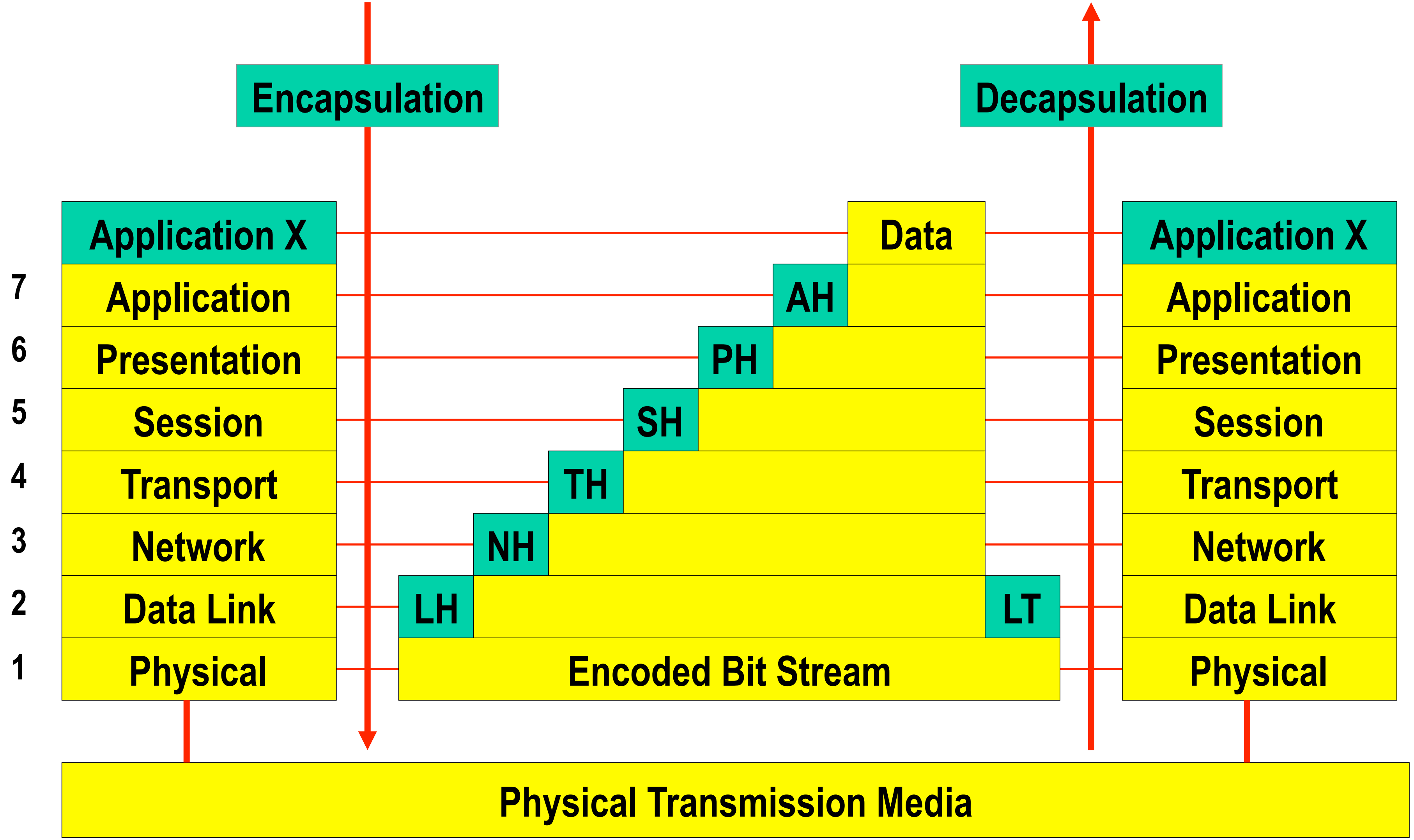
OSI Basics

- **Point-to-Point, no shared media**
- **Nodes are called**
  - End Systems (ES)
  - Intermediate Systems (IS)
- **Each layer of the OSI model detects and handles errors**
- **Hence connection-oriented per se**
- **Dumb hosts and intelligent network**
  - Compared with Internet: dumb network, intelligent hosts

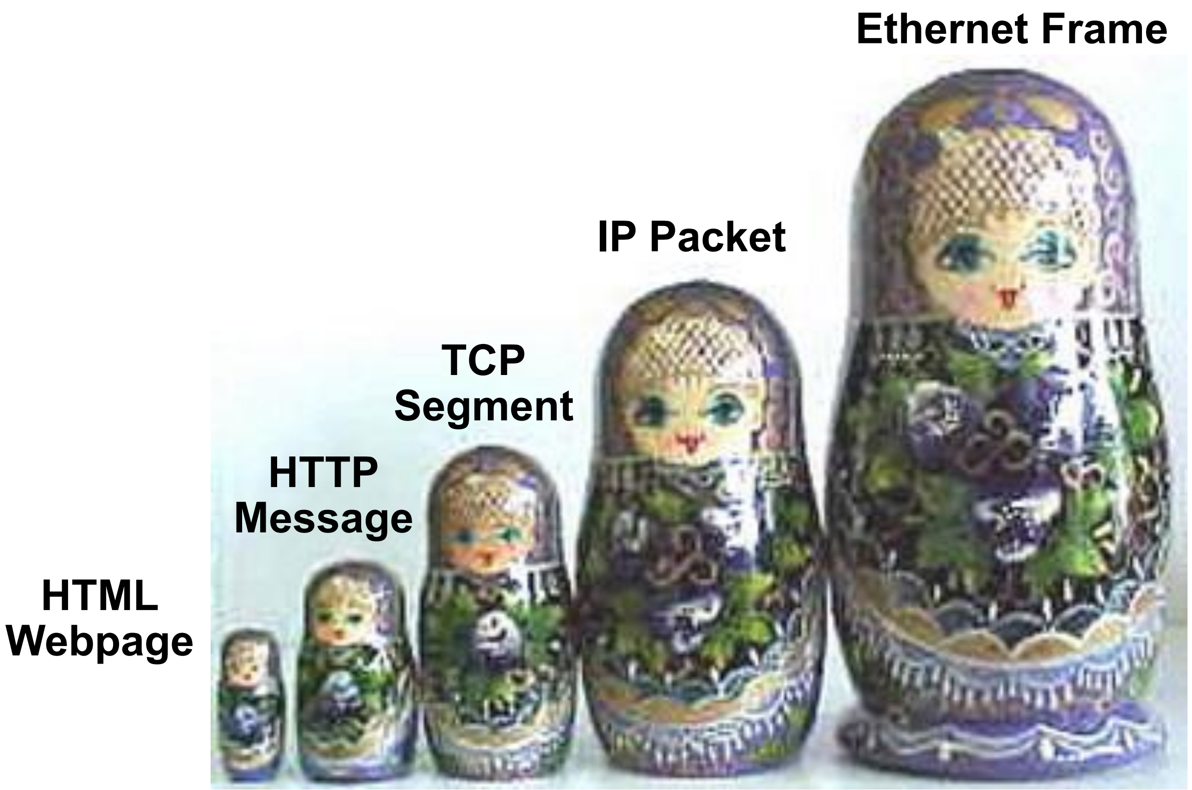
The OSI Truth

- **OSI model was created before protocols**
  - Good: Not biased, general approach
  - Bad: Designers had little experience, no ideas in which layers to put which functionality...
- **Not widespread (complex, expensive)**
- **But serves as good teaching aid !!!**

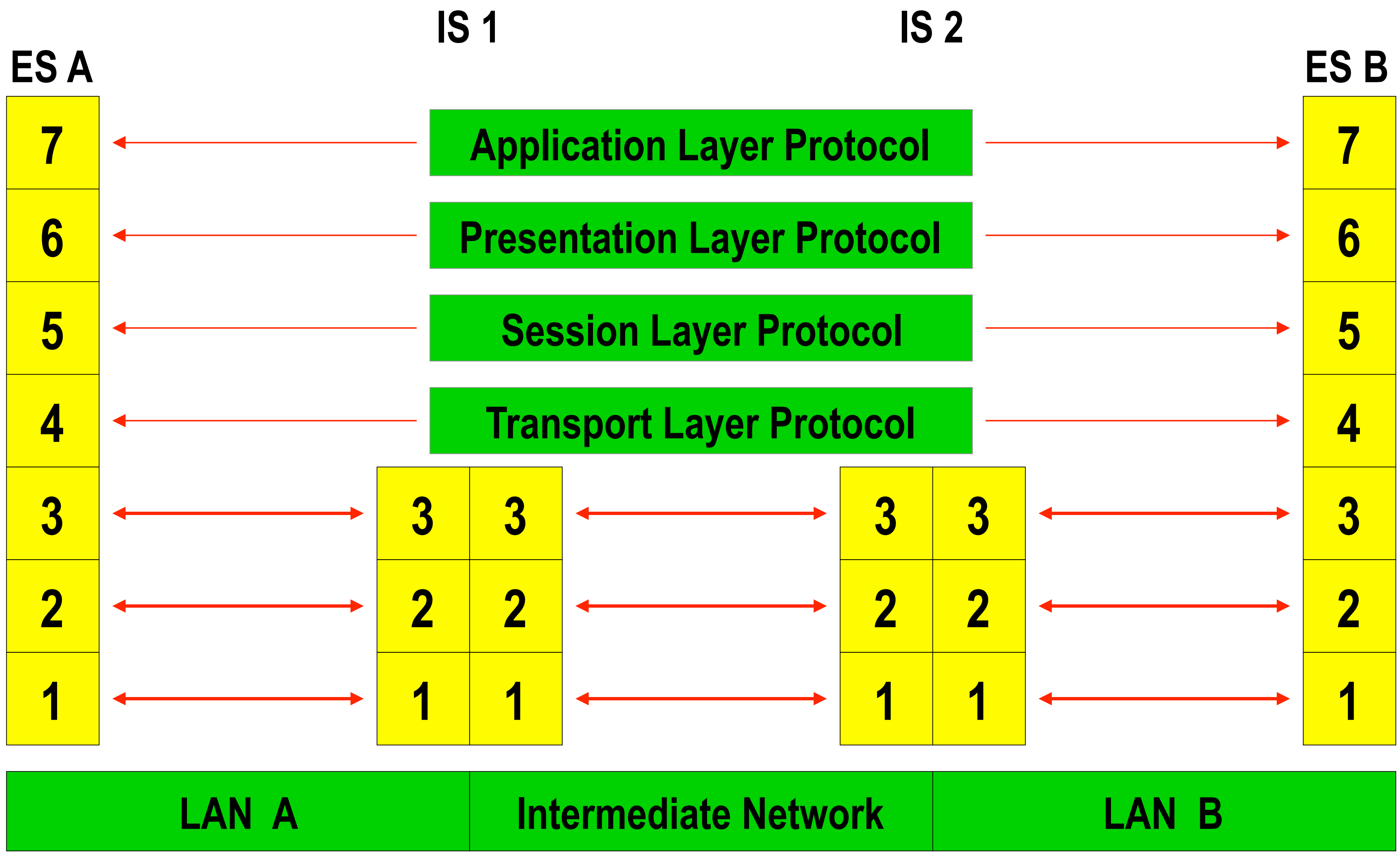
Encapsulation and Decapsulation



Practical Encapsulation



OSI Model with Intermediate Systems



OSI Speak (1)

- **Entities**
  - Anything capable of sending or receiving information
- **System**
  - Physically distinct object which contains one or more entities
- **Protocol**
  - Set of rules governing the exchange of data between two entities

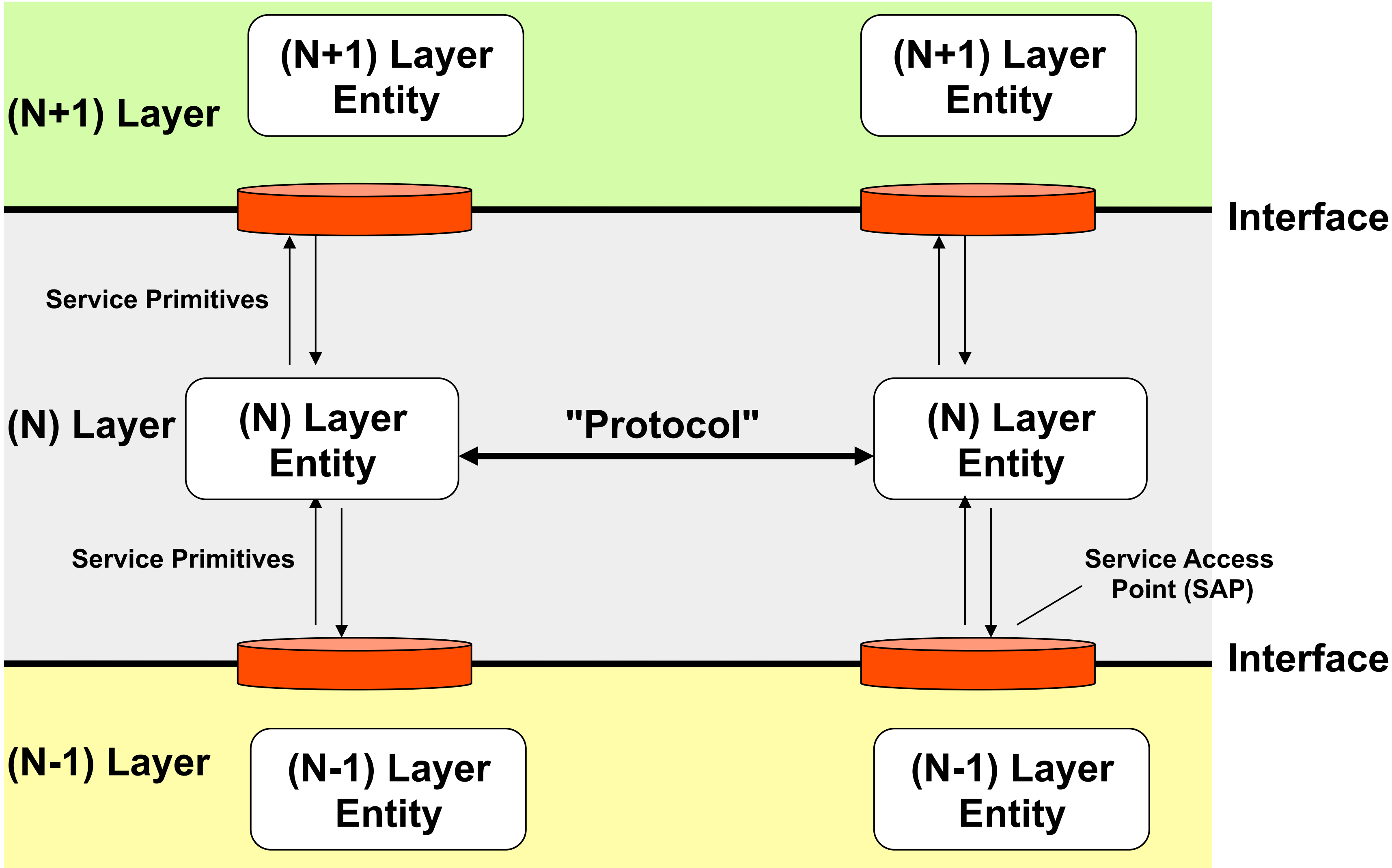
OSI Speak (2)

- **Layer**
  - A set of entities
- **Interface**
  - Boundary between two layers
- **Service Access Point (SAP)**
  - Virtual port where services are passed through

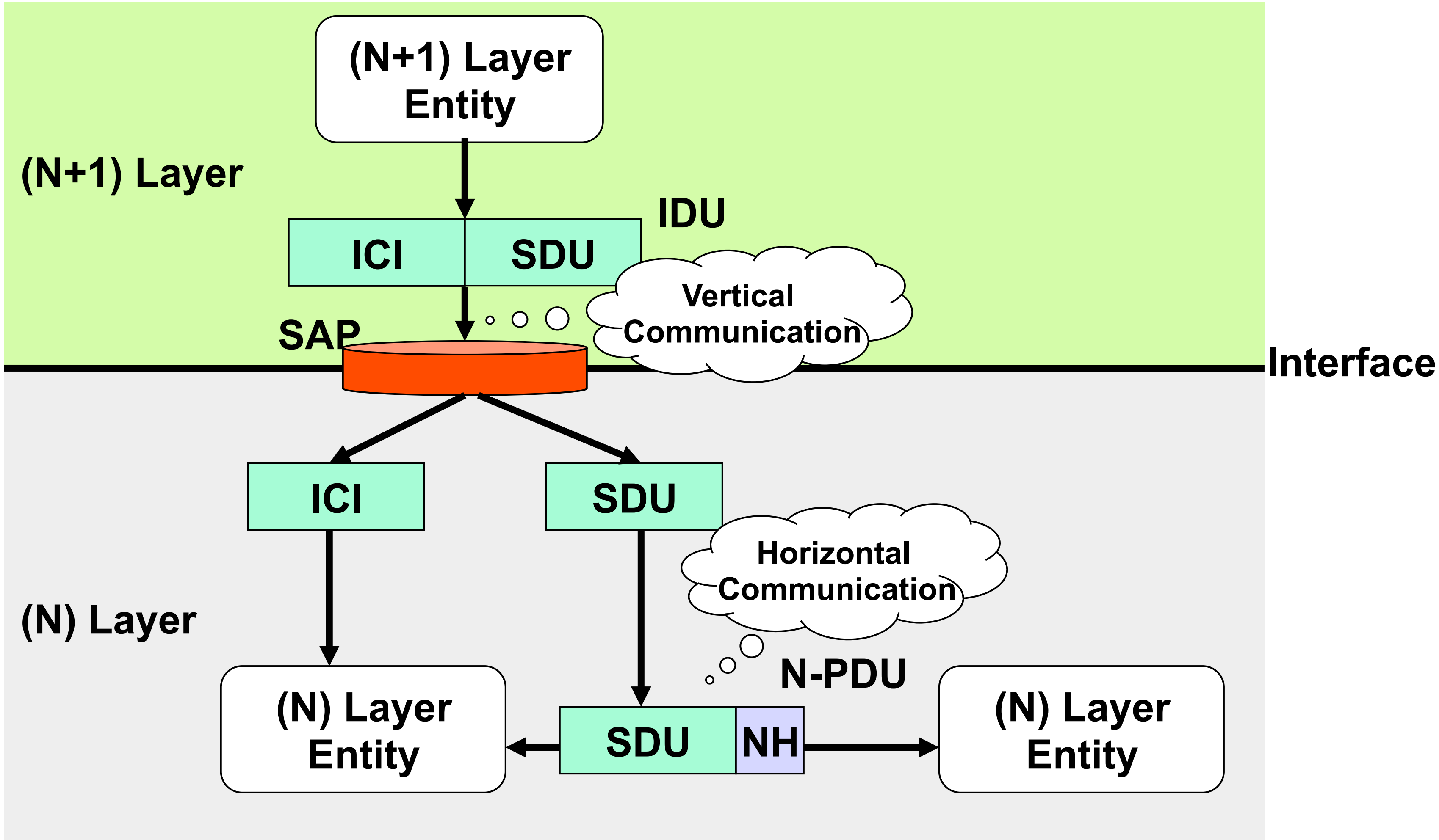
OSI Speak (3)

- **Interface Data Unit (IDU)**
  - Data unit for vertical communication (between adjacent layers of same system)
- **Protocol Data Unit (PDU)**
  - Data unit for horizontal communication (between same layers of peering systems)
- **Interface Control Information (ICI)**
  - Part of IDU
  - Destined for entity in target-layer
- **Service Data Unit (SDU)**
  - Part of IDU
  - Destined for further communication
  - Contains actual data ;-)

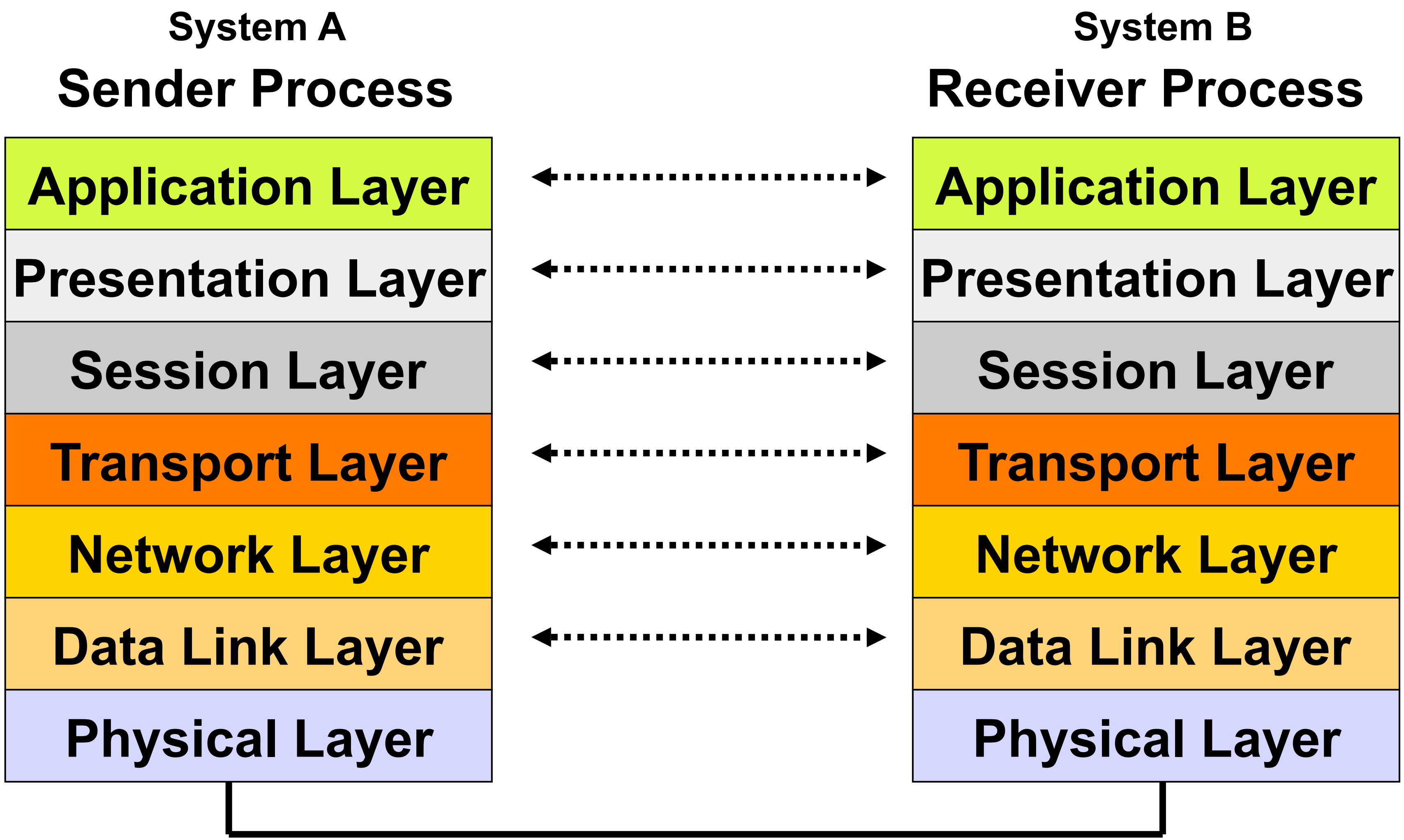
OSI Speak Summary (1)



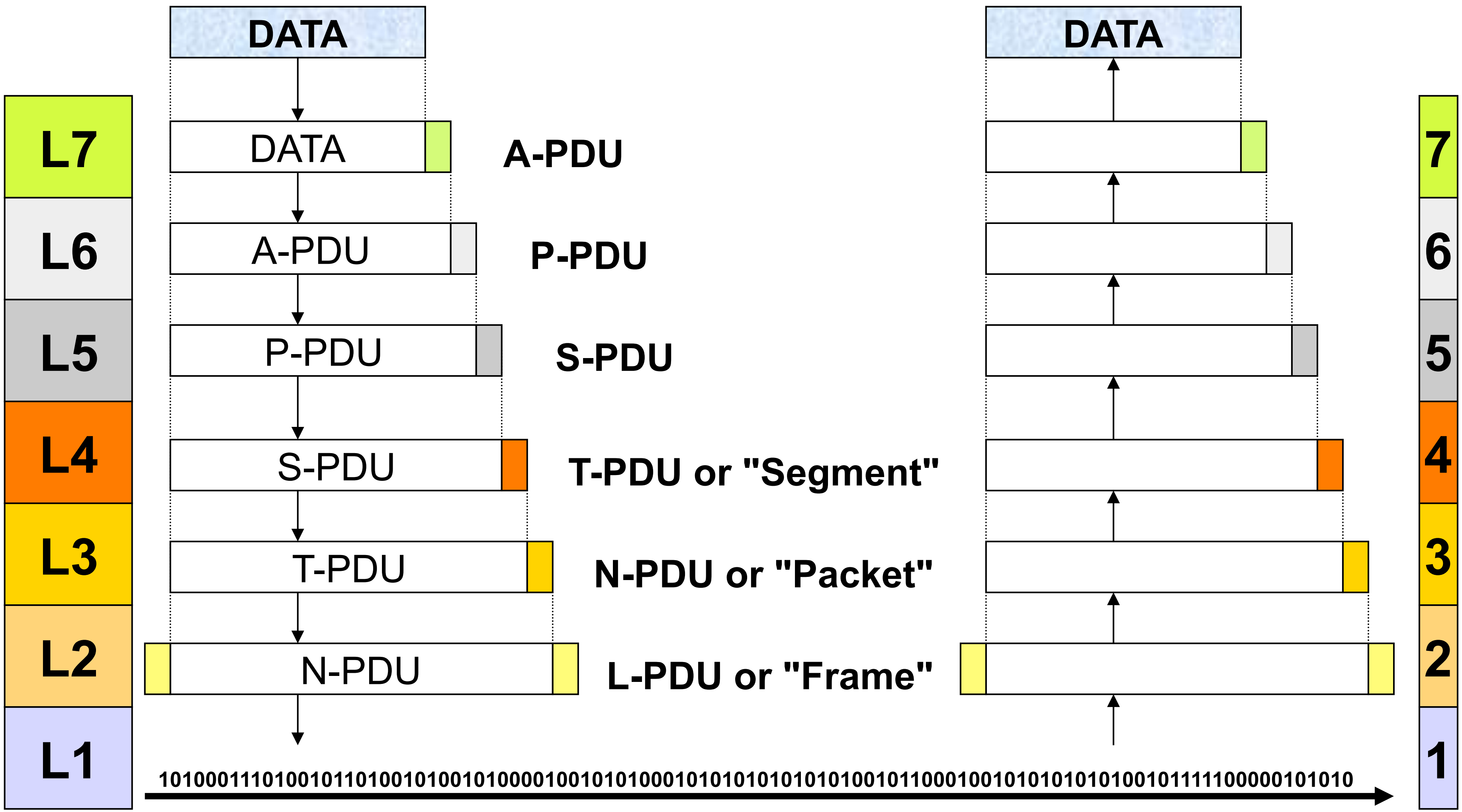
OSI Speak Summary (2)



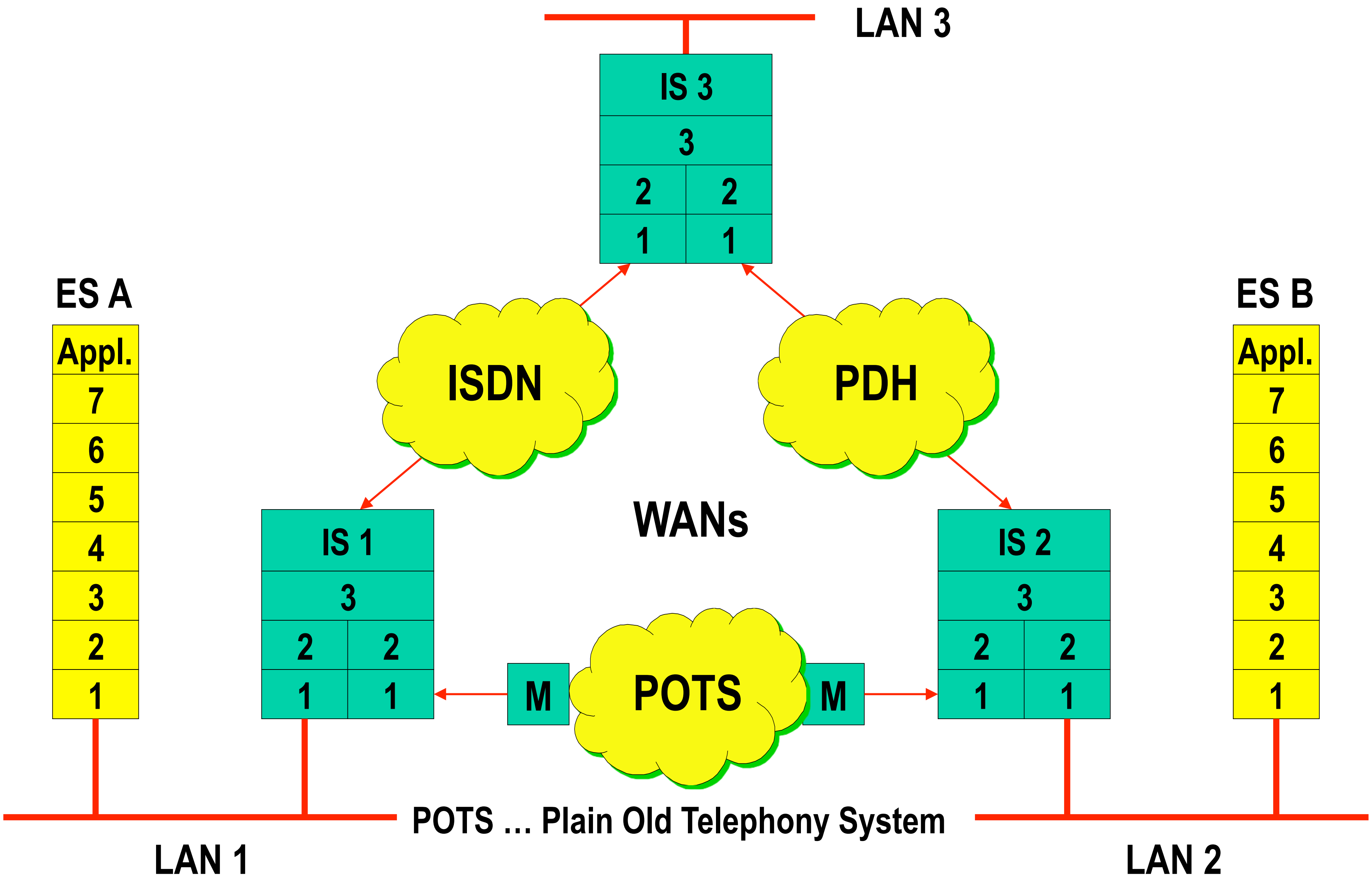
The 7 OSI Layers



Encapsulation and Decapsulation Principle



Example Topology with ES and IS

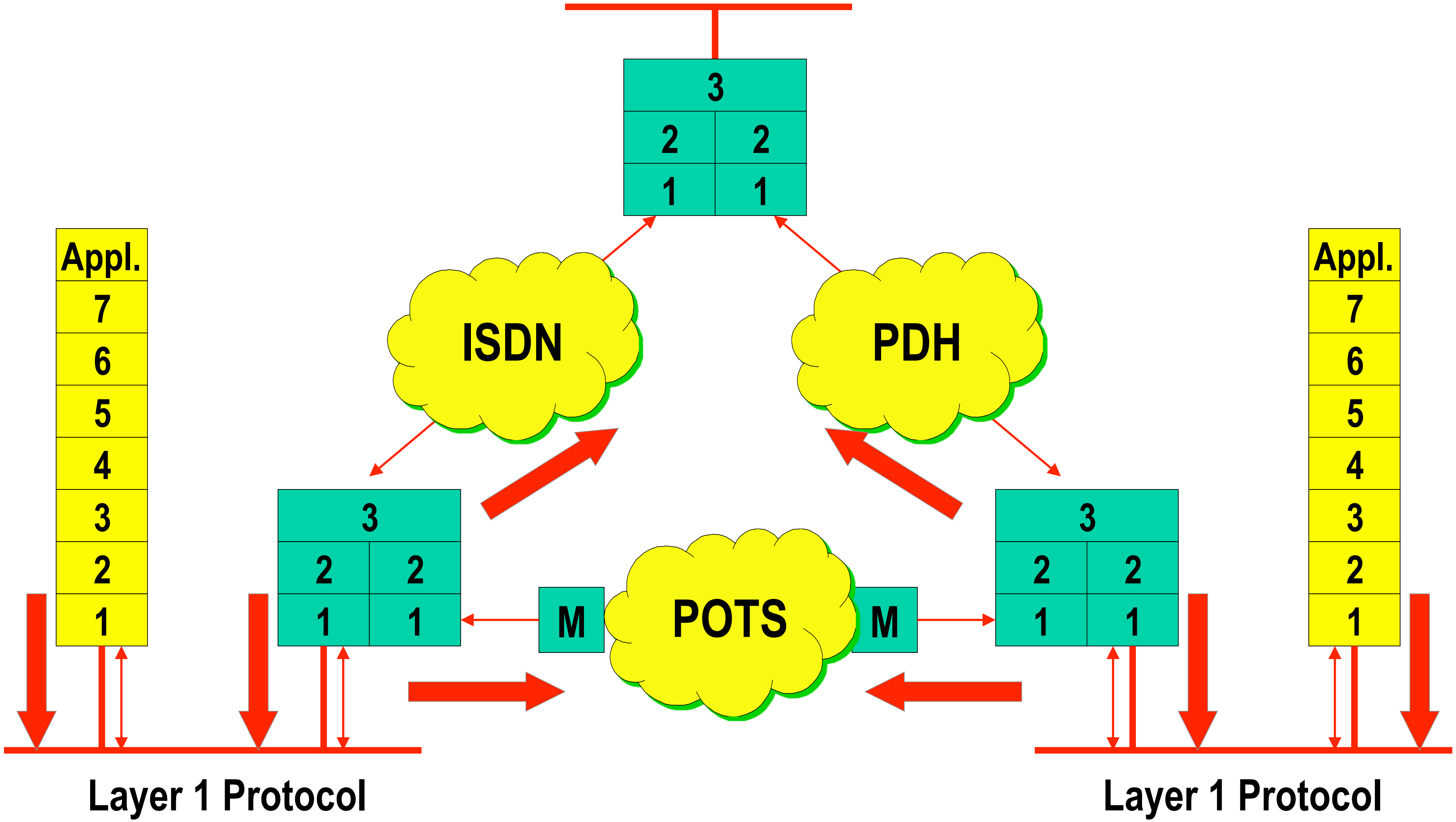


Physical Layer (1)

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- **Mechanical and electrical specifications**
- **Access to physical medium**
- **Generates bit stream**
- **Line coding and clocking**
- **Bit synchronization**
- **Link management**
- **Examples**
  - LAN: Ethernet-PHY, 802.3-PHY
  - WAN: X.21, I.400 (ISDN), RS-232

Physical Layer (1)

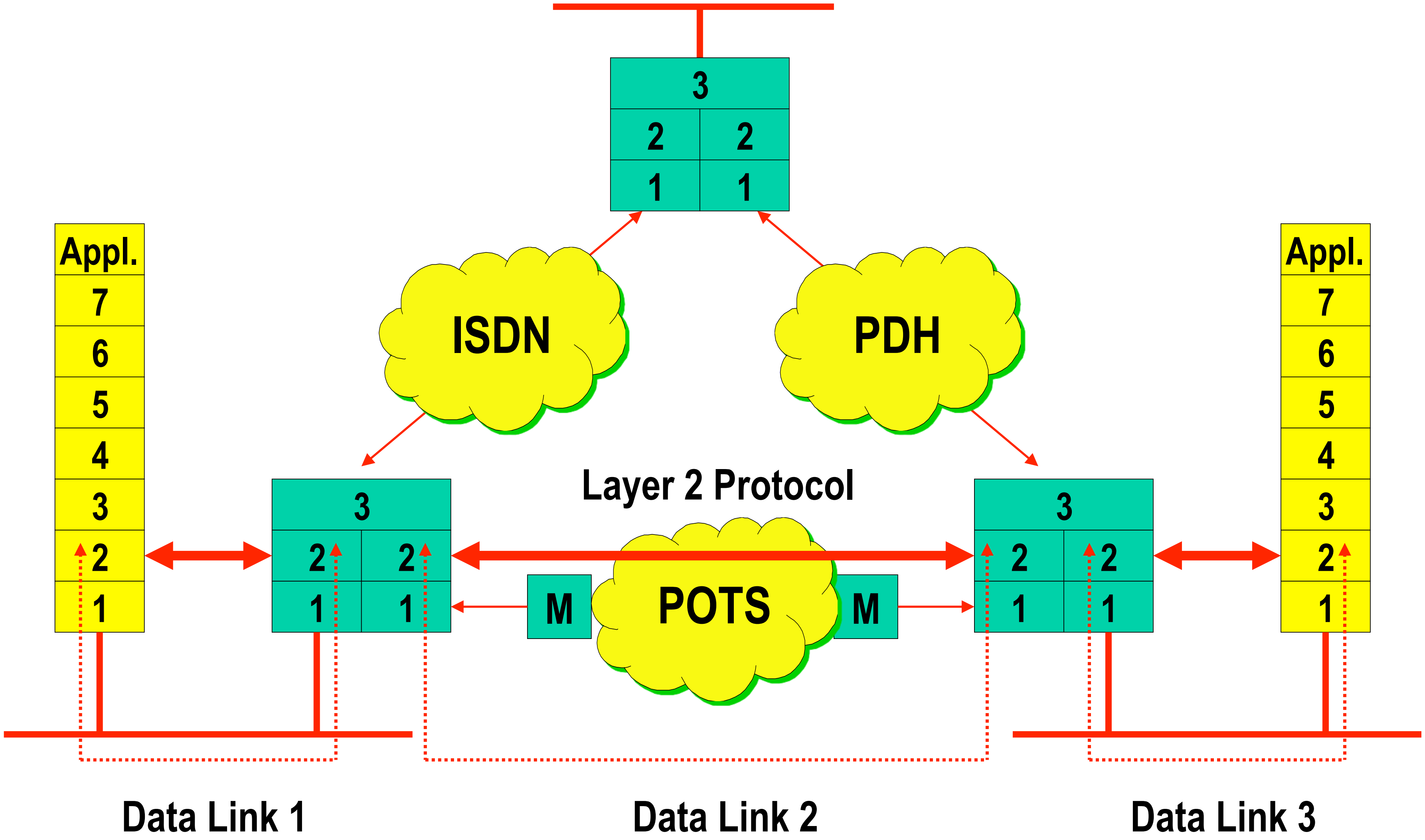


Data Link Layer (2)

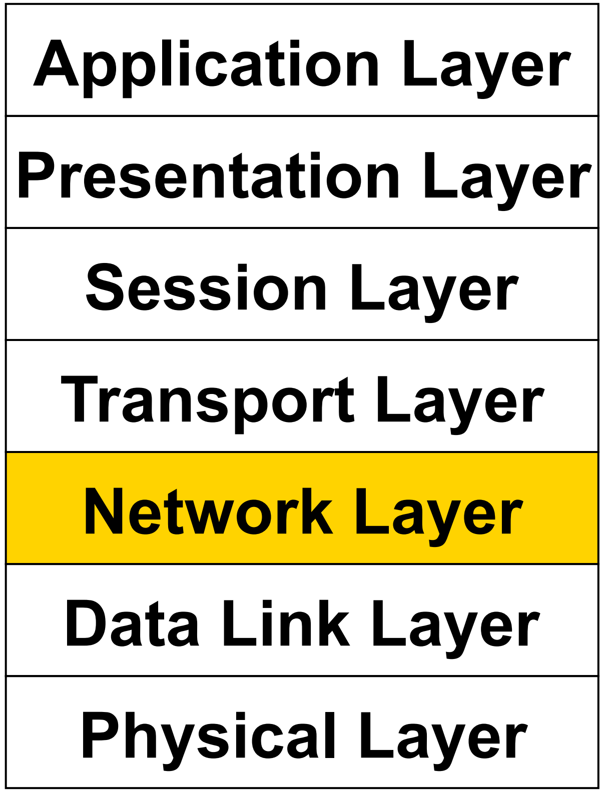
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- **Reliable transmission of *frames* between two NICs**
- **Framing**
- **Frame Synchronization**
- **FCS**
- **Physical Addressing of NICs**
- **Optional error recovery**
- **Optional flow control**
- **Examples:**
  - LAN: 802.2
  - PPP, LAPD, LAPB, HDLC

Data Link Layer (2)

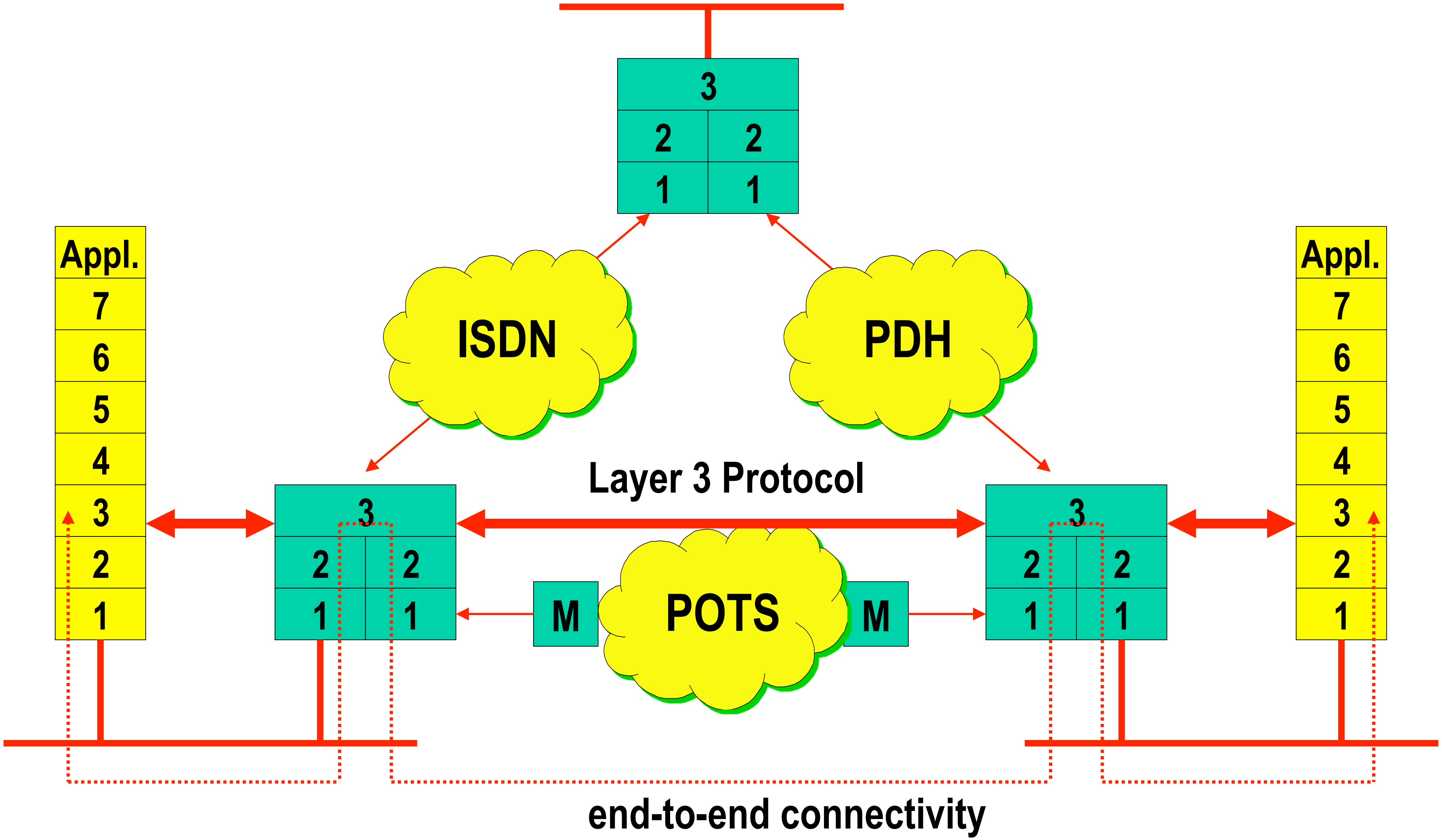


Network Layer (3)



- **Transports *packets* over packet switching networks**
  - Routing / Switching
- **Provides structured addresses to name networks**
  - N-SAP address
- **Fragmentation and reassembling**
- **Examples:**
  - CLNP
  - IP, IPX
  - Q.931, X.25

Network Layer (3)

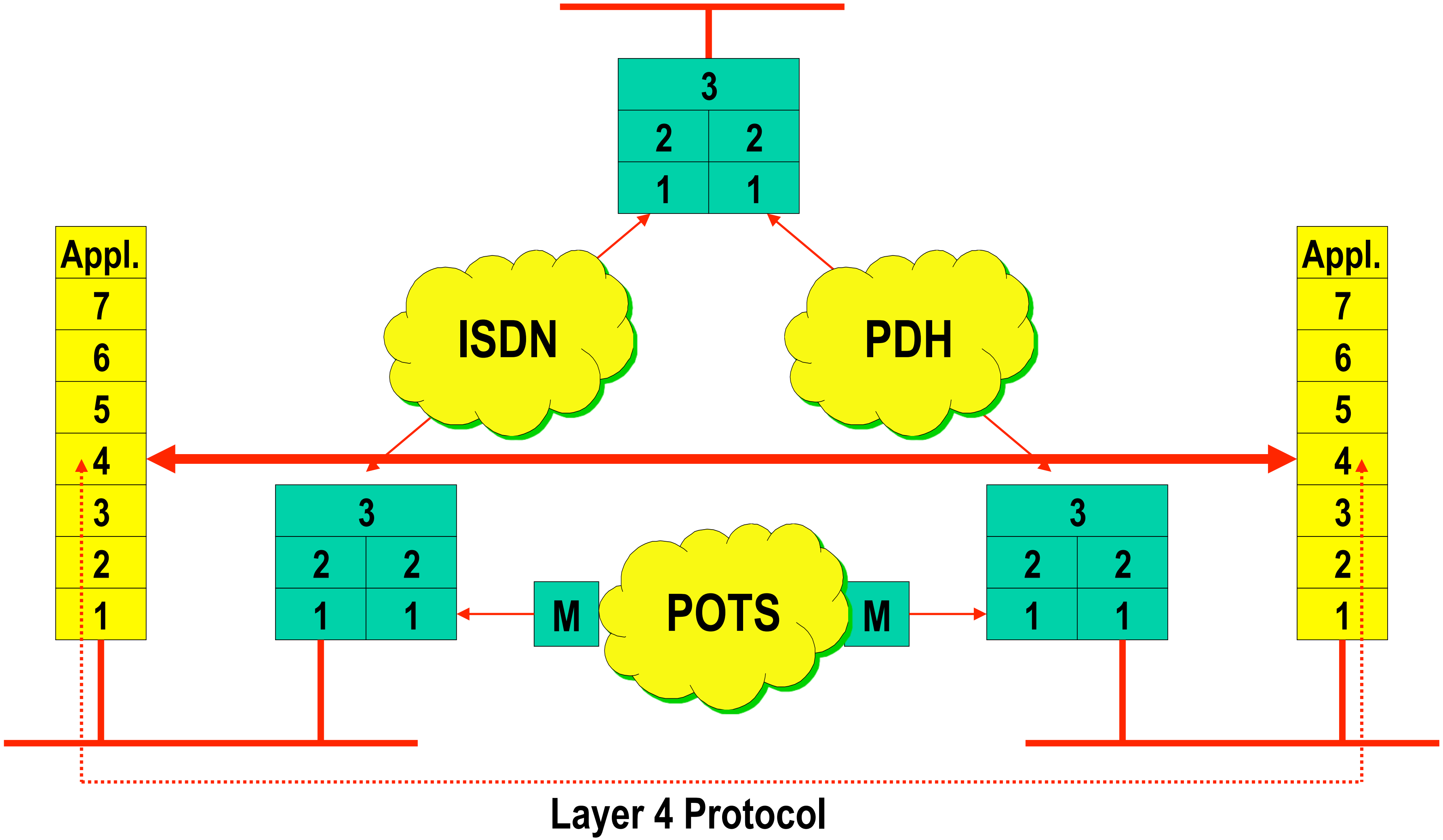


Transport Layer (4)

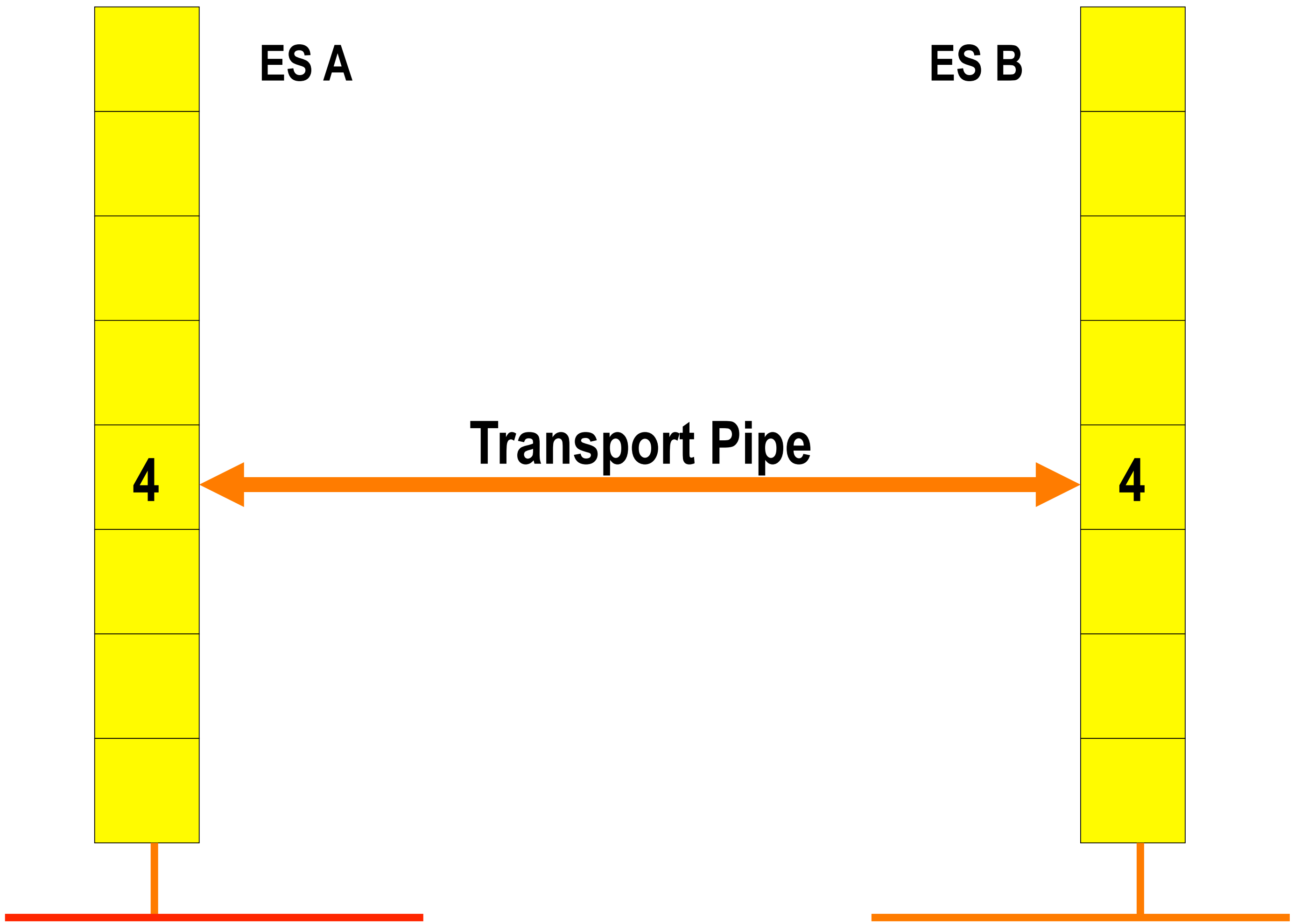
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- **Transport of *segments* between applications (end systems)**
  - Reliable if error recovery by ARQ
- **Application multiplexing through T-SAPs**
  - Transport Addresses
- **Sequence numbers and Flow control**
- **Optional QoS Capabilities**
- **Examples:**
  - TCP (UDP)
  - ISO 8073 Transport Protocol

Transport Layer (4)



How Layer 5 sees the Network



Functions of Higher Layers

- **Layer 5 (session layer)**
  - Coordinates and controls dialogue between different end systems
- **Layer 6 (presentation layer)**
  - Responsible for common language between end systems (conversion, adaptation of data)
- **Layer 7 (application layer)**
  - Supports user with common network applications (e.g. file transfer, virtual terminal) or basic network procedures in order to implement distributed applications (e.g. transaction systems)

Session Layer (5)

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- **Provides a user-oriented connection service**
  - *Synchronization Points*
- **Little capabilities, usually not implemented or part of application layer**
  - Telnet: GA and SYNCH
  - FTP: re-get allows to continue an interrupted download
  - ISO 8327 Session Protocol

Presentation Layer (6)

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- **Specifies the data representation format for the application**
- **Examples:**
  - MIME (part of L7) and UUENCODING (part of L7)
  - ISO: ASN.1 and BER

Application Layer (7)

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

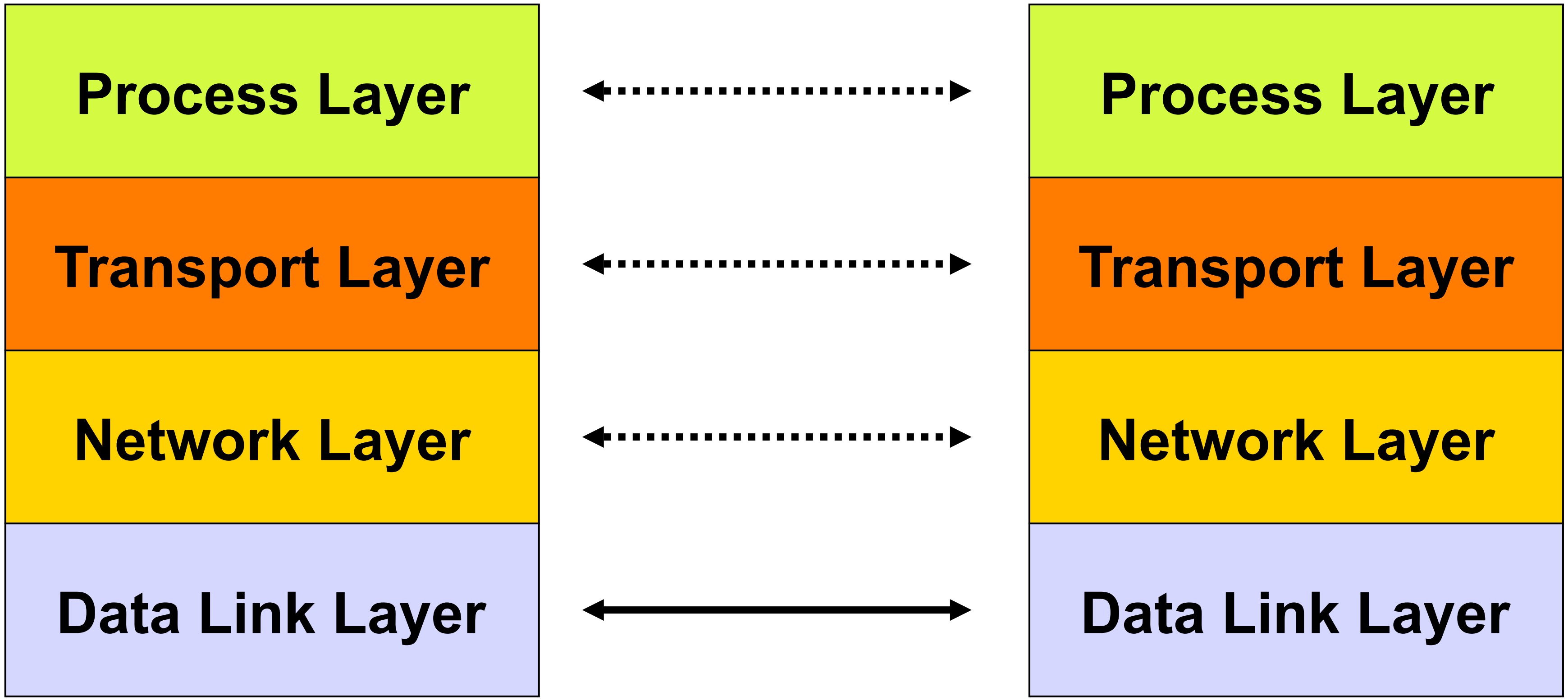
- **Provides network-access for applications**
- **Examples:**
  - ISO 8571 FTAM File Transfer Access + Management,
    X.400 Electronic Mail, CMIP
  - SMTP, FTP, SNMP, HTTP, Telnet, DNS, …

Padlipsky's Rule

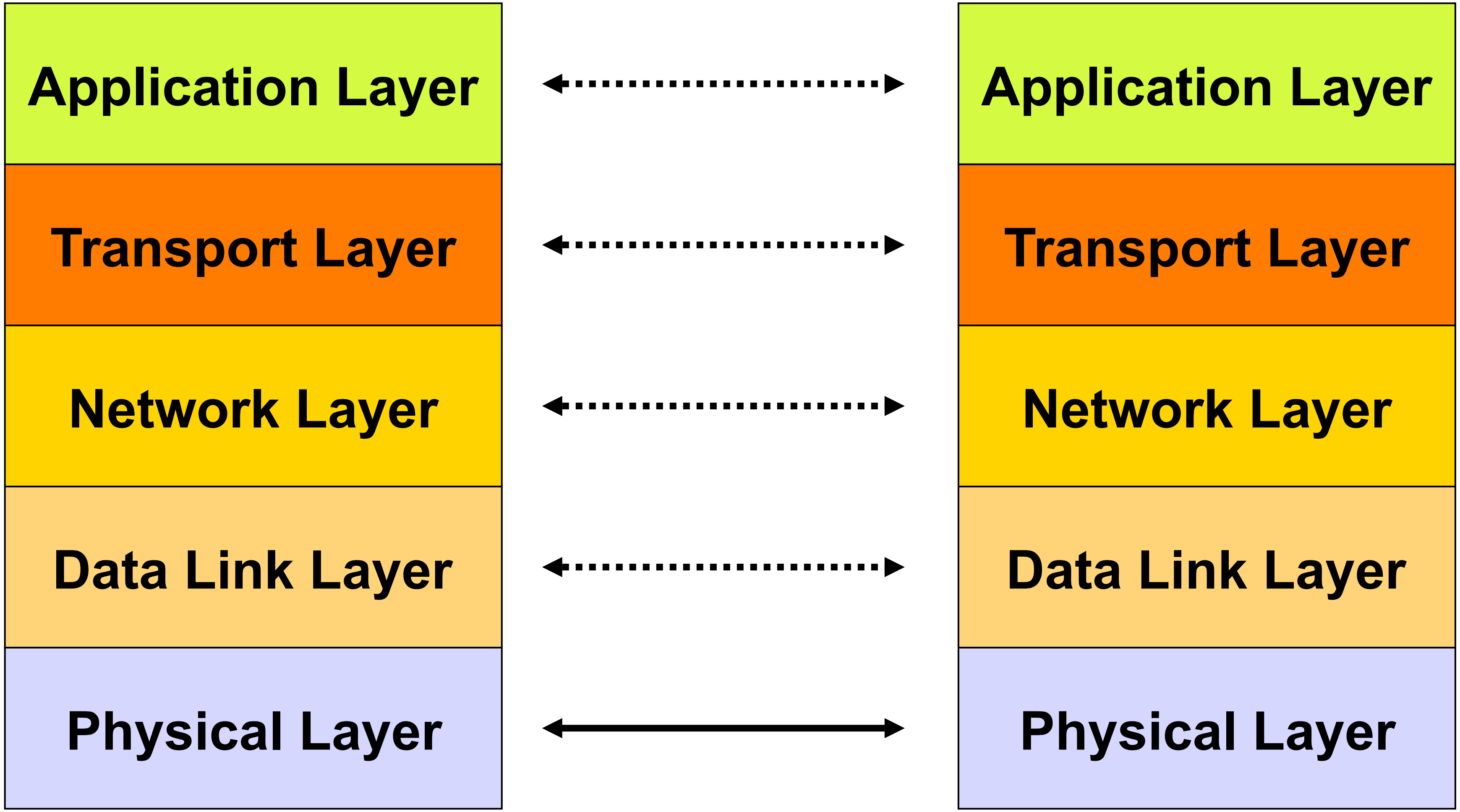
If you know what you're doing, three layers is enough. If you don't, even seventeen won't help.

Stevens 4-Layer Model

Equivalent to the DoD Model (Internet)



Tanenbaum 5-Layer Model



The Internet perspective is implement it, make it work well, then write it down.

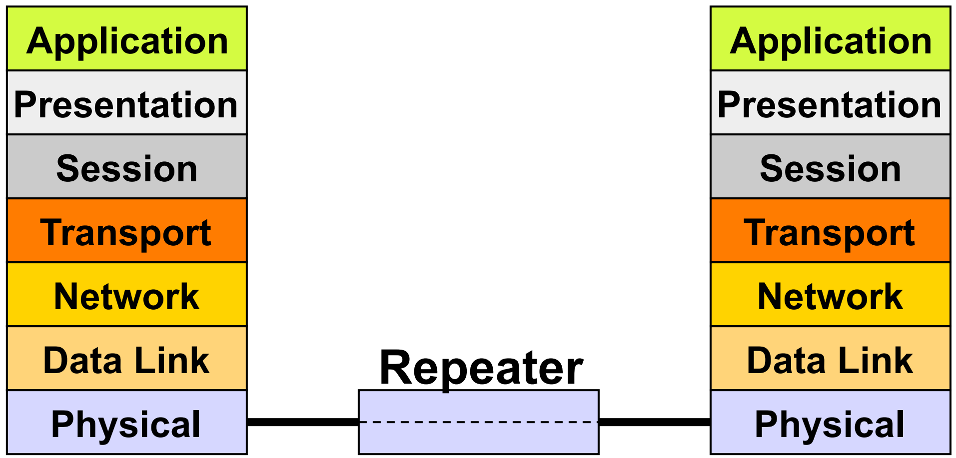
The OSI perspective is to agree on it, write it down, circulate it a lot and now we'll see if anyone can implement it after it's an international standard and every vendor in the world is committed to it.

One of those processes is backwards, and I don't think it takes a Lucasian professor of physics at Oxford to figure out which.

Marshall Rose, "The Pied Piper of OSI"

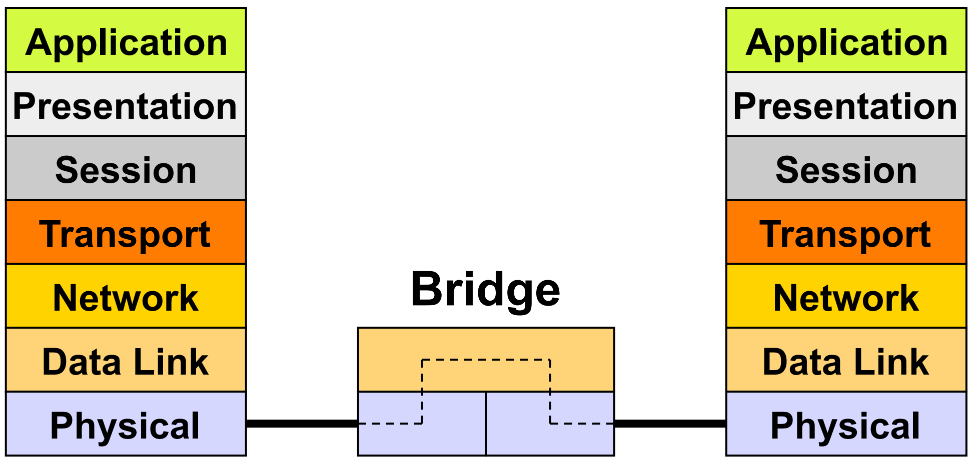
Layer 1 Devices

- Adapts to different physical interfaces
- Amplifies and/or refreshes the physical signal
- No intelligence
- Examples: Repeater, Hub, ISDN NT1



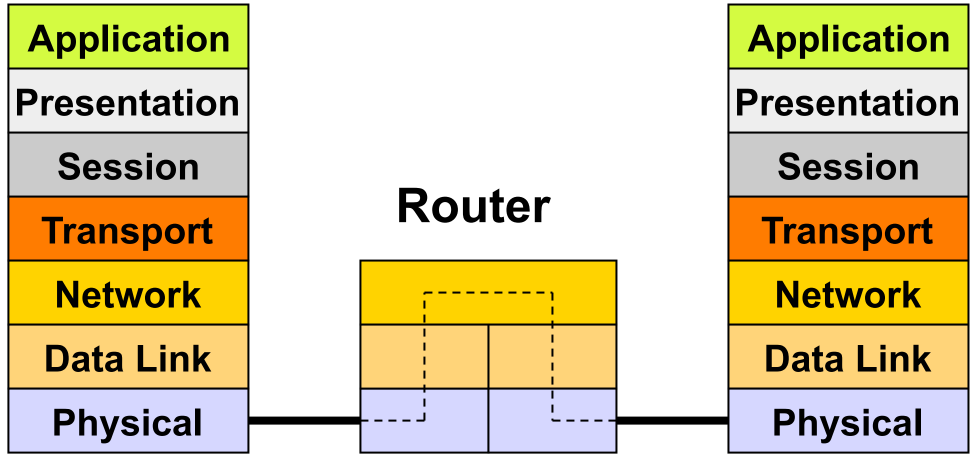
Layer 2 Devices

- Filter/Forwards frames according Link Layer Address
- Incorporates Layer 1-2
- LAN-Bridge (“Ethernet Switch")

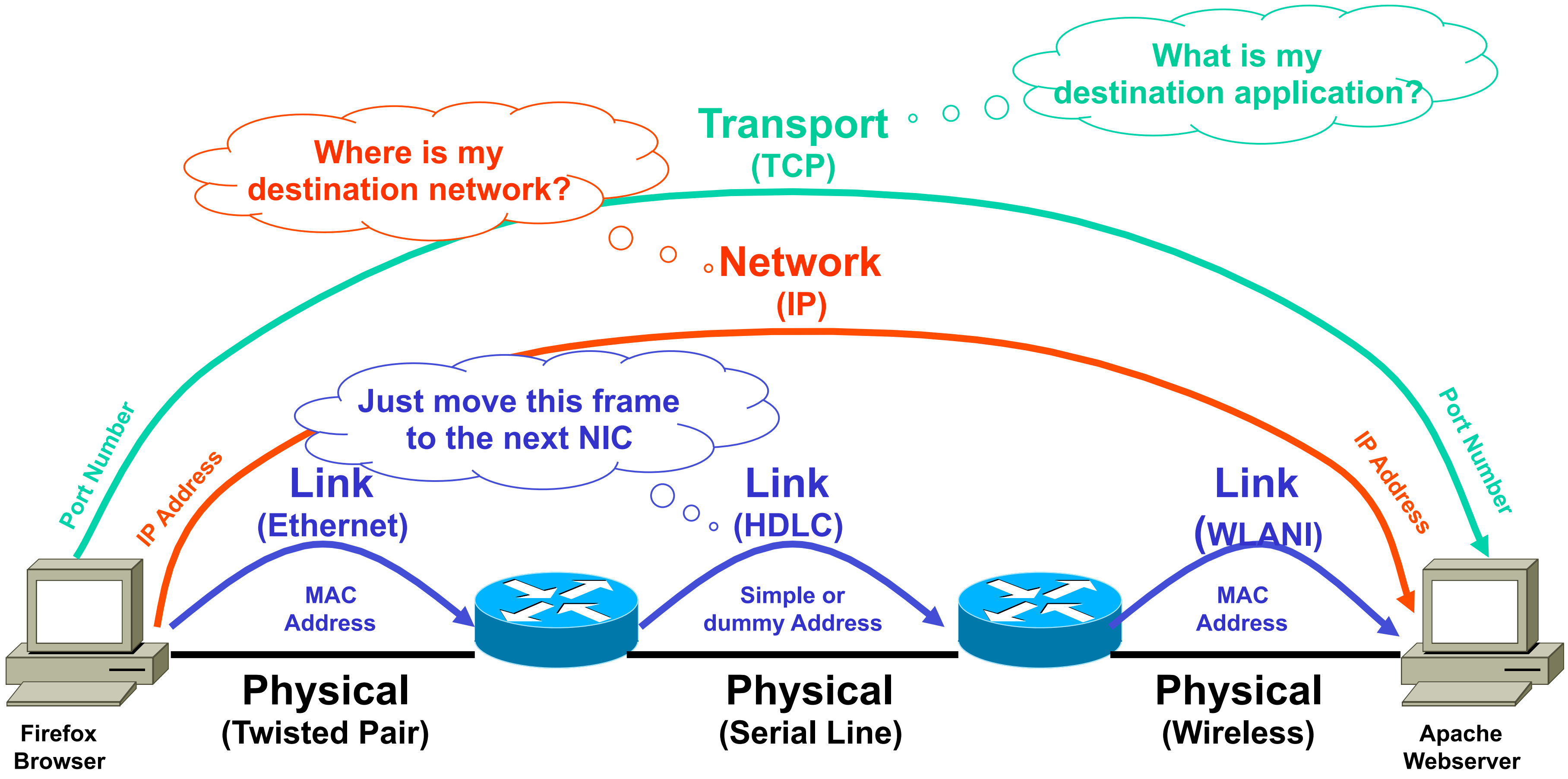


Layer 3 Devices

- "Packet Switch" or "Intermediate System"
- Forwards packets to other ***networks*** according ***structured*** address
- Terminates Links
- IP Router,
  WAN-Switch
  - X.25
  - Frame-Relay
  - ATM



A Practical Example



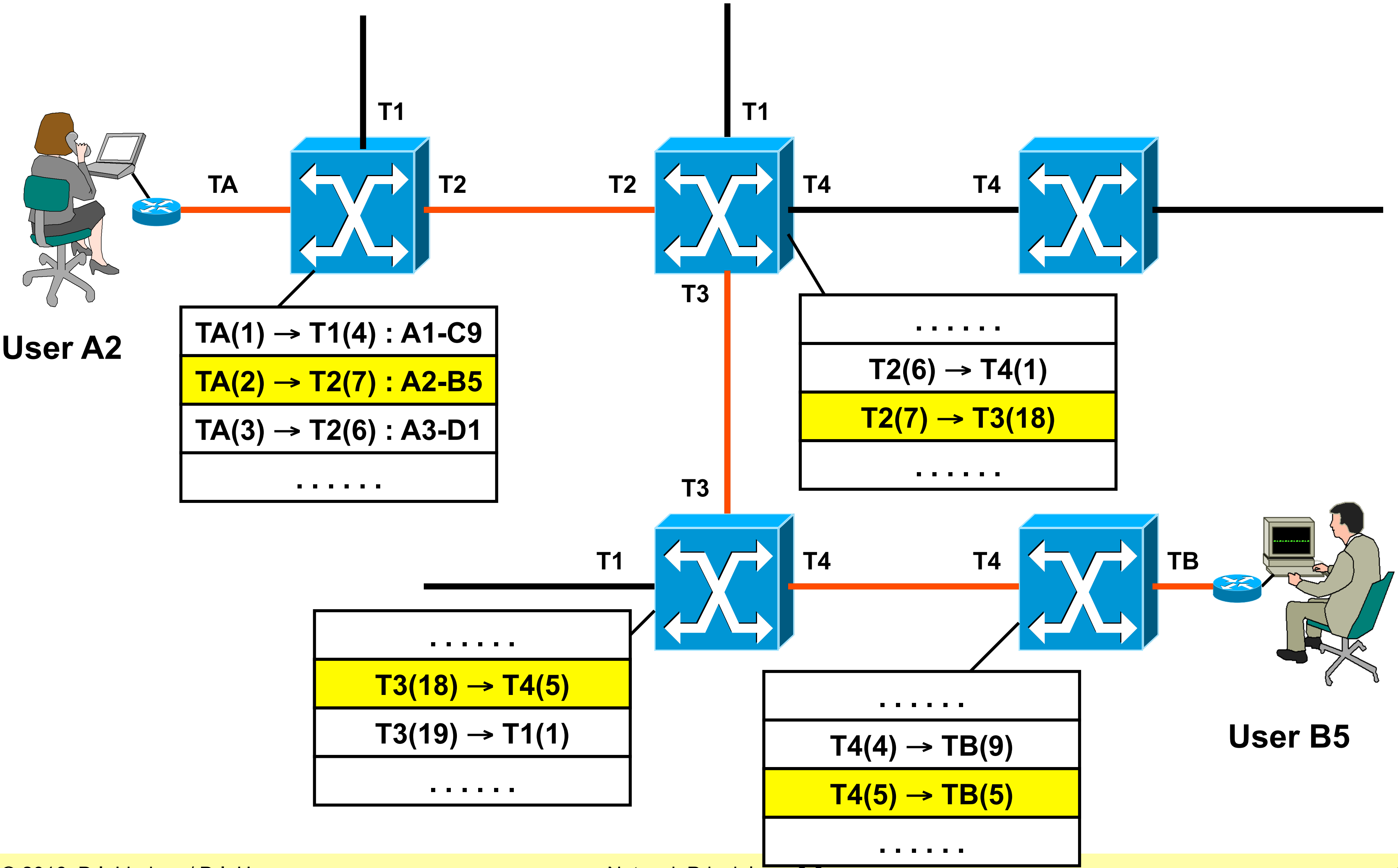
OSI Summary

- **Network layers ensures interoperability and eases standardization**
- **ISO/OSI 7 layer model is an important reference model**
- **Practical technologies employ a different layer set, but it's always possible to refer to OSI**

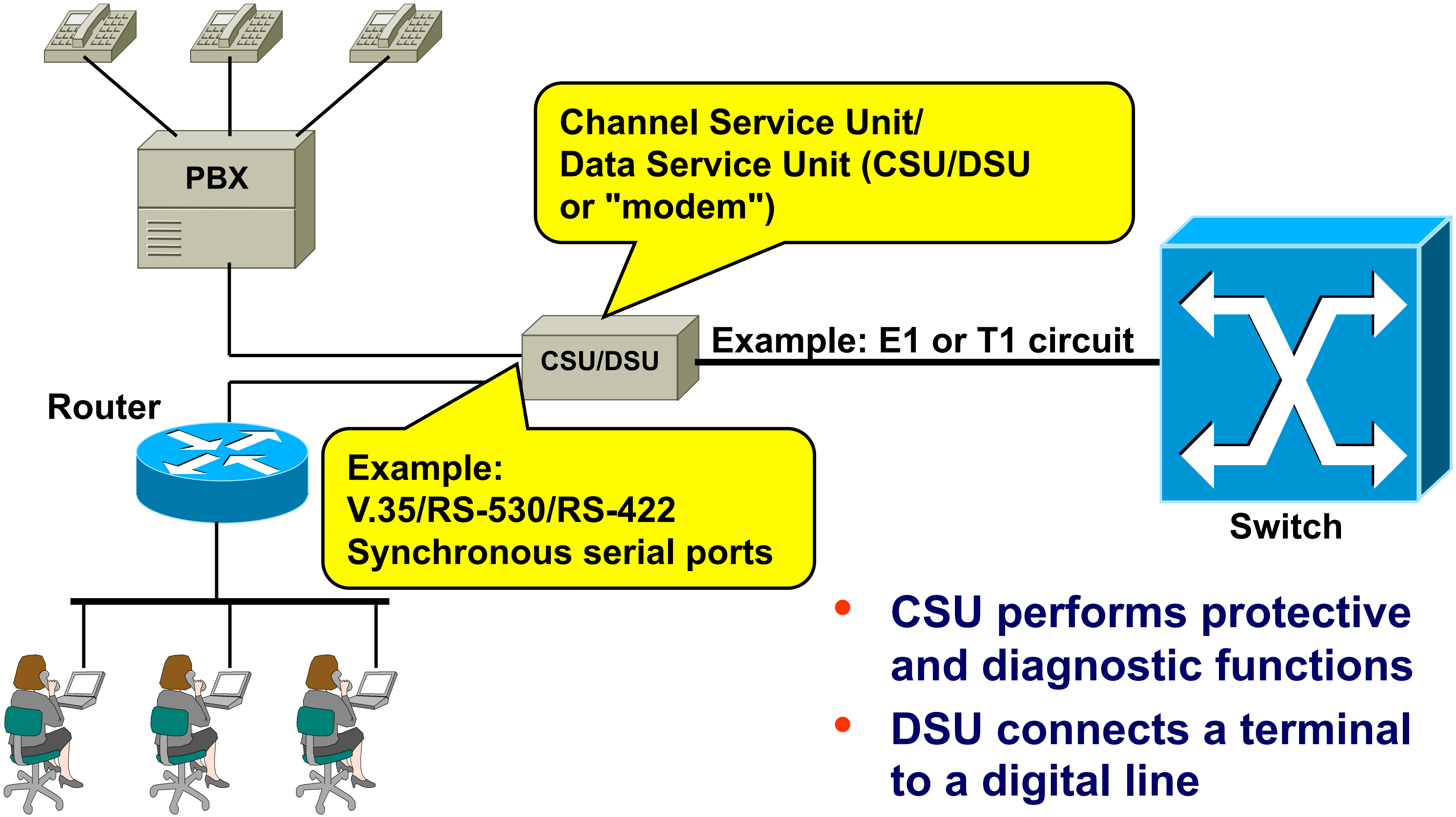
Agenda

- **Introduction**
- **Circuit Switching**
- **Packet Switching**
  - Principles
  - Datagram Service
  - Virtual Call Service
- **OSI Reference Model**
- **<u>Summary of Network Methods</u>**

Circuit Switching

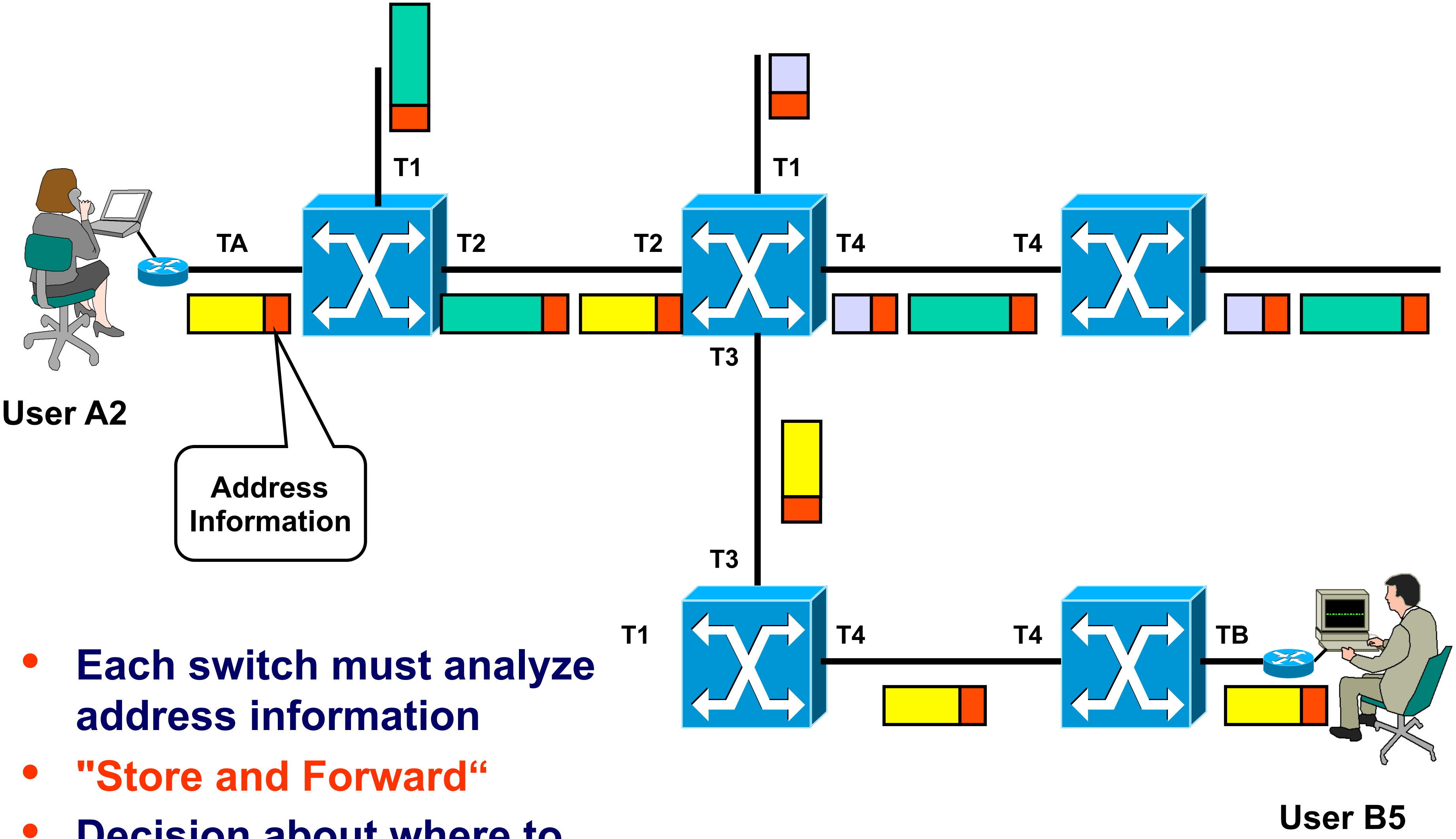


Legacy Company Access (in the past)



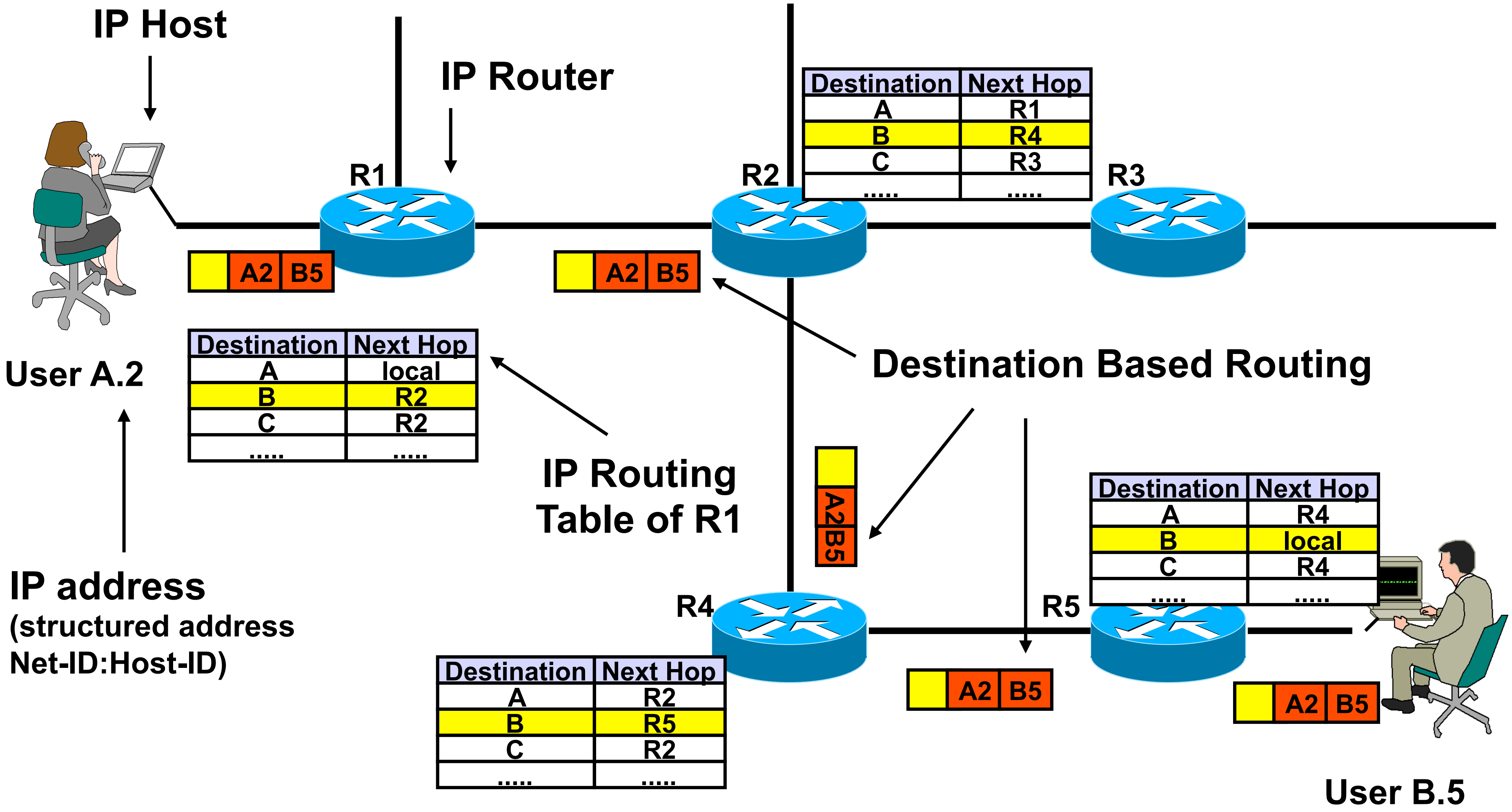
- CSU performs protective and diagnostic functions
- DSU connects a terminal to a digital line

Packet Switching



- Each switch must analyze address information
- "Store and Forward“
- Decision about where to forward is based on tables

IP Datagram Service



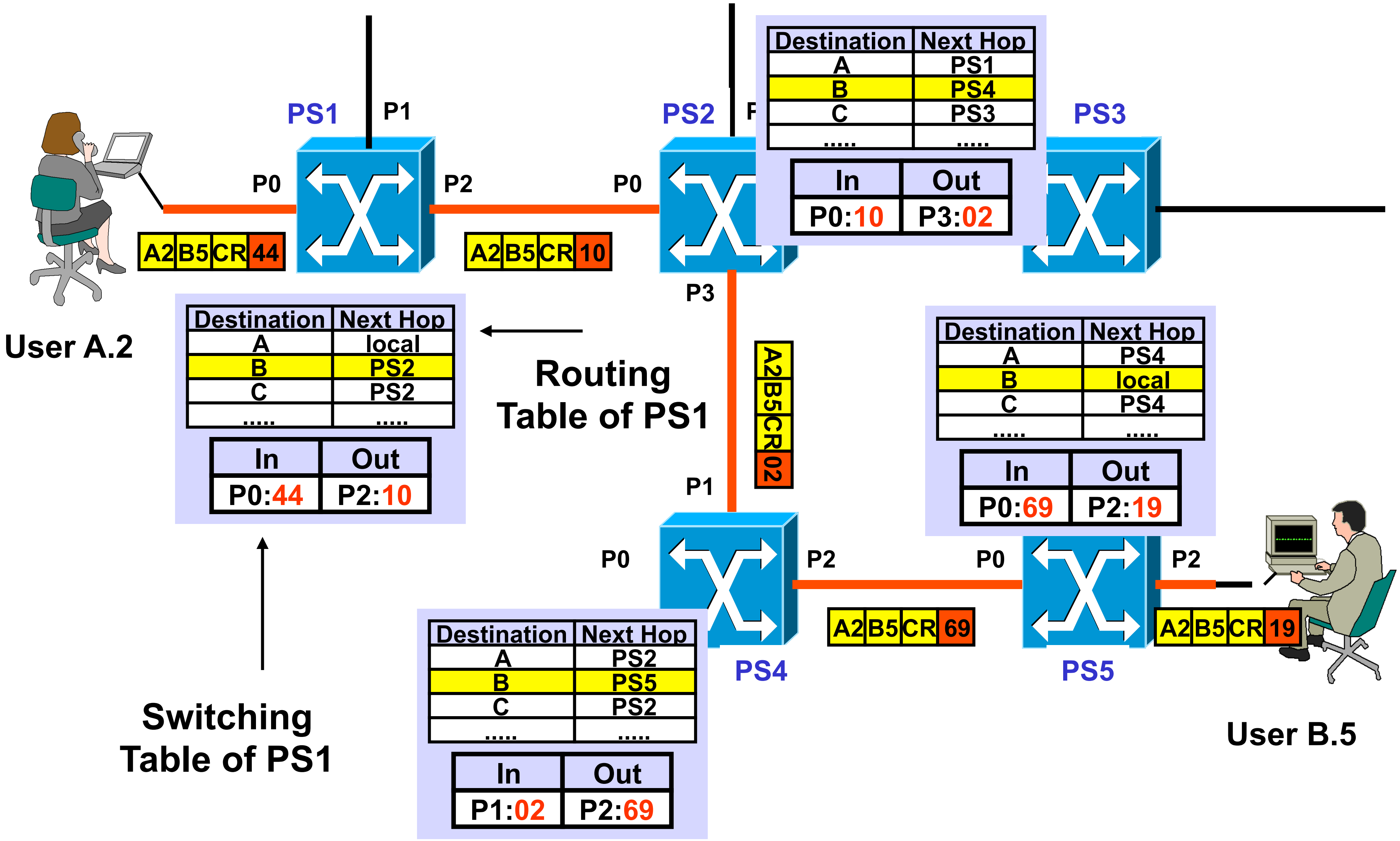
Destination	Next Hop
A	local
B	R2
C	R2
.....	.....

Destination	Next Hop
A	R1
B	R4
C	R3
.....	.....

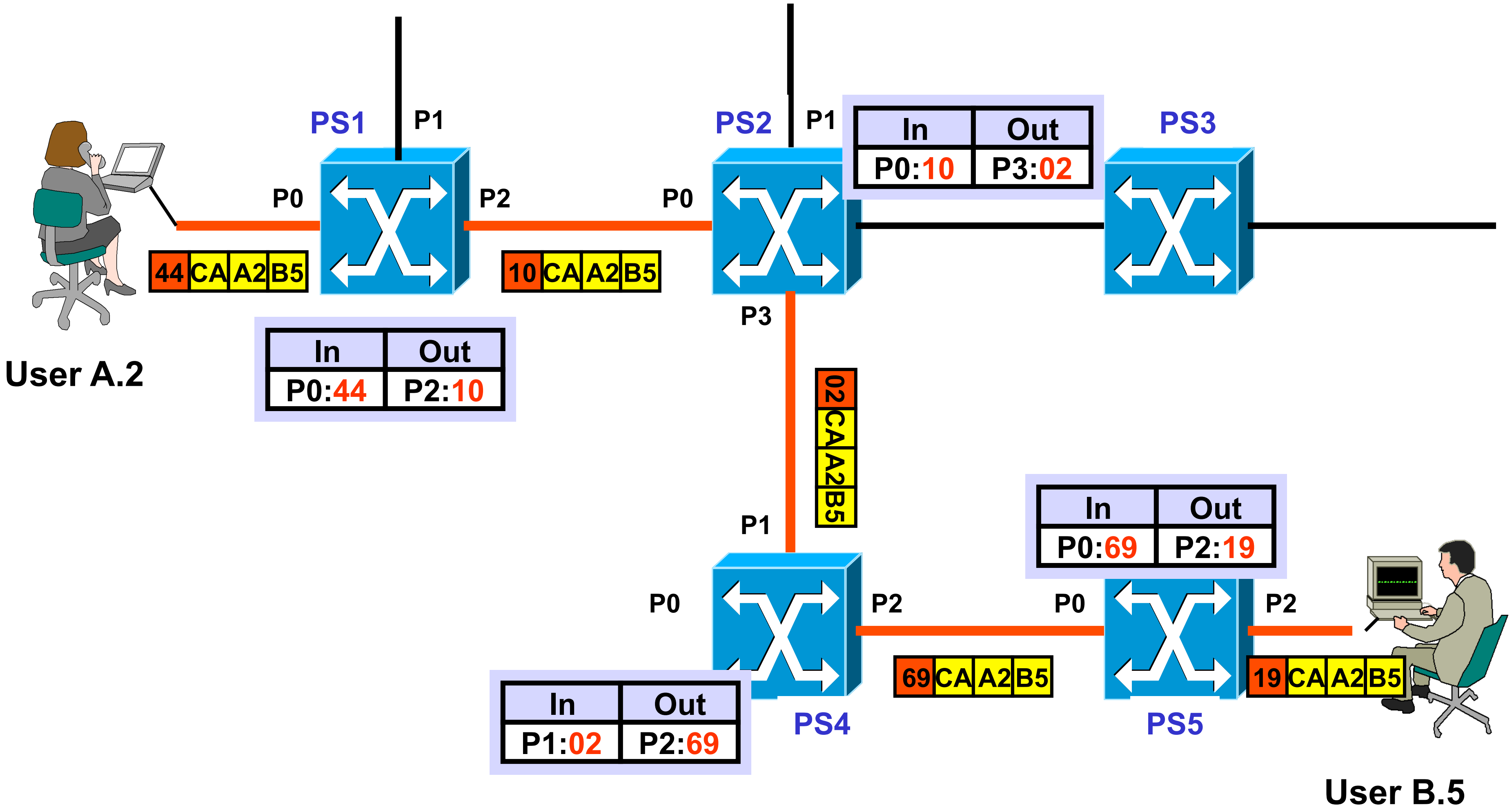
Destination	Next Hop
A	R2
B	R5
C	R2
.....	.....

Destination	Next Hop
A	R4
B	local
C	R4
.....	.....

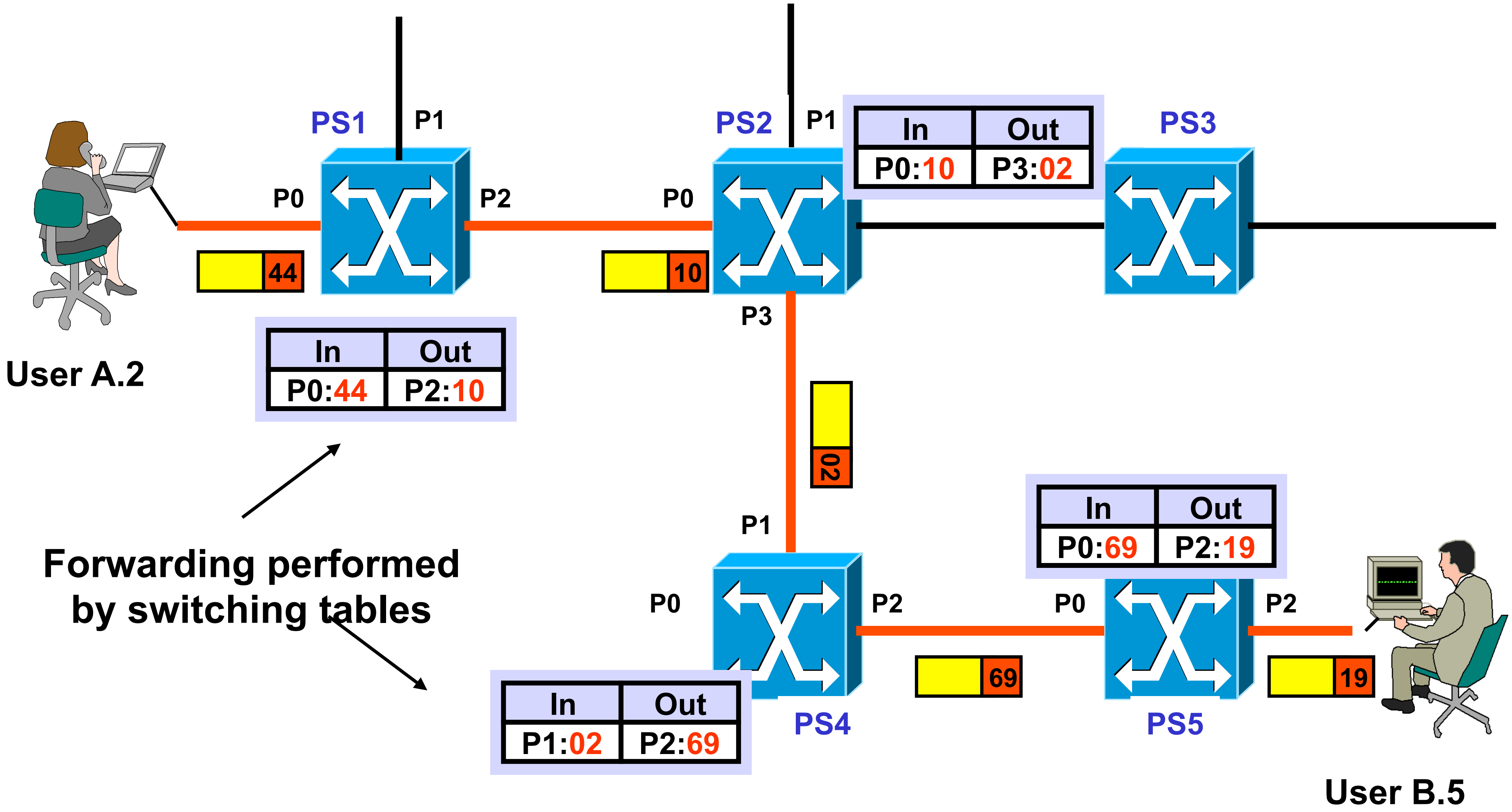
Virtual Call – Call Request (CR)



Virtual Call – Call Accepted (CA)



Virtual Call – Data Transfer



Taxonomy of Network Technologies

Circuit Switching

- Synchronous (Deterministic) Multiplexing
- Low latency (constant delay)
- Designed for isochronous traffic

Dynamic Signalling

Q.931, SS7, ...

ISDN

Static Configuration

Manual configuration

PDH
SONET/SDH

Packet Switching

- Asynchronous (Statistical) Multiplexing
- Store and forward (variable delay)
- Addressing necessary
- Designed for data traffic

Datagram

Connectionless

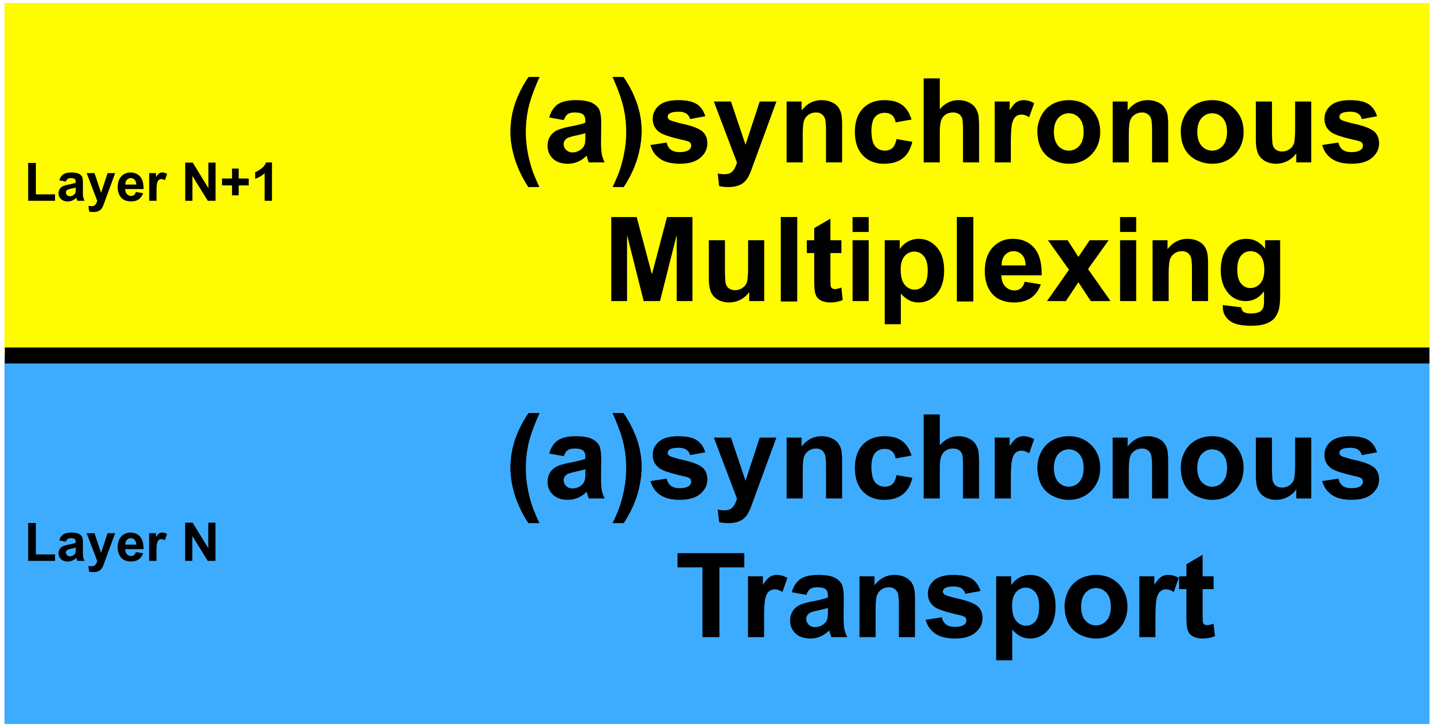
IP
IPX
AppleTalk

Virtual Call

Connection-oriented

X.25
Frame Relay
ATM

Multiplexing Revisited



Summary

- **Only two fundamental network principles**
  - Circuit switching
  - Packet switching
  - The first is good for real-time voice (traffic) the latter is good for data traffic
  - But everybody wants to have the best of both worlds
- **Packet switching allows two basic types:**
  - Datagram (CL) versus Virtual Call (CO)
  - Different address types (!) for forwarding decision of data packet
    - Unique routable address (CL)
    - Local connection identifier (CO)