Concepts LAN

Network fundamentals, LAN architecture & Ethernet focus

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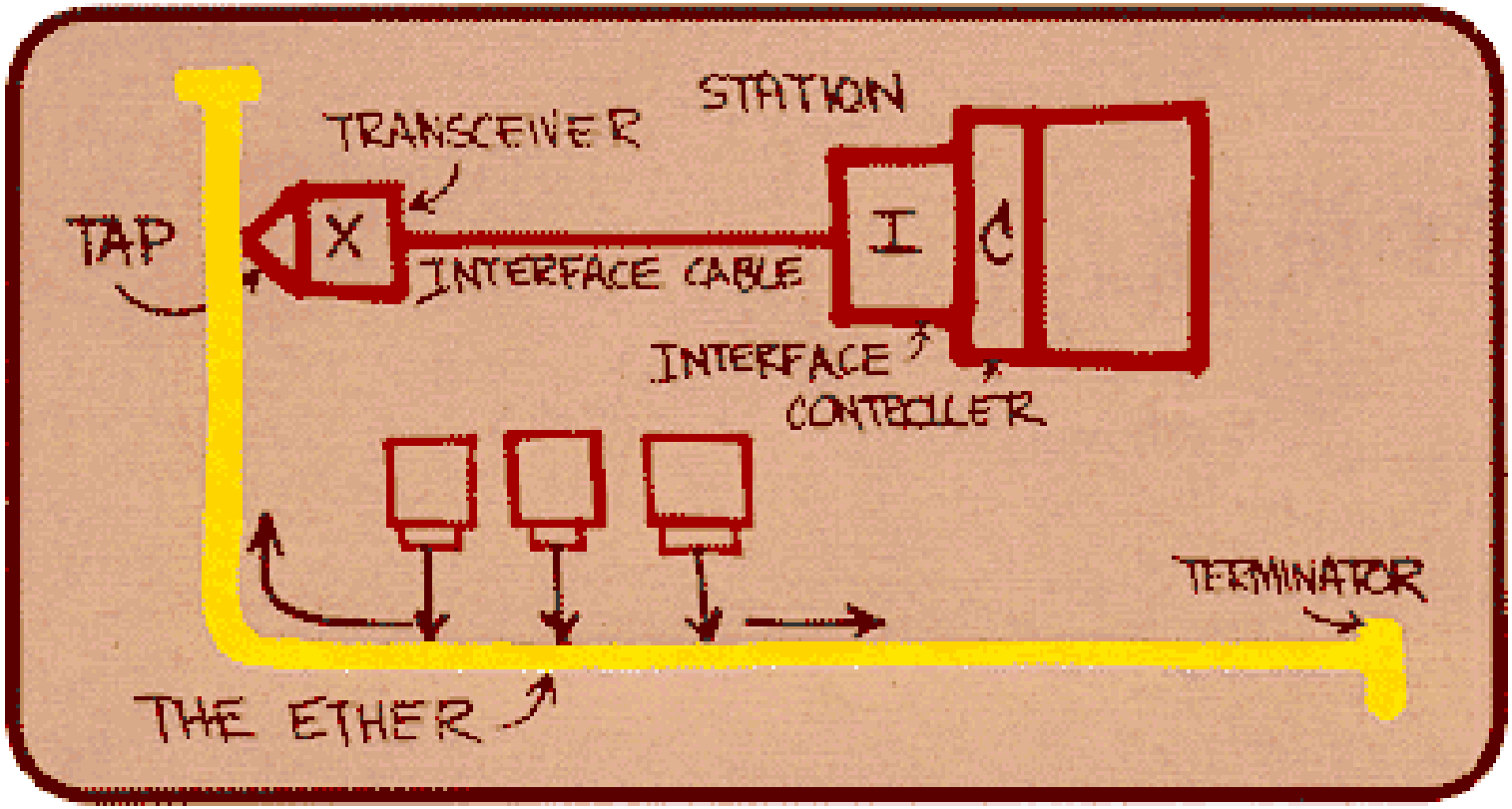
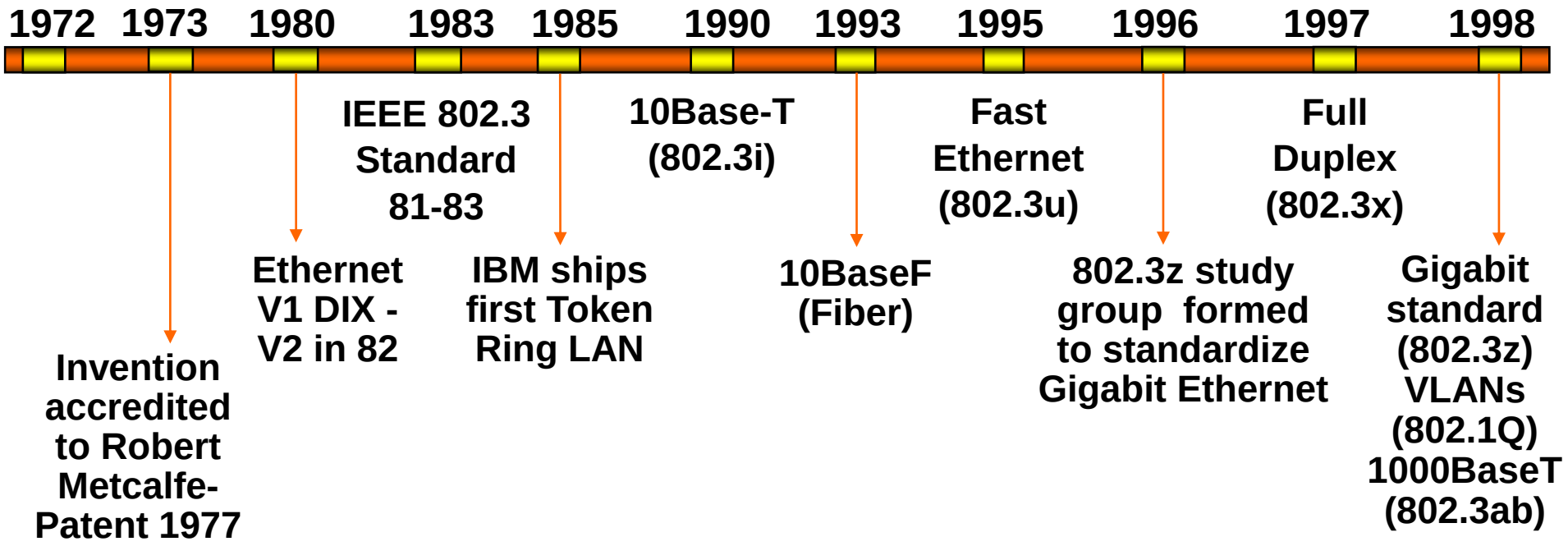
EPITA - MAJEURES SRS & TCOM

Ethernet Evolution

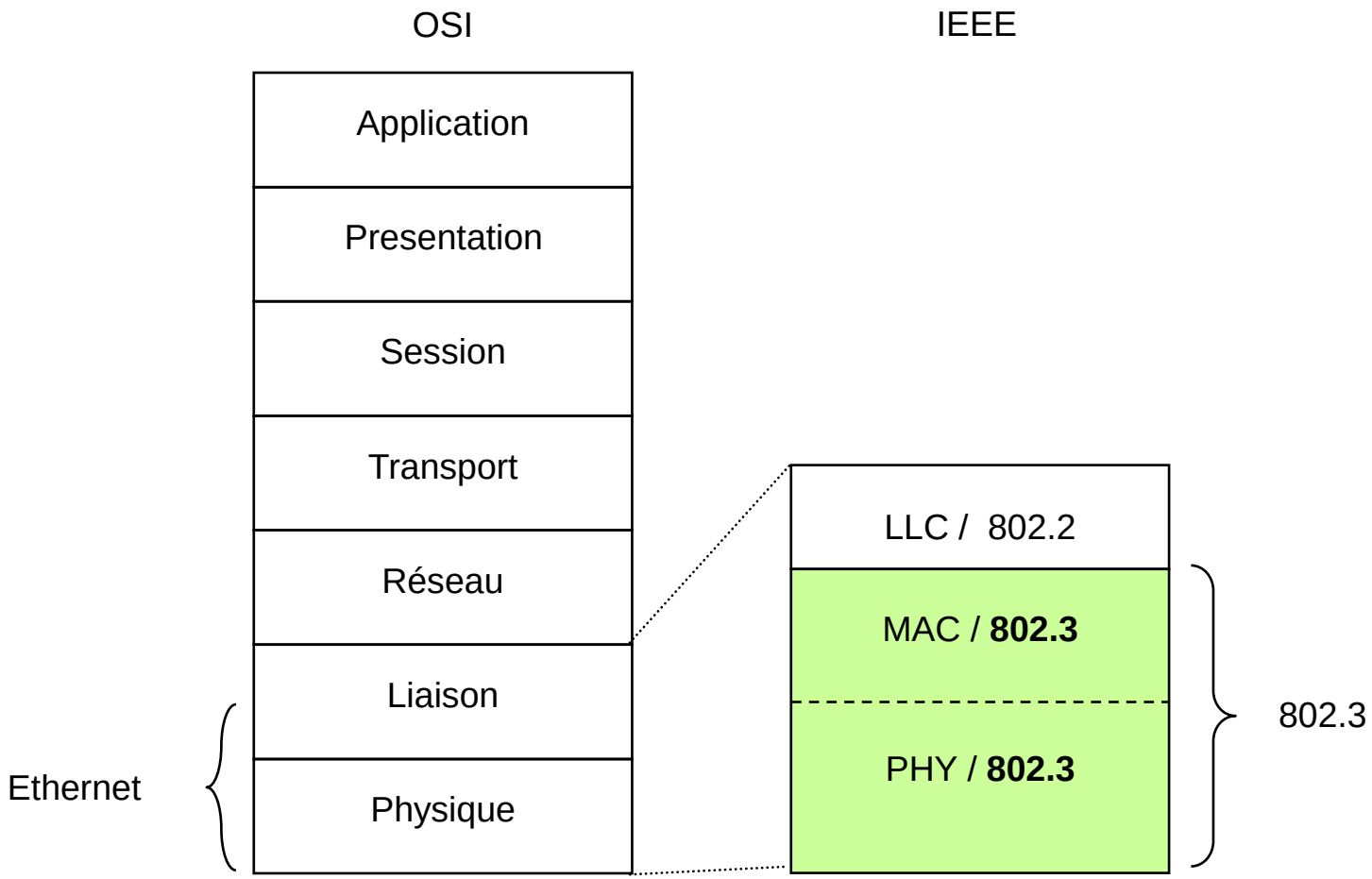


Ethernet Evolution

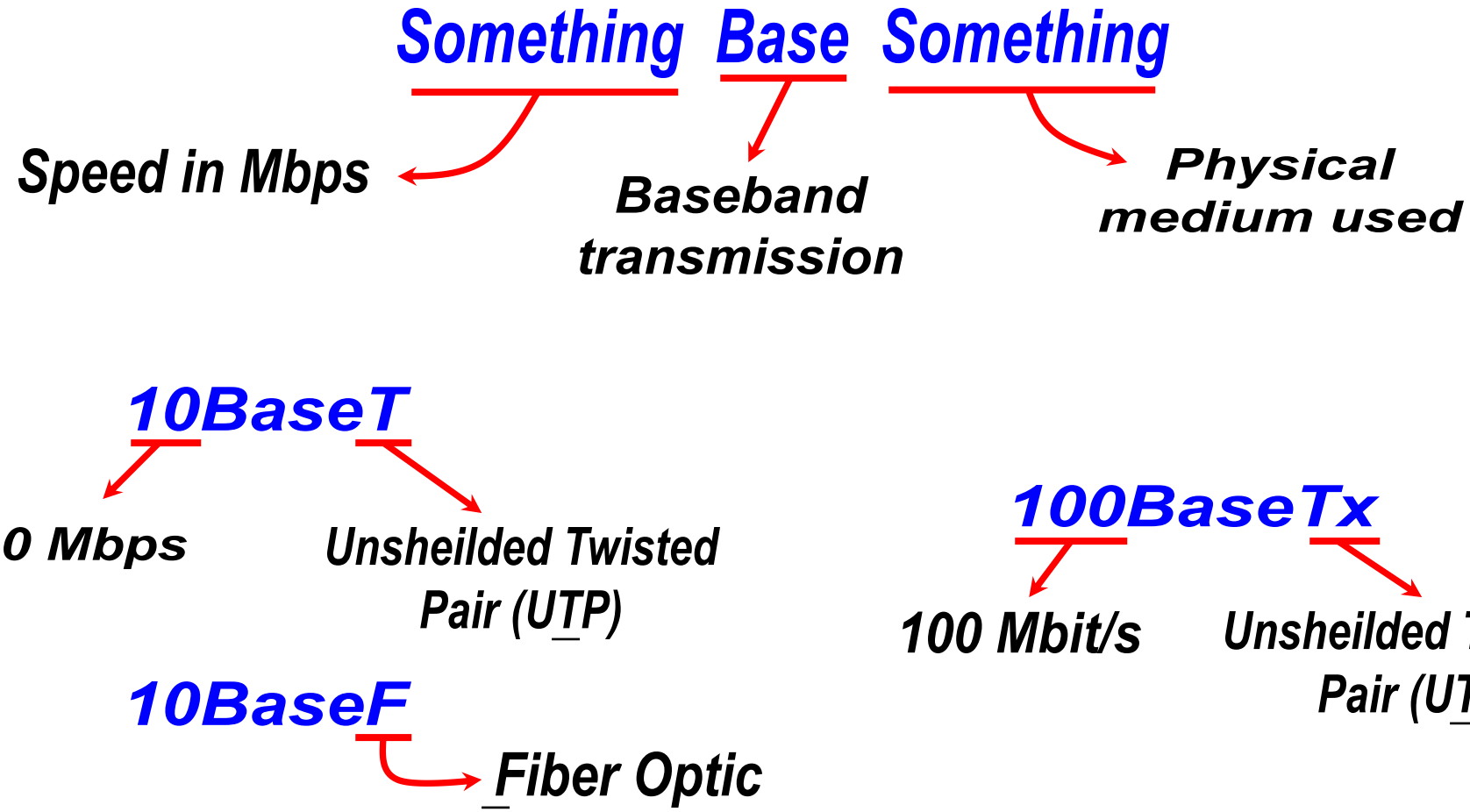


- **Ethernet Design Goals**
  - **Simplicity**
  - **Efficient use of shared resources**
  - **Ease of reconfiguration and maintenance**
  - **Compatibility**
  - **Low cost**

Ethernet and the OSI / IEEE models



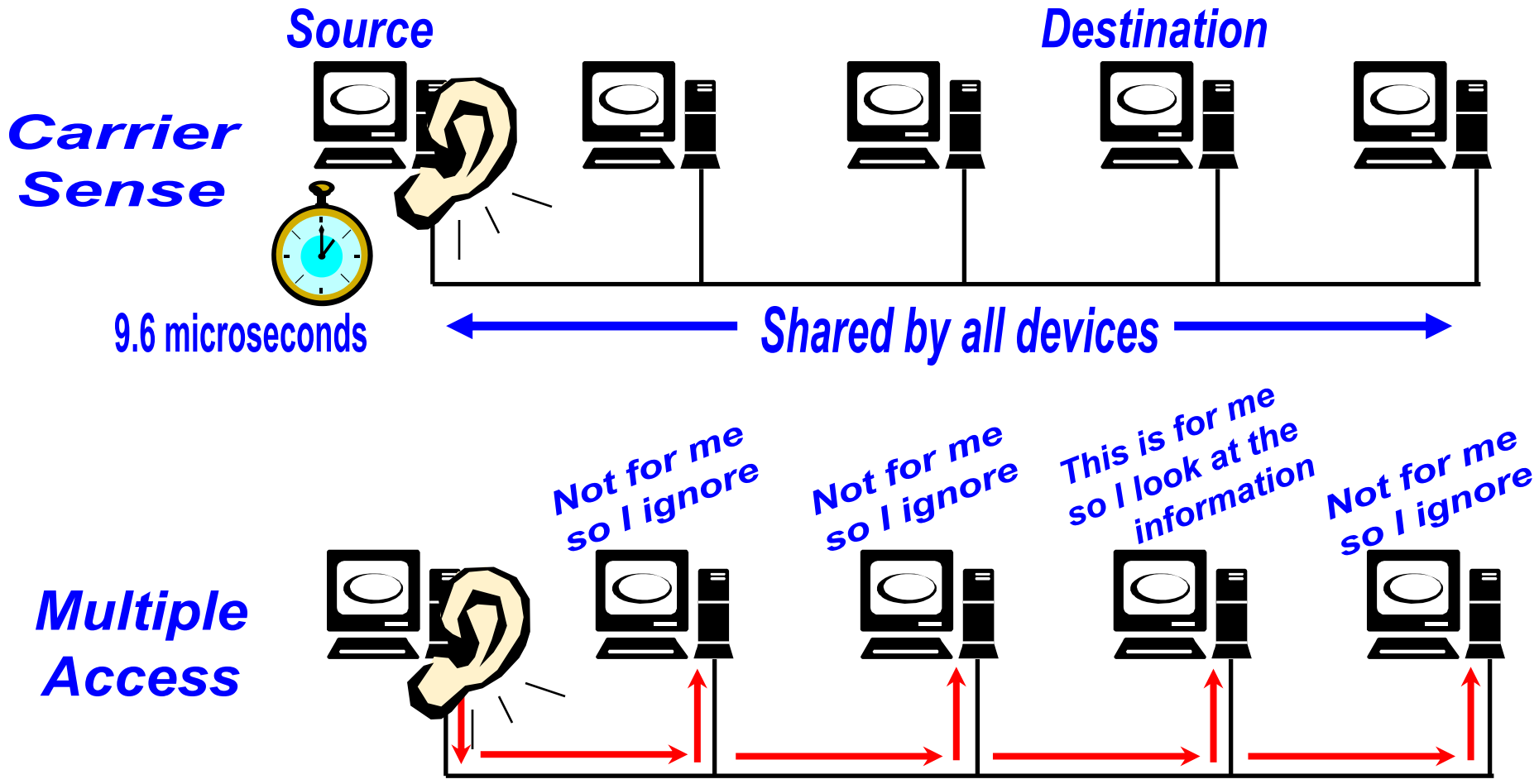
Ethernet Naming Conventions



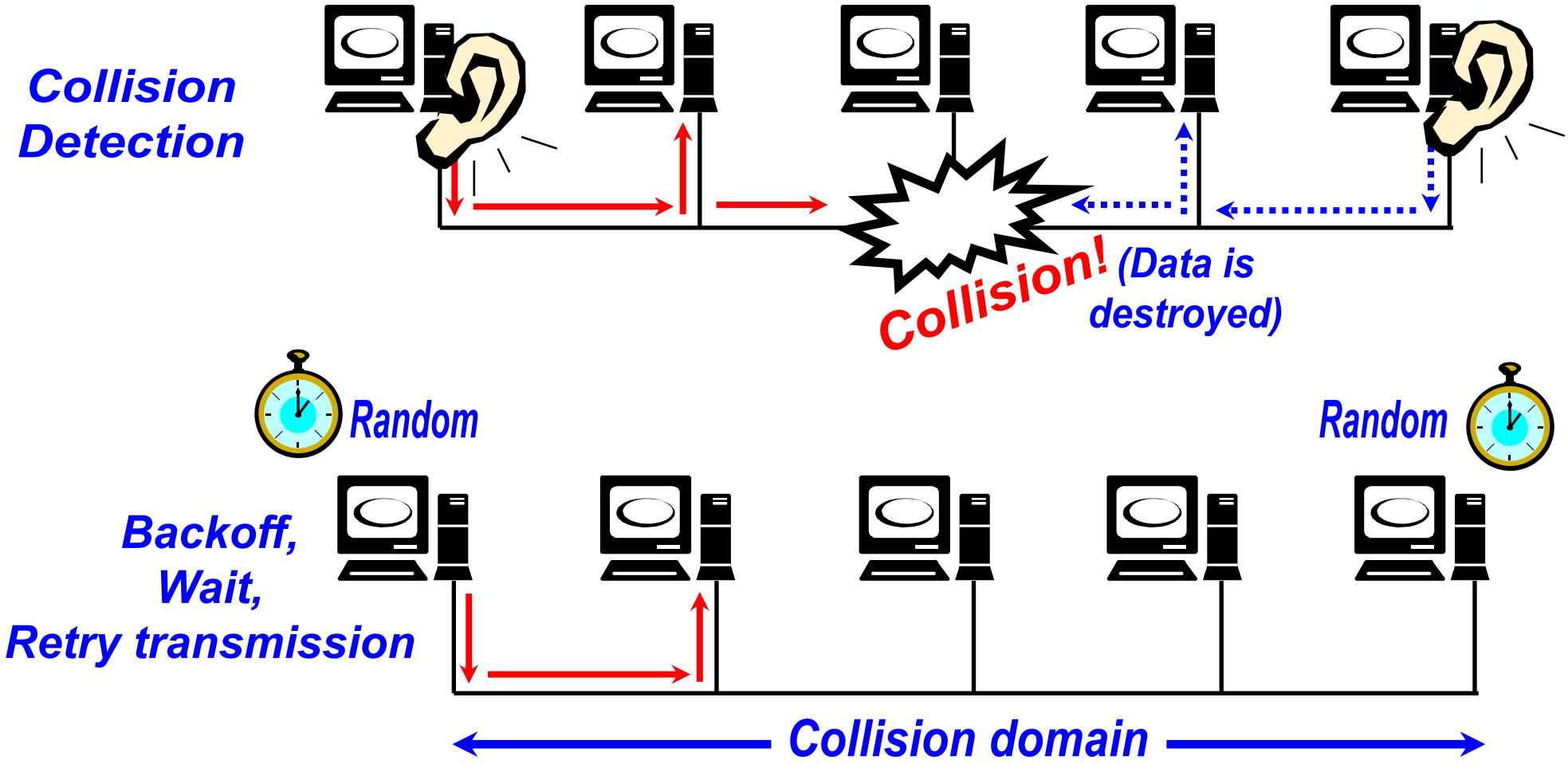
Ethernet Principle – CSMA/CD

- Carrier Sense (Is someone already talking?)
- Multiple Access (I hear what you hear!)
- Collision Detection (Hey, we're both talking!)
- 1. If the medium is idle, transmit anytime.
- 2. If the medium is busy, wait and transmit right after.
- 3. If a collision occurs, backoff for a random period, then go back to 1.

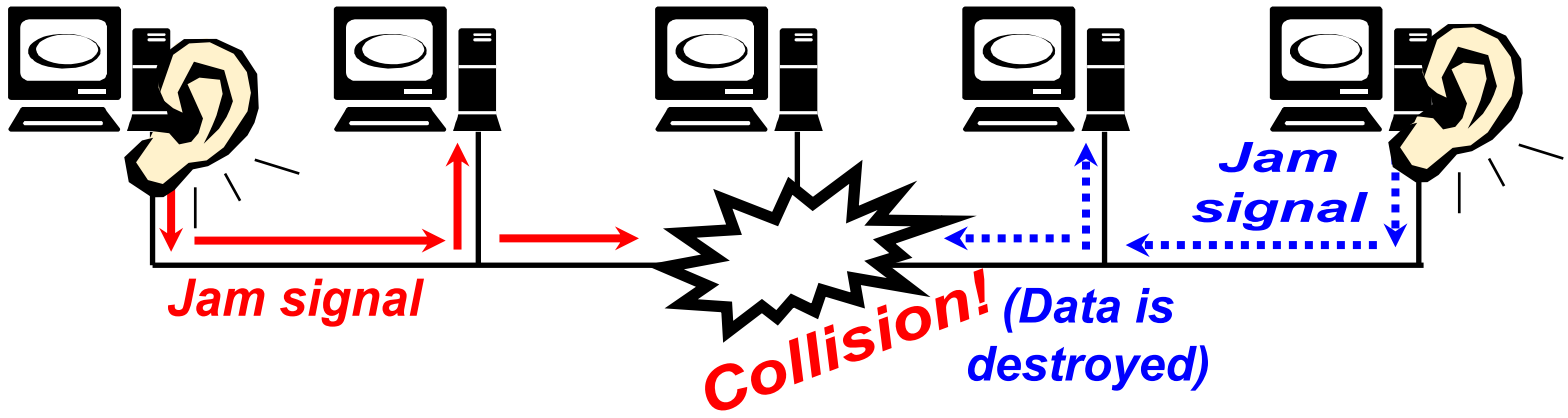
Ethernet Operation – CSMA



Ethernet Operation – CD

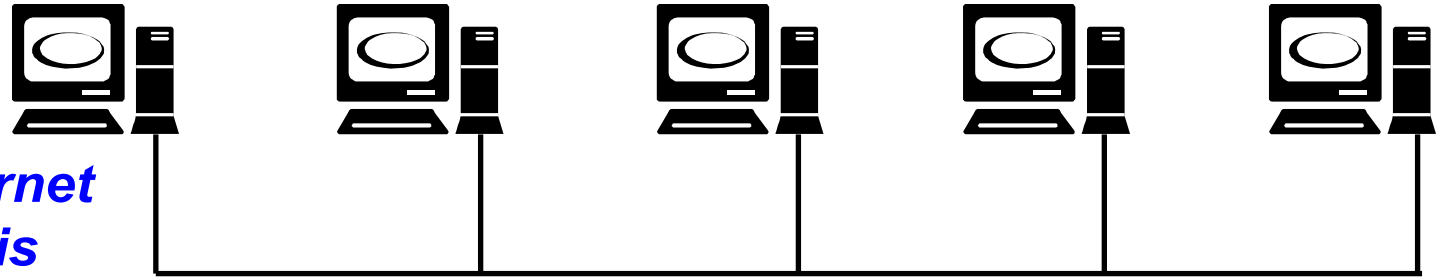


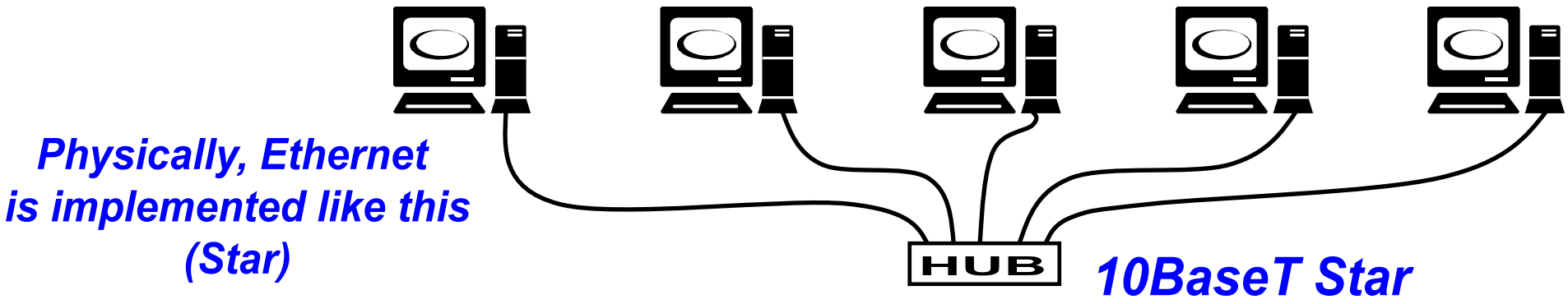
Ethernet Collisions – More Detail



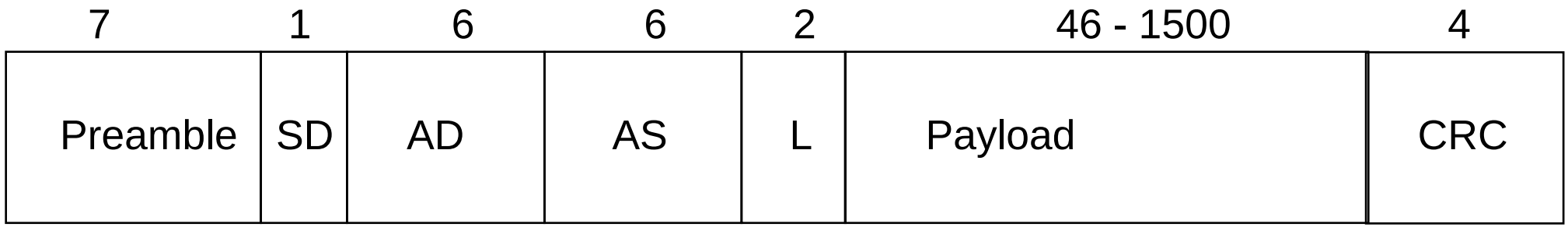
- The adapters have to hear the collision <u>while they are still transmitting</u>
- They then transmit a 32-bit jam signal
- They wait a random time before retransmission
- If there are repeated collisions the adapter tries again, up to a a maximum of 16 times
  - Uses “truncated binary exponential backoff” algorithm

Ethernet, Logical vs Physical

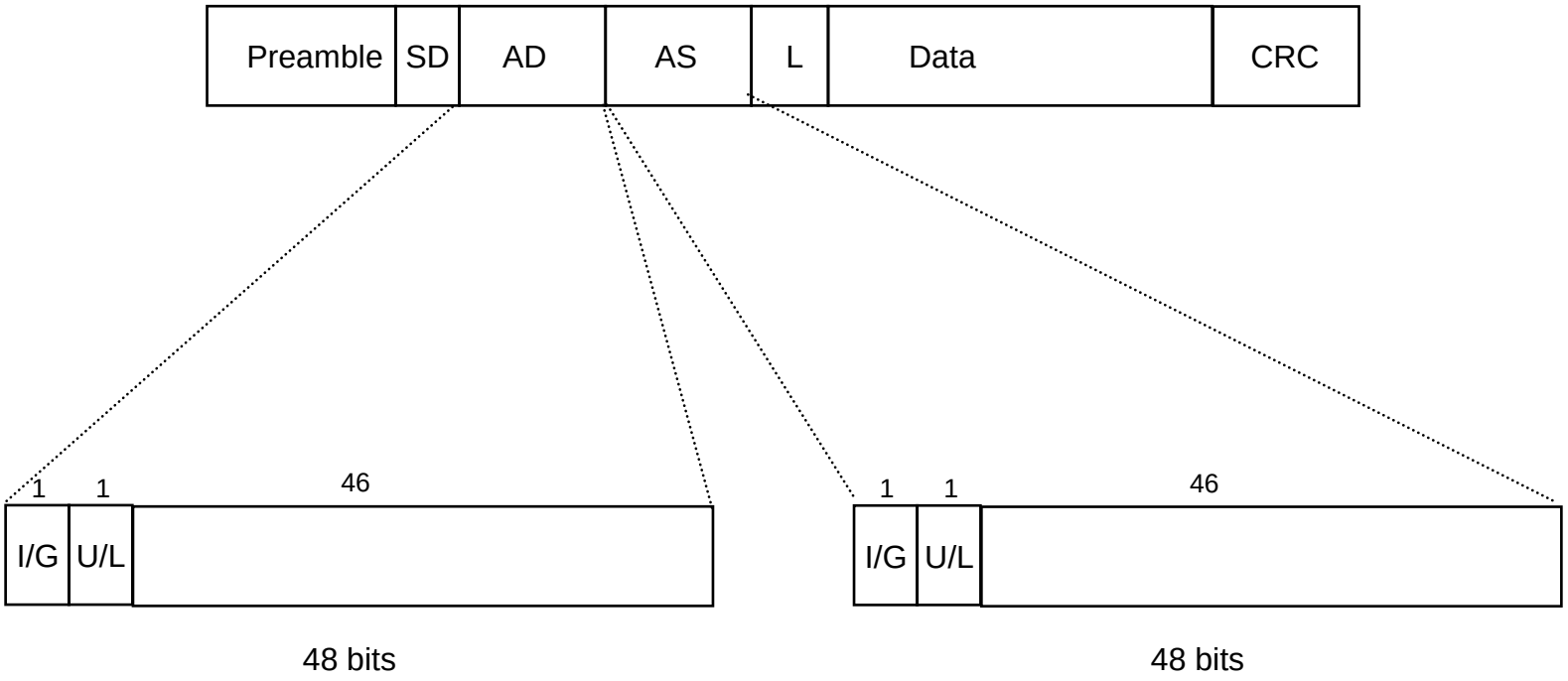




Format of the IEEE 802.3 frame



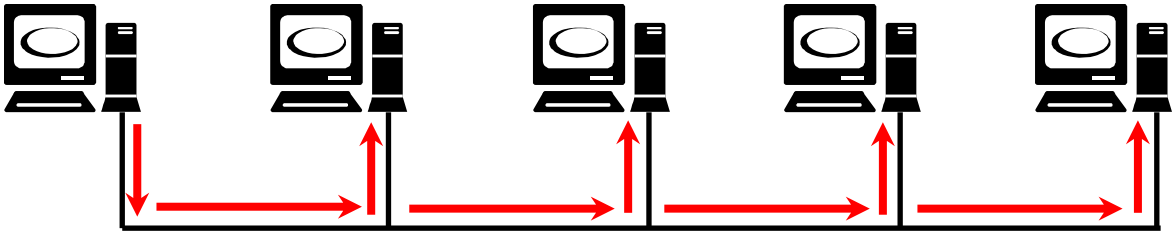
Ethernet or MAC addresses



Ethernet addresses : Broadcasts

- Ethernet inherently supports broadcasts
- Broadcast mechanism is used frequently
  - Example ARP – Address Resolution Protocol
- A Broadcast Domain is all devices that will see a broadcast frame

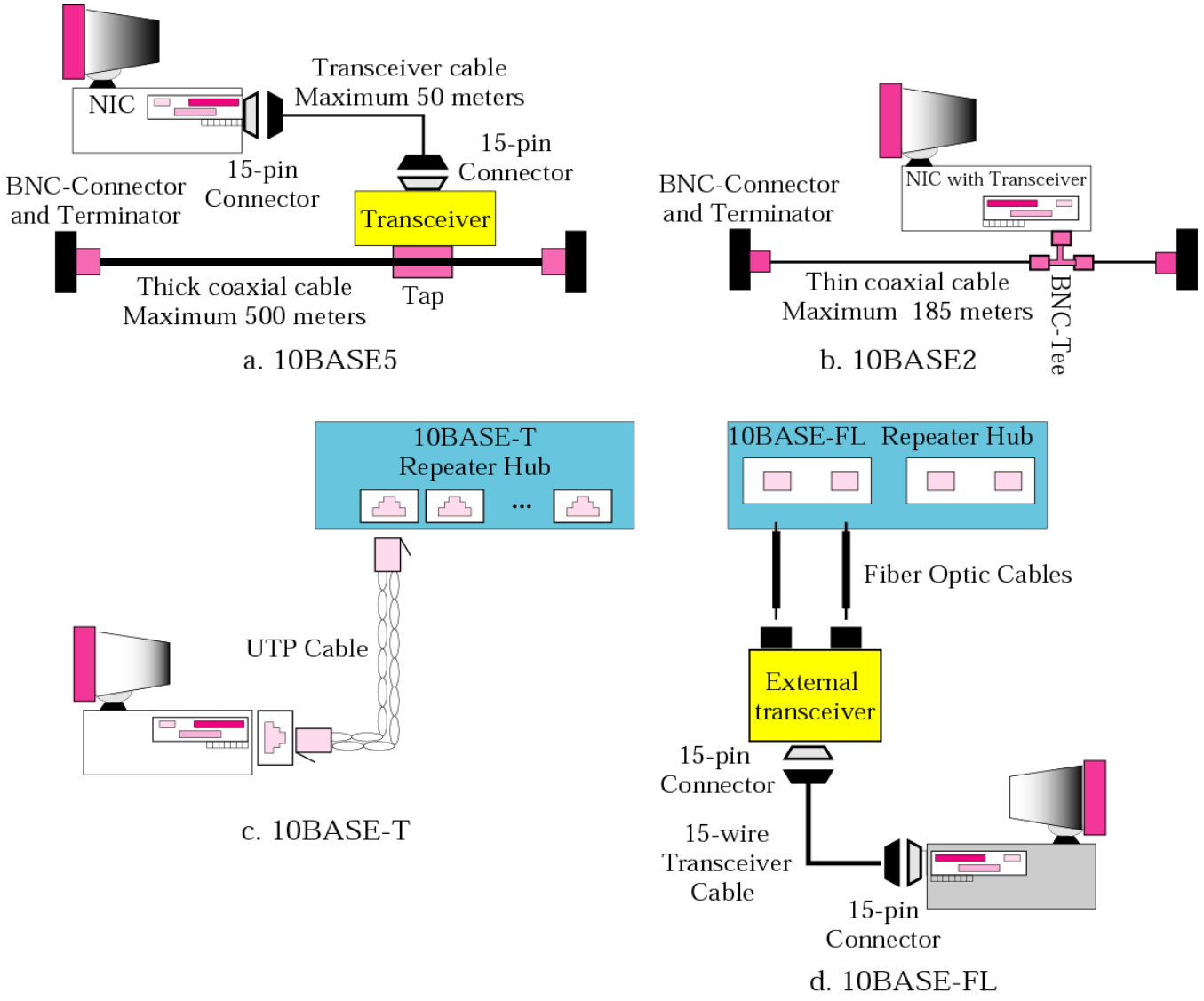
Broadcast frame: uses FF:FF:FF:FF:FF:FF address



Ethernet implementations

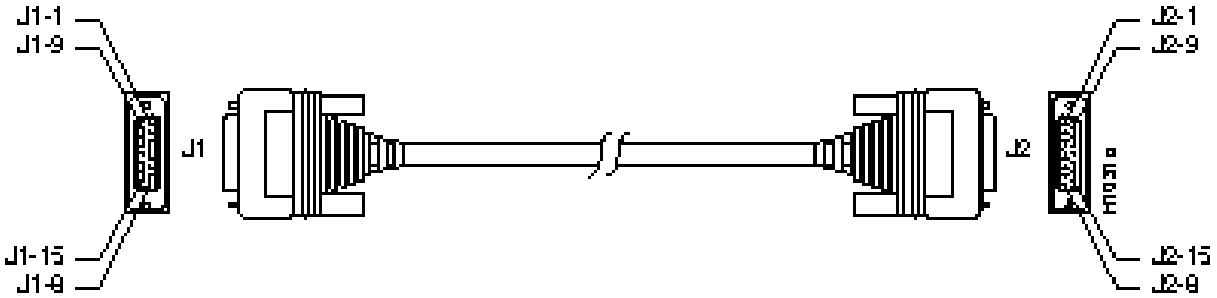
- **10BaseT**
  - 2 pairs of Cat 3 UTP
  - By far the most widely used specification
- **10BaseF**
  - 2 strands of MMF
- **10Base2**
  - Thin coaxial or “Thinnet” (Dead)
- **10Base5**
  - Thick coaxial or “Thicknet” (Dead)
- **10Broad36**
  - Coaxial (Dead)

Ethernet implementations



Source : B. Forouzan

Ethernet implementations : 10Base5

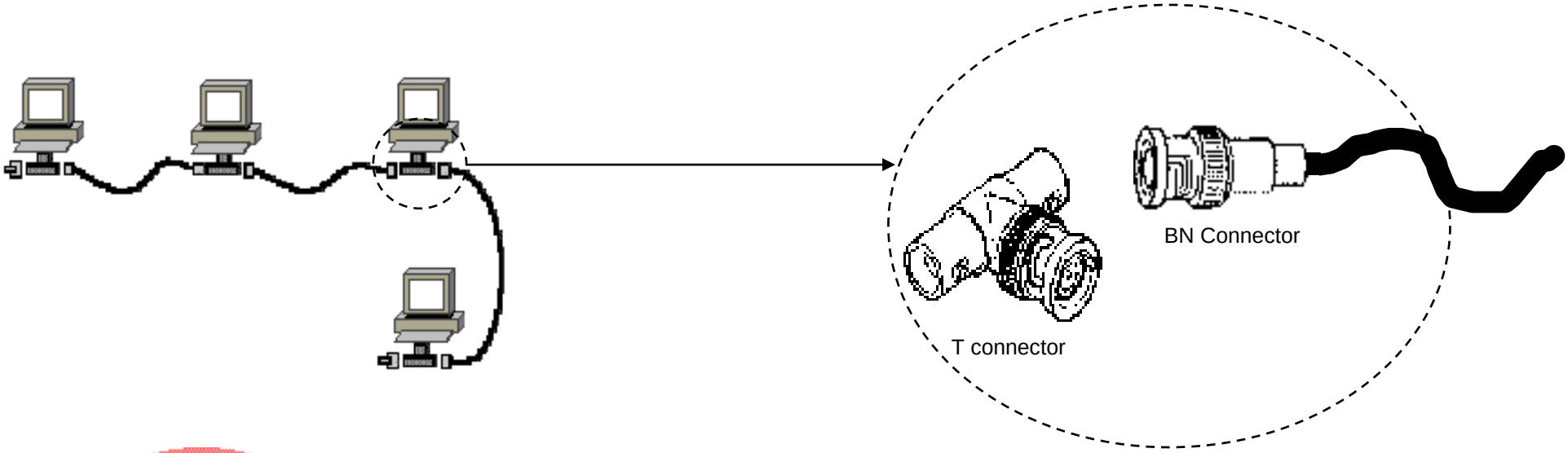


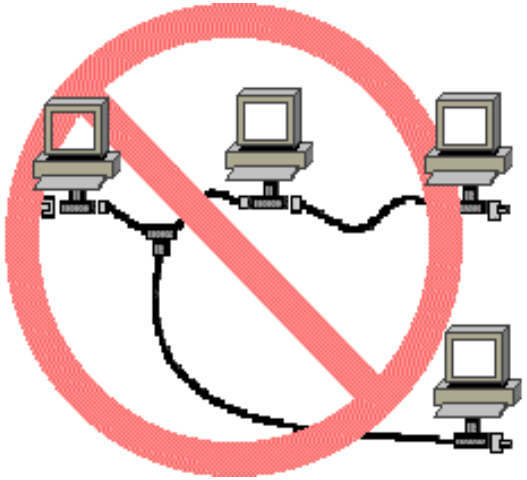
Pin	Ethernet Circuit	Signal Name
3	DO-A	Data Out Circuit A
10	DO-B	Data Out Circuit B
11	DO-S	Data Out Circuit Shield
5	DI-A	Data In Circuit A
12	DI-B	Data In Circuit B
4	DI-S	Data In Circuit Shield
7	CO-A	Control Out Circuit A (not connected)
15	CO-B	Control Out Circuit B (not connected)
8	CO-S	Control Out Circuit Shield (not connected)
2	CI-A	Control In Circuit A
9	CI-B	Control In Circuit B
1	CI-S	Control In Circuit Shield
6	VC	Voltage Common
13	VP	Voltage Plus
14	VS	Voltage Shield (L25 and M25) Shell PG Protective Ground

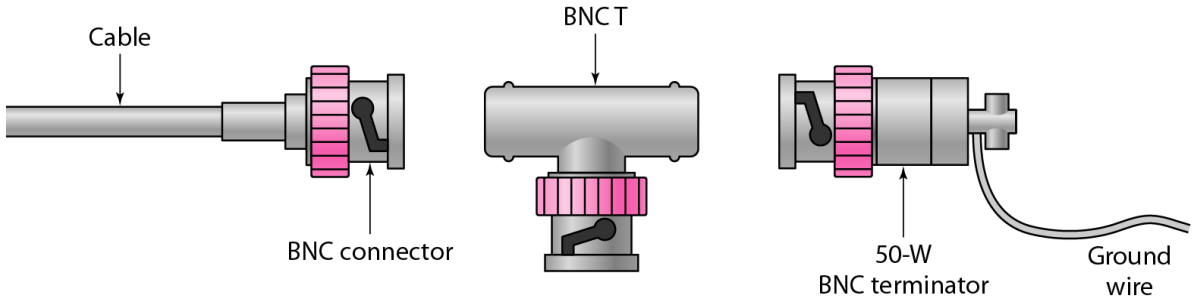
Ethernet implementations : 10Base2

- Thin Ethernet, Thinnet, Cheapernet, …
- Coaxial cable 50 Ohms
- Daisy chain topology
- BNC- connector / T- Connector
- 50 ohms terminator
- Maximum segment length : 185 m
- Maximum coverage : 925 m
- Maximum number of stations per segment : 30
- Minimum distance between two stations : 0,5 m

Ethernet implementations : 10Base2

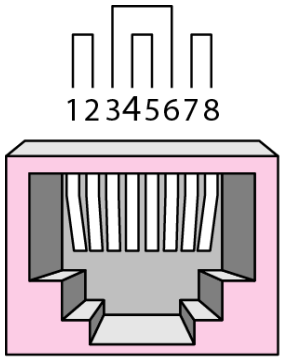




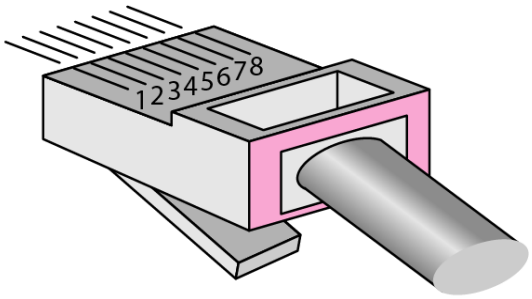


Ethernet implementations : 10BaseT

Pin	Signal
1	Transmit Data +
2	Transmit Data -
3	Receive Data +
4	Unused
5	Unused
6	Receive Data -
7	Unused
8	Unused

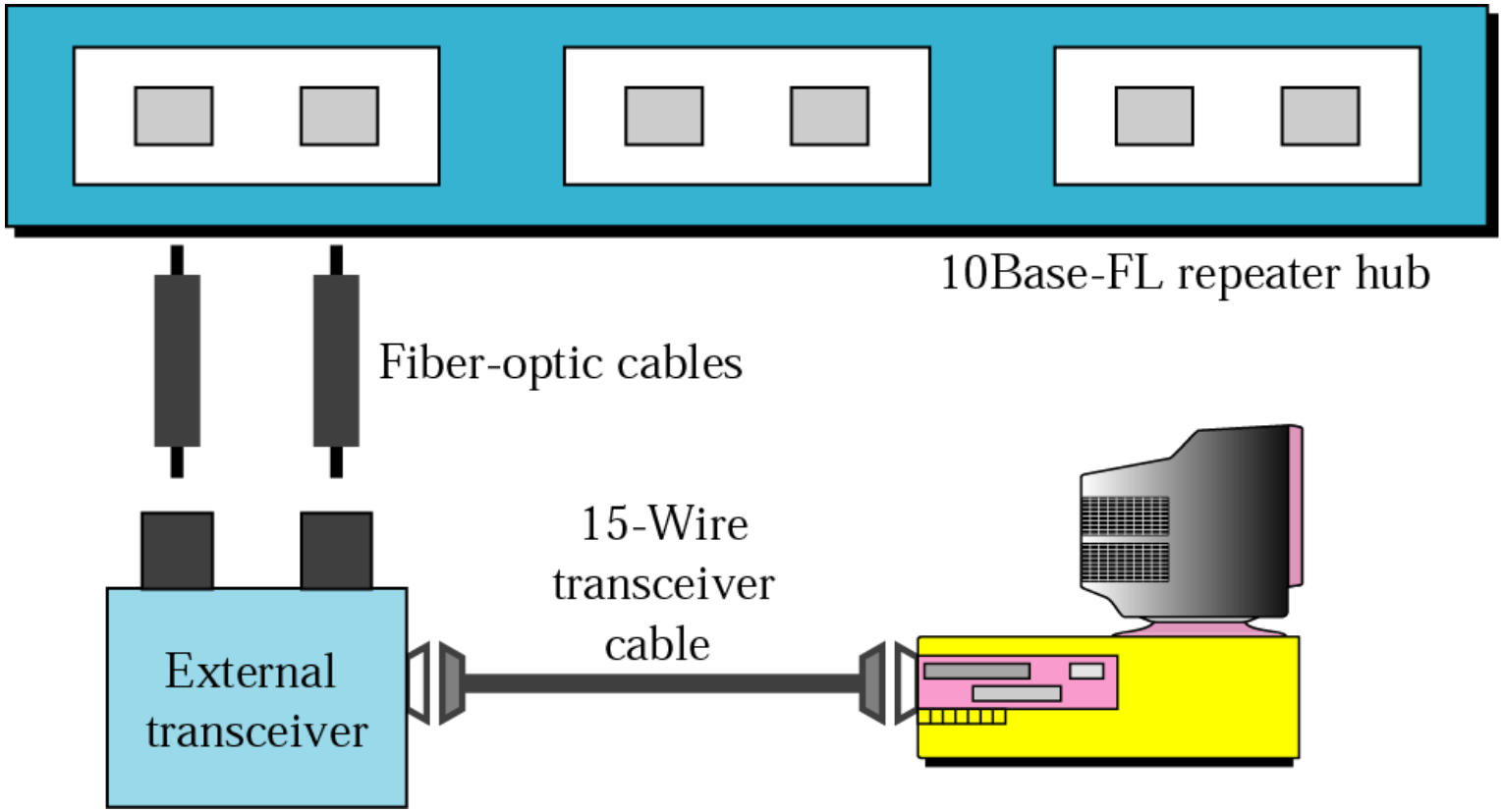


RJ-45 Female



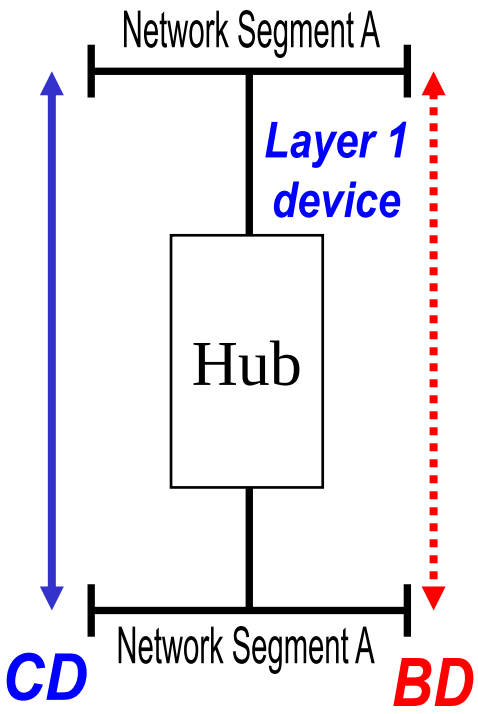
RJ-45 Male

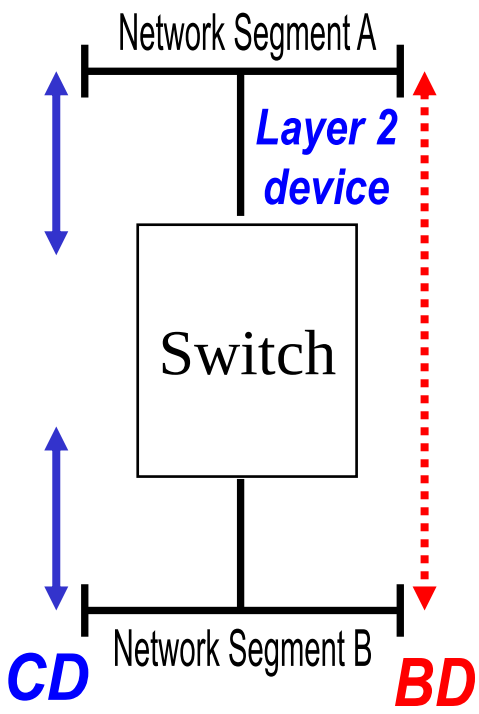
Ethernet implementations : 10BaseFL

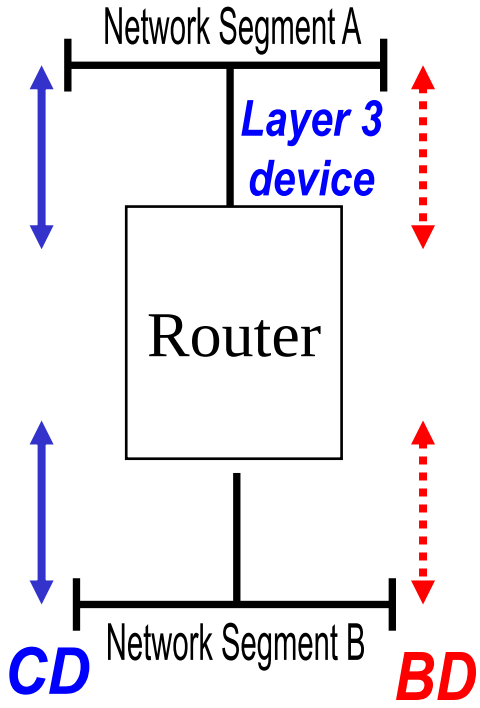


Source : B. Forouzan

L1, L2 and L3 equipments





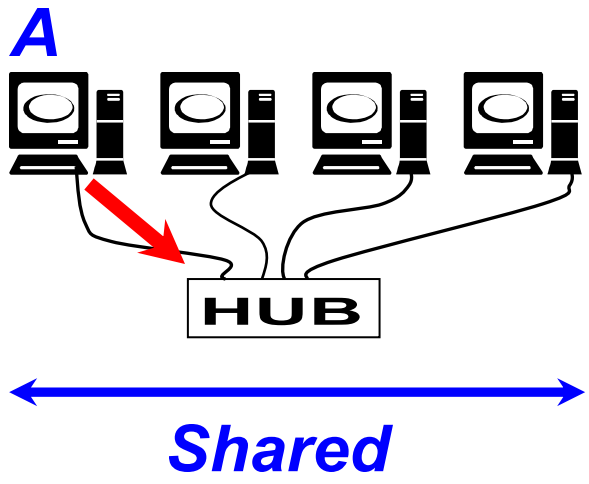


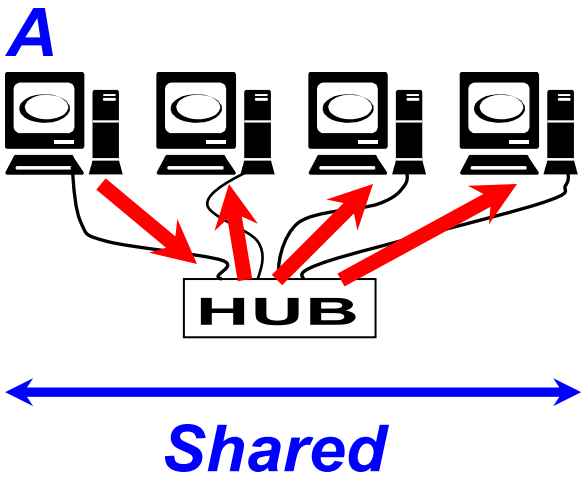
CD = Collision Domain

BD = Broadcast Domain

Hubs

- **A hub is a simple OSI layer 1 device: a hub just repeats the incoming signal**



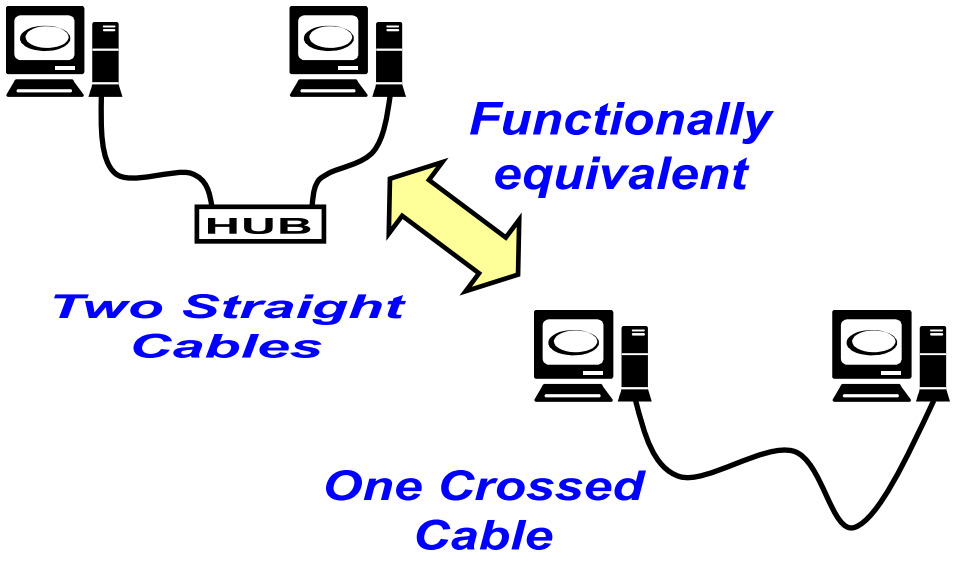


1. *If PC A transmits...*

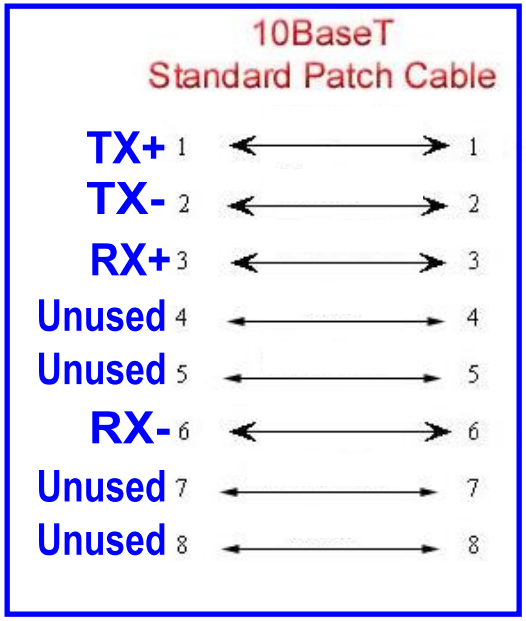
2. *...the hub simply repeats that signal - all devices connected to the hub will see the frame*

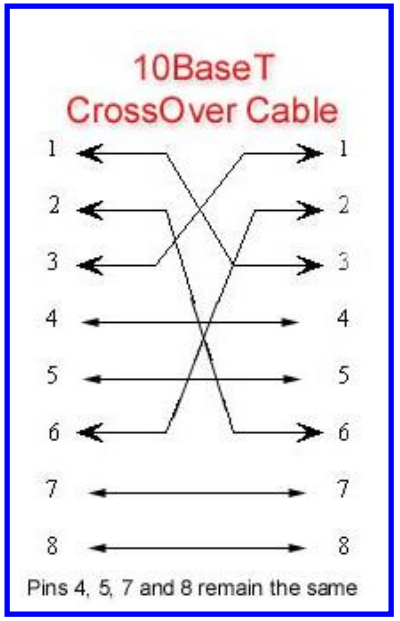
Crossover Cables

- **A “crossover” or “crossed” cable may be used to directly connect two Ethernet devices**
  - Transmit/Receive reversed at one end
  - Crossover cables can be made or bought



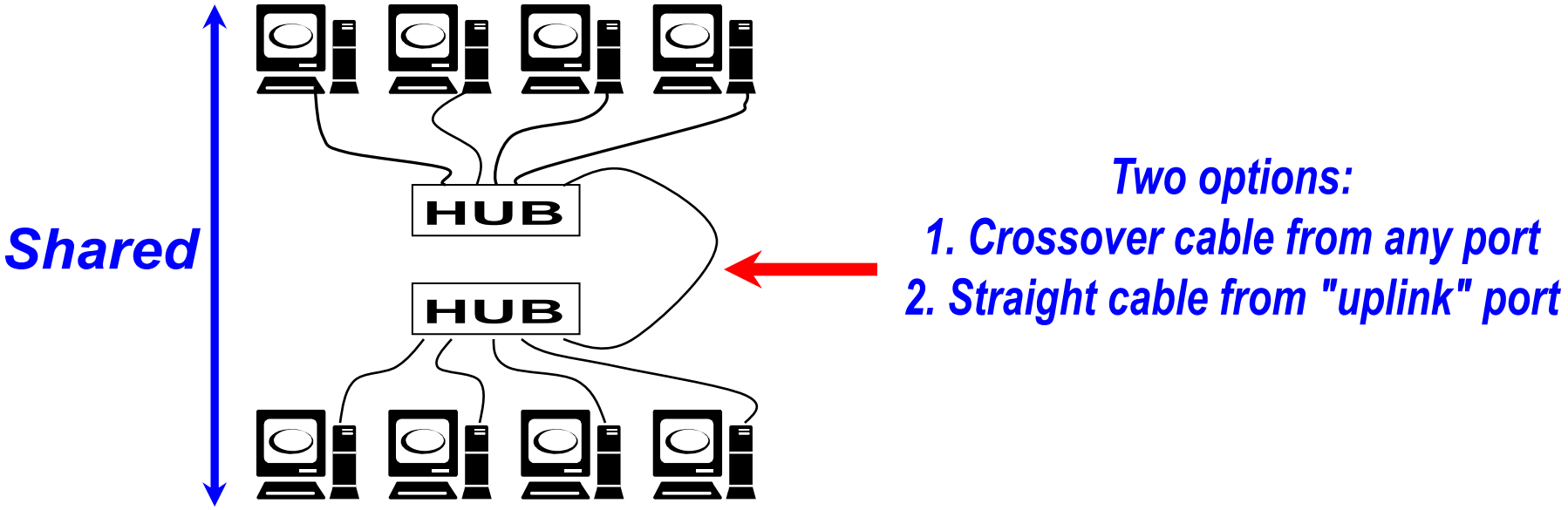
Pin 1 on right when looking at RJ-45 connector with tab on bottom and contacts on top



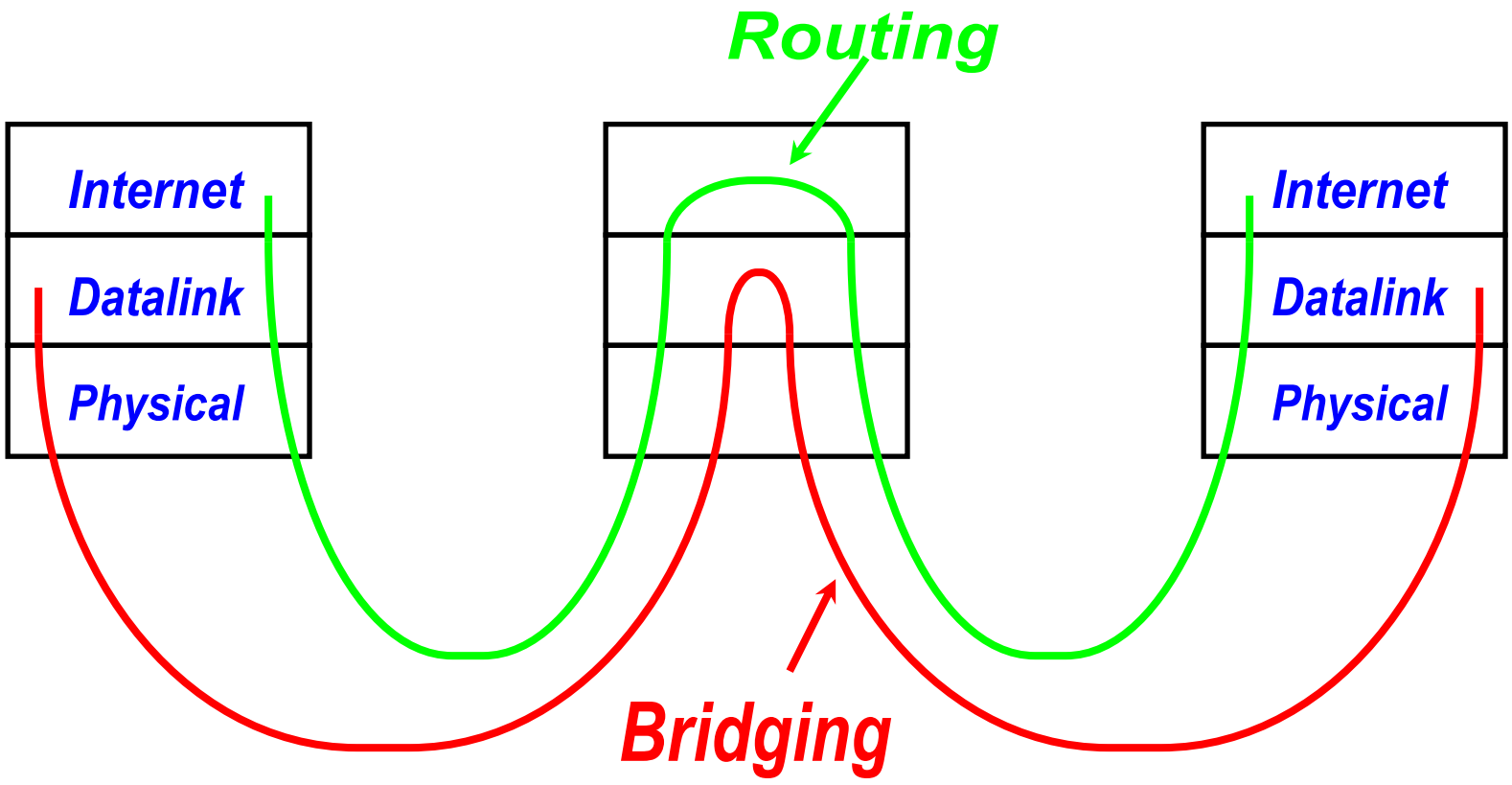


Connecting Hubs

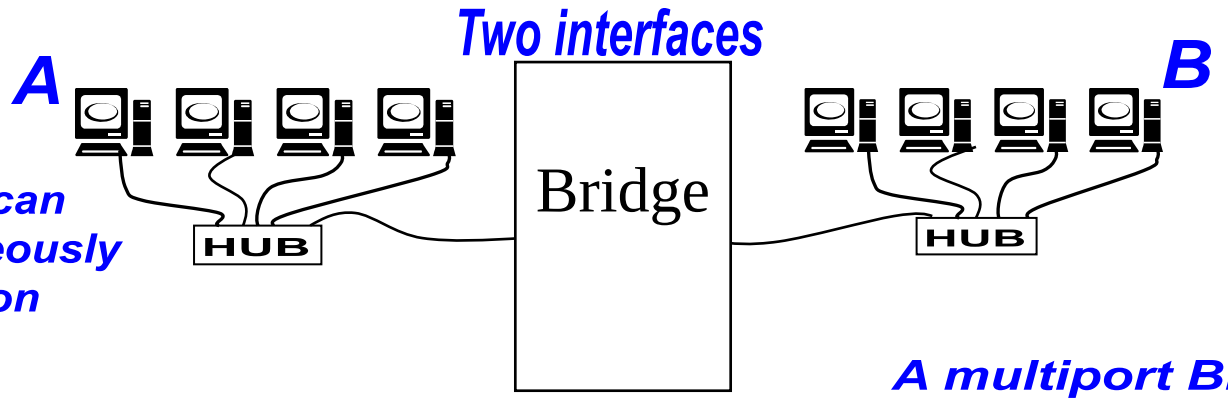
- Hubs may be connected or “cascaded”
  - Connected hubs behave like one “big” hub



Transparent Bridging

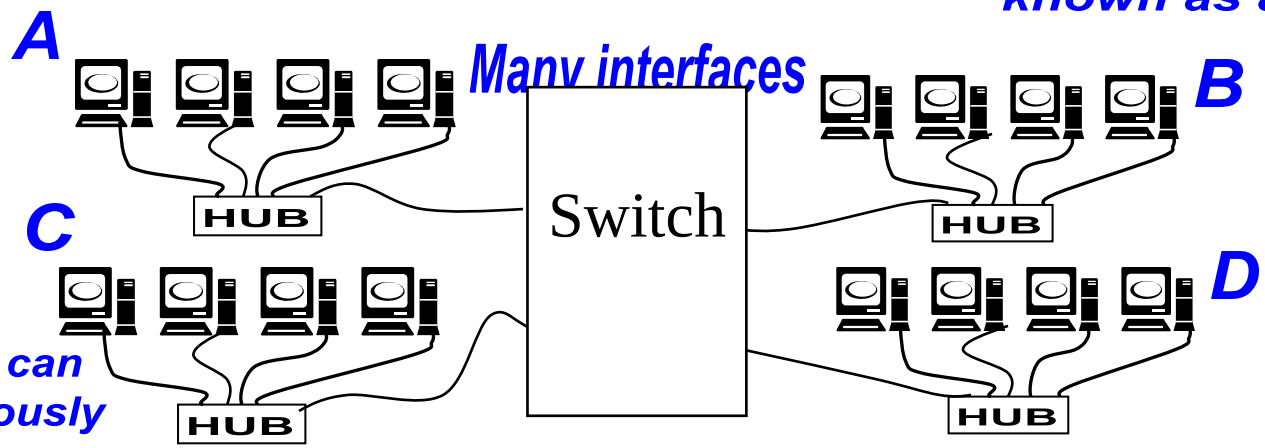


Bridges and Switches



PC A and PC B can transmit simultaneously without collision

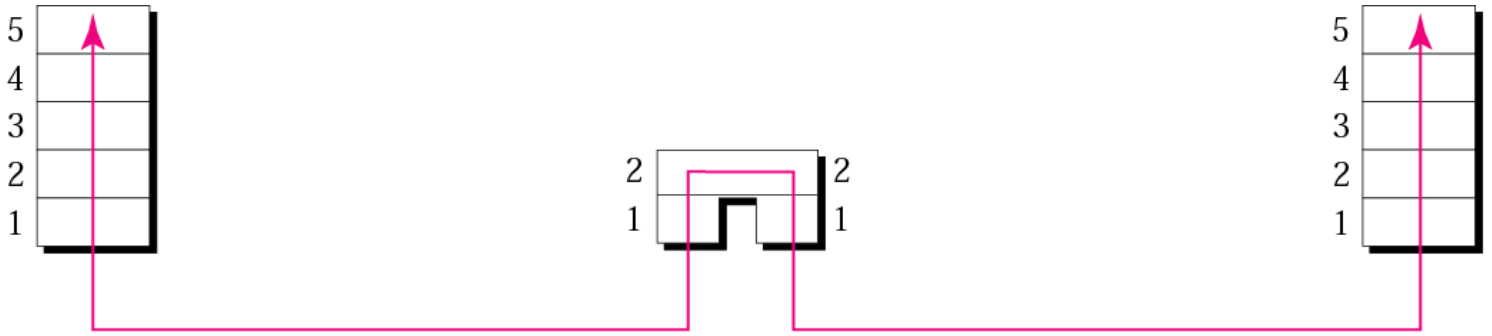
A multiport Bridge became known as a Switch



PCs A, B, C and D can transmit simultaneously without collision

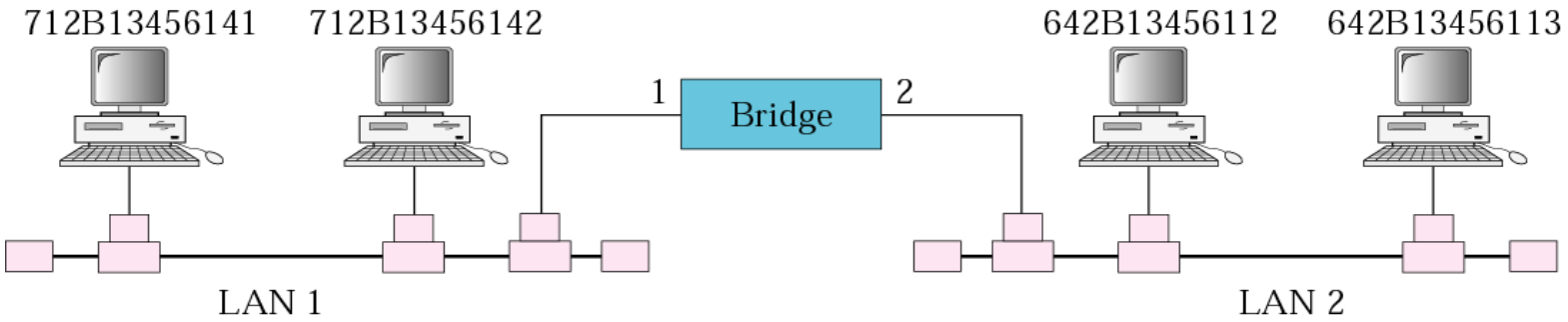
Essentially, a LAN Switch is a faster more modern version of a Bridge

Bridges operation



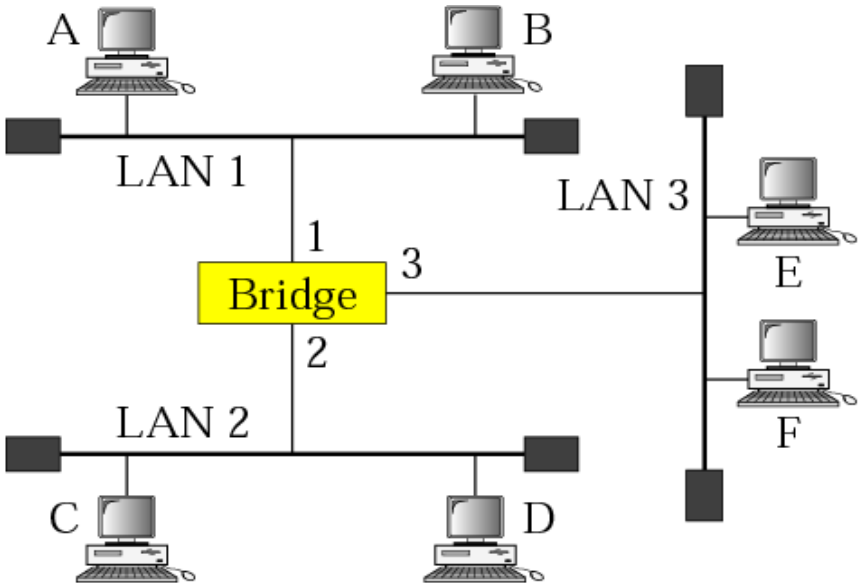
Address	Port
712B13456141	1
712B13456142	1
642B13456112	2
642B13456113	2

Bridge table



Source : B. Forouzan

Learning bridge



Address	Port

a. Original

Address	Port
A	1

b. After A sends a frame to D

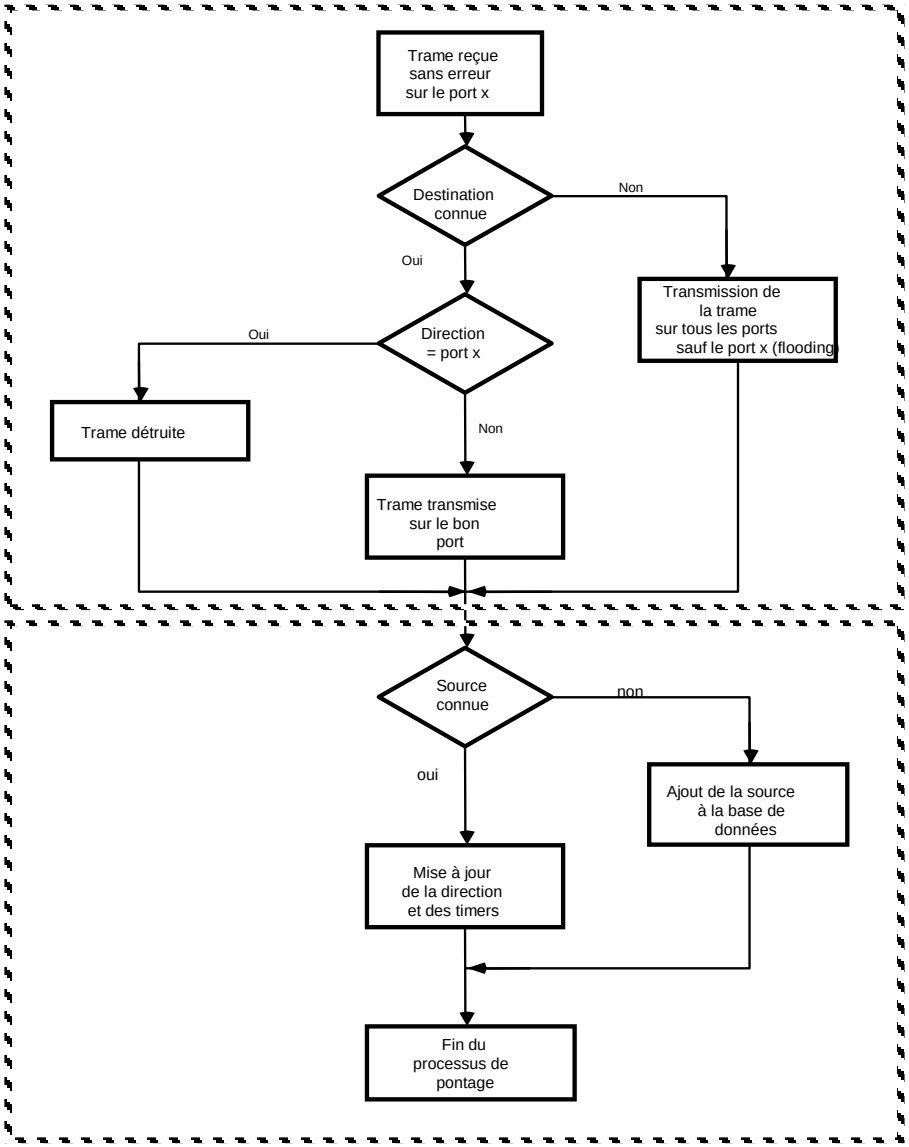
Address	Port
A	1
E	3

c. After E sends a frame to A

Address	Port
A	1
E	3
B	1

d. After B sends a frame to C

Bridges : learning process

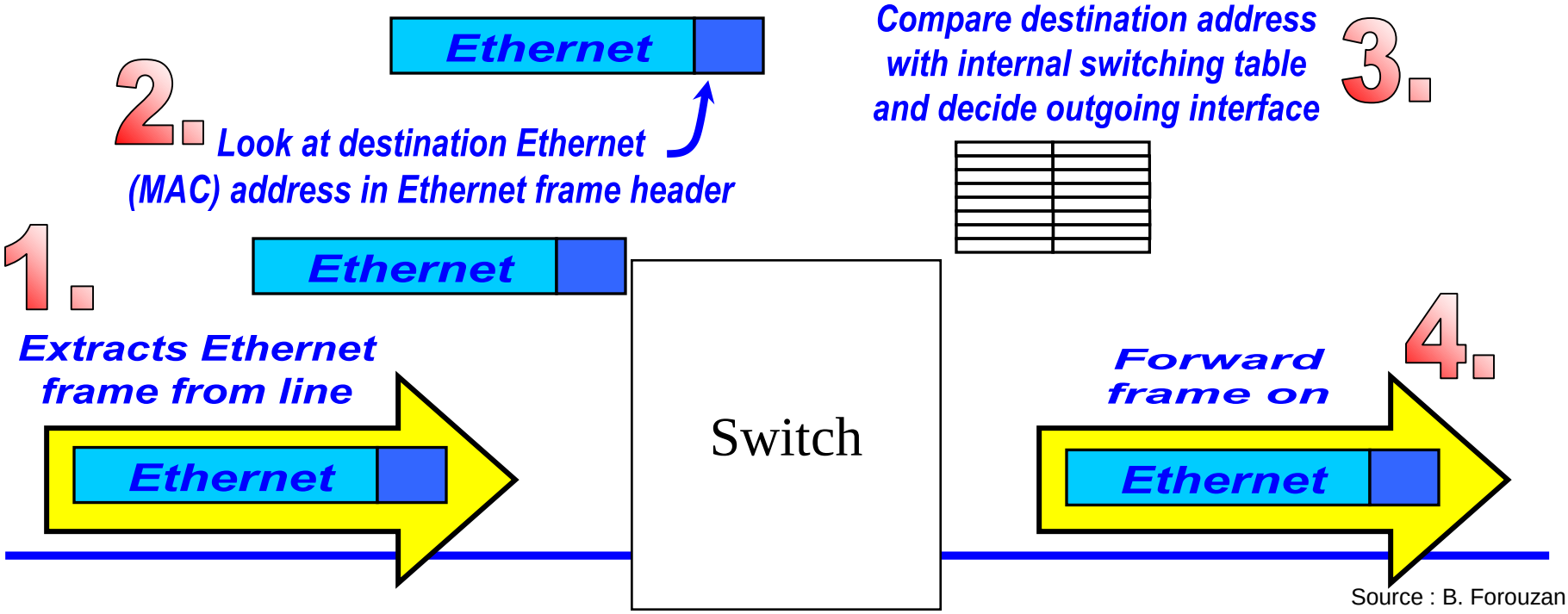


LAN Switch Operation

- Flooding
- Learning
- Forwarding
- Filtering

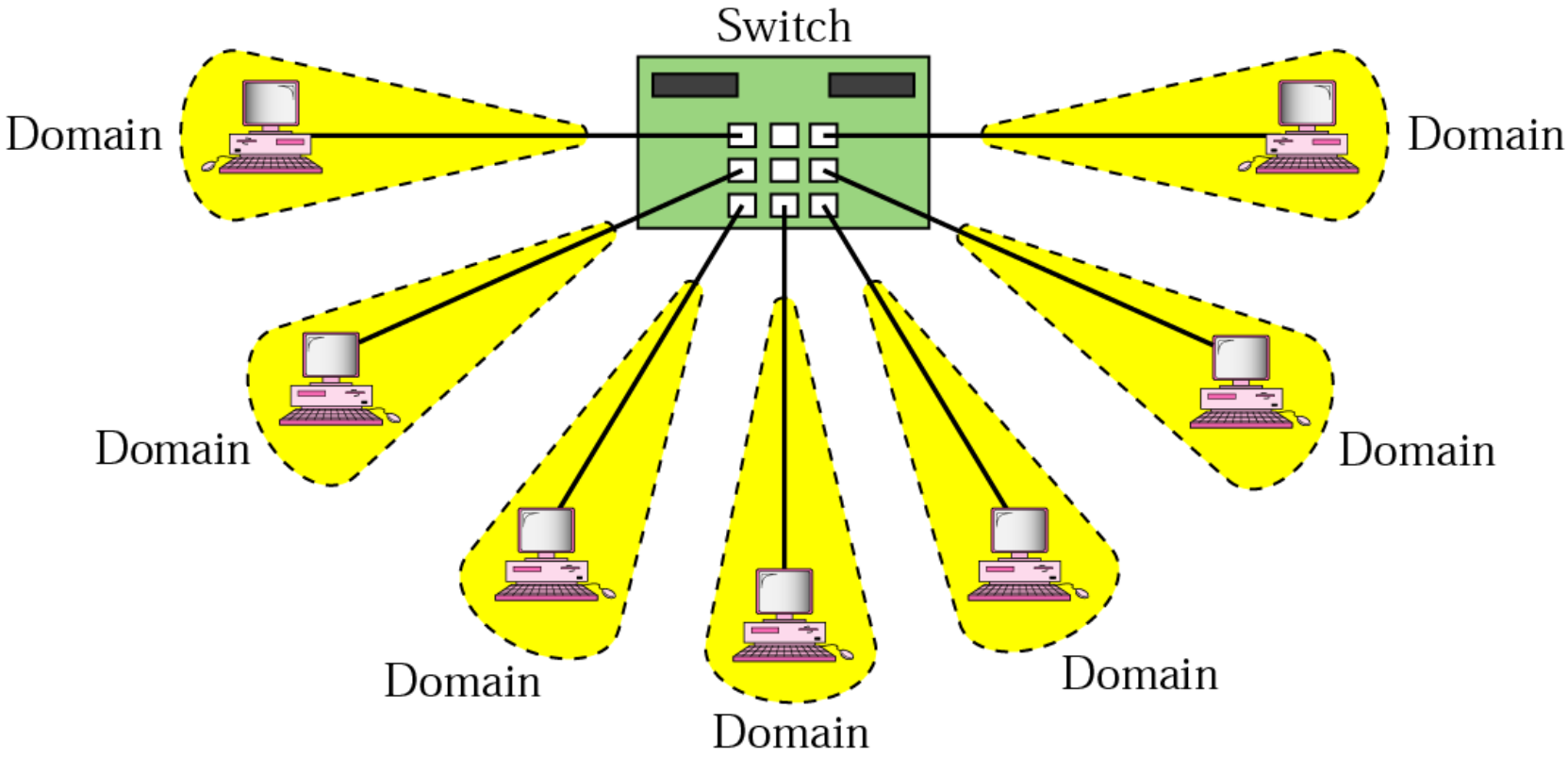
LAN Switch Operation

- **Having learned about destination addresses on the network the switch will forward frames intelligently on the basis of their MAC address**



Source : B. Forouzan

Switches



Source : B. Forouzan

Full-Duplex Ethernet

Half-duplex Ethernet (Typical situation)

Transmit on one pair

Listen for collisions on other pair

No collisions possible

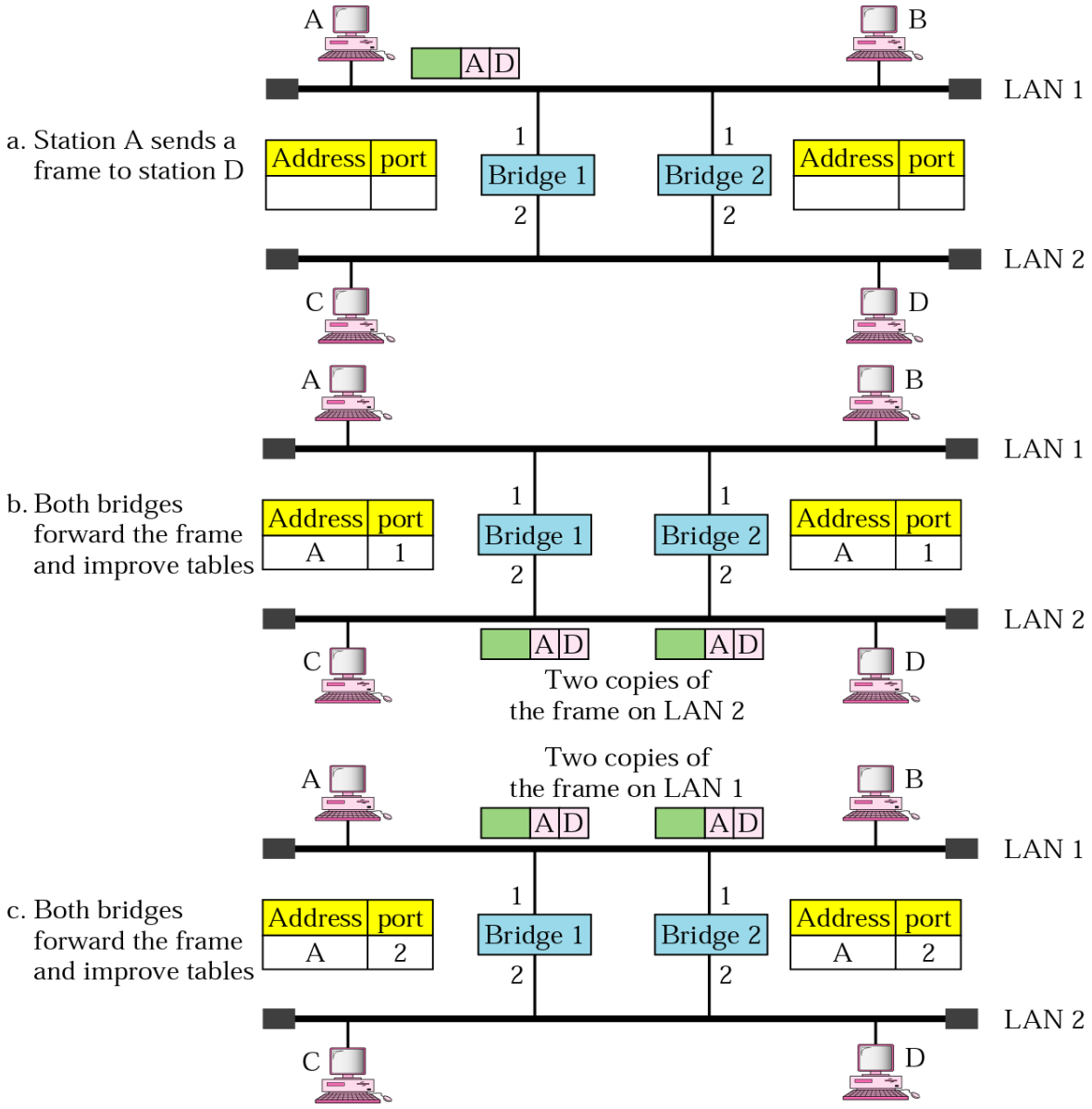
Full-duplex Ethernet

Transmit on one pair

Receive on other pair

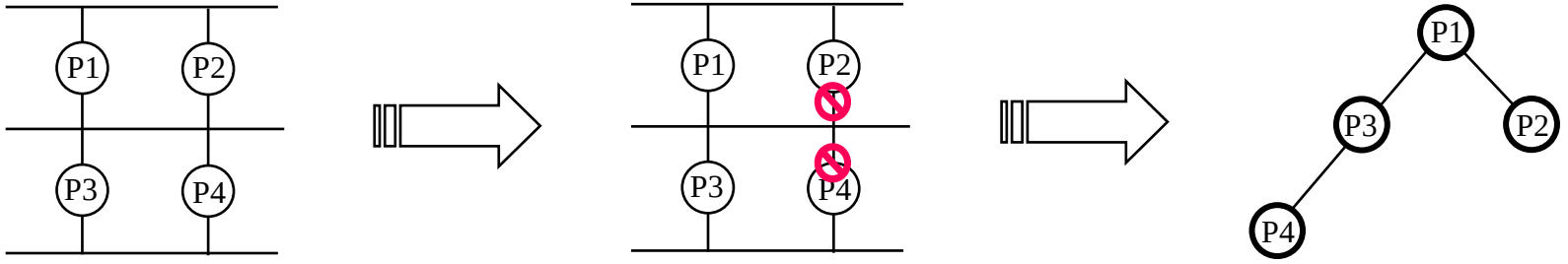
Switch

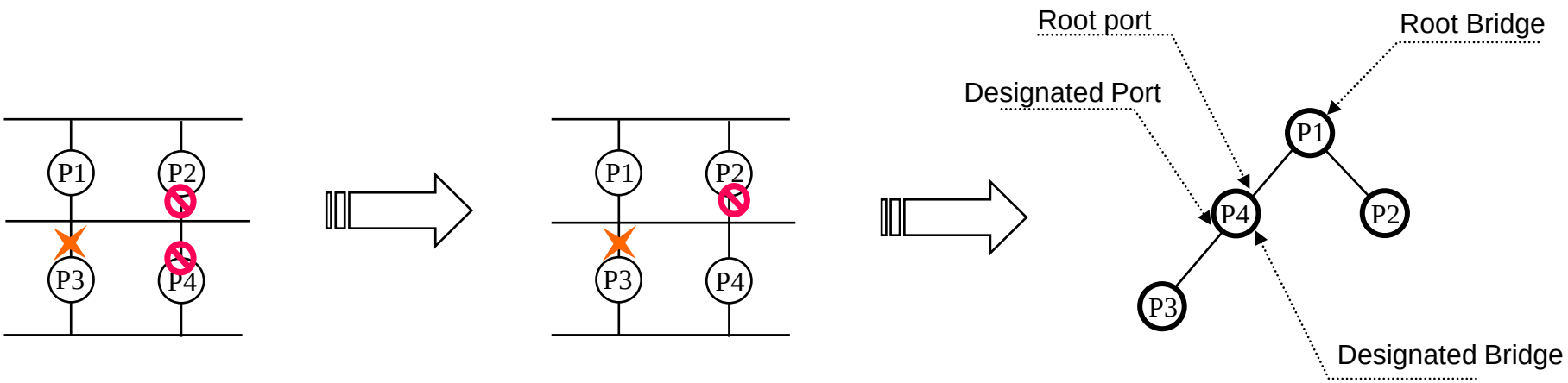
Loop problem



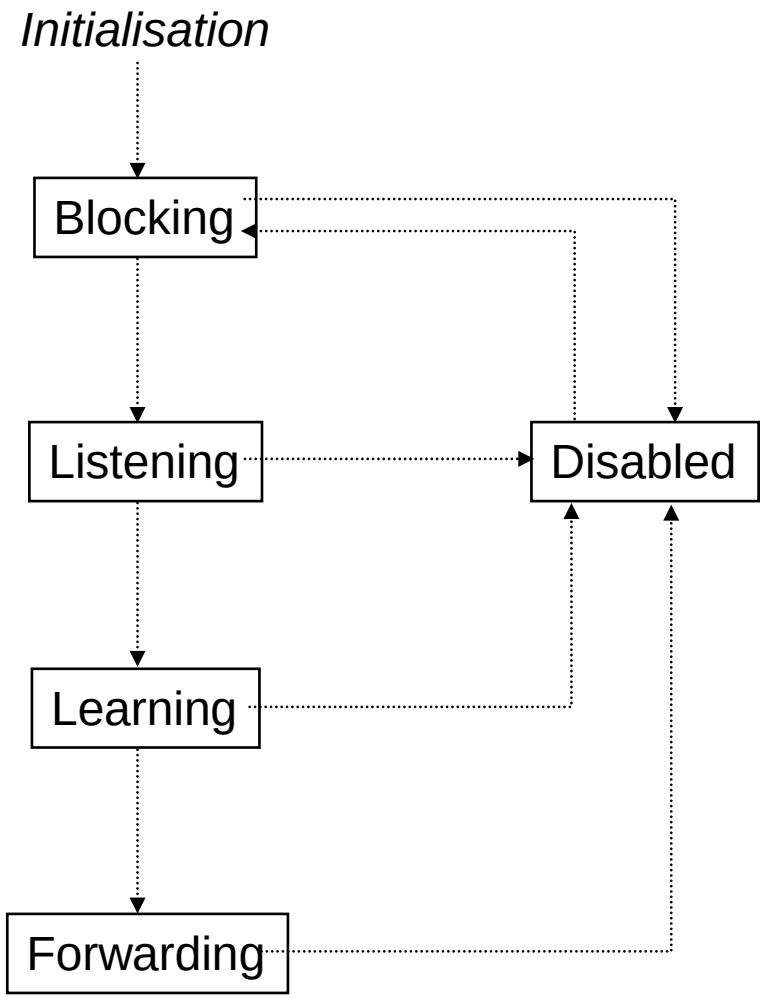
Source : B. Forouzan

802.1d / STP

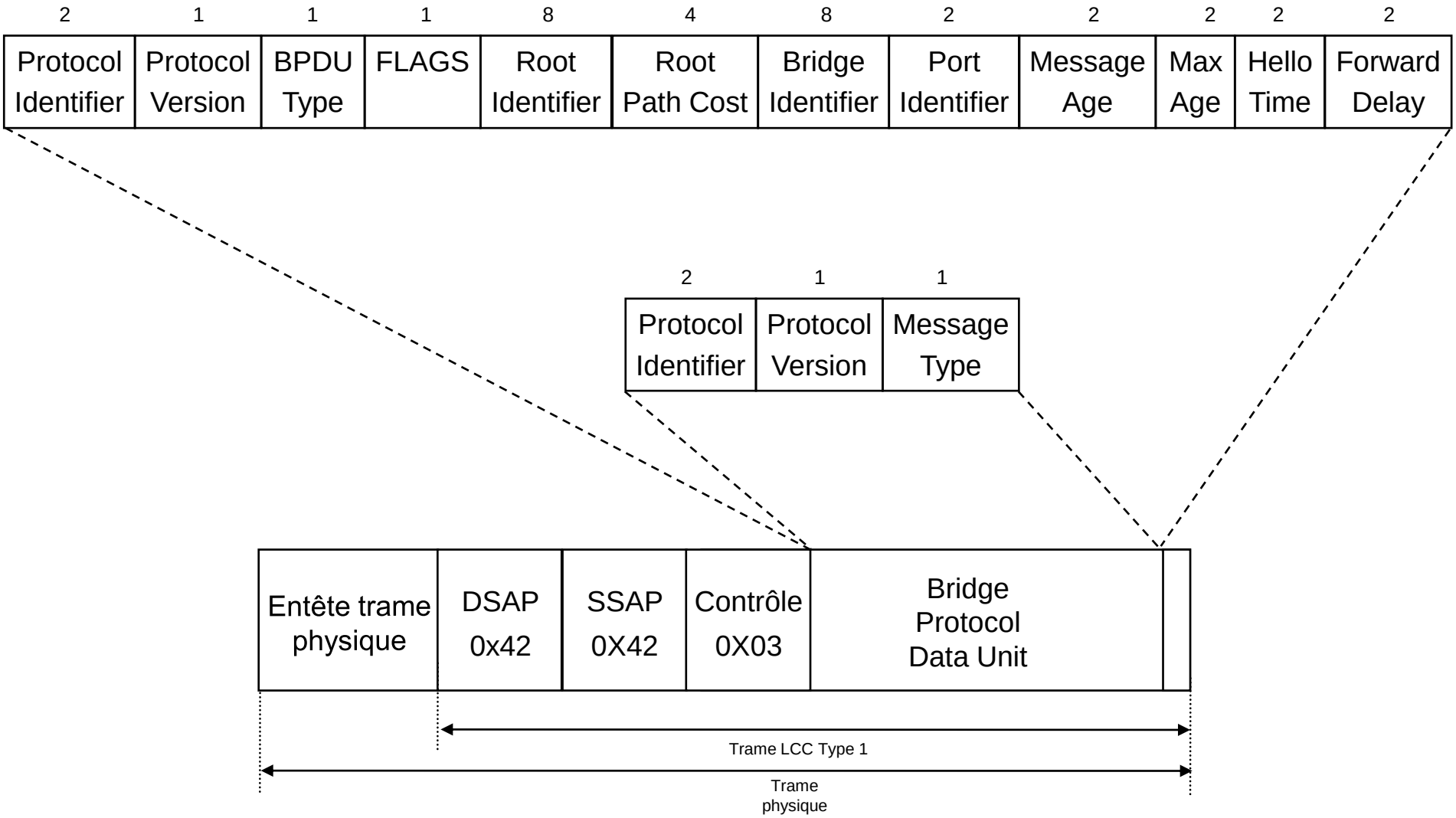

P1
P2
P3
P4
P1
P2
P3
P4
P1
P3
P2
P4


P1
P2
P3
P4
P1
P2
P3
P4
Root port
Root Bridge
Designated Port
P1
P4
P2
P3
Designated Bridge

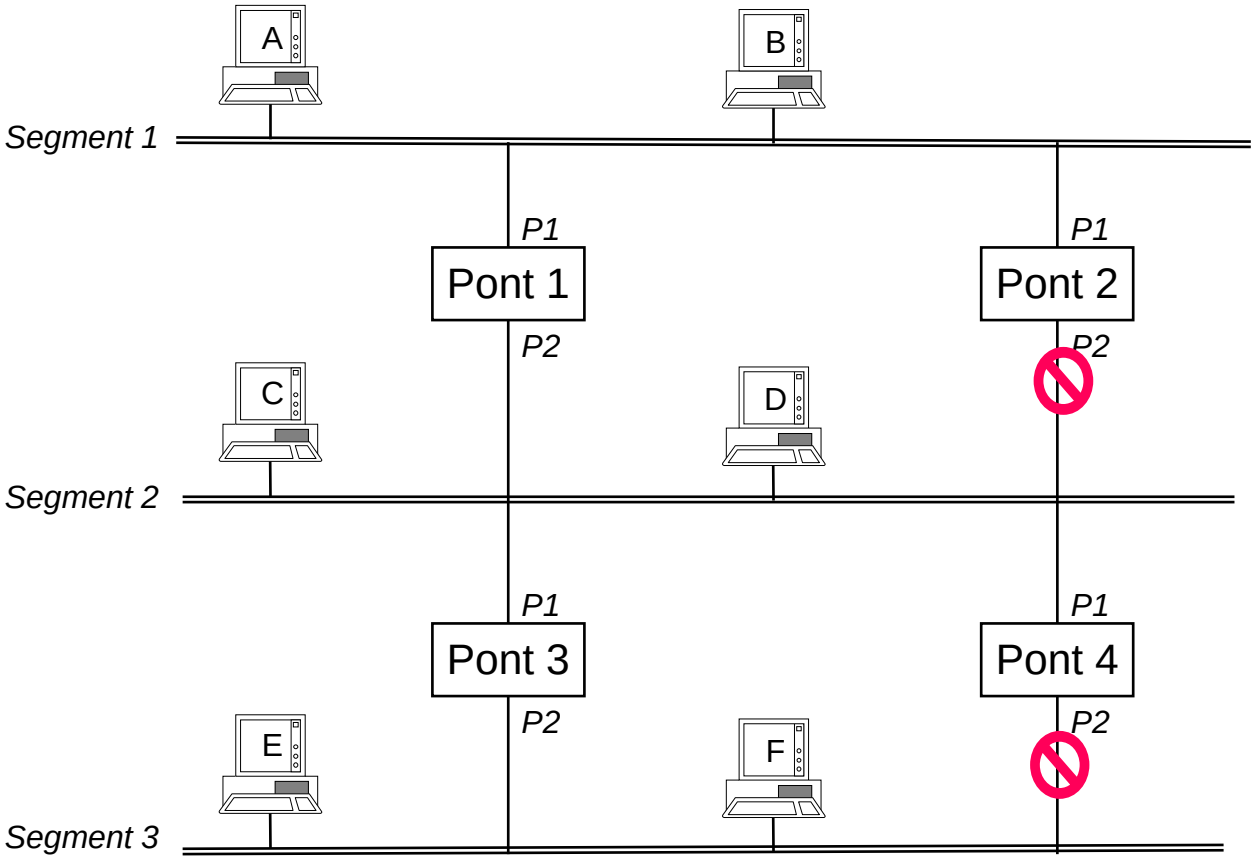
802.1d / STP

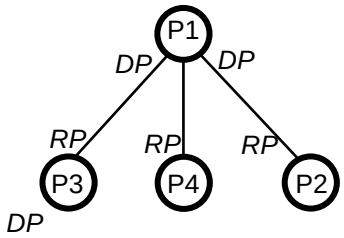

Initialisation
Blocking
Listening
Disabled
Learning
Forwarding

802.1d / STP


2
1
1
1
8
4
8
2
2
2
2
2
Protocol Identifier
Protocol Version
BPDU Type
FLAGS
Root Identifier
Root Path Cost
Bridge Identifier
Port Identifier
Message Age
Max Age
Hello Time
Forward Delay
2
1
1
Protocol Identifier
Protocol Version
Message Type
Entête trame physique
DSAP 0x42
SSAP 0X42
Contrôle 0X03
Bridge Protocol Data Unit
Trame LCC Type 1
Trame physique

802.1d / STP


A
B
Segment 1
P1
Pont 1
P2
P1
Pont 2
P2
C
D
Segment 2
P1
Pont 3
P2
P1
Pont 4
P2
E
F
Segment 3


P1
DP
DP
RP
RP
RP
P3
P4
P2
DP

RSTP

- **STP takes 30 –50 seconds to converge, with default settings**
- **Rapid Spanning Tree Protocol**
- **IEEE 802.1w**
- **Full-duplex mode**
- **No shared links**
- **RSTP has two more port designations**
  - Alternate Port—backup for Root Port
  - Backup port—backup for Designated Port on the segment
- **In RSTP, all bridges send BPDUs automatically**
  - in STP, the root triggers BPDUs
- **In RSTP, bridges act to bring the network to convergence**
  - While in STP, bridges passively wait for time-outs before changing port states

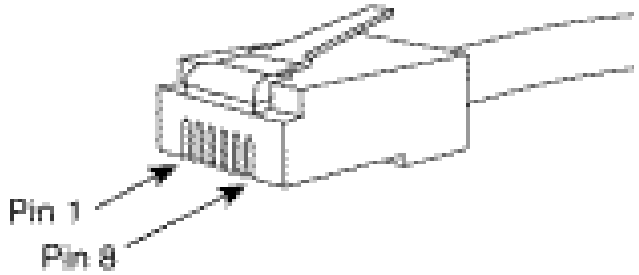
Fast Ethernet Essentials

- **10BaseT and 100BaseT**
  - Both use CSMA/CD
  - Frame formats and frame lengths the same
  - Usually deployed over Category 5 UTP
  - Interconnections made with hubs, switches, routers etc.
  - Standard defined by IEEE 802.3u
- **10BaseT vs 100BaseT**
  - Transmits 10 times as much data in the same time
  - New physical standards
  - Interframe gap .96 microseconds instead of 9.6 microseconds (unchanged at 96 bit times)

Fast Ethernet Essentials

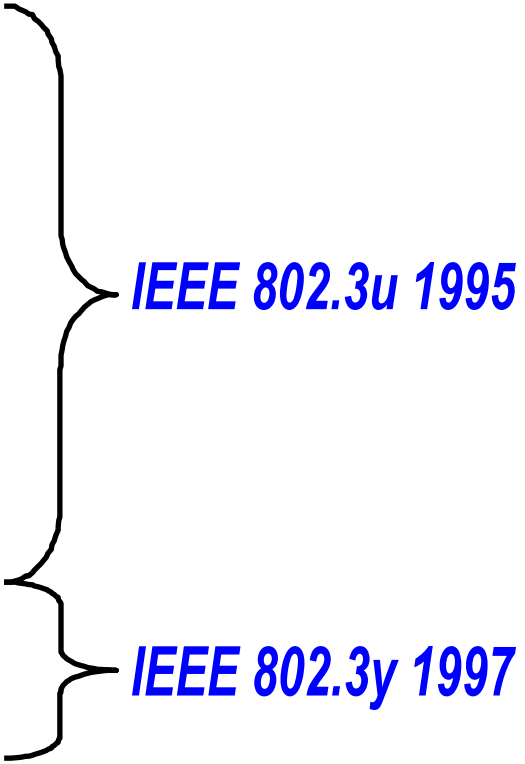
- **100Base-TX**

Pin	Signal
1	Transmit Data +
2	Transmit Data -
3	Receive Data +
4	Unused
5	Unused
6	Receive Data -
7	Unused
8	Unused

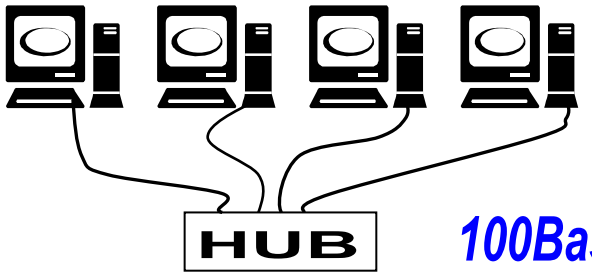


Fast Ethernet : 100BaseT Specifications

- **100BaseTX**
  - 2 pairs of Cat 5 UTP or Cat 1 STP
  - By far the most widely used specification (95%+)
- **100BaseFX**
  - 2 strands of SMF or MMF
- **100BaseT4**
  - 4 pairs of Cat 3/4/5 UTP
- **100BaseT2**
  - 2 pairs of Cat 3/4/5 UTP

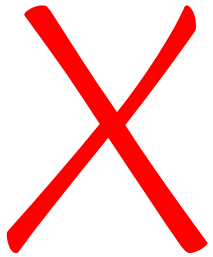


Fast Ethernet : Matching Interfaces

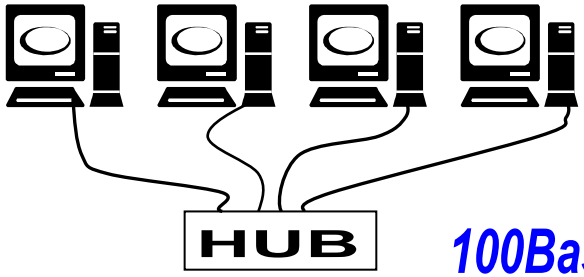


10BaseT NICs

100BaseTx Hub



Won't work!



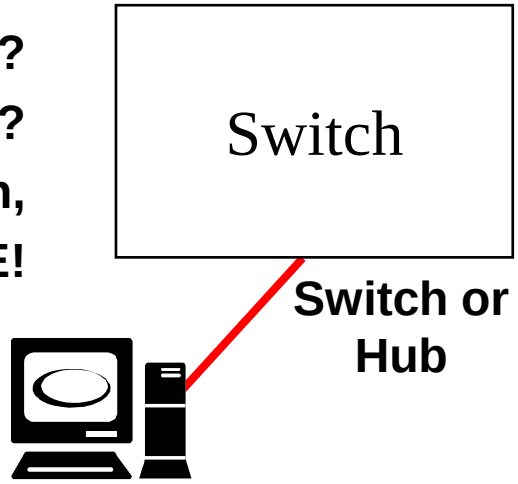
10/100BaseT NICs

100BaseTx Hub

Fast Ethernet : Auto-Negotiation

??

10 or 100?
Full or half?
Then,
AUTO-NEGOTIATE!



Useful if unsure what you're plugging in to - AND when upgrading to a 100BASE-T hub

Algorithm used to negotiate common data service
Common RJ-45 connector for 1 of 8 services
Fast link pulses (FLP) similar to link integrity (LI)

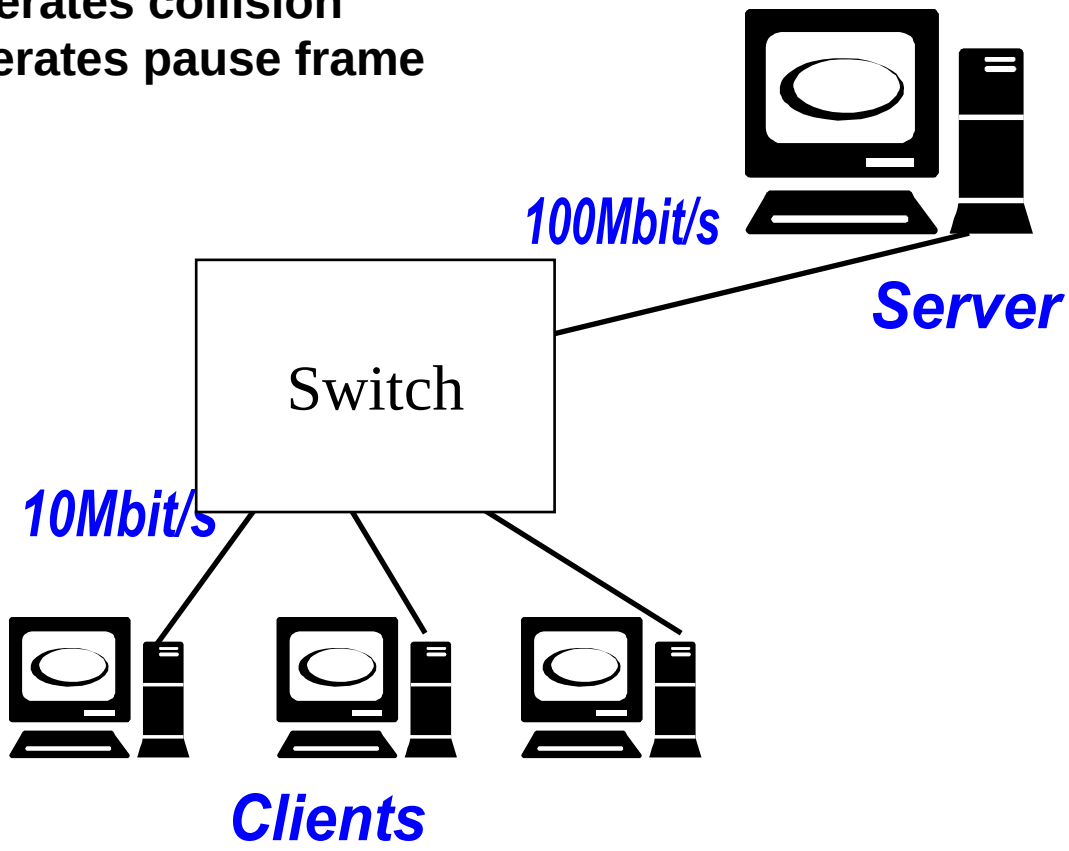
Hub/NIC adjust speed to highest common mode

Order:

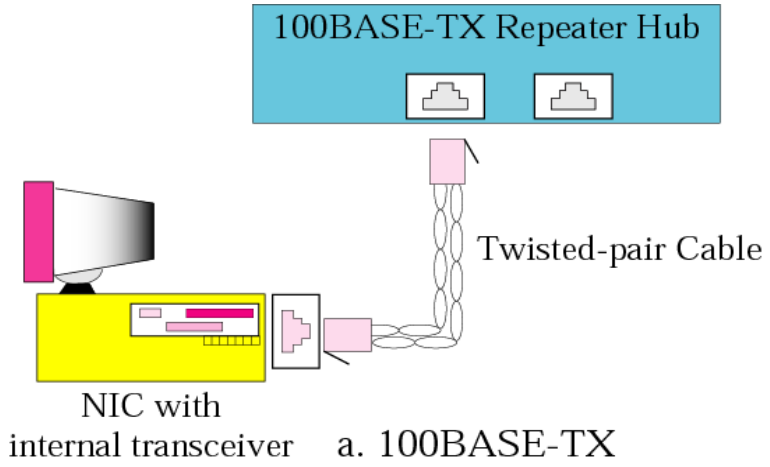
1. 1000BaseT FDX
2. 100BaseT2 FDX
3. 100BaseT2 HDX
4. 100BaseTX FDX
5. 100BaseT4
6. 100BaseTX
7. 10BaseT FDX
8. 10BaseT

Fast Ethernet : Flow control

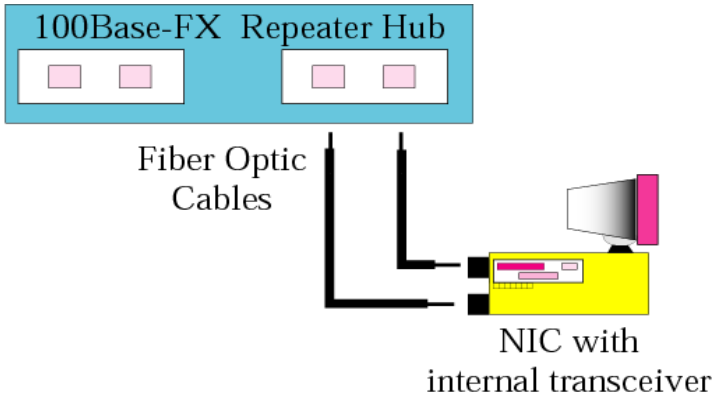
HDX - Switch generates collision
FDX - Switch generates pause frame



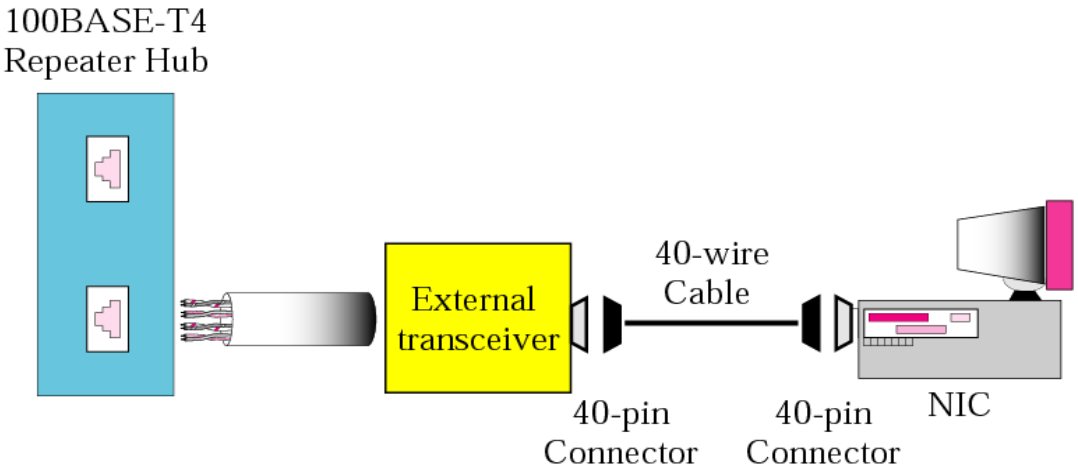
Fast Ethernet implementations



a. 100BASE-TX



b. 100BASE-FX



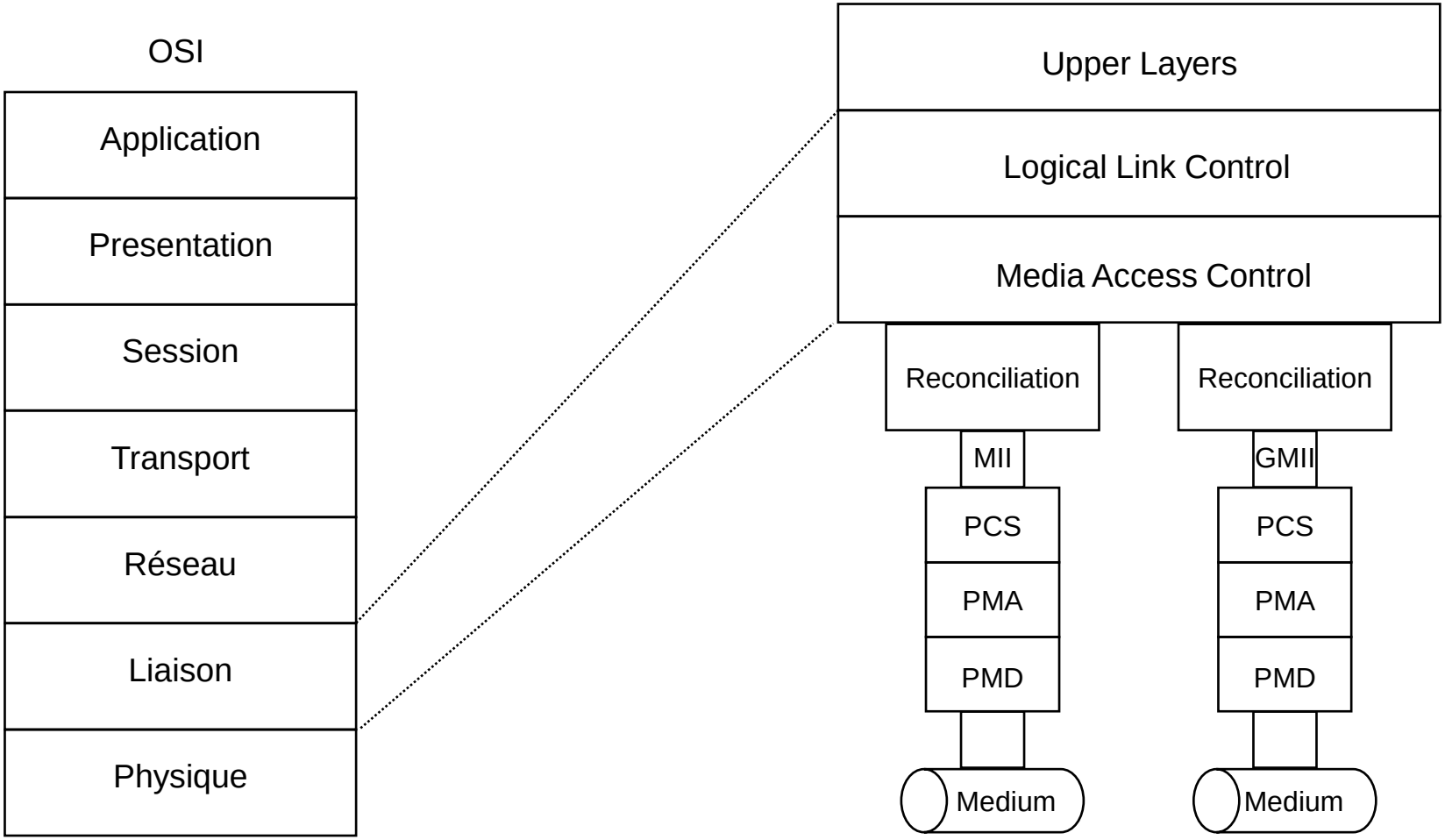
c. 100BASE-T4

Source : B. Forouzan

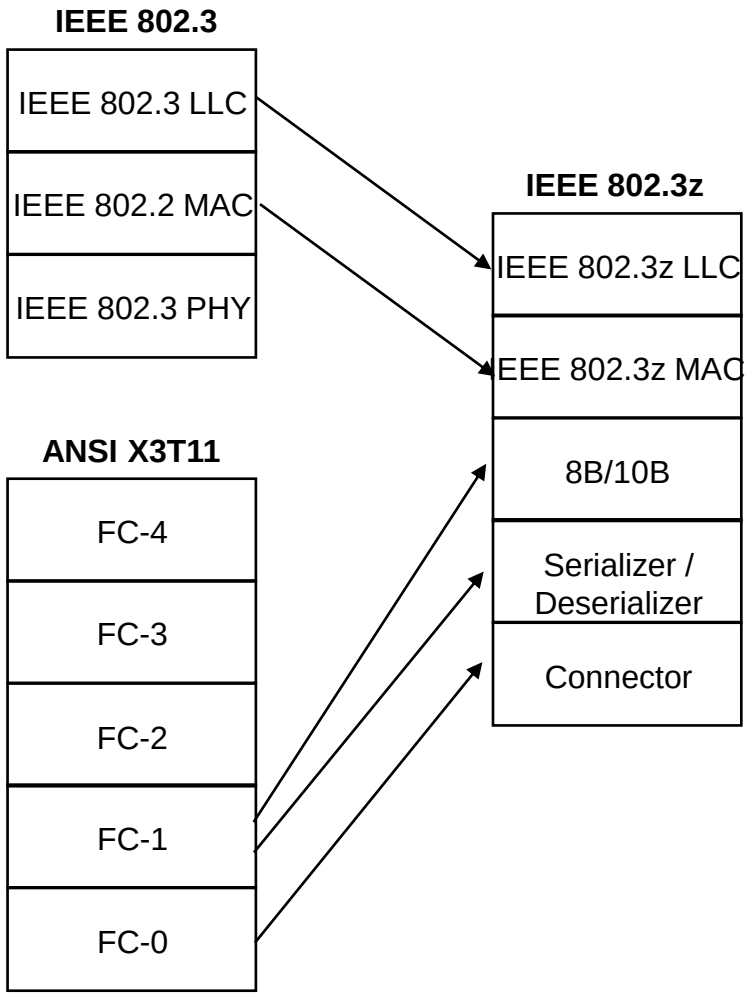
Gigabit Ethernet Essentials

- Latest extension to Ethernet
- 1000 Mbit/s - 10 times faster than fast Ethernet
- Compatible with existing Ethernet

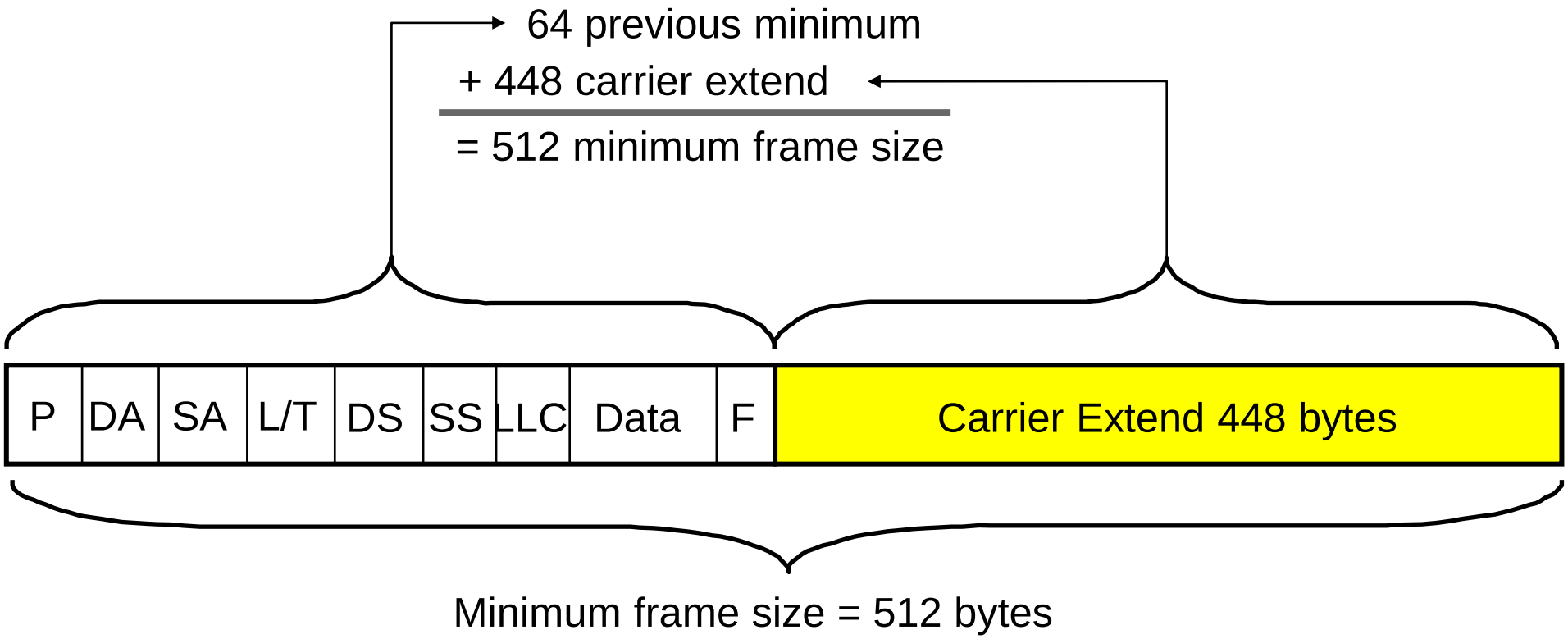
Gigabit Ethernet Essentials



Gigabit Ethernet : IEEE / ANSI convergence



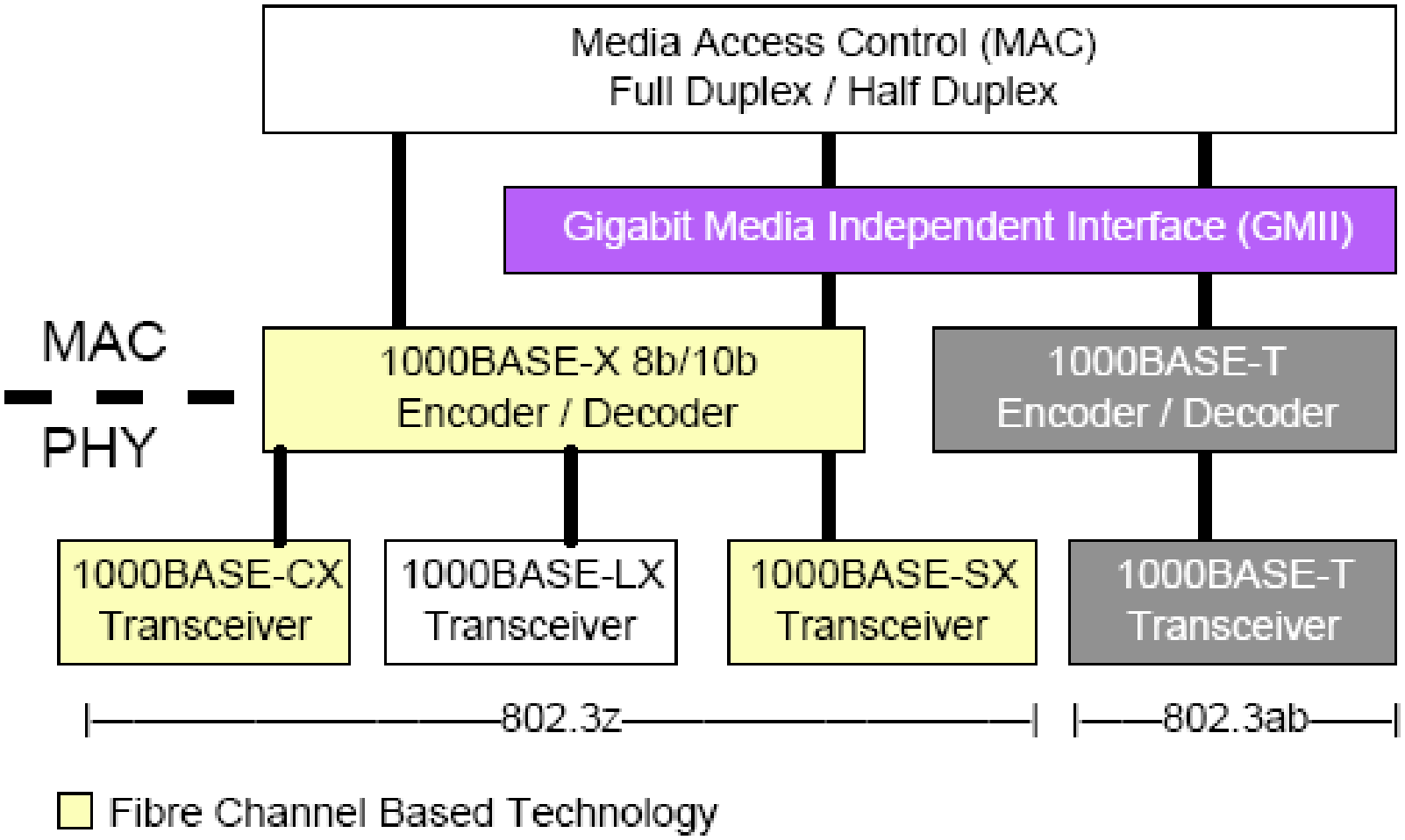
Gigabit Ethernet : Carrier Extend



Gigabit Ethernet : Frame Bursting

- **Frame Bursting is a means to reduce the Inefficiency of Carrier Extension**
- **The first frame is transmitted using the normal procedures for gigabit Ethernet.**
- **A frame burst timer is started to allow transmissions of up to 64 Kbits.**
- **If additional frames are queued for transmission and the 64 Kbit timer has not expired, two things happen**
  - The first frame is followed by carrier extend
  - The next frame is transmitted

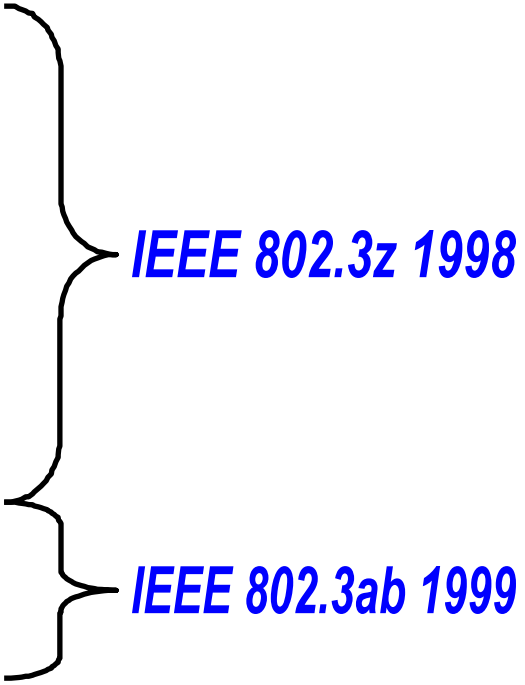
Gigabit Ethernet : technology family



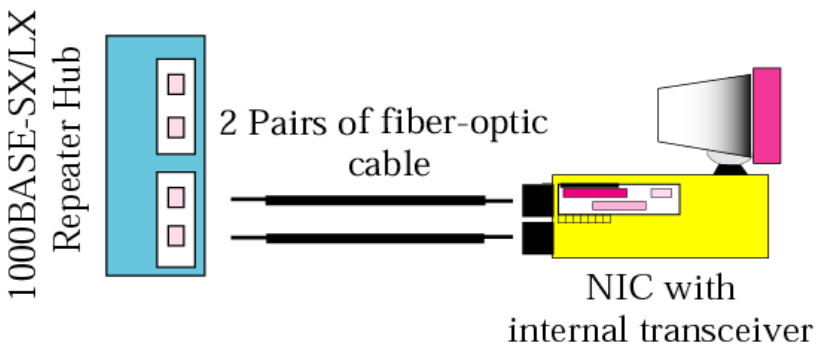
Source : Gigabit Ethernet Alliance

Gigabit Ethernet implementations

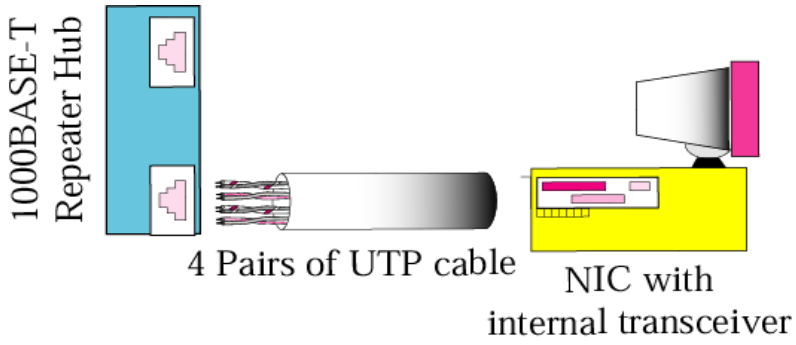
- **1000BaseLX**
  - 2 strands of SMF or MMF
- **1000BaseSX**
  - 2 strands of SMF
- **1000BaseCX**
  - 2 pairs of twinax
- **1000BaseT**
  - 4 pairs of Cat 5 UTP



Gigabit Ethernet implementations



a. 1000BASE-SX/LX



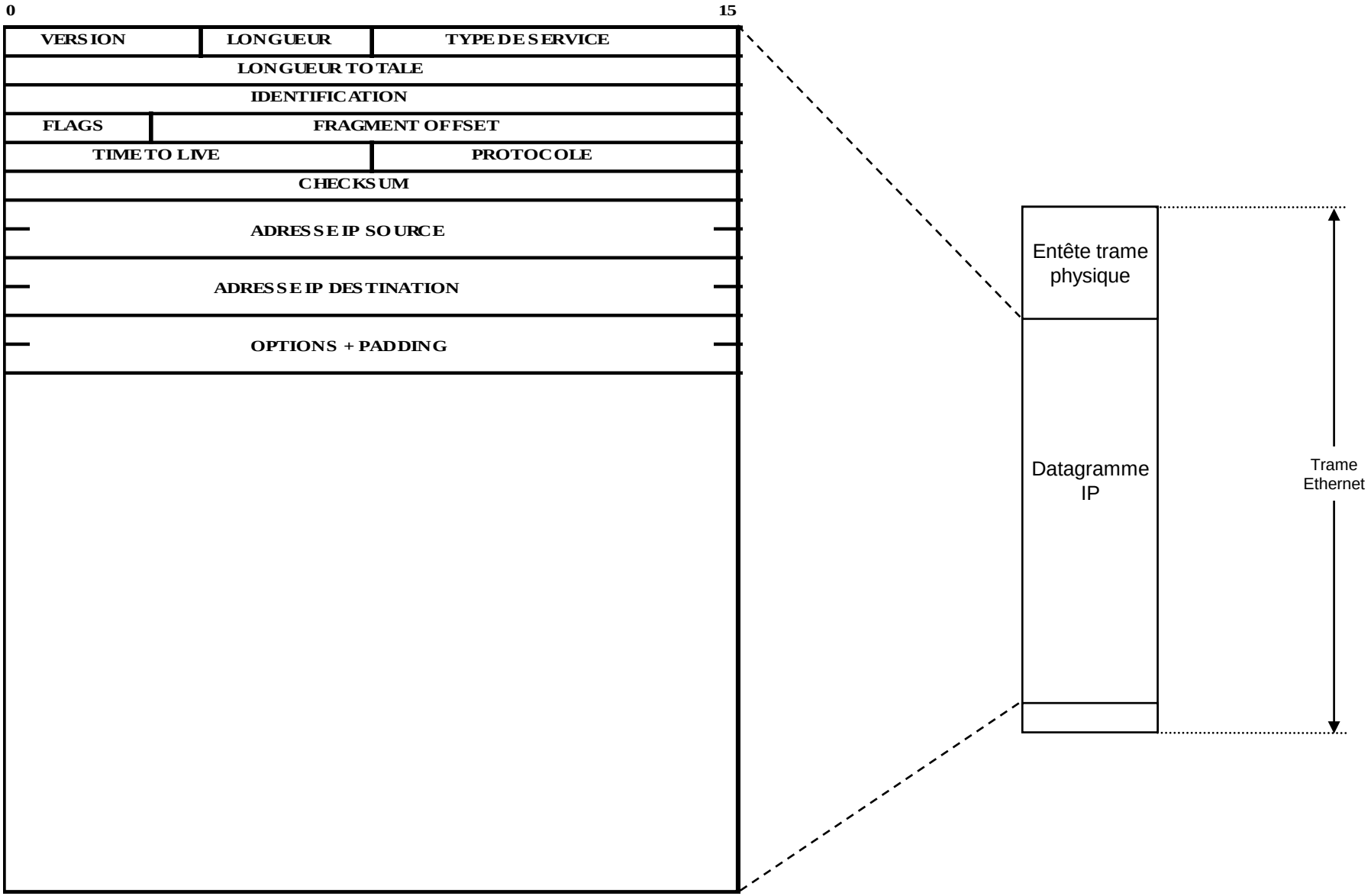
b. 1000BASE-T

Source : B. Forouzan

Ethernet Comparison

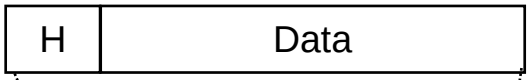
Parameter	Ethernet, 802.3	Fast Ethernet 802.3u	Gigabit Ethernet, 802.3z
Inter Frame Gap	96 bit times	96 bit times	96 bit times
Attempt Limit	16 tries	16 tries	16 tries
Max Frame Size	1518 Bytes	1518 Bytes	1518 Bytes
Min Frame Size	64 Bytes	64 Bytes	512 Bytes
Address Size	48 bits	48 bits	48 bits

IP over Ethernet v2 (1/2)

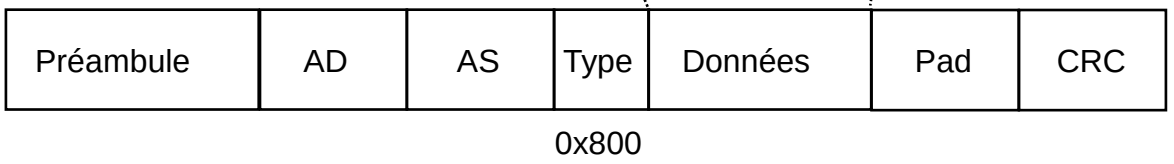


IP over Ethernet v2 (2/2)

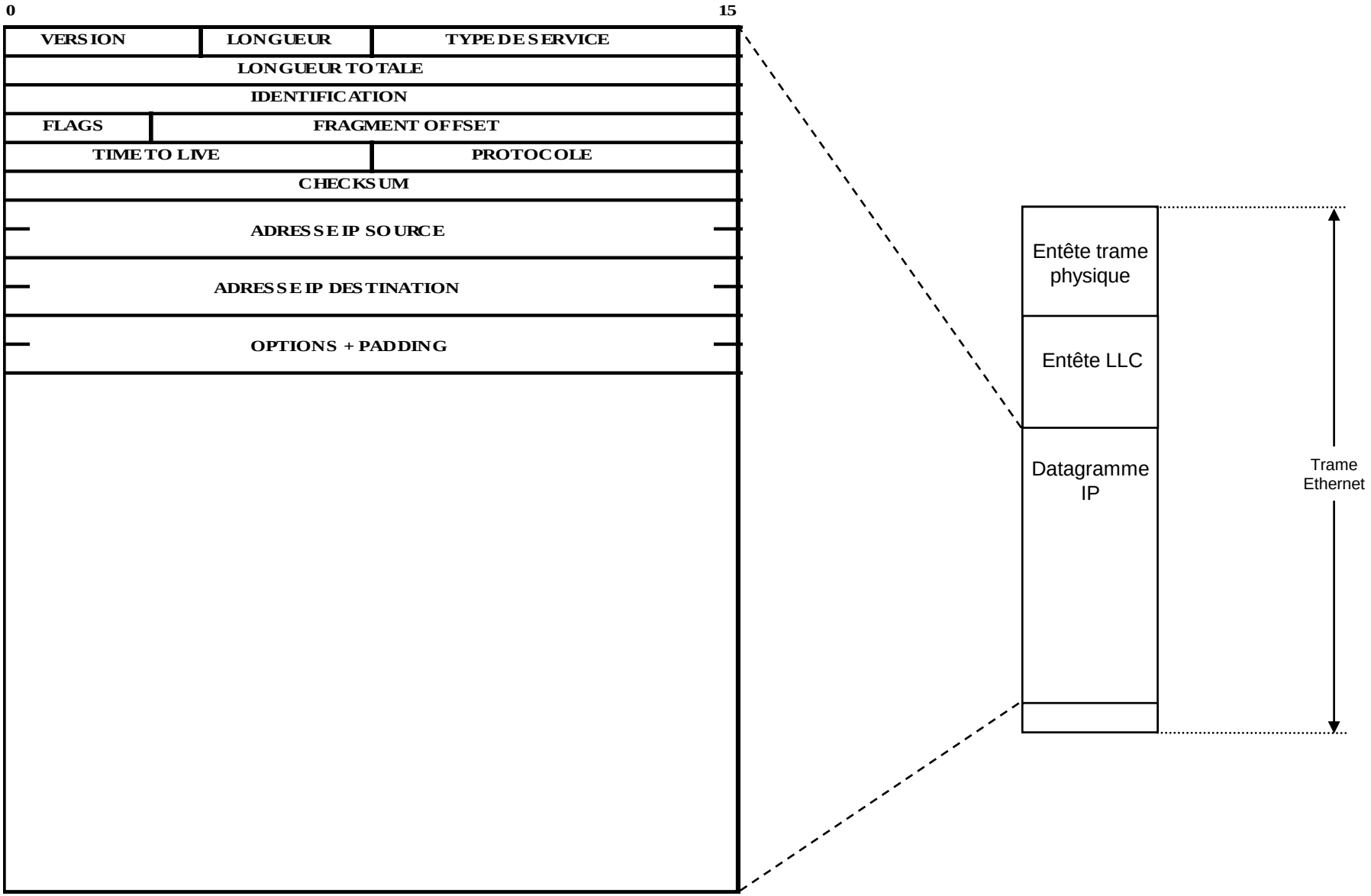
Datagramme IP



Trame Ethernet



IP over Ethernet : LLC encapsulation (1/2)

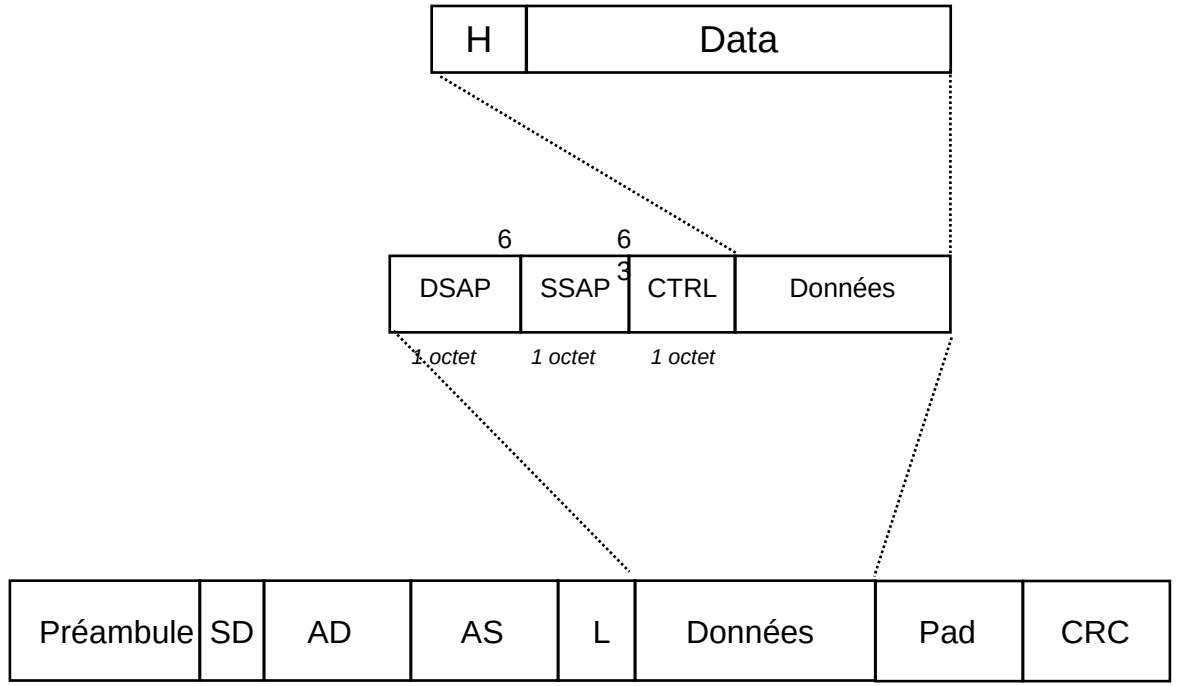


IP over Ethernet : LLC encapsulation (2/2)

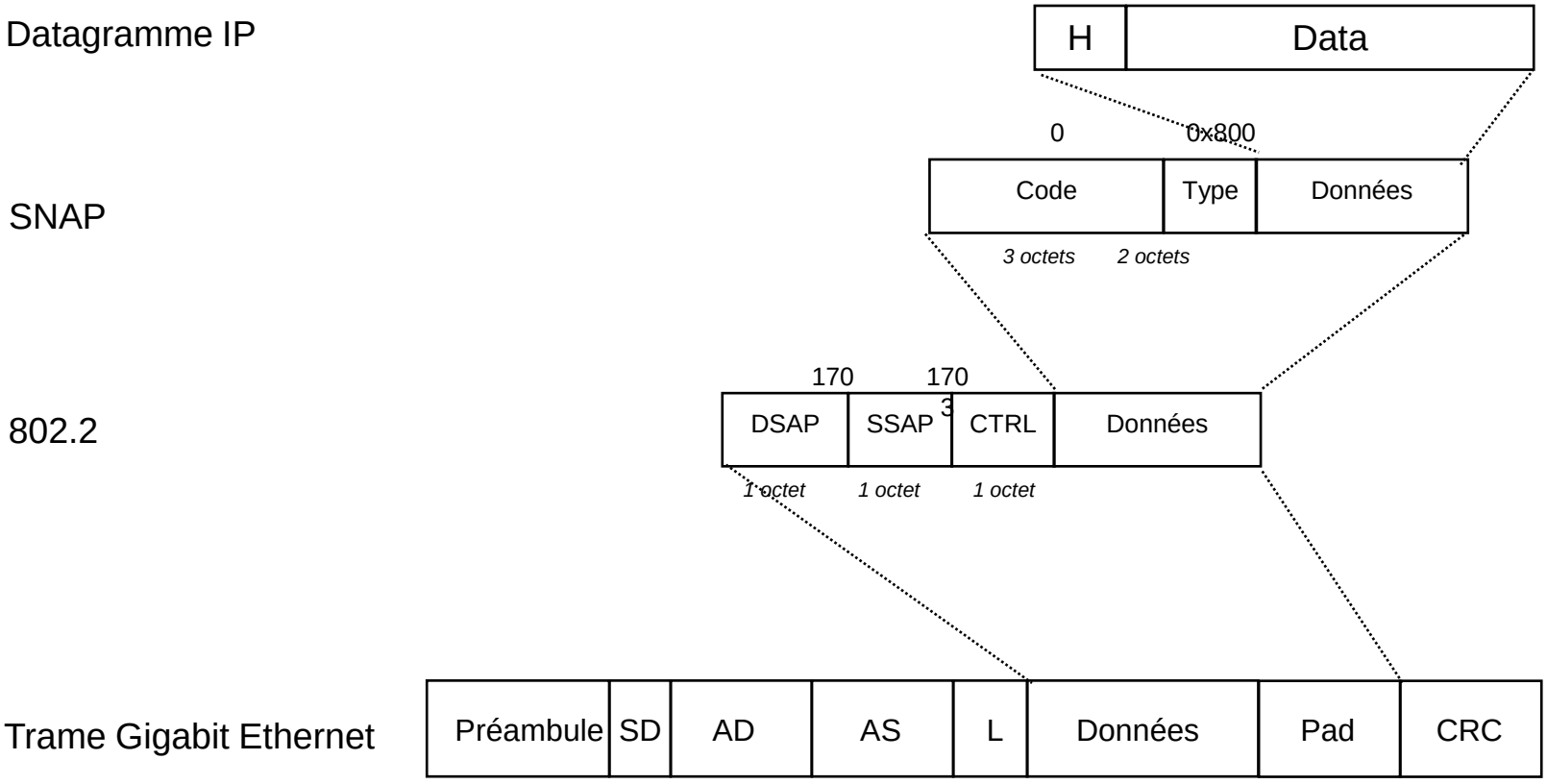
Datagramme IP

802.2

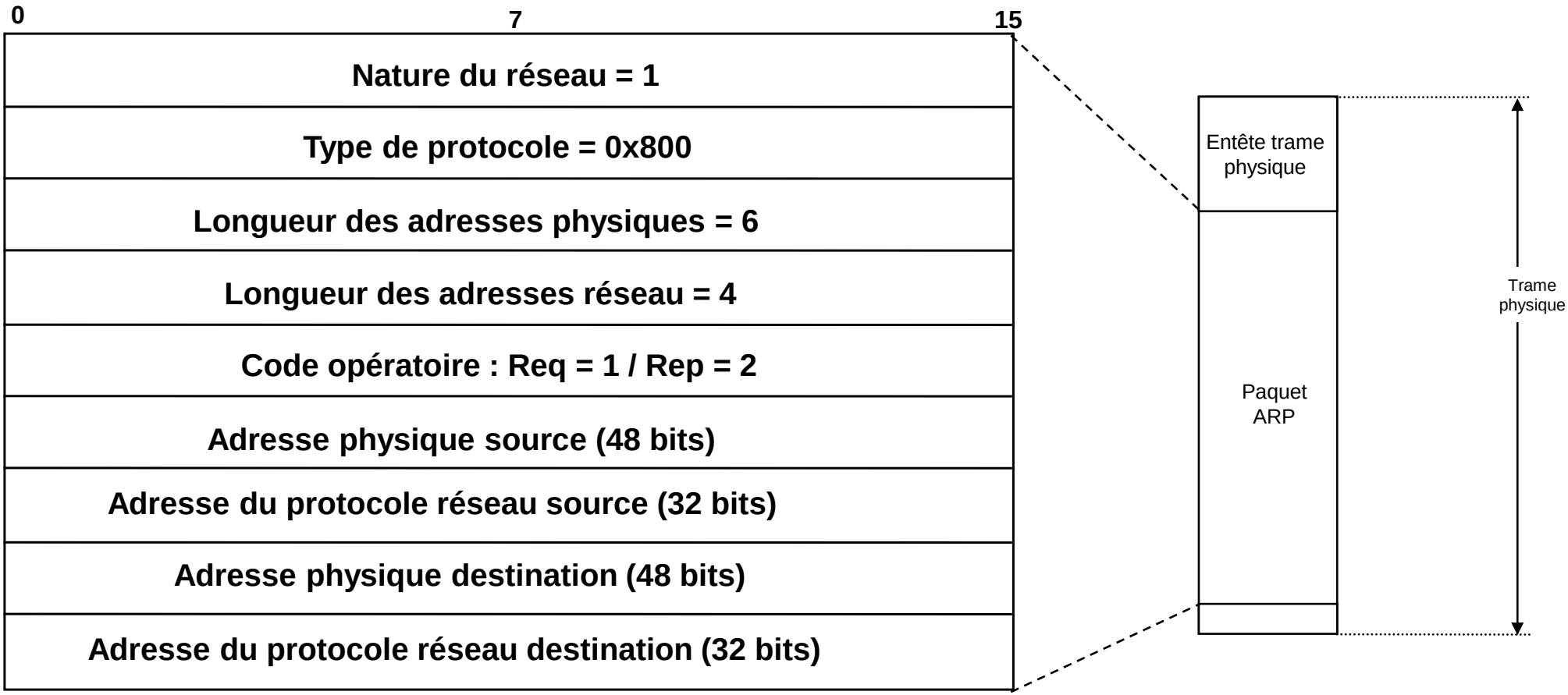
Trame Ethernet



IP over Ethernet : SNAP/LLC encapsulation

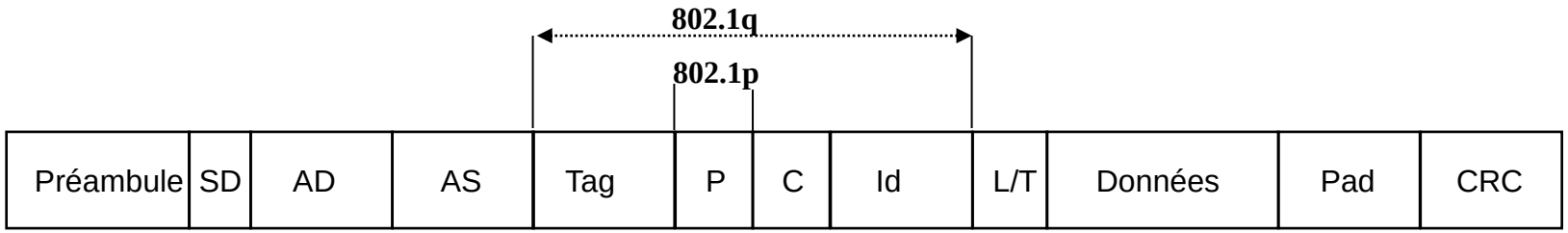


IP over Ethernet : ARP



VLAN

- A VLAN is a logical grouping of nodes (clients and servers) residing in a common broadcast domain
- The broadcast domain has been artificially created within a LAN switch
- IEEE 802.1p
- Extension of the frame size of the Ethernet standard by four bytes : IEEE 802.3ac



VLAN: frame tagging

- **TAG 802.1P/Q**
  - 802.1P used for QoS / 802.1Q used for VLAN

...	
Destination Address	6 Byte
Source Address	6 Byte
Length/Type	2 Byte
Data	46-1500 Byte
Frame Check Sequence	4 Byte

Standard Ethernet Frame (1518 Byte)

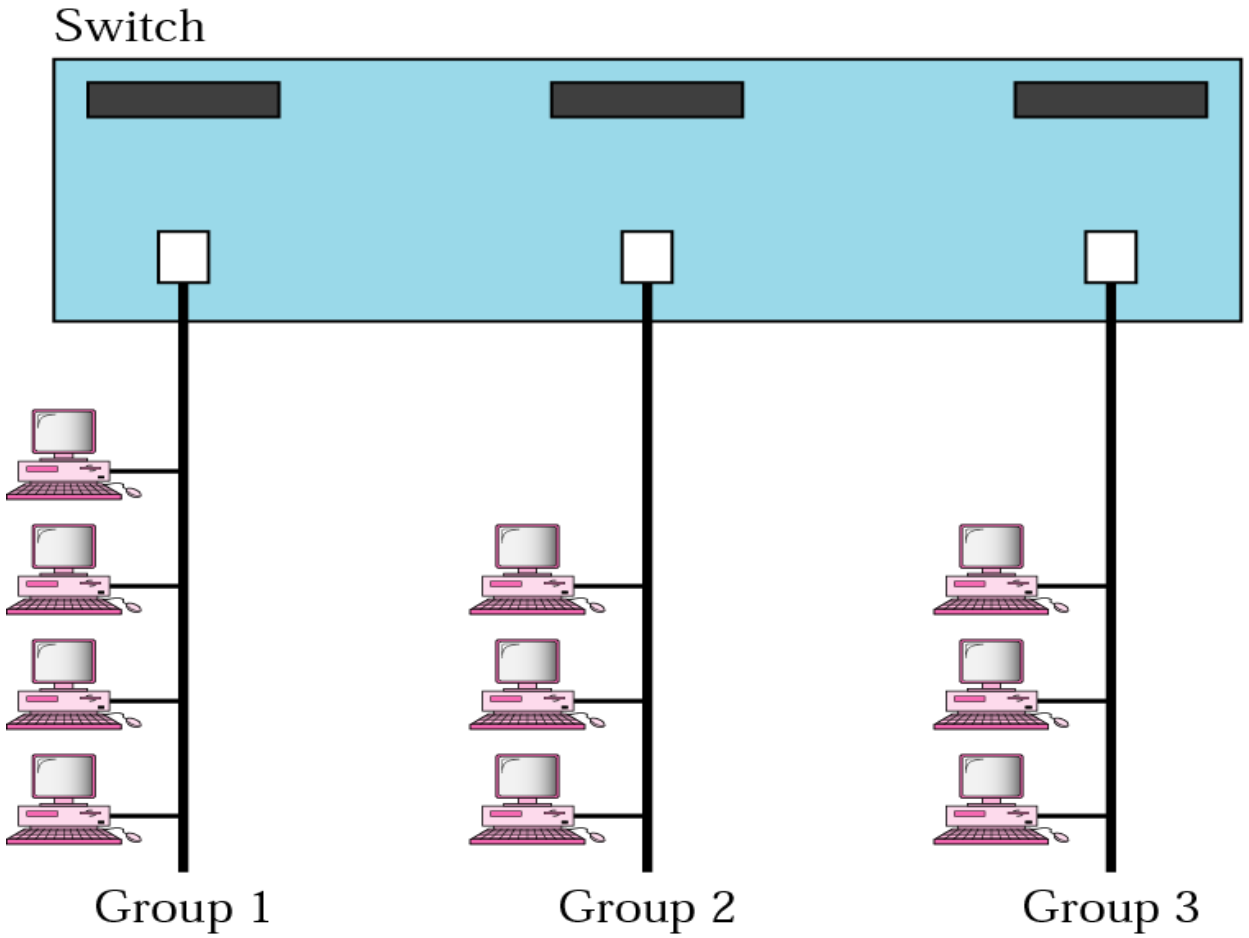
...	
Destination Address	6 Byte
Source Address	6 Byte
VLAN tag	4 Byte
Length/Type	2 Byte
Data	46-1500 Byte
Frame Check Sequence	4 Byte

Tagged VLAN Frame (1522 Byte)

- **Structure of the 4 bytes-802.1P/Q Tag**

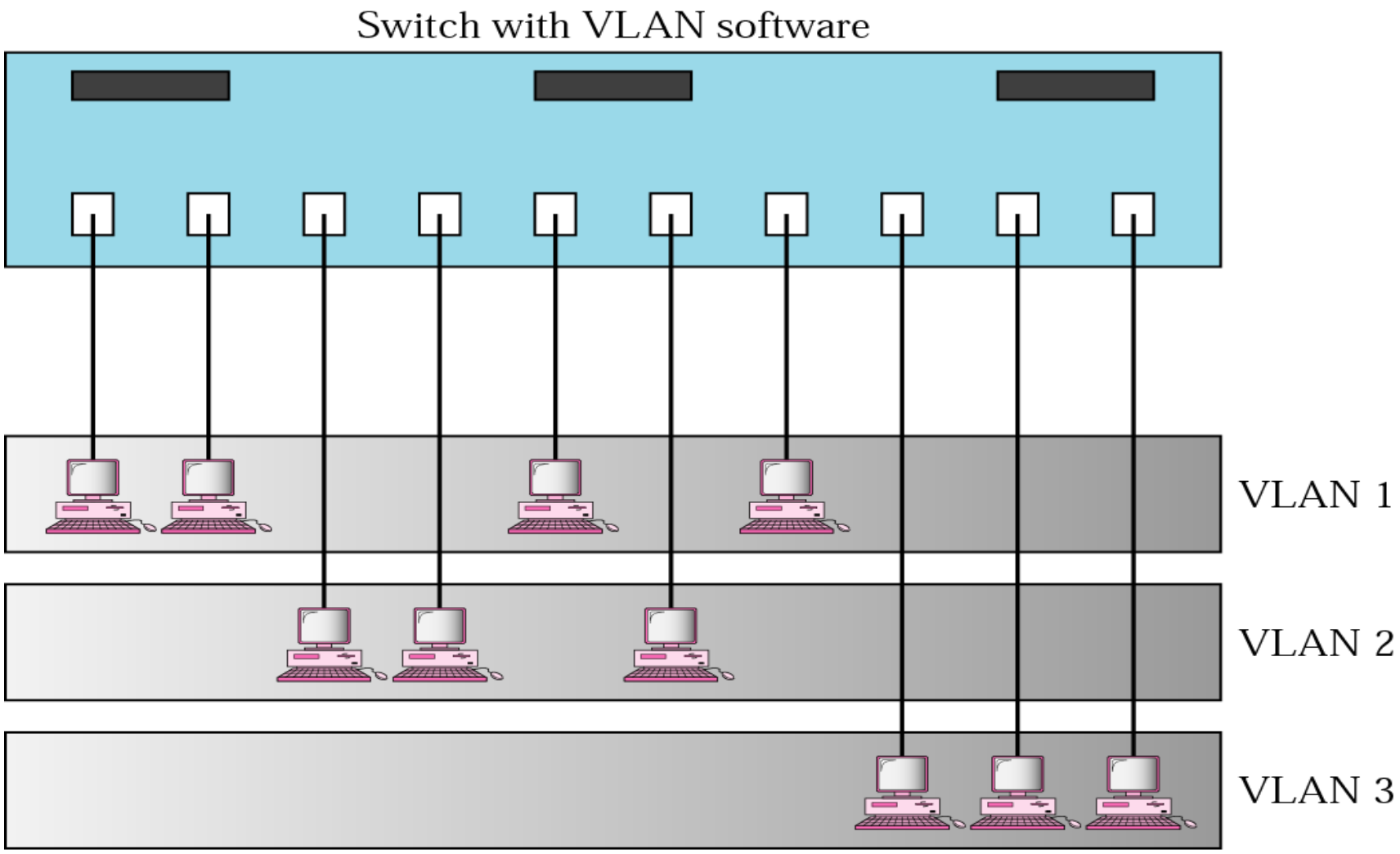
TPID (Tag Protocol Identifier)	**TCI (Tag Control Information)**		
Identification for the VLAN header: 0x8100 (16 Bit)	User Priority: 0-7 (3 Bit)	CFI (1 Bit)	VLAN ID: 0-4095 (12 Bit)

VLAN



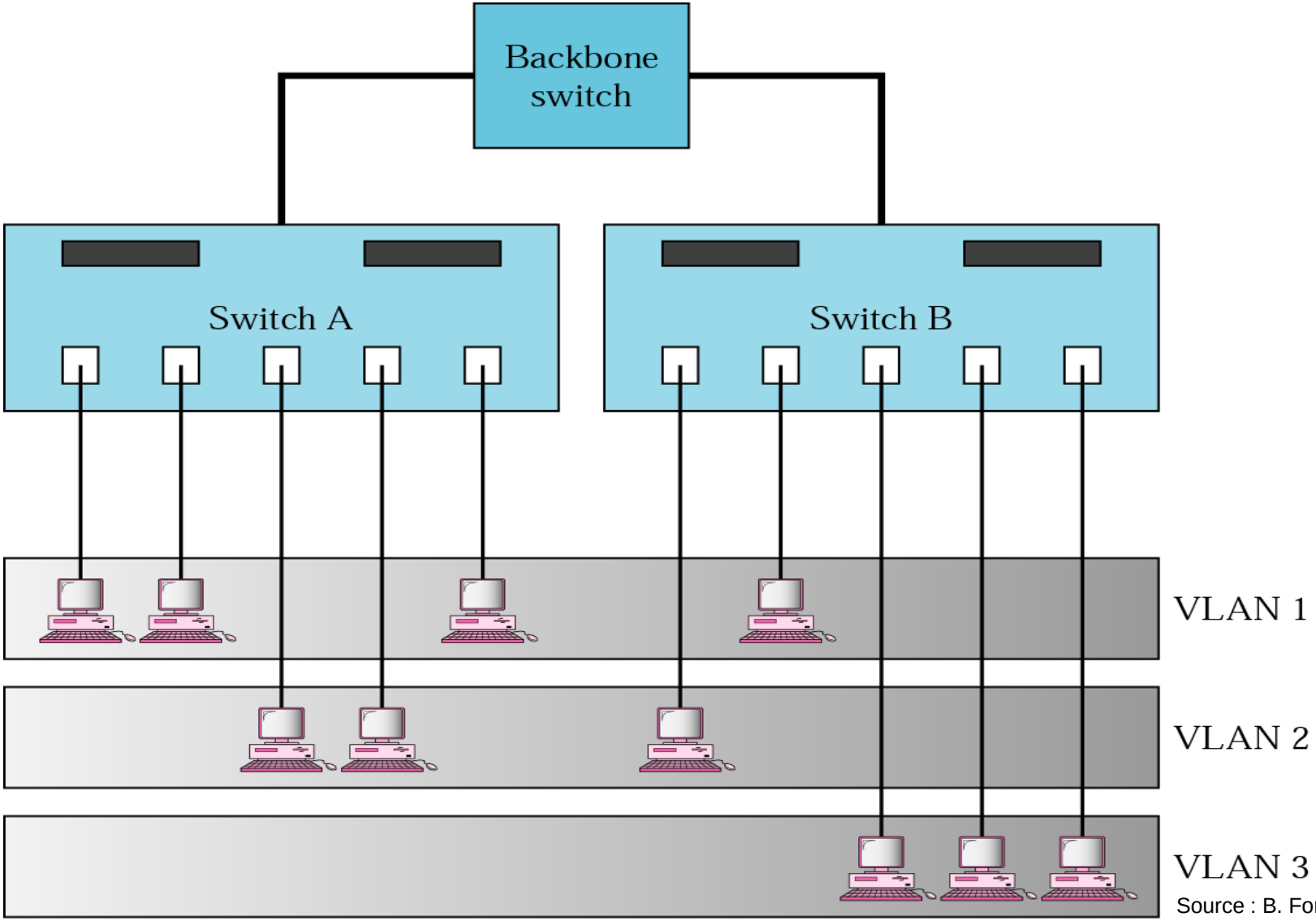
Source : B. Forouzan

VLAN



Source : B. Forouzan

VLAN

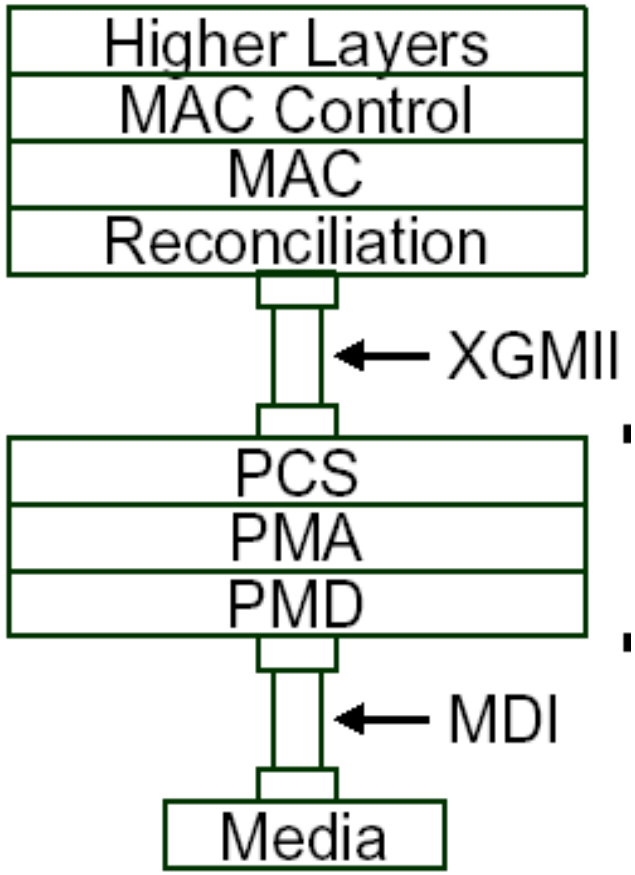


Source : B. Forouzan

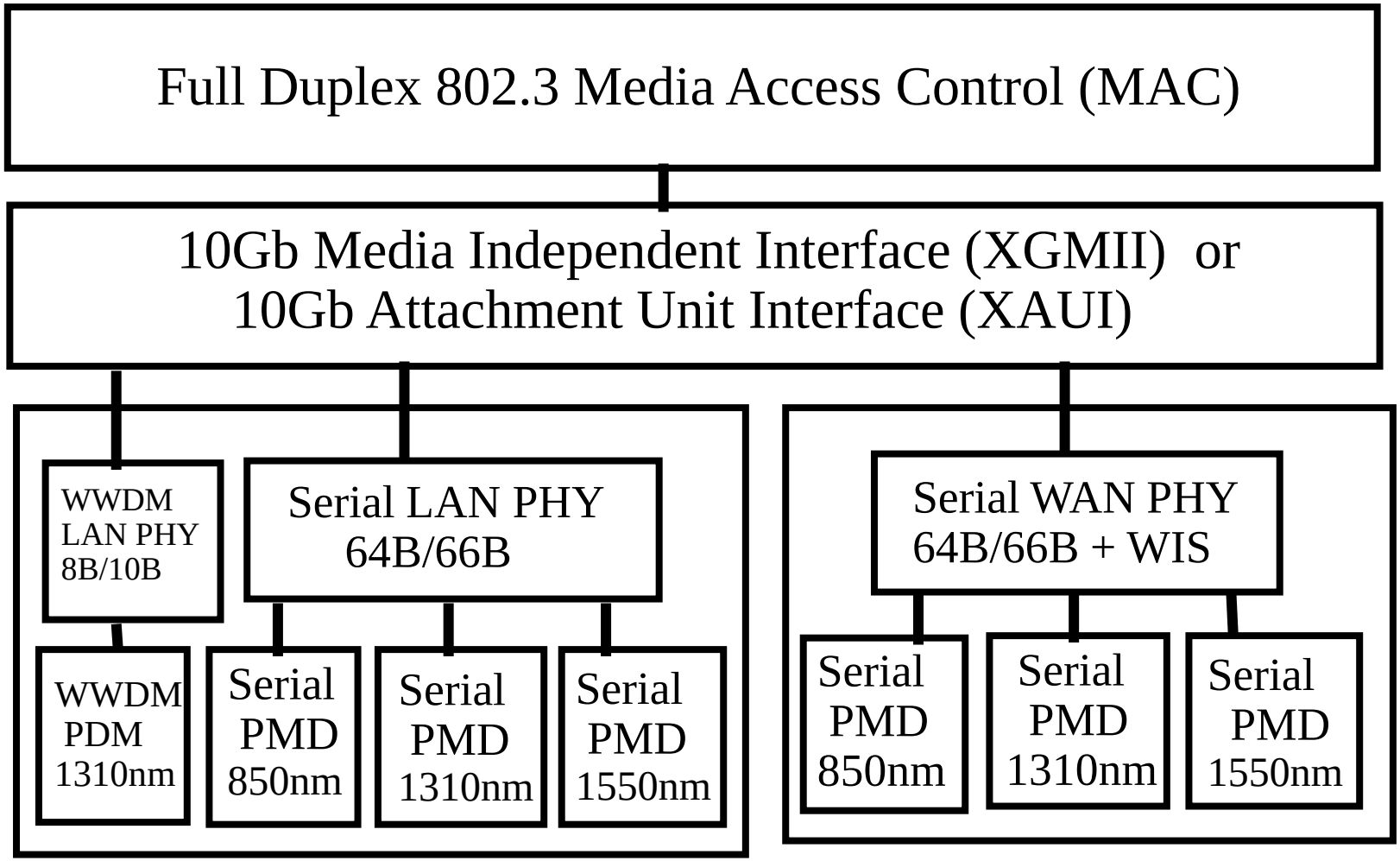
10 Gigabit Ethernet Alliance

- **802.3ae**
- **Membres fondateurs**
  - 3Com Corporation
  - Cisco Systems
  - Extreme Networks
  - Intel Corporation
  - Nortel Networks
  - Sun Microsystems
  - World Wide Packets
- **Q2 03 finalisation du standard**
- **Q1 99 formation d’un groupe d’étude**

10 Gigabit Ethernet



10 Gigabit Ethernet

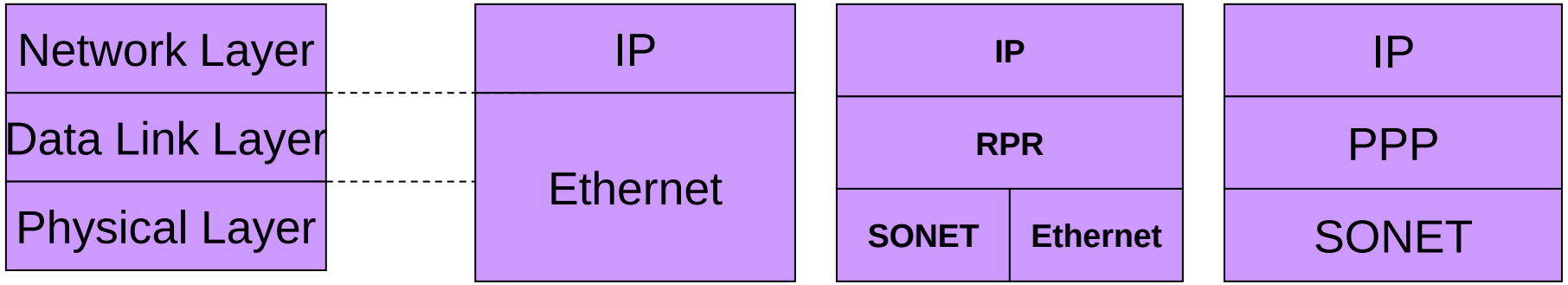


10 Gigabit Ethernet implementations

- **10GBase-SR**
  - 300m sur fibre noire
- **10GBase-SW**
  - 300m sur SONET
  - 850nm, multimode
- **10GBase-LR**
  - 2m à 10km sur fibre noire
- **10GBase-LW**
  - 2m-10km sur SONET
  - 1310nm, fibre monomode
- **10Base-ER**
  - 2m à 40km sur fibre noire
- **10Base-EW**
  - 2m – 40km sur SONET
  - Both 1550nm, single mode fiber
- **10GBase-LX4**
  - 4 parallel wavelengths over single multi- or single-mode fiber pair at 1310nm

Resilient Packet Ring

- MAC protocol based on a ring topology
- IEEE 802.17
- An efficient use of network bandwidth (statistical multiplexing not time division multiplexing)
- A resilient network (< 50ms recovery time)
- Can have up to 128 nodes in a ring



Exercice : frame decoding

```
08 00 5A 57 49 54 08 00 38 03 07 43 08 00
45 00 00 49 49 35 00 00 1D 06 C8 85 87 E4
06 04 B8 0C 52 0C 00 15 51 0C 71 12 4A 2A
00 00 51 19 50 18 10 00 F3 FF 00 00 33 33
31 20 50 61 73 73 77 6F 72 64 20 72 65 71
75 69 72 65 64 20 66 6F 72 20 6A 65 61 6E
2E 0D 0A
```

Appendice : assigned values for the type field

0000-05DC	IEEE802.3 Length Field
0101-01FF	Experimental
0200	XEROX PUP (see 0A00)
0201	PUP Addr Trans (see 0A01)
0400	Nixdorf
0600	XEROX NS IDP
0660	DLOG
0661	DLOG
0800	Internet IP (IPv4)
0801	X.75 Internet
0802	NBS Internet
0803	ECMA Internet
0804	Chaosnet
0805	X.25 Level 3
0806	ARP
0807	XNS Compatability
081C	Symbolics Private
0888-088A	Xyplex
0900	Ungermann-Bass net debugr
0A00	Xerox IEEE802.3 PUP
0A01	PUP Addr Trans
0BAD	Banyan Systems
1000	Berkeley Trailer nego
1001-100F	Berkeley Trailer encap/IP
1600	Valid Systems
4242	PCS Basic Block Protocol
5208	BBN Simnet
6000	DEC Unassigned (Exp.)
6001	DEC MOP Dump/Load
6002	DEC MOP Remote Console
6003	DEC DECNET Phase IV Route
6004	DEC LAT
6005	DEC Diagnostic Protocol
6006	DEC Customer Protocol
6007	DEC LAVC, SCA
6008-6009	DEC Unassigned
6010-6014	3Com Corporation
7000	Ungermann-Bass download
7002	Ungermann-Bass dia/loop
7020-7029	LRT
7030	Proteon
7034	Cabletron
8003	Cronus VLN
8004	Cronus Direct
8005	HP Probe
8006	Nestar
8008	AT&T
8010	Excelan
8013	SGI diagnostics
8014	SGI network games
8015	SGI reserved
8016	SGI bounce server
8019	Apollo Computers
802E	Tymshare
802F	Tigan, Inc.
8035	Reverse ARP
8036	Aeonic Systems
8038	DEC LANBridge
8039-803C	DEC Unassigned
803D	DEC Ethernet Encryption
803E	DEC Unassigned
803F	DEC LAN Traffic Monitor
8040-8042	DEC Unassigned
8044	Planning Research Corp.
8046	AT&T
8047	AT&T
8049	ExperData
805B	Stanford V Kernel exp.
805C	Stanford V Kernel prod.
805D	Evans & Sutherland
8060	Little Machines
8062	Counterpoint Computers
8065	Univ. of Mass. @ Amherst
8066	Univ. of Mass. @ Amherst
8067	Veeco Integrated Auto.
8068	General Dynamics
8069	AT&T
806A	Autophon
806C	ComDesign
806D	Computgraphic Corp.
806E-8077	Landmark Graphics Corp.
807A	Matra
807B	Dansk Data Elektronik
807C	Merit Internodal
807D-807F	Vitalink Communications
8080	Vitalink TransLAN III
8081-8083	Counterpoint Computers
809B	Appletalk
809C-809E	Datability
809F	Spider Systems Ltd.
80A3	Nixdorf Computers
80A4-80B3	Siemens Gammasonics
Inc.	
80C0-80C3	DCA Data Exchange
Cluster	
80C4	Banyan Systems
80C5	Banyan Systems
80C6	Pacer Software
80C7	Applitek Corporation
80C8-80CC	Intergraph Corporation
80CD-80CE	Harris Corporation
80CF-80D2	Taylor Instrument
80D3-80D4	Rosemount Corporation
80D5	IBM SNA Service on Ether
80DD	Varian Associates
80DE-80DF	Integrated Solutions TRFS
80E0-80E3	Allen-Bradley
80E4-80F0	Datability
80F2	Retix
80F3	AppleTalk AARP (Kinetics)
80F4-80F5	Kinetics
80F7	Apollo Computer
80FF-8103	Wellfleet Communications
8107-8109	Symbolics Private
8130	Hayes Microcomputers
8131	VG Laboratory Systems
8132-8136	Bridge Communications
8137-8138	Novell, Inc.
8139-813D	KTI
8148	Logicraft
8149	Network Computing Devices
814A	Alpha Micro
814C	SNMP
814D	BIIN
814E	BIIN
814F	Technically Elite Concept
8150	Rational Corp
8151-8153	Qualcomm
815C-815E	Computer Protocol Pty Ltd
8164-8166	Charles River Data System
817D-818C	Protocol Engines
818D	Motorola Computer
819A-81A3	Qualcomm
81A4	ARAI Bunkichi
81A5-81AE	RAD Network Devices
81B7-81B9	Xyplex
81CC-81D5	Apricot Computers
81D6-81DD	Artisoft
81E6-81EF	Polygon
81F0-81F2	Comsat Labs
81F3-81F5	SAIC
81F6-81F8	VG Analytical
8203-8205	Quantum Software
8221-8222	Ascom Banking Systems
823E-8240	Advanced Encryption Syste
827F-8282	Athena Programming
8263-826A	Charles River Data System
829A-829B	Inst Ind Info Tech
829C-82AB	Taurus Controls
82AC-8693	Walker Richer & Quinn
8694-869D	Idea Courier
869E-86A1	Computer Network Tech
86A3-86AC	Gateway Communications
86DB	SECTRA
86DE	Delta Controls
86DF	ATOMIC
86E0-86EF	Landis & Gyr Powers
8700-8710	Motorola
8A96-8A97	Invisible Software
9000	Loopback
9001	3Com(Bridge) XNS Sys Mgmt
9002	3Com(Bridge) TCP-IP Sys
9003	3Com(Bridge) loop detect
FF00	BBN VITAL-LanBridge cache
FF00-FF0F	ISC Bunker Ramo