Chapter 4-2
Bridge, Switch, VLAN

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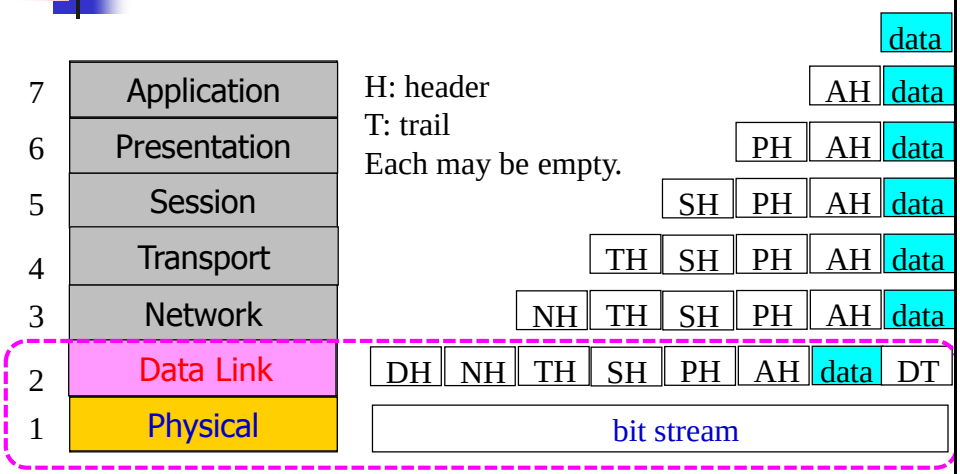
Adapted from Computer Networks,
Andrew S. Tanenbaum, Vrije University, Netherlands
& Computer Networking: A Top Down Approach,
Jim Kurose, Keith Ross & 計算機網路概論,清大資工黃能富教授

The Data Link & Physical Layers

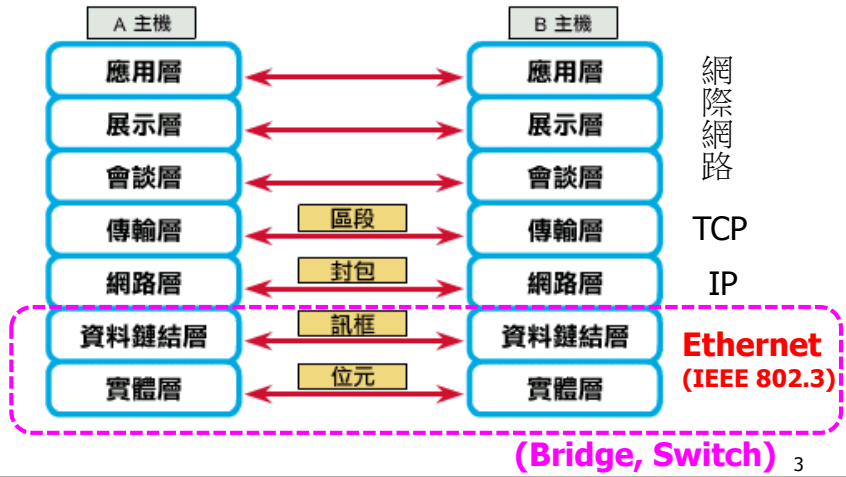


OSI Reference Model

(Bridge, Switch)

LAN (cont.)

- 對等式通訊(Peer-to-Peer)



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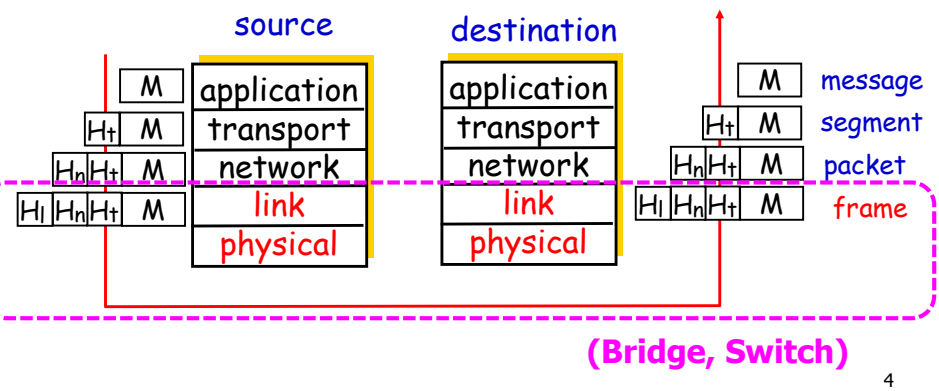
Protocol layering and data

Each layer takes data from above

- adds header information to create new data unit
- passes new data unit to layer below



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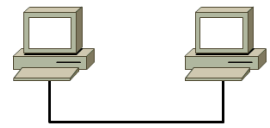
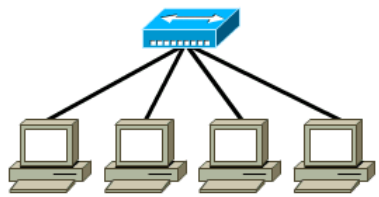
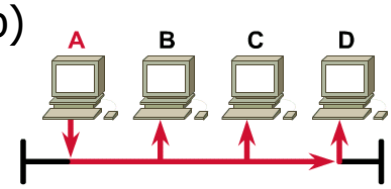
LAN的建構

- 最小的區域網路: 二個節點(Two nodes)



- 集線式網路(with Hub)

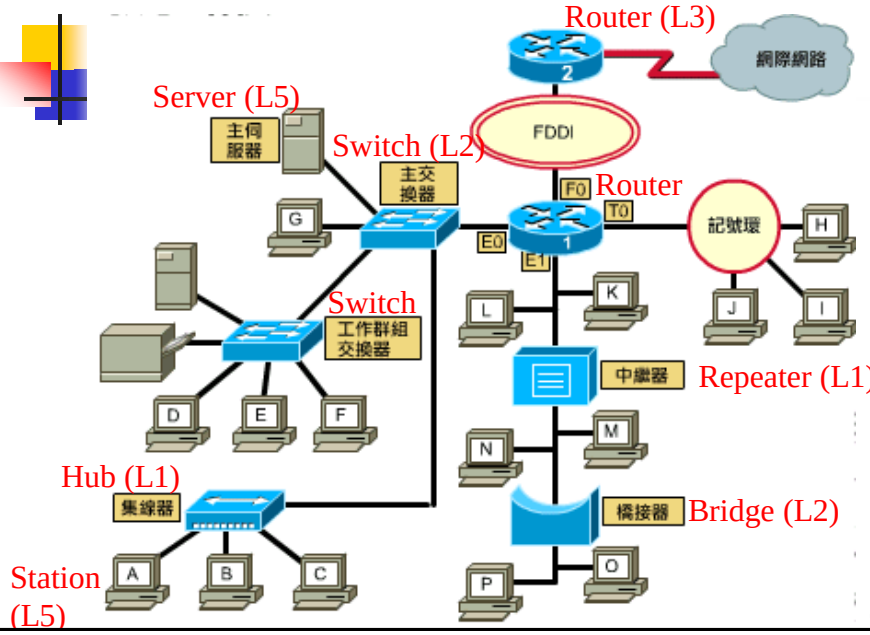




Layer 1 Physical

LAN的建構(cont.)

L1: Layer 1 device



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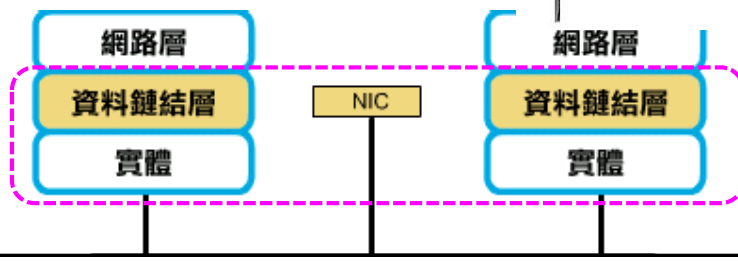
L2: 網路介面卡 (Adaptor) (network interface card, NIC):

- 每張網路卡都有一個唯一的硬體位址，叫做MAC address。

00:60:2F:3A:07:BC



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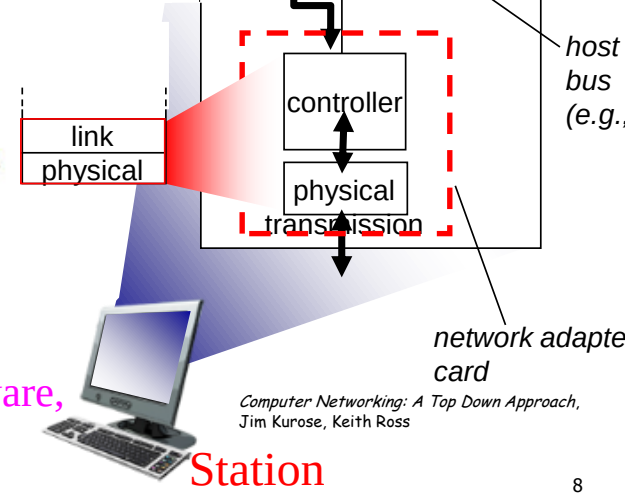
Adaptor (NIC)



- Combination of hardware, software, firmware

Computer Networking: A Top Down Approach, Jim Kurose, Keith Ross

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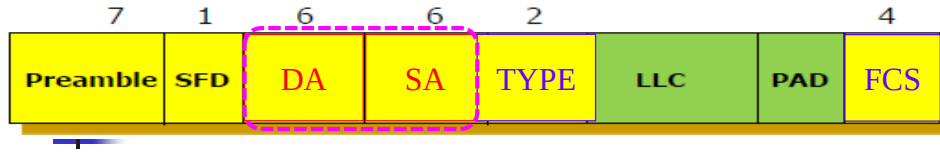
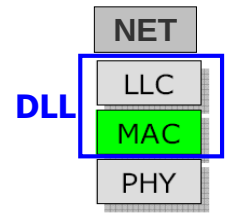
Ethernet Frame Format



- DA: Destination MAC Address
- SA: Source MAC Address



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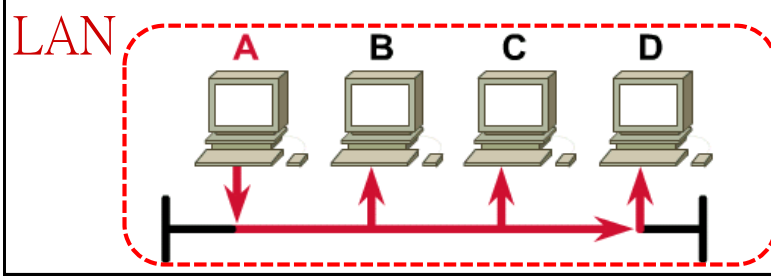
Classic Ethernet(乙太網路): LAN

- 廣播式傳輸(Broadcasting)
- 採用CSMA/CD技術：
  - 載波感測(Carrier Sense)
  - 碰撞偵測(Collision Detection)



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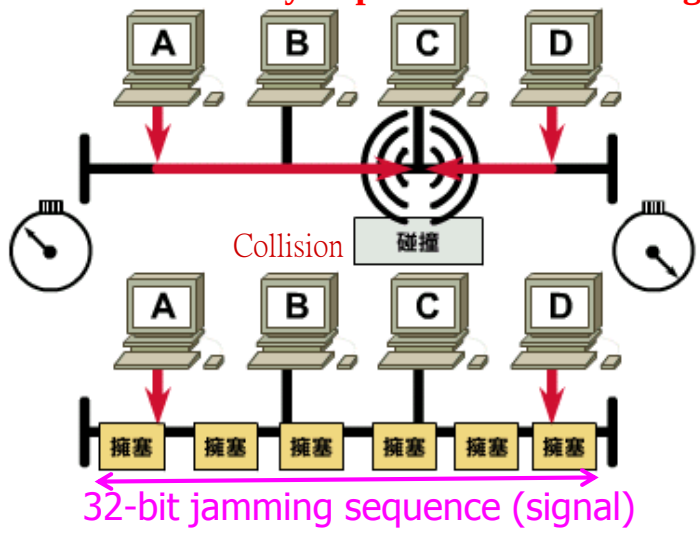
Ethernet MAC Sublayer Protocol

- 碰撞(collide)

BEBA:
Binary Exponential Backoff Algorithm



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Ethernet MAC Sublayer Protocol

- 偵測碰撞(collision detection) (512 bit time)
  1. RTT(Round Trip Time) < **51.2*μs*** (2α)
  2. Frame(訊框)大小 >= 64 bytes
     以10Mbps計算
     $10^7 \times 51.2 \times 10^{-6} = 512$ bits = 64 bytes
  3. Frame(訊框)大小 <= 1518 bytes
     為免某工作站佔用傳輸媒介太久(**fairness**)
  3. 網路最大長度約2500公尺

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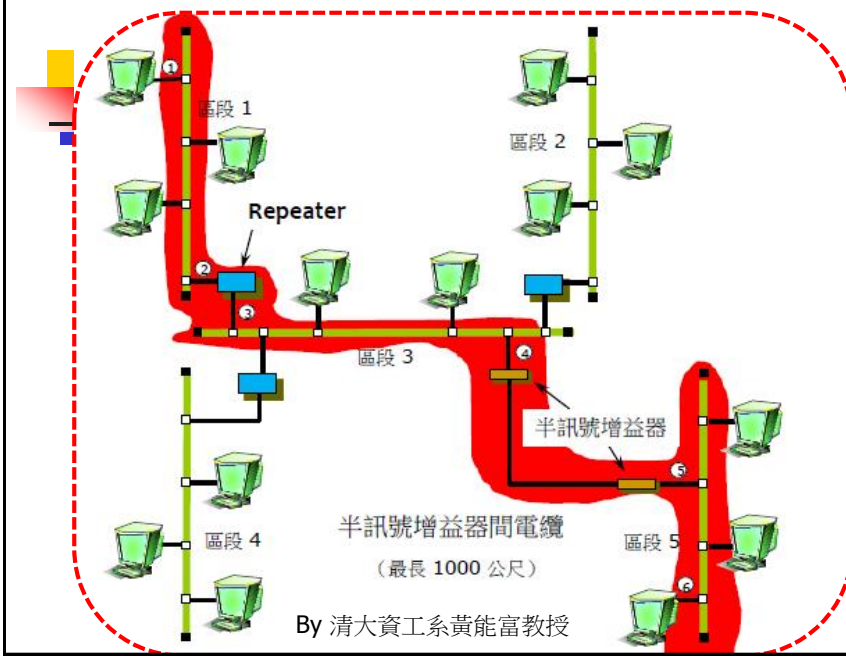
L A N



By 清大資工系黃能富教授

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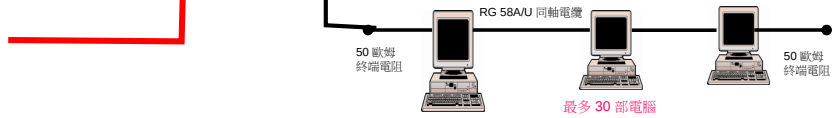
L1: Repeater(中繼器)

A *repeater* is a device that forwards digital signals

這台中繼器正面具有光纖和 BNC 接頭

翻到背面, 則可看到 2 個 RJ-45 接頭



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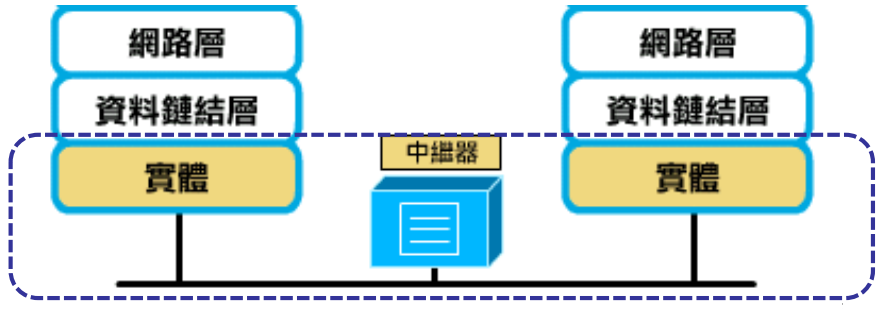
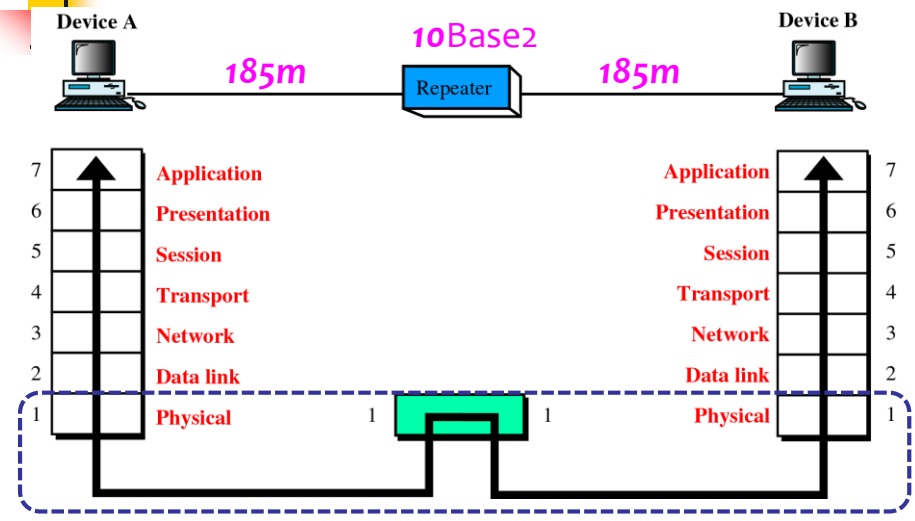
中繼器(Repeater): Layer 1 device

- Coax.同軸電纜最大長度限制185m, 500m
- UTP 纜線的最大長度限制100m
- 節點太多或纜線不足時可採用中繼器



A Repeater: Layer 1 device



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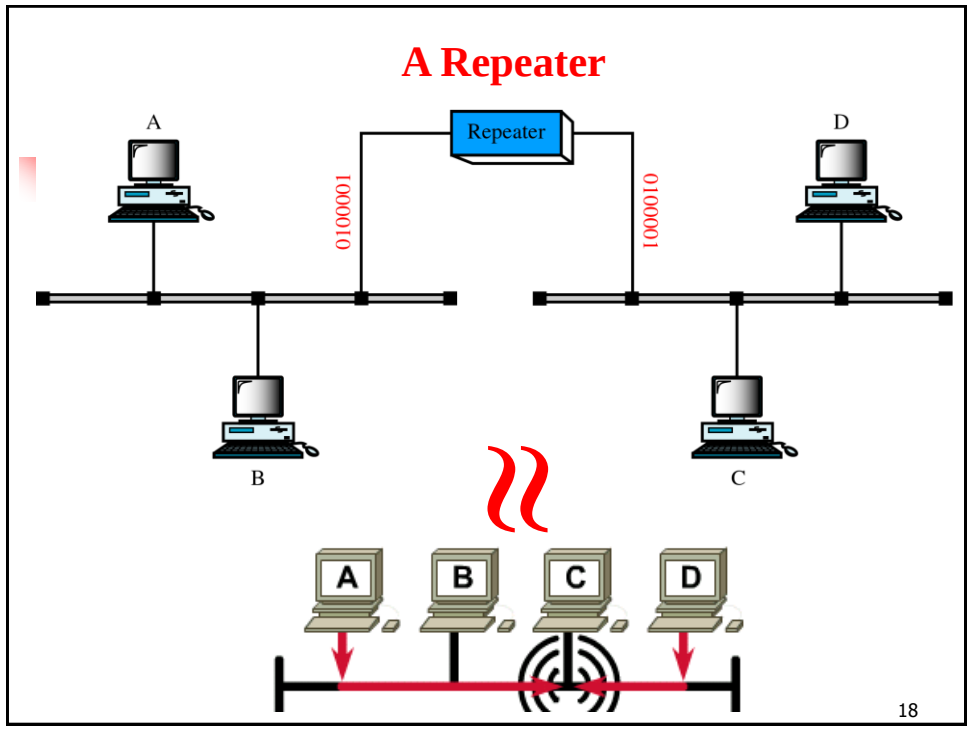
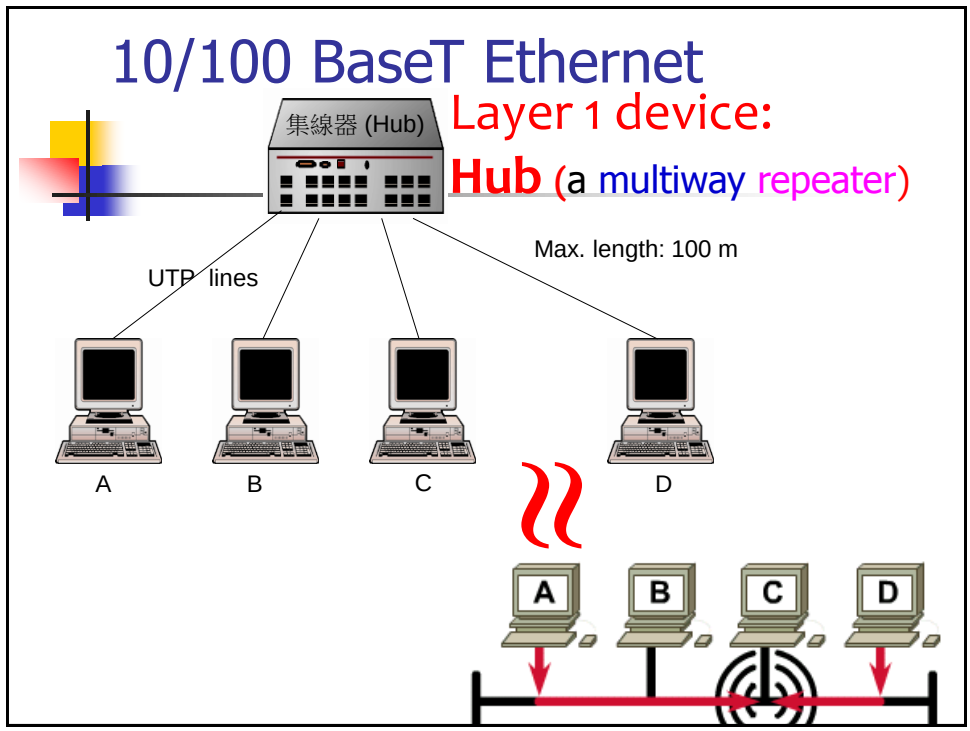
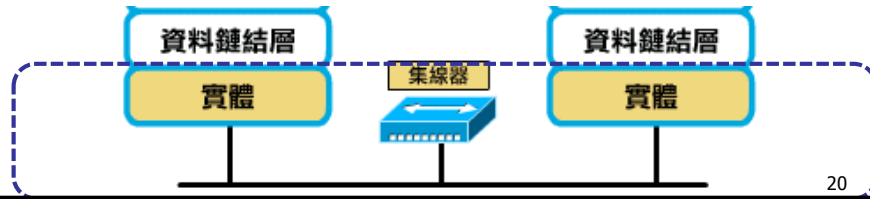

A Repeater
A
Repeater
D
0100010
1000010
B
C
A
B
C
D
18


10/100 BaseT Ethernet
集線器 (Hub)
Layer 1 device:
Hub (a multiway repeater)
Max. length: 100 m
UTP lines
A
B
C
D
A
B
C
D

L1集線器(Hub):

- 延長通訊距離
- 多台主機或網路設備之連通(集線)
- Layer 1設備，不具MAC位址過濾能力➔本設備所連接網路屬相同碰撞領域(The Same Collision Domain)
- 常見於公司小部門或學校電腦教室之內部網路



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碰撞領域(Collision Domain)

- 僅由第一層設備(Layer 1 devices)所連結之網路(LAN)屬相同碰撞領域。
- 頻寬由此領域所有節點分享(同一時間只有一個節點會成功傳送資料)(Shared bandwidth)
- 10Mbps Ethernet同一碰撞領域任兩節點距離需<2500m, 若所接集線器較多，則距離更應縮短。Hub會有延遲，故以51.2 us為訊號來回時間為考量。
- 若是100Mbps Fast-Ethernet，同一碰撞領域任兩節點距離需<250m

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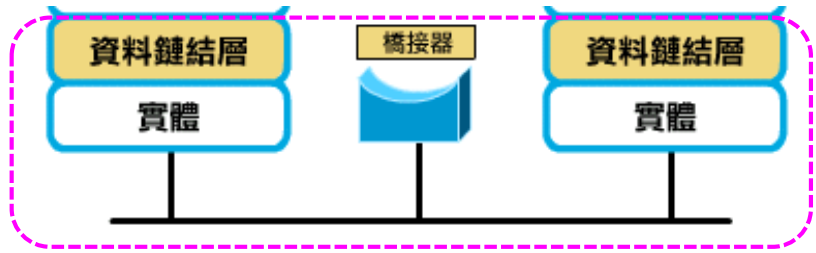
橋接器(Bridge): Layer 2 device

- 連接兩個 LAN 區段(Connecting two LANs)
- 根據MAC address過濾(Filtering) LAN 的資料流量
- 碰撞領域之分割(頻寬不分享)(Dedicated bandwidth)



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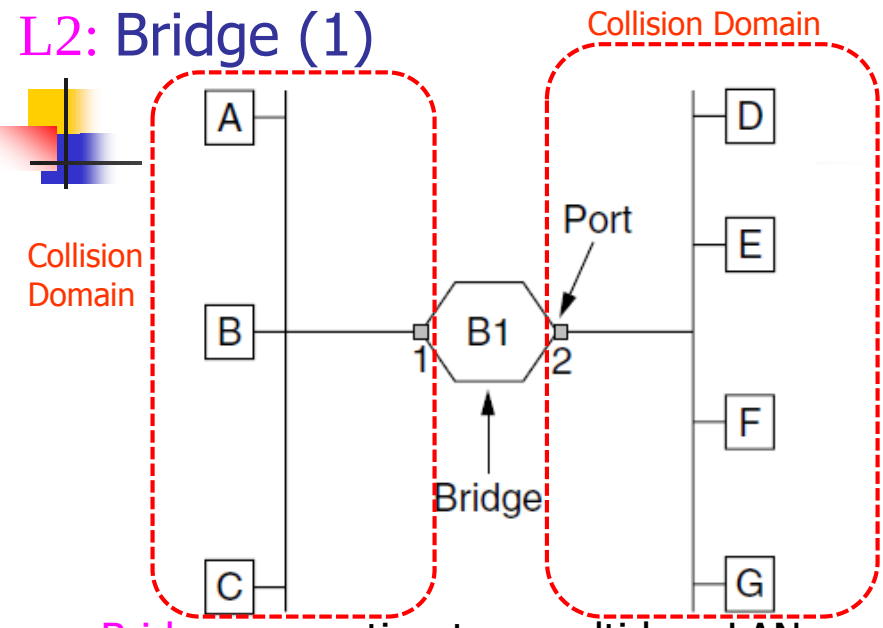
L2: Bridge (1)



Bridge connecting two multidrop LANs

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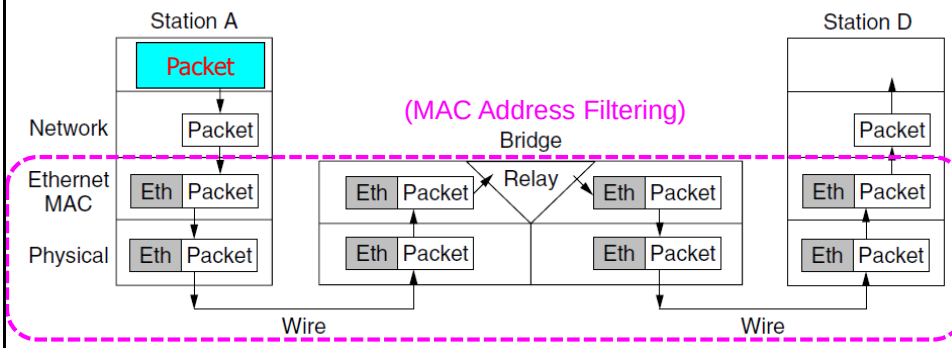
Bridge (2)



Protocol processing at a bridge.

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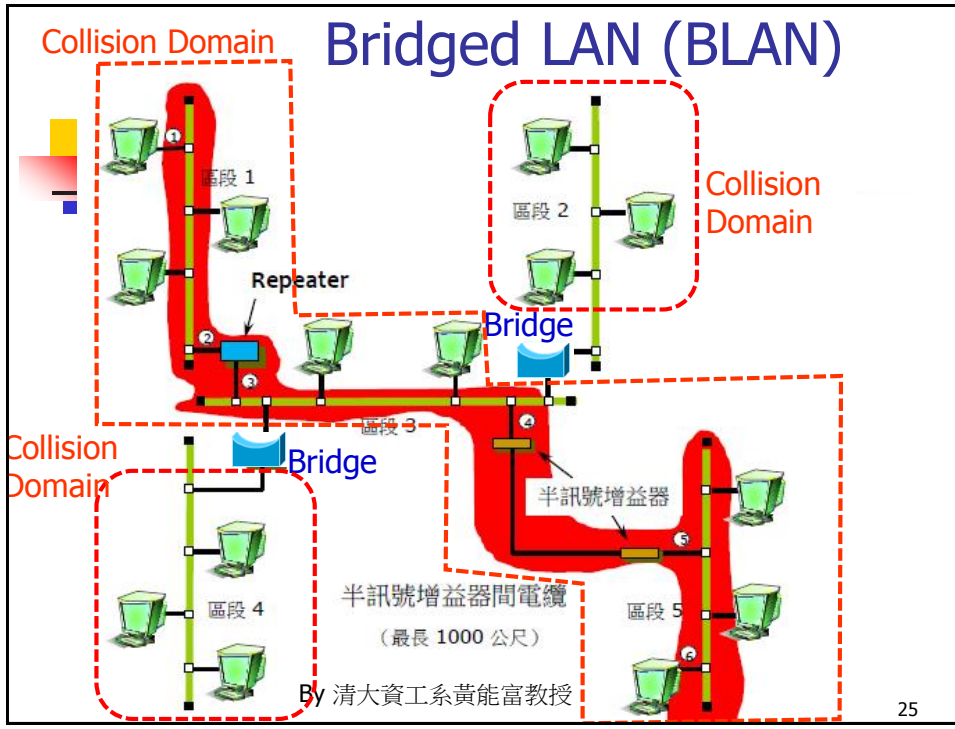
Bridged LAN (BLAN)



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Basic Functions of a Bridge

- **Address Learning**
  (Bridge table)(Switch table)
  (Filtering database)
- **Frame Filtering**
- **Frame Forwarding**
- **Resolving Possible Loops in the Topology**

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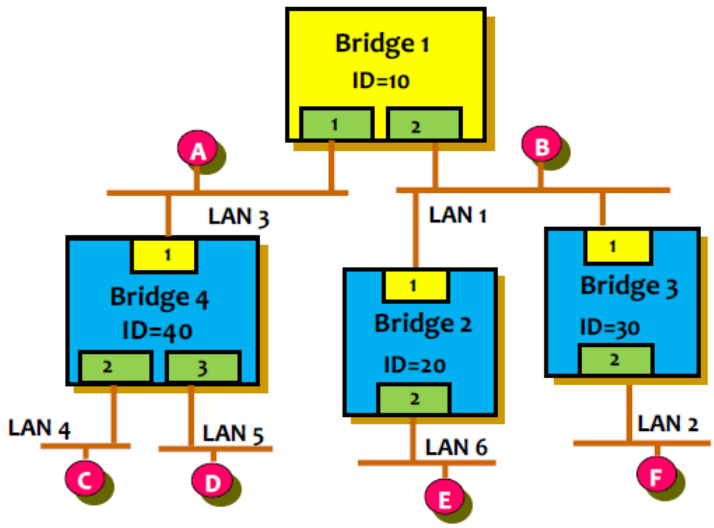
A BLAN Example Without loop



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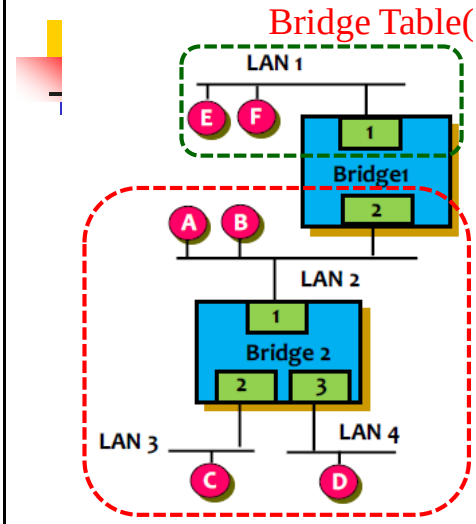
Bridge (Switch) Table Examples



Bridge Table(Filtering Database)(Bridge 1)

MAC Addr	Port	Time (S)
A	2	20
B	2	18
C	2	25
D	2	4
E	1	5
F	1	12

Lifetime
default: 300 sec.

Bridge Table (Bridge 2)

MAC Addr	Port	Time(S)
A	1	19
B	1	17
C	2	24
D	3	3
E	1	6
F	1	13

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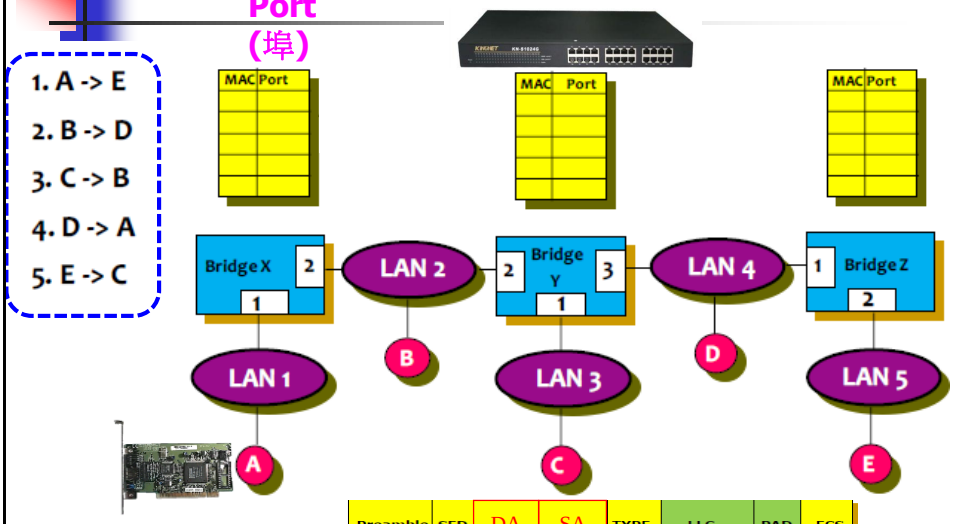
Addresses Learning Example (Initial)

Port (埠)

1. A -> E
2. B -> D
3. C -> B
4. D -> A
5. E -> C



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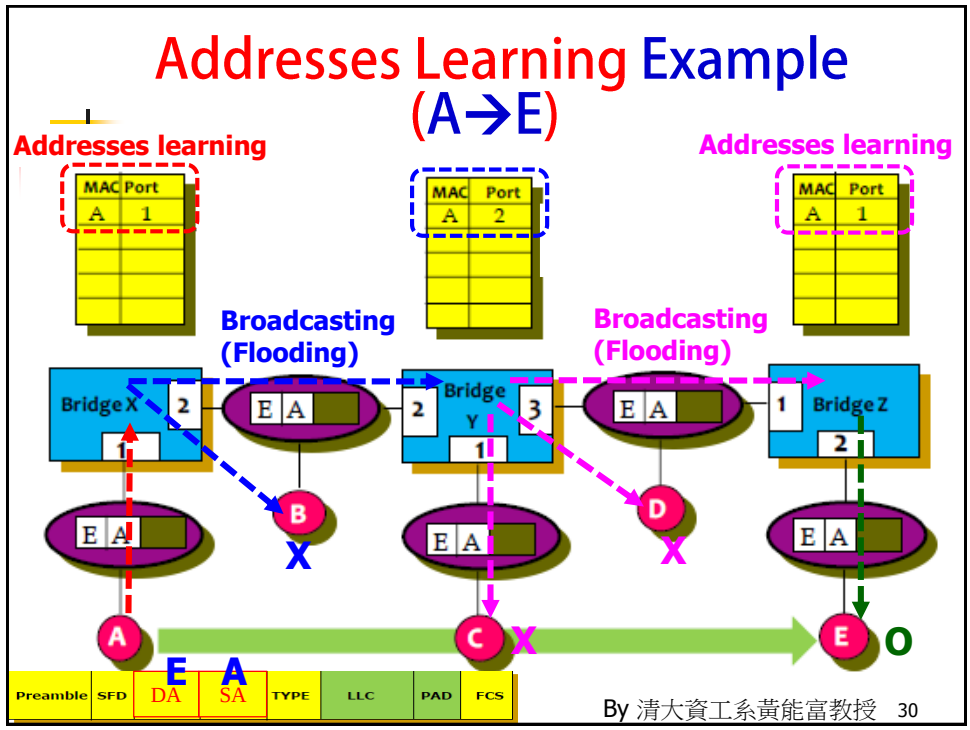
Addresses Learning Example
(A→E)
Addresses learning
Addresses learning
MAC Port
A 1
MAC Port
A 2
MAC Port
A 1
Broadcasting
(Flooding)
Broadcasting
(Flooding)
Bridge X
Bridge Y
Bridge Z
E A
B
D
X
X
A
C
X
E
O
E A
Preamble SFD DA SA TYPE LLC PAD FCS
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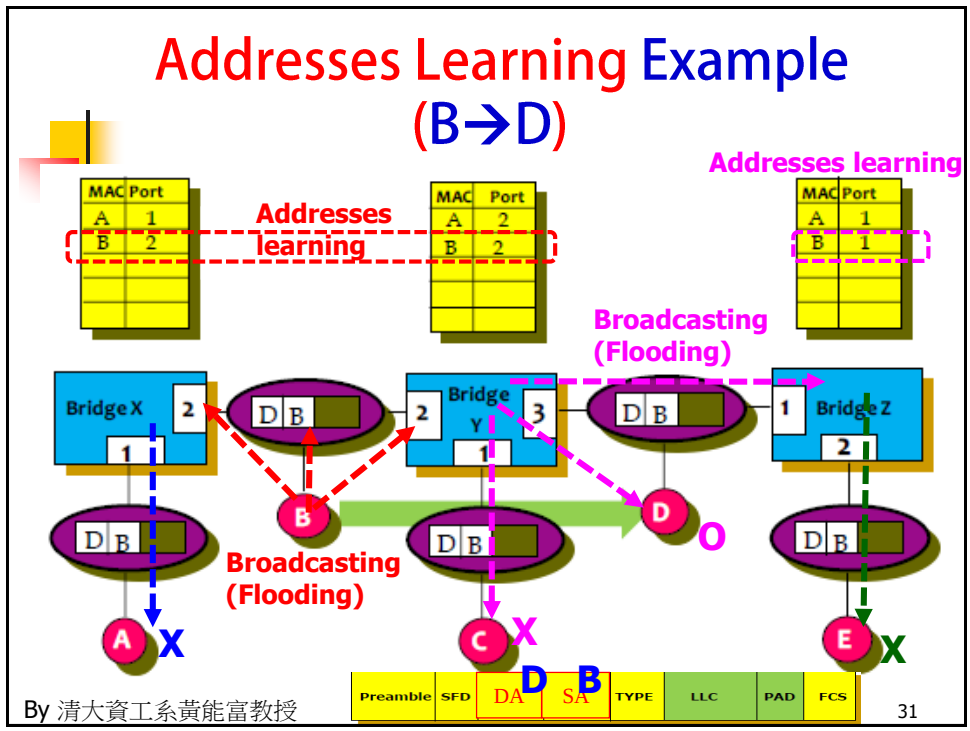
Addresses Learning Example
(B→D)
Addresses learning
Addresses learning
MAC Port
A 1
B 2
MAC Port
A 2
B 2
MAC Port
A 1
B 1
Broadcasting
(Flooding)
Bridge X
Bridge Y
Bridge Z
D B
B
D
O
A
X
Broadcasting
(Flooding)
C
X
E
X
D B
Preamble SFD DA SA TYPE LLC PAD FCS
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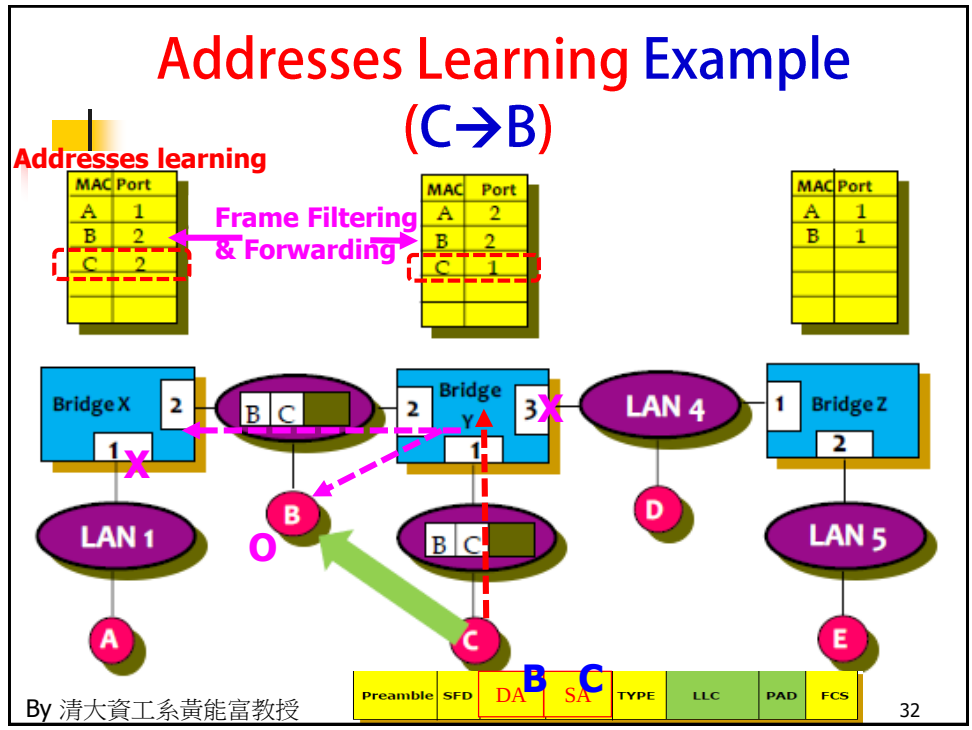
Addresses Learning Example
(C→B)
Addresses learning
MAC Port
A 1
B 2
C 2
Frame Filtering
& Forwarding
MAC Port
A 2
B 2
C 1
MAC Port
A 1
B 1
Bridge X
Bridge Y
Bridge Z
LAN 1
LAN 4
LAN 5
A
B
C
D
E
X
O
Preamble
SFD
DA
SA
TYPE
LLC
PAD
FCS
B
C
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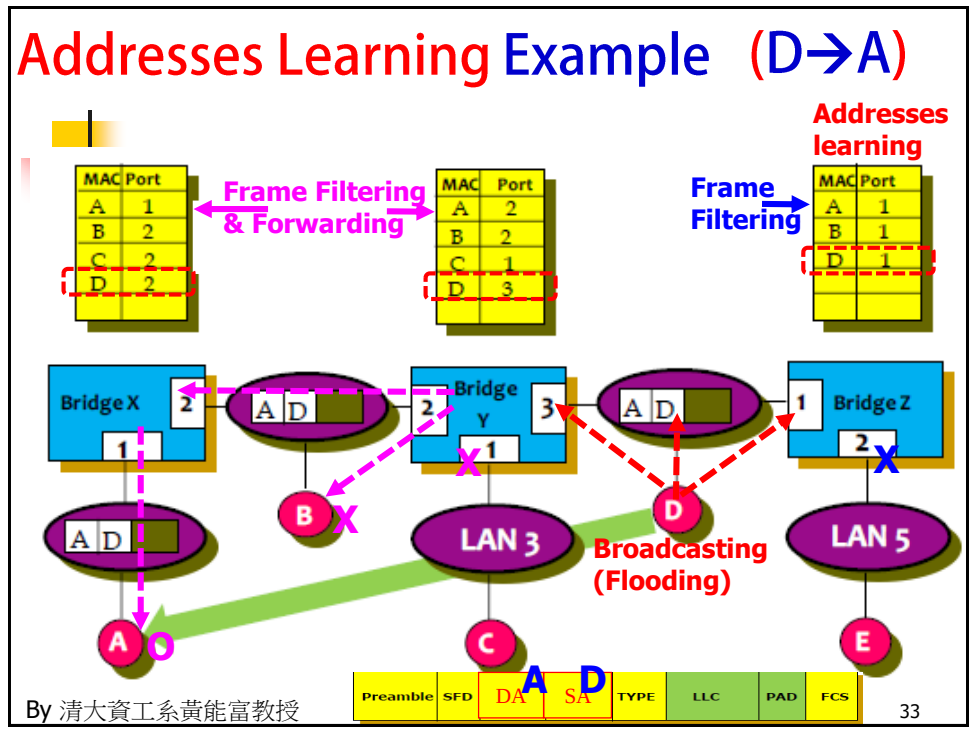
Addresses Learning Example (D→A)
Addresses learning
MAC Port
A 1
B 2
C 2
D 2
Frame Filtering
& Forwarding
MAC Port
A 2
B 2
C 1
D 3
Frame Filtering
MAC Port
A 1
B 1
D 1
Bridge X
Bridge Y
Bridge Z
LAN 3
LAN 5
A
B
C
D
E
X
O
Broadcasting
(Flooding)
Preamble
SFD
DA
SA
TYPE
LLC
PAD
FCS
A
D
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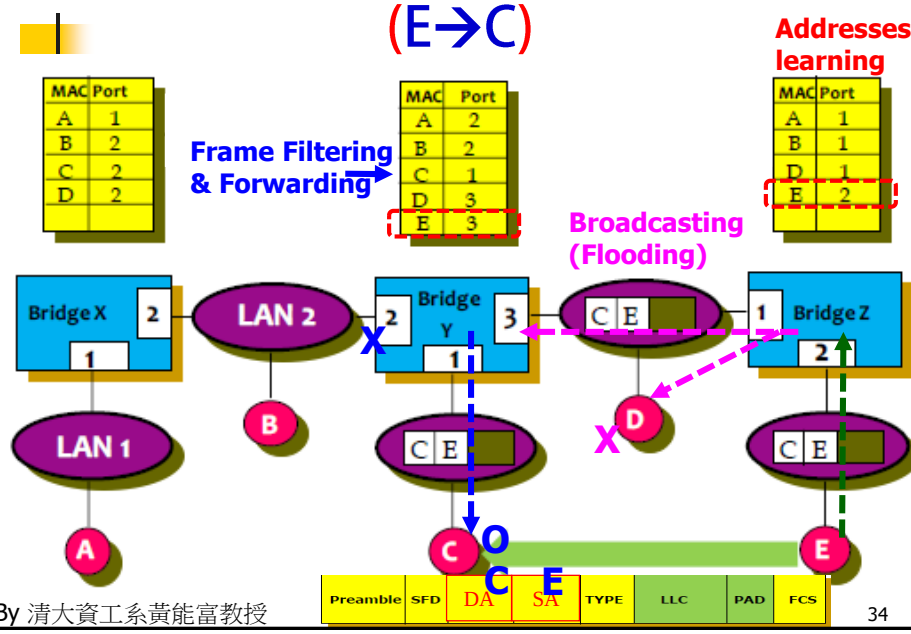
Addresses Learning Example (E→C)



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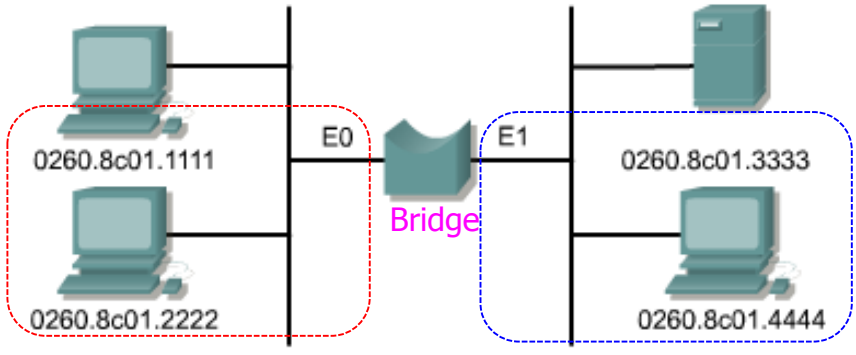
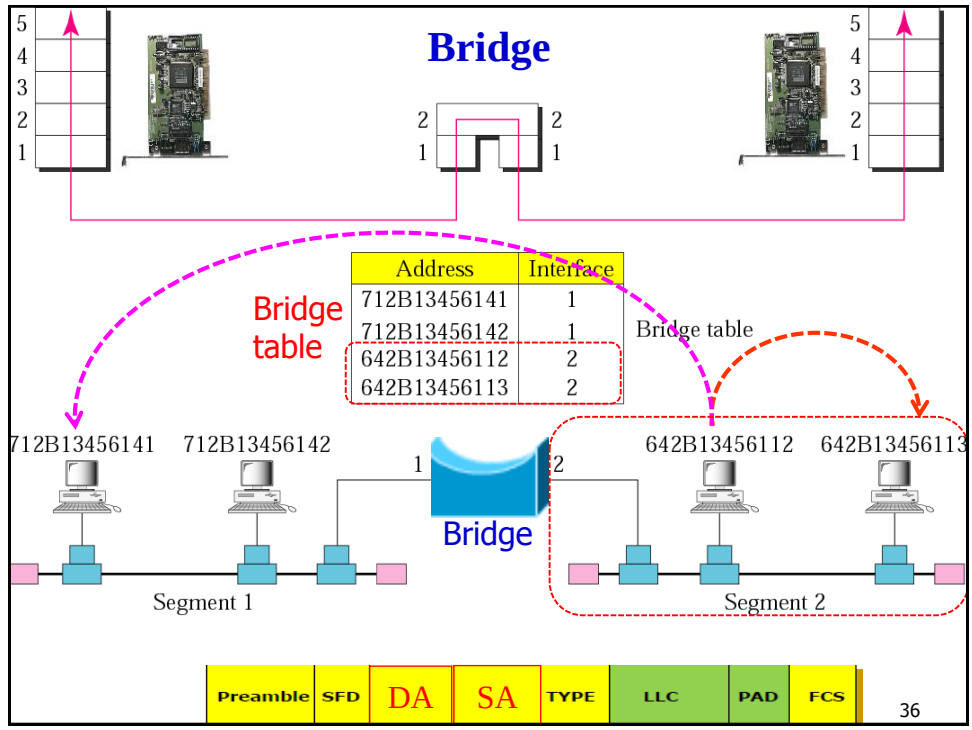


Bridge table

Interface	MAC address
E0	0260.8c01.1111
E0	0260.8c01.2222
E1	0260.8c01.3333
E1	0260.8c01.4444

Picture sources by Cisco Systems, Inc.



碰撞領域之分割

Splitting of collision domain

- Layer 2 device: Bridge、**Switch**
  - 過濾MAC位址(**Frame Filtering**)
- 可解決以下問題(Resolved issues):
  - 專屬頻寬(Dedicated bandwidth)
  - 安全議題(Security)


Bridge


Switch

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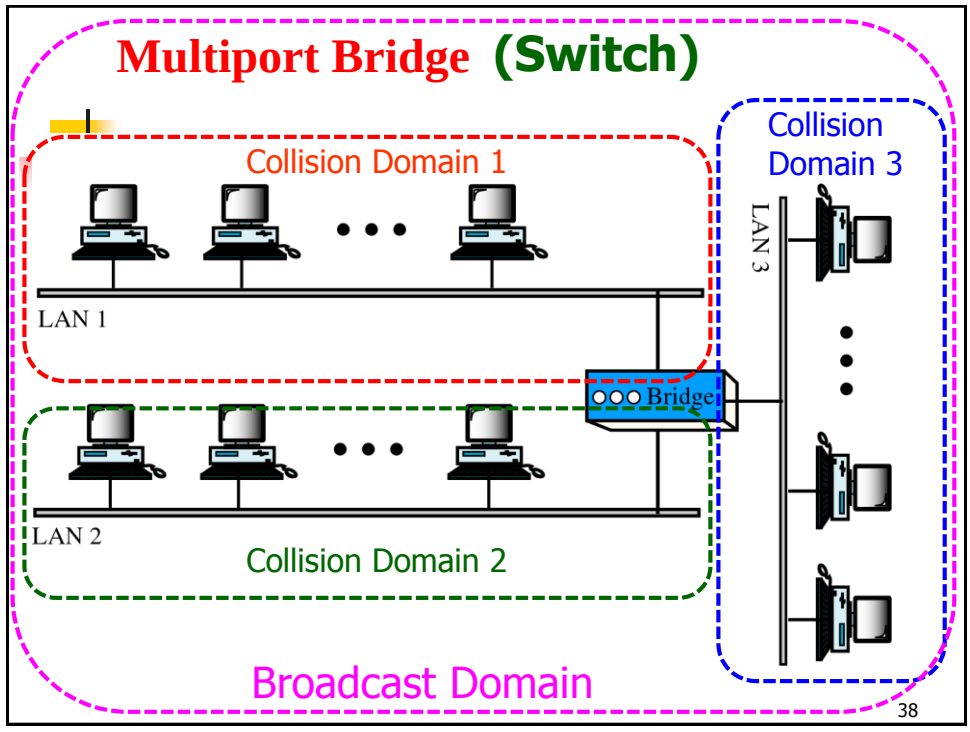
Multiport Bridge (Switch)
Collision Domain 1
Collision Domain 3
LAN 3
LAN 1
Bridge
LAN 2
Collision Domain 2
Broadcast Domain
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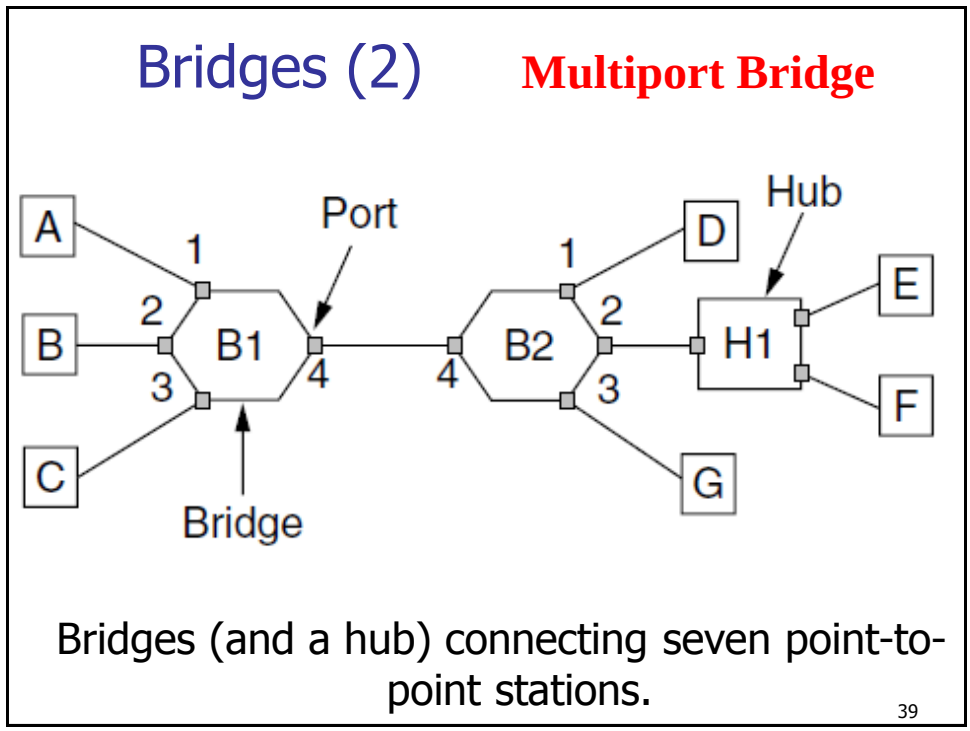
Bridges (2)
Multiport Bridge
A
B
C
1
2
3
B1
4
Port
Bridge
4
1
2
3
B2
D
G
Hub
H1
E
F
Bridges (and a hub) connecting seven point-to-point stations.
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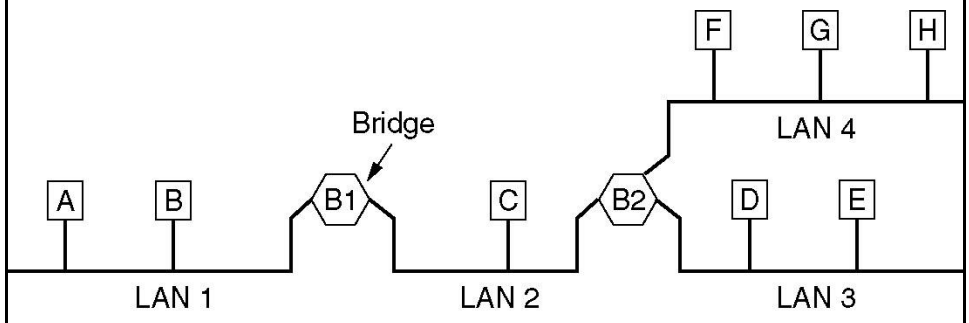
Local Internetworking

A configuration with four LANs and two bridges.



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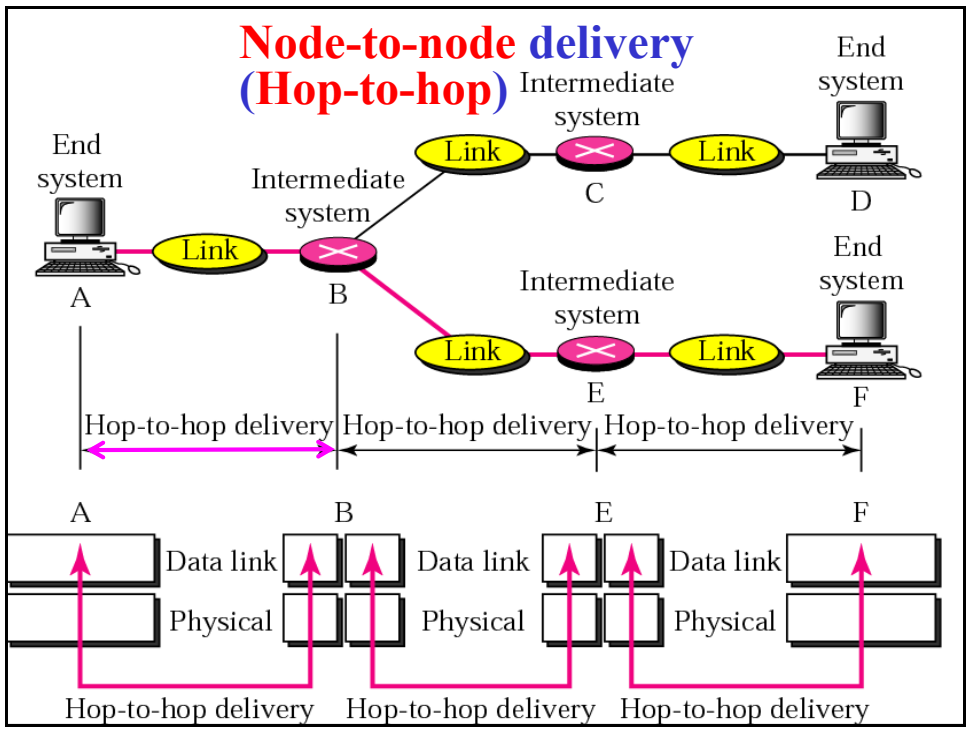
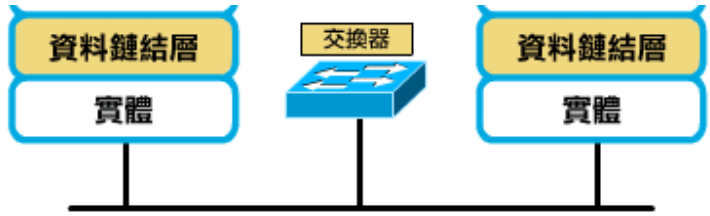


交換器(Switch): Layer 2 device

- 多埠式橋接器(A **Multiport Bridge)**
- **碰撞**領域之分割(Dedicated bandwidth)
  - 提高區域網路效率(Efficient)
- 安全(Secure)



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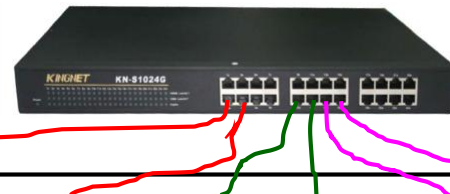
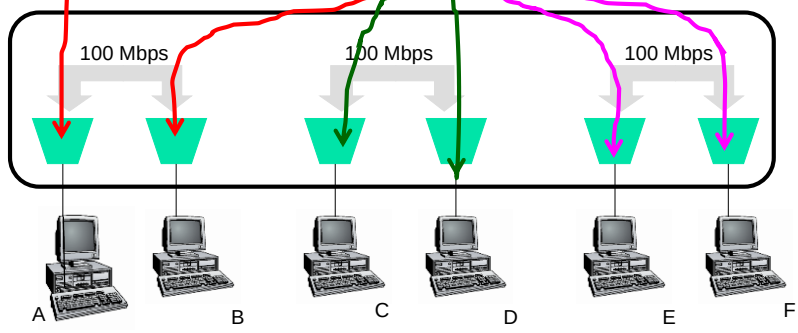
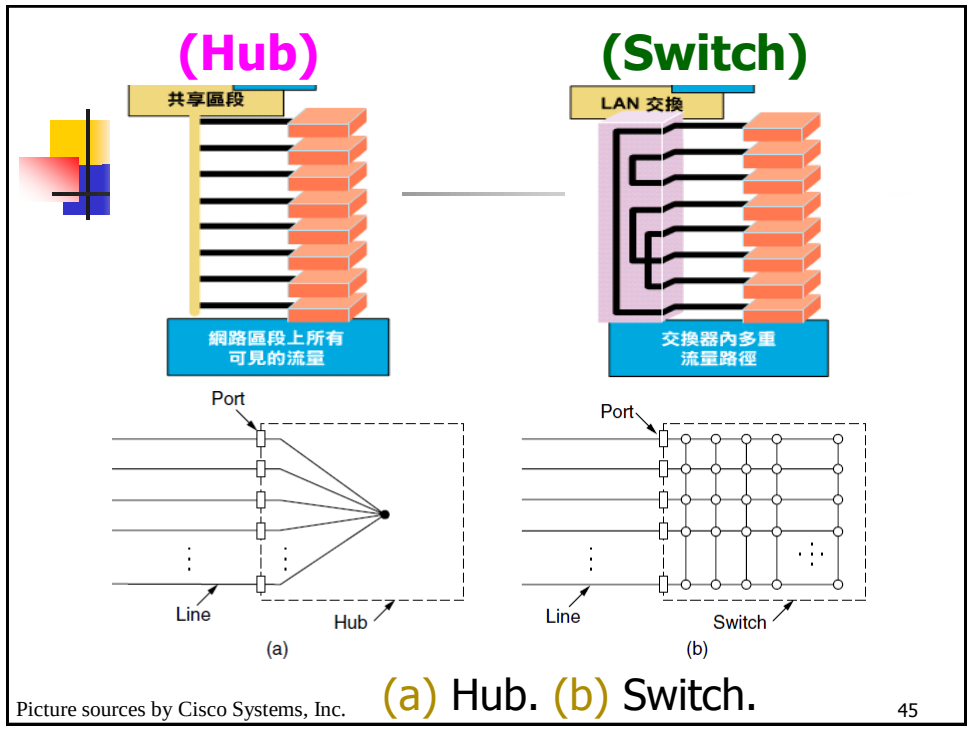
認識第 2 層交換器(L2 Switch)



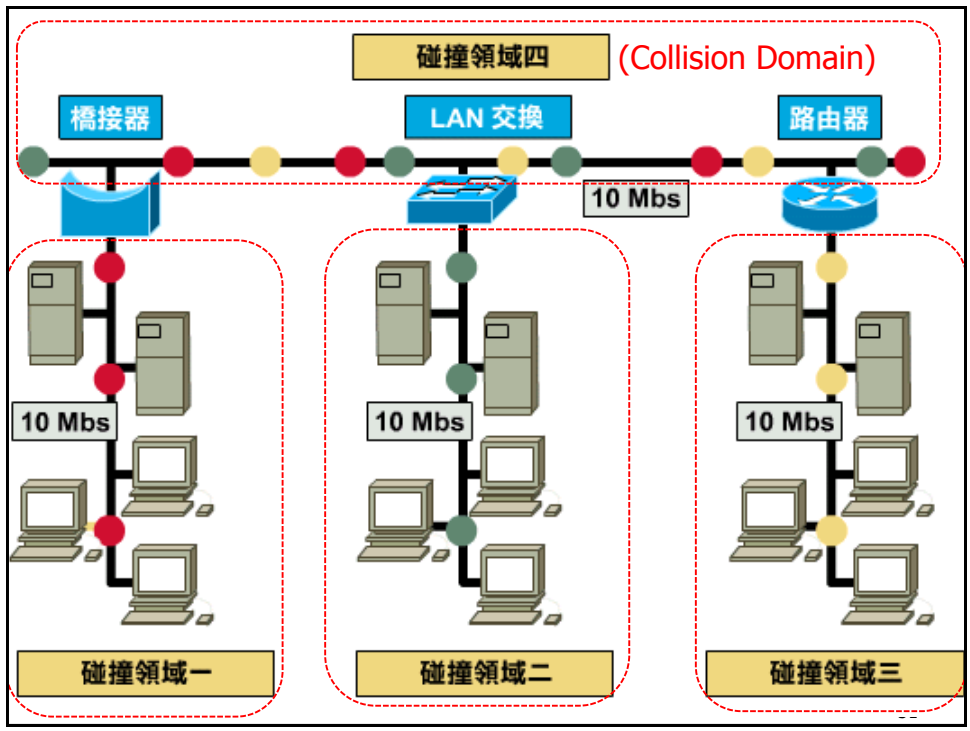


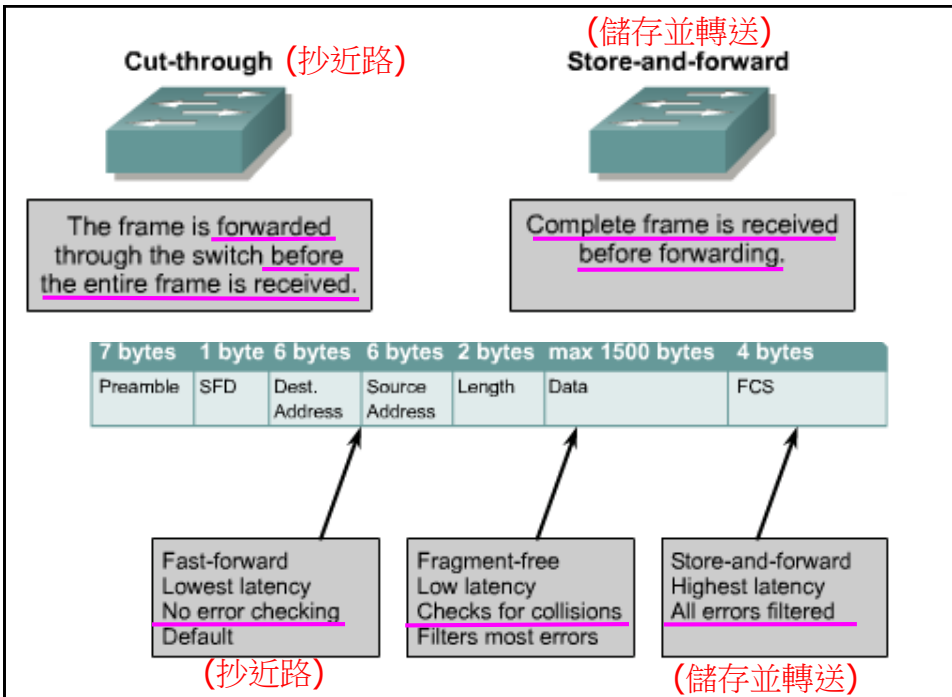
6 Port 100 Mbps Switch最多可擁有 300 Mbps 的頻寬

43



Picture sources by Cisco Systems, Inc. (a) Hub. (b) Switch. 45





Picture sources by Cisco Systems, Inc.

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網路規劃(Network planning)

- **碰撞**領域(Collision Domain)
  - 僅由第一層設備(Layer 1 devices)所連結之網路屬相同**碰撞**領域
- **廣播**領域(Broadcast Domain)
  - 僅由第一層及第二層設備(L1 & L2 devices)所連結之網路屬相同**廣播**領域
  - 一個區域網路(LAN)的範圍

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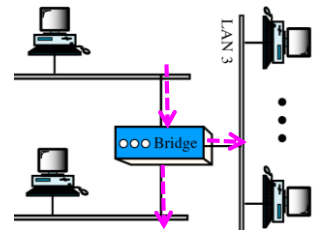
Ethernet Addresses

00:60:2F:3A:07:BC

- **Unicast** address: each adaptor recognizes those frames addressed to its address
- **Broadcast** address: ff:ff:ff:ff:ff:ff



- **Multicast** address has the first bit set to 1, e.g., f0:05:7a:8b:00:13

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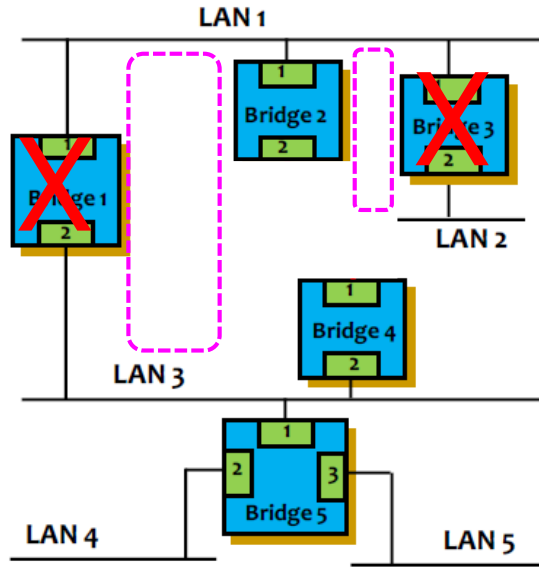
Network reliability



Loops!

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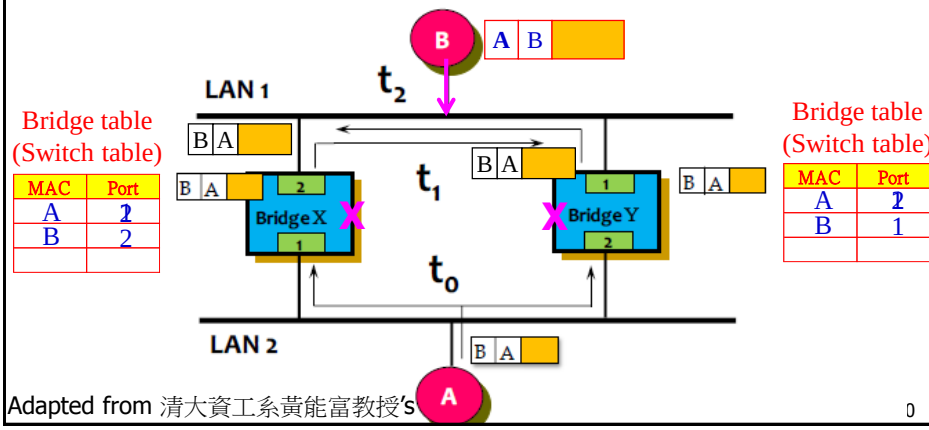
Loop Problems and Resolution

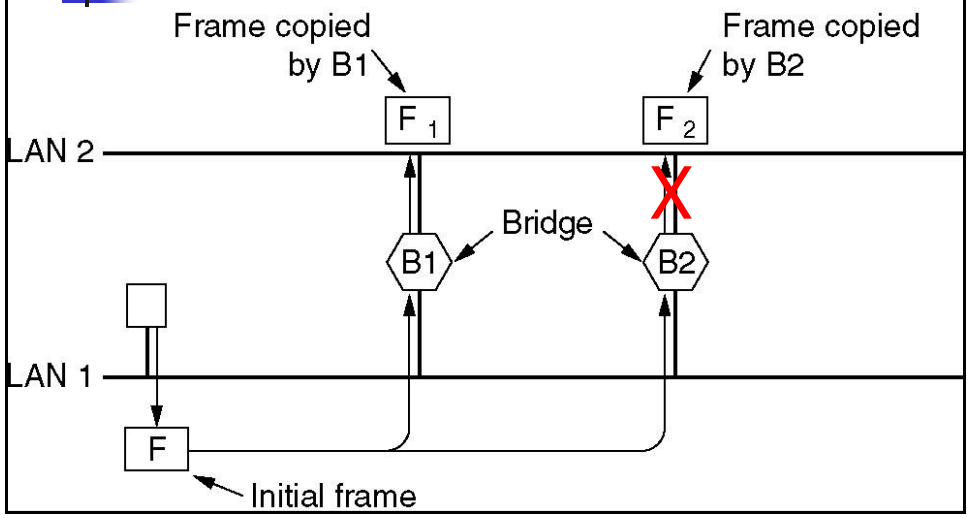
- Loops provide network reliability
- But loops make frames duplication
- Loops also make wrong address learning



Adapted from 清大資工系黃能富教授's

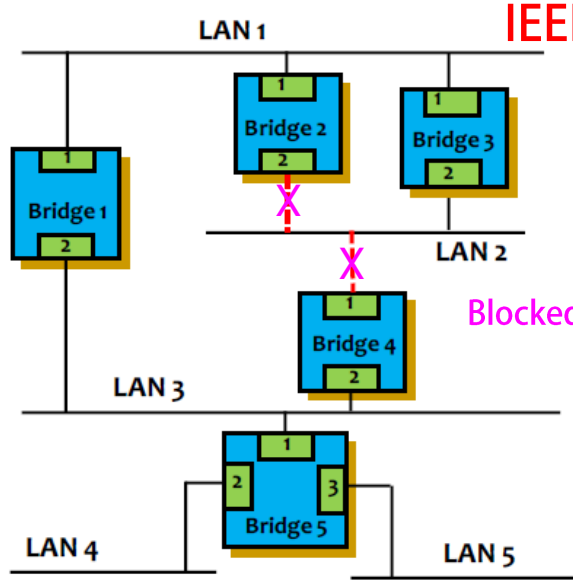
Spanning Tree Bridges

Two parallel transparent bridges.



Spanning Tree Algorithm

IEEE 802.1D



Blocked by software

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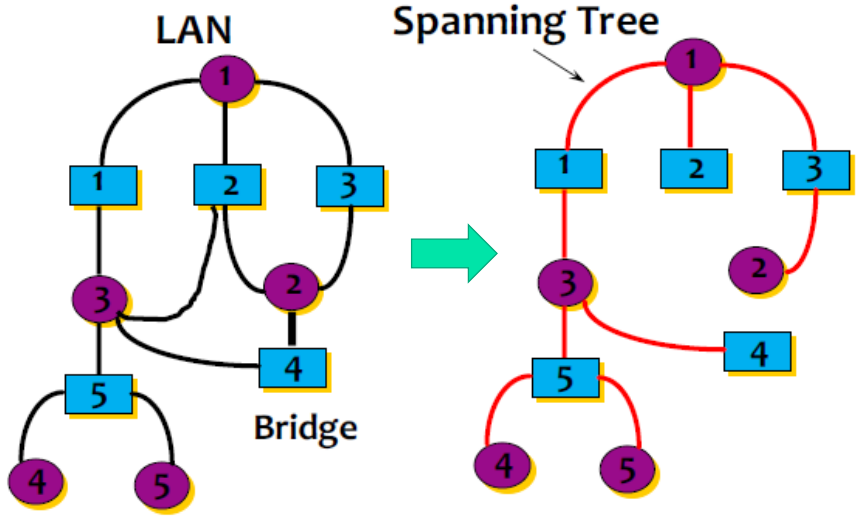
Spanning Tree Algorithm

IEEE 802.1D



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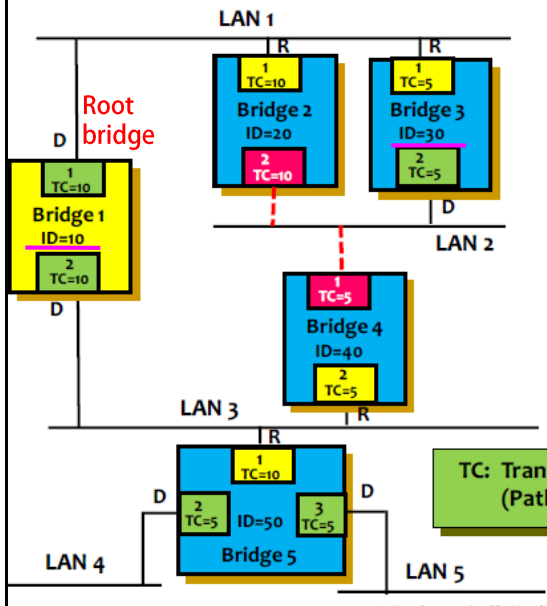
IEEE 802.1D



1. Determine the root bridge. (The least ID)
2. Determine the root port (R) on all other bridges. (TC & Port#)
3. Determine the designated port (D) on each LAN. (TC & ID)

TC: Transmission Cost (Path cost) TC

Bridge Protocol Data Unit (BPDU)
Multicast, ID: 8 bytes

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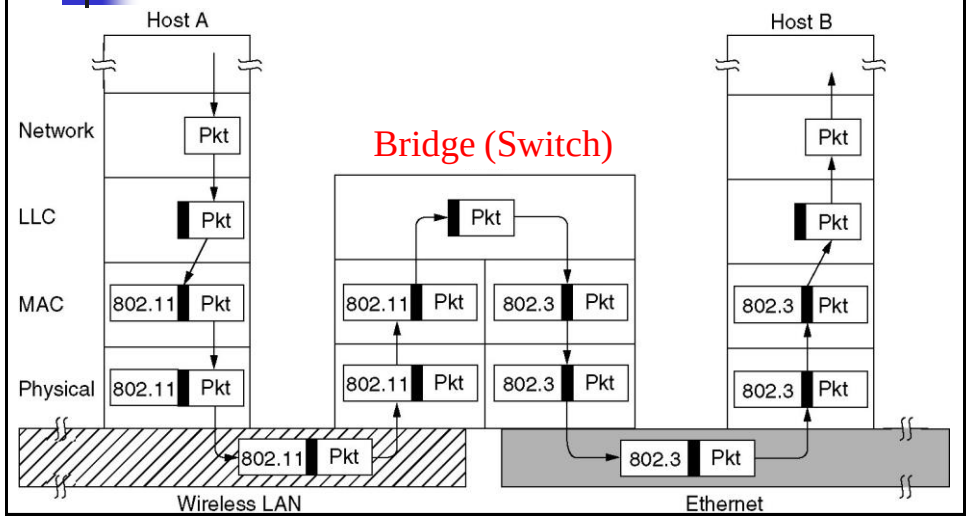
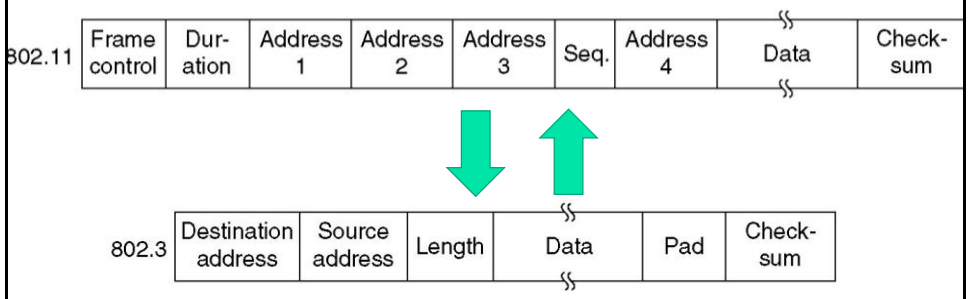
Bridges from 802.x to 802.y

Operation of a LAN bridge from 802.11 to 802.3.



Bridges from 802.x to 802.y (2)

The IEEE 802 frame formats.



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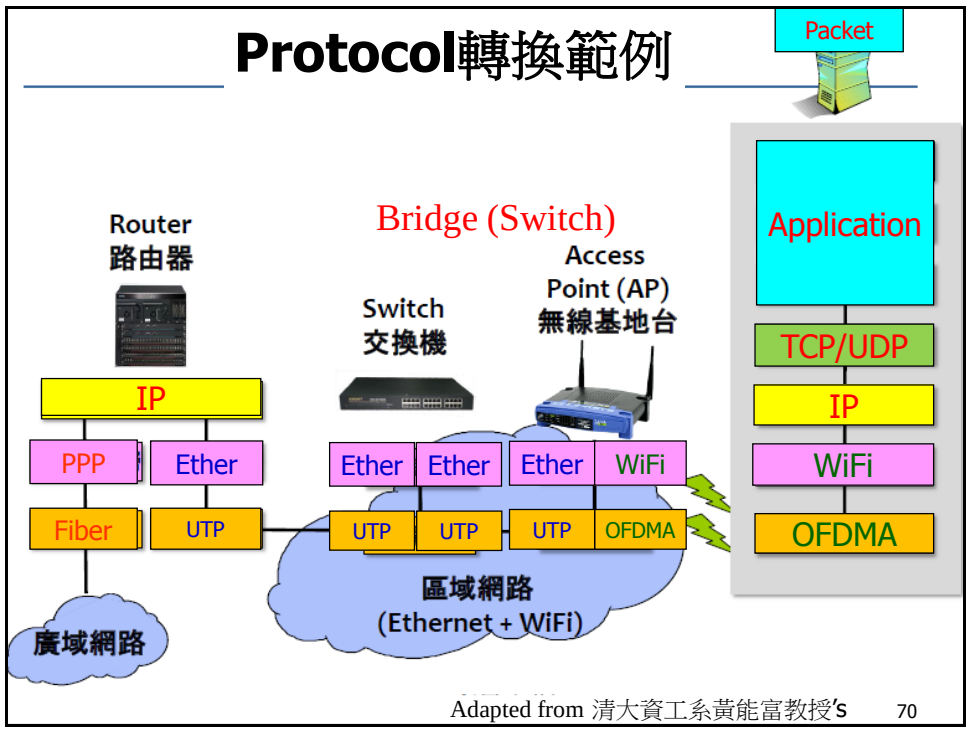
Protocol轉換範例



Adapted from 清大資工系黃能富教授's

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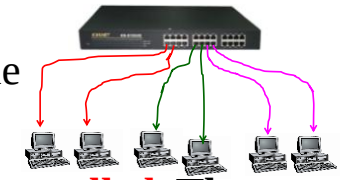
Virtual LAN (VLAN, 虛擬區域網路)

- **Without VLAN, the layer 2 switches/bridges will forward received broadcast and multicast frames to all ports.**
  - Bandwidth wasting issue
  - Security issue



- **Traffic between VLANs is firewalled. The propagation of multicast and broadcast traffic between VLANs is limited.**

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Virtual LAN (VLAN, 虛擬區域網路)

- 將交換器上的連接埠劃分成不同的群組, 當廣播封包在傳送時, 便只會在該連接埠所屬的群組內傳送, 不同群組的連接埠不會收到這個封包, 如此可以減少不必要的干擾。 (Bandwidth wasting issue)
- 將多個交換器分割成不同的群組, 並且限制不同群組間的資料存取權限, 提高管理的安全性。 (Security issue)

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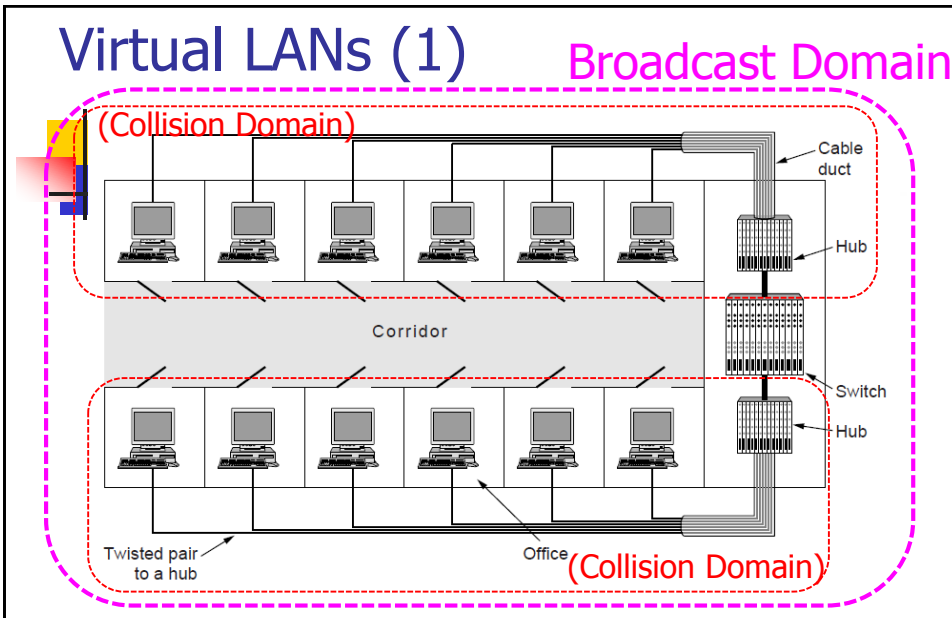
Virtual LANs (1)



A building with centralized wiring using hubs and a switch.

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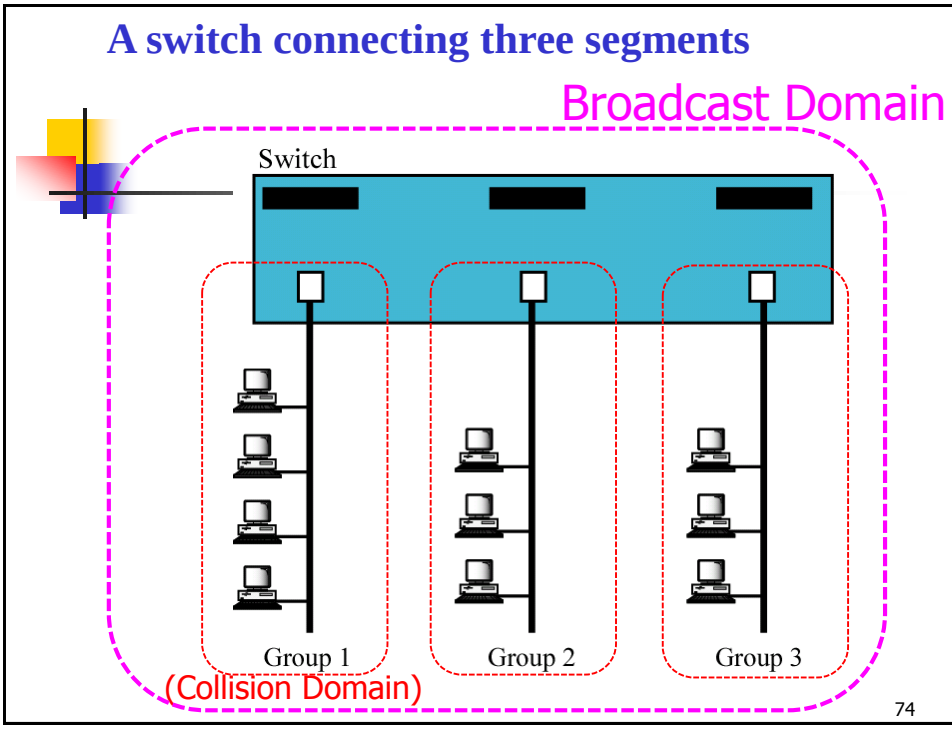
A switch connecting three segments



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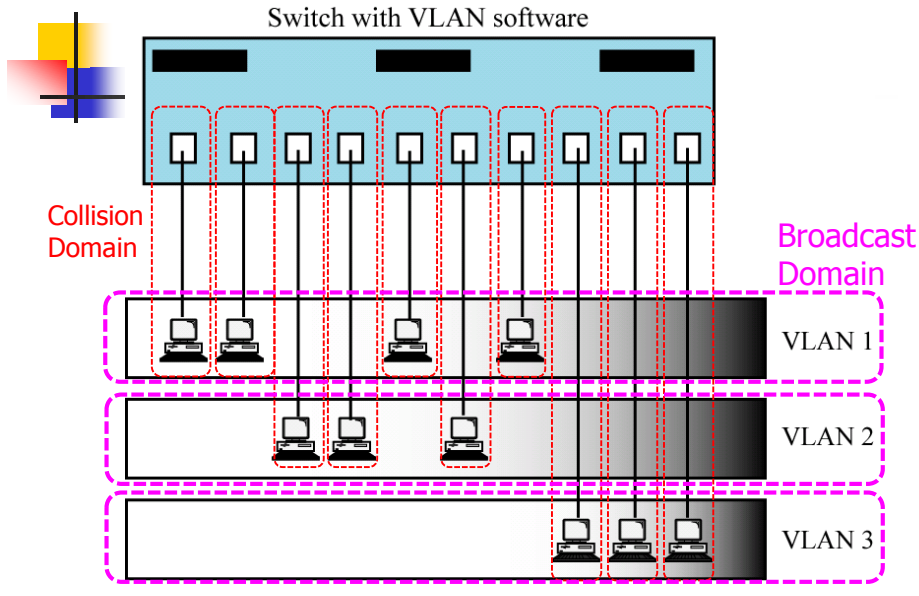
A switch using VLAN software



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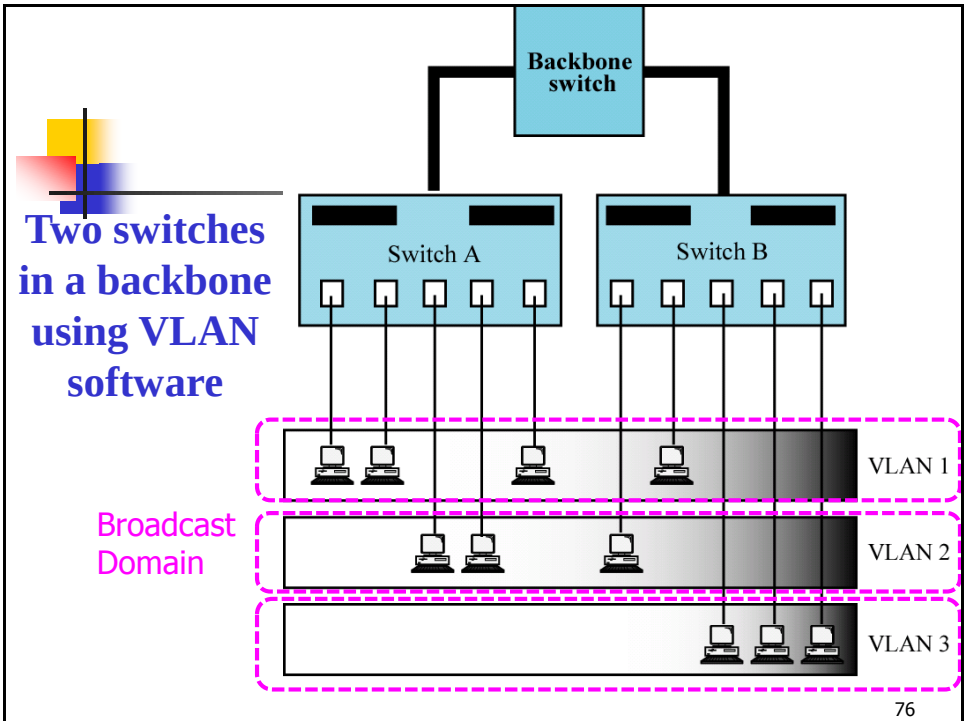
Two switches in a backbone using VLAN software



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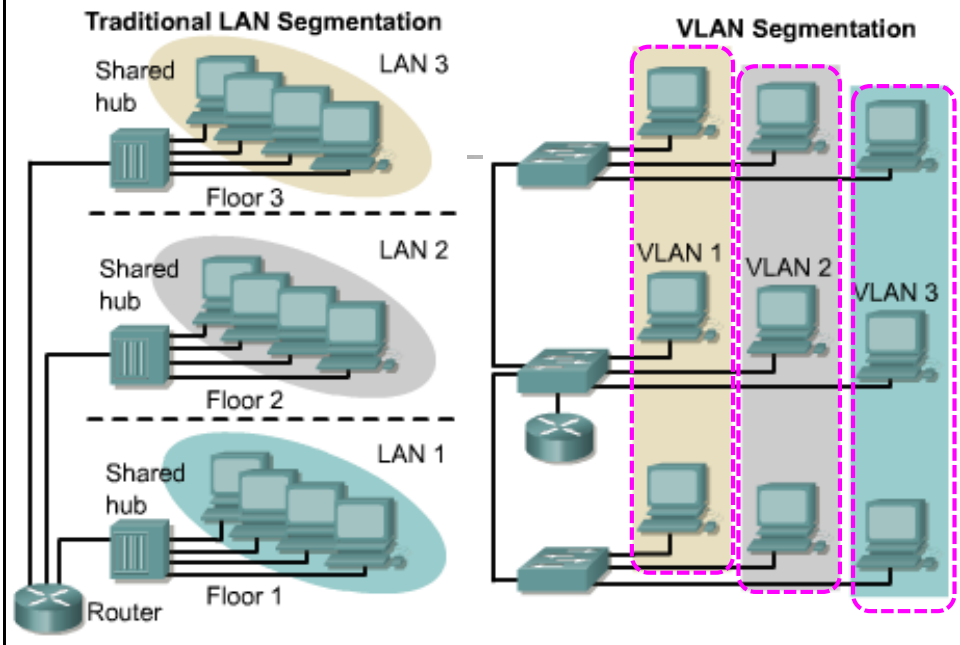
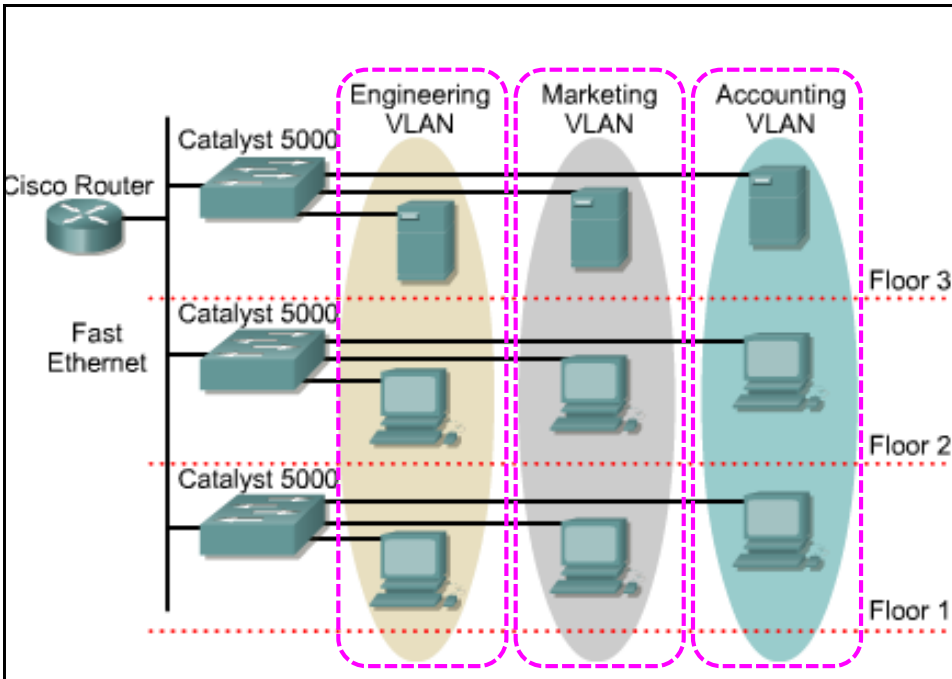


Picture sources by Cisco Systems, Inc. 77



Picture sources by Cisco Systems, Inc. 78

Three methods for VLAN

- **Port centric**
  - Port-based VLAN
  - IEEE 802.1Q
- MAC centric
- Protocol centric (Layer 3)
- IP-subnet based VLAN

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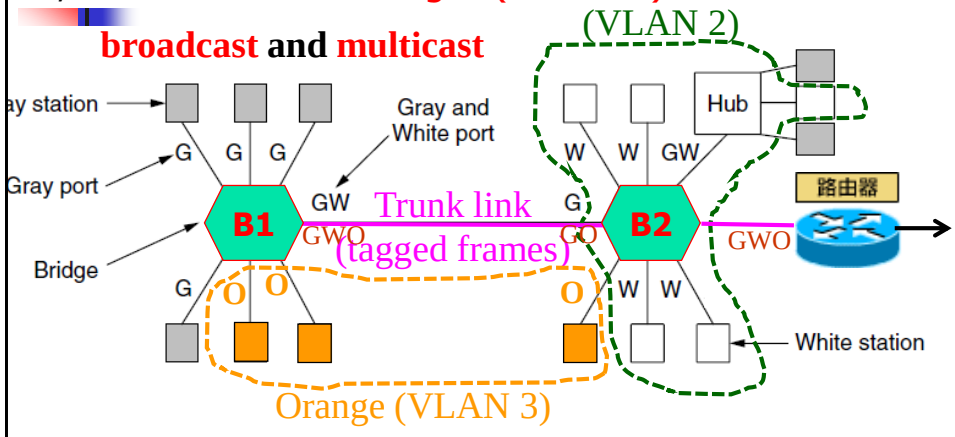
Bridged VLANs

IEEE 802.1Q
Port-based VLAN

B1, B2: VLAN-aware Bridges (Switches)

broadcast and multicast



Two VLANs, gray and white, on a bridged LAN.

(VLAN 1) (VLAN 2)

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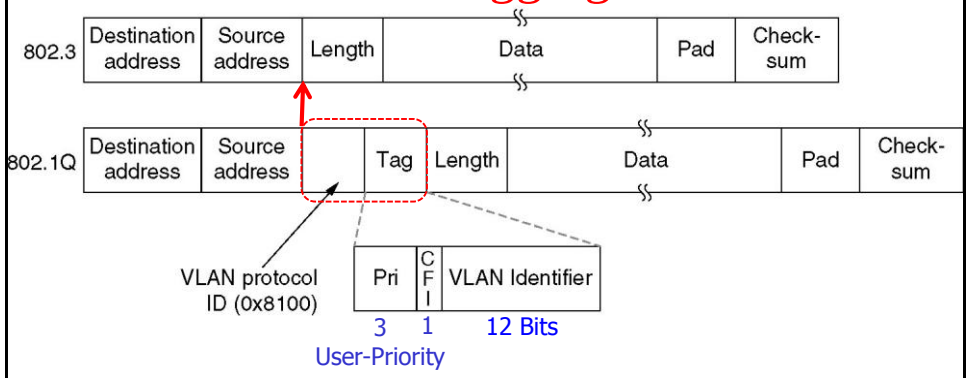
The IEEE 802.1Q Standard (2)

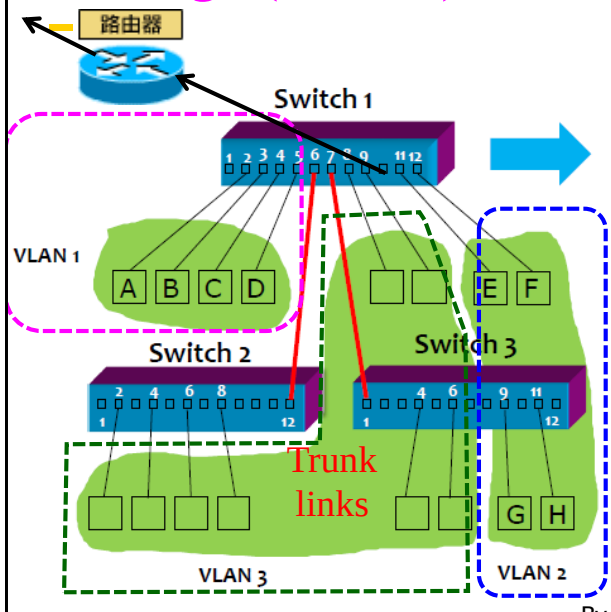
The 802.3 (legacy) and 802.1Q Ethernet frame formats.

Frame tagging



CFI: Canonical Format Indicator

Bridge (Switch) Tables of Switch 1



(FD: Filtering Database)

FD of VLAN 1

MAC Addr	Port	Time (S)
A	2	20
B	3	18
C	4	25
D	5	4

MAC Addr	Port	Time (S)
E	11	20
F	12	18
G	7	25
H	7	4

FD of VLAN 2

FD of VLAN 3

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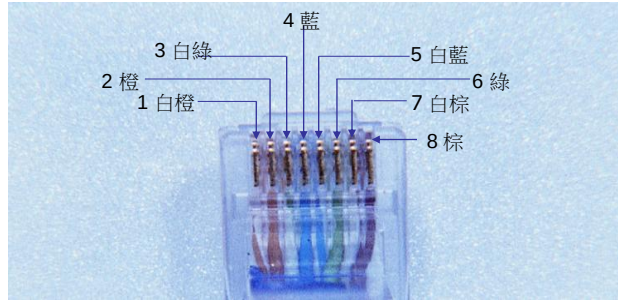
Rollover/ Crossover/ Straight through

UTP line (雙絞線)的顏色

EIA/TIA 568B 的標準雙絞線								
編號	1	2	3	4	5	6	7	8
顏色	白橙	橙	白綠	藍	白藍	綠	白棕	棕



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100 BaseTX 中 網路卡RJ-45 的腳位功能

100 BaseTX 腳位功能表		
腳　　位	功　　用	簡　　稱
1	傳輸資料正極 (Transmit Data+)	Tx+
2	傳輸資料負極 (Transmit Data-)	Tx-
3	接收資料正極 (Transmit Data+)	Rx+
4	未使用	
5	未使用	
6	接收資料負極 (Transmit Data-)	Rx-
7	未使用	
8	未使用	

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交換器或集線器之 RJ-45 插槽的腳位功能

集線器之 RJ-45 插槽的腳位功能表		
腳　位	功　用	簡　稱
1	接收資料正極 (Receive Data+)	Rx+
2	接收資料負極 (Receive Data-)	Rx-
3	傳輸資料正極 (Receive Data+)	Tx+
4	未使用	
5	未使用	
6	傳輸資料負極 (Receive Data-)	Tx-
7	未使用	
8	未使用	

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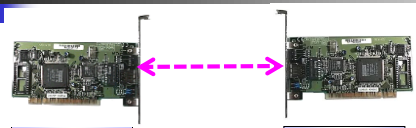
Crossover UTP cable

- 當兩台相同設備相連時, 要讓傳送端與接收端可以正常接通, 就要利用 Crossover 線。



Tx+ 1
Tx- 2
Rx+ 3
Rx- 6

1 Tx+
2 Tx-
3 Rx+
6 Rx-

『傳送端』對上『傳送端』,
『接收端』對上『接收端』,
當然無法傳輸

Tx+ 1
Tx- 2
Rx+ 3
Rx- 6

1 Tx+
2 Tx-
3 Rx+
6 Rx-

『傳送端』對『接收端』,網路就順利成章地接通了

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架設 100 BaseTX 網路

現代**Switch**通常具有

- Auto detection: 線路腳位自動切換功能
- Auto negotiation: 10/100/1000M/10Gbps速度協商

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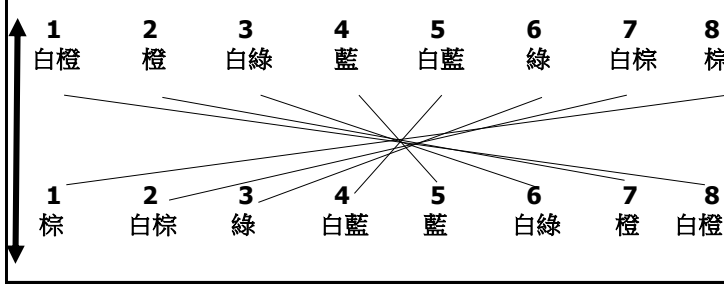
主控台纜線(Rollover) for switches/routers

- 這條纜線是用來連接電腦到路由器(Router)或交換器(Switch)，用以管理及設定。

Console port (management)



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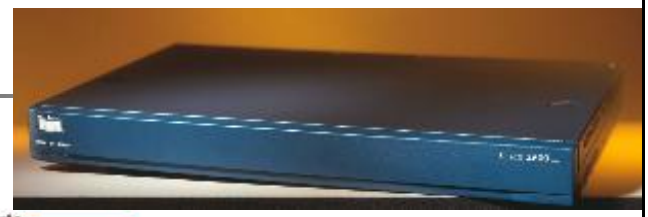
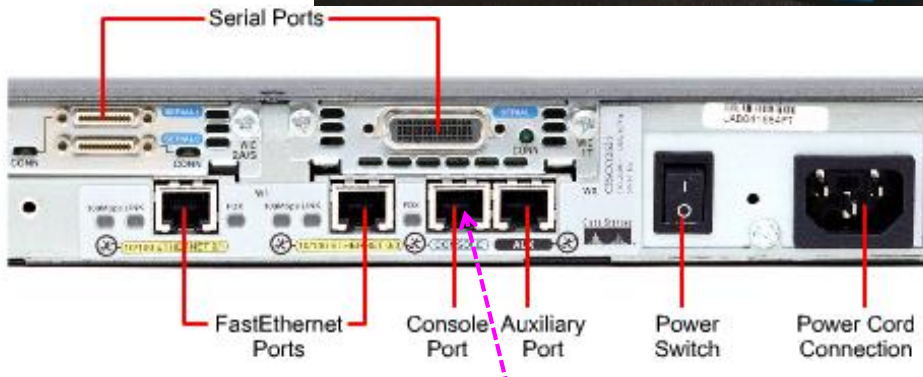
Cisco 2600 router





Picture sources by Cisco Systems, Inc.

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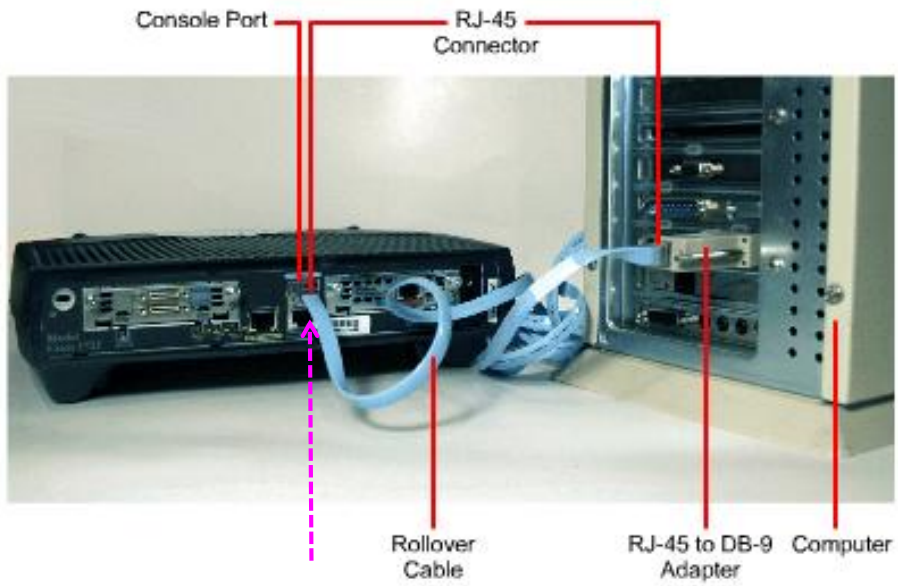
Terminal console connection

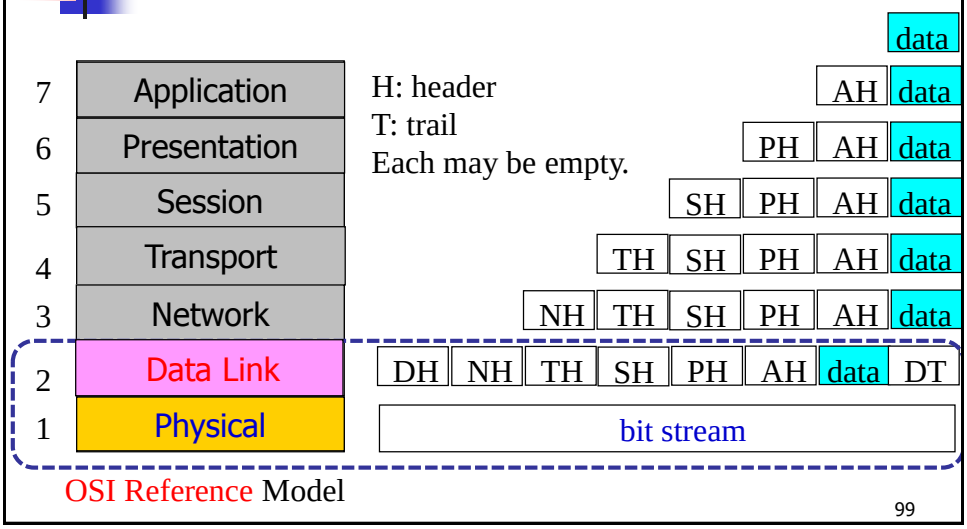


Picture sources by Cisco Systems, Inc.

The Data Link & Physical Layers

IEEE 802.1D Spanning Tree Algorithm

IEEE 802.1Q Virtual LAN



OSI Reference Model

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End of Chapter 4-2

Questions?

Thank you!