Chapter 4-2
Bridge, Switch, VLAN

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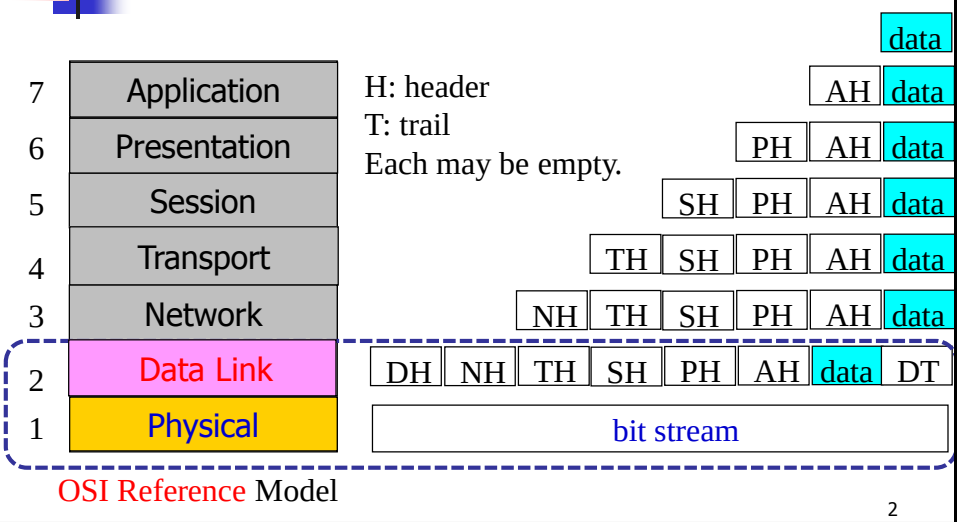
Adapted from Computer Networks,
Andrew S. Tanenbaum, Vrije University, Netherlands
& Computer Networking: A Top Down Approach,
Jim Kurose, Keith Ross & 計算機網路概論,清大資工黃能富教授

Computer Networks, Fifth Edition by Andrew Tanenbaum and David Wetherall, © Pearson Education-Prentice Hall, 2011

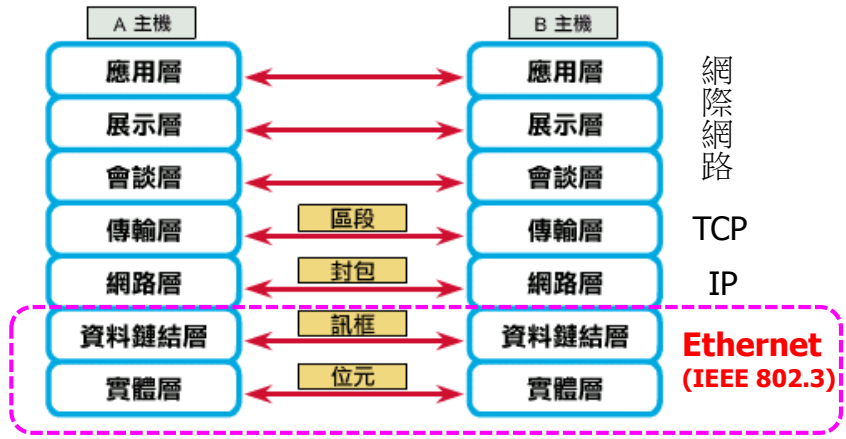
The Data Link & Physical Layers



OSI Reference Model

LAN (cont.)

- 對等式通訊(Peer-to-Peer)

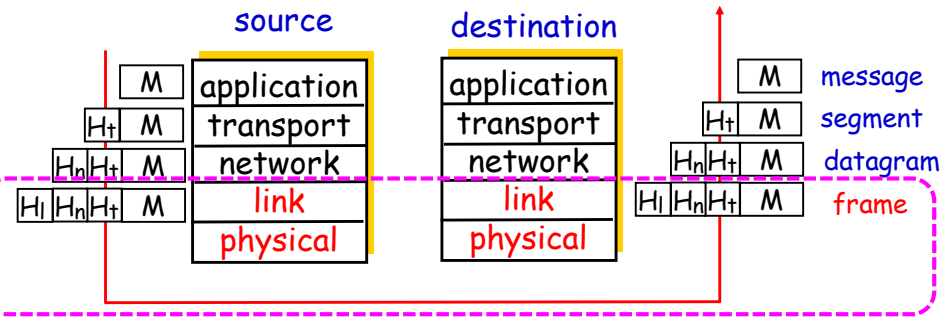


3

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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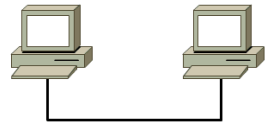
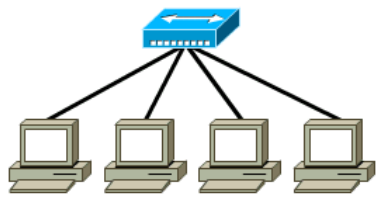
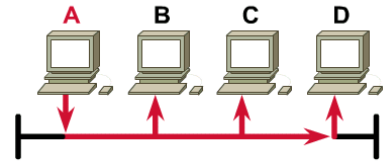
LAN的建構

- 最小的區域網路: 二個節點



- 集線式網路





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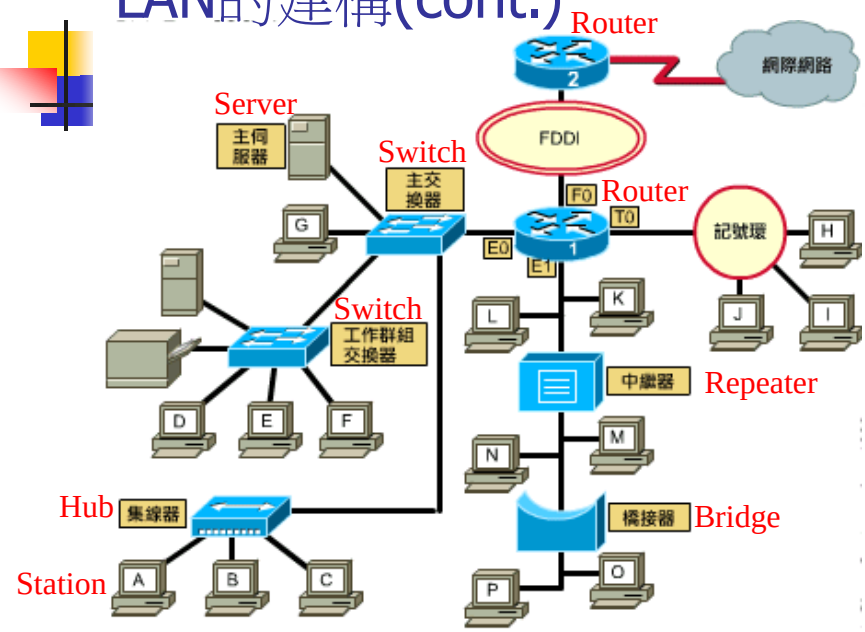
LAN的建構(cont.)



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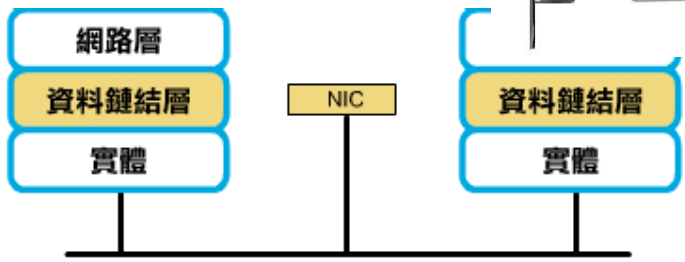
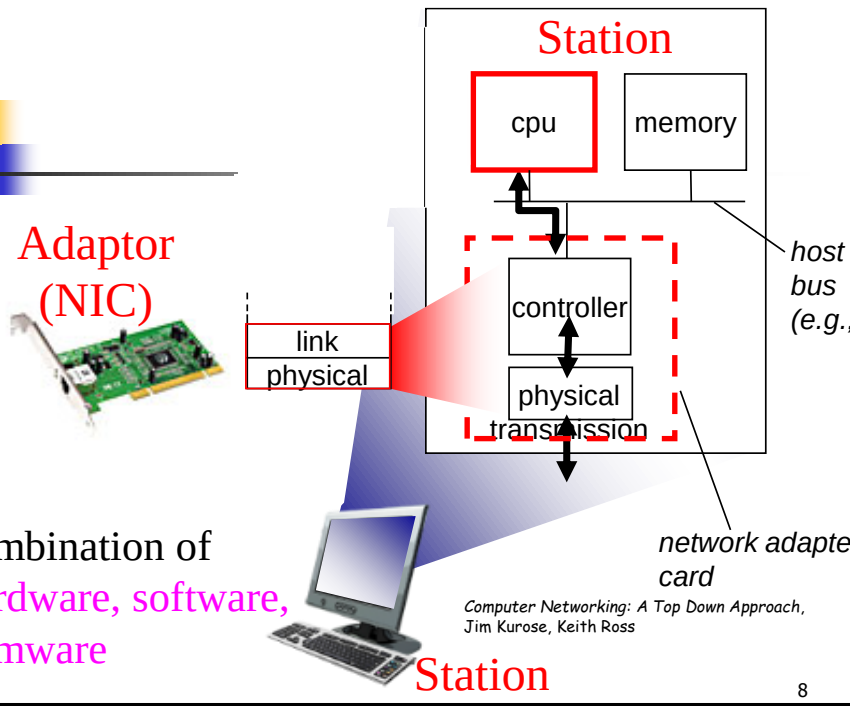
網路介面卡 Adaptor (network interface card, NIC):

- 每張網路卡都有一個唯一的硬體位址，叫做MAC位址

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



7



- combination of hardware, software, firmware

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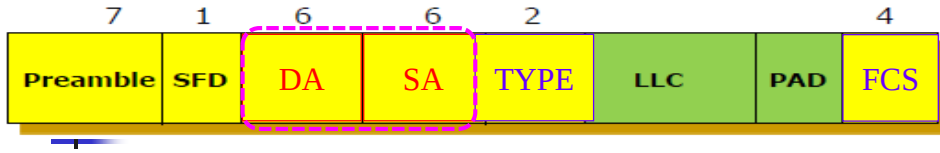
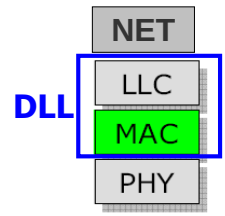
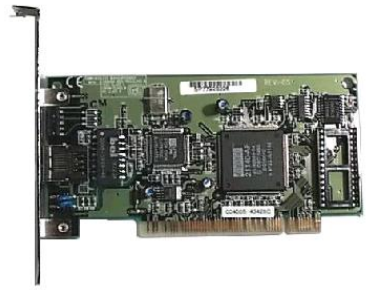
Ethernet Frame Format



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





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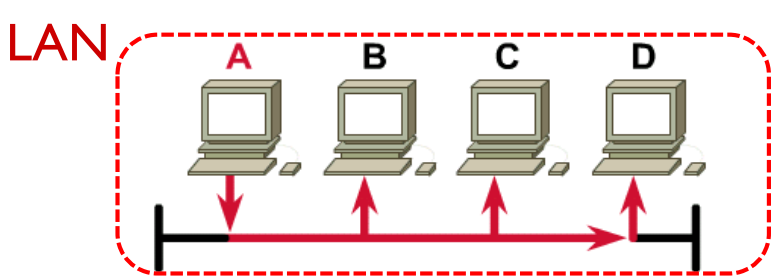
Ethernet(乙太網路): LAN

- 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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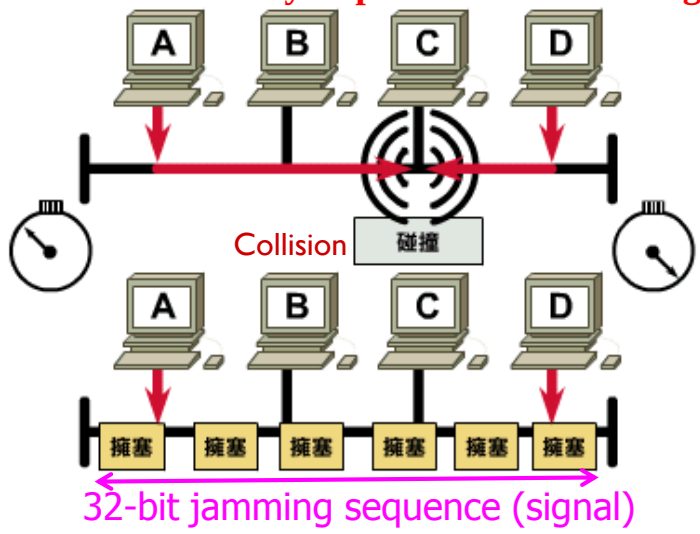
Ethernet MAC Sublayer Protocol

- 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*us*** (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(公平)
3. 網路最大長度約2500公尺

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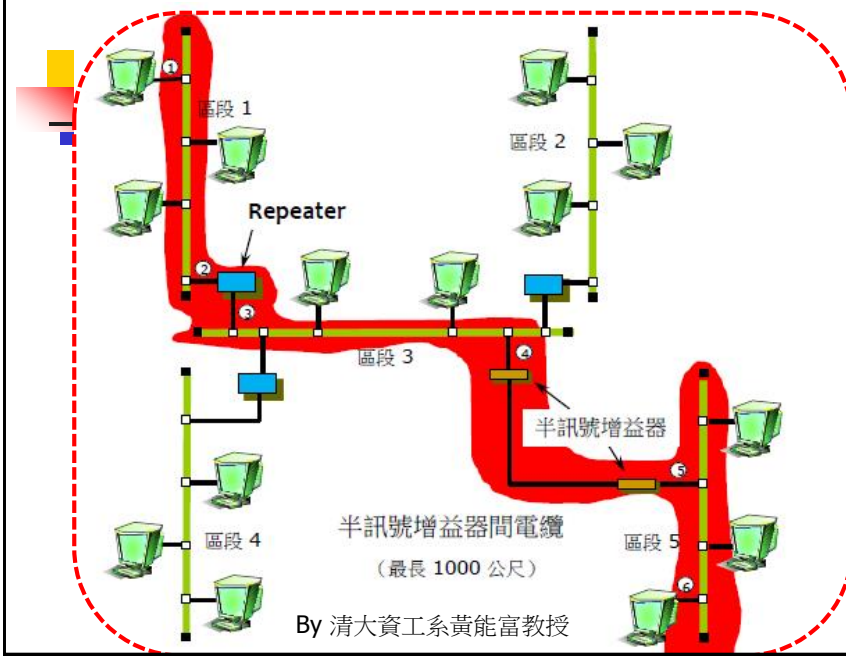
LAN



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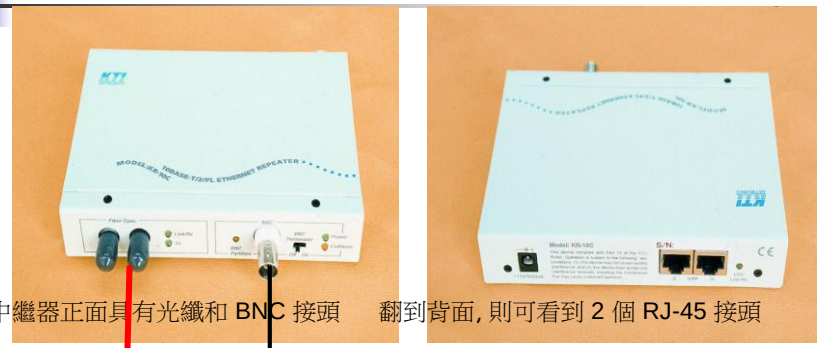
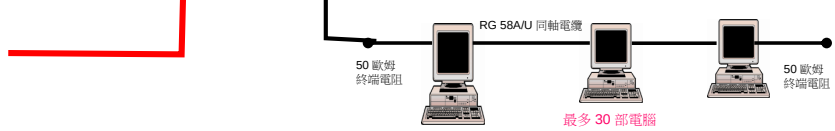
Repeater(中繼器)

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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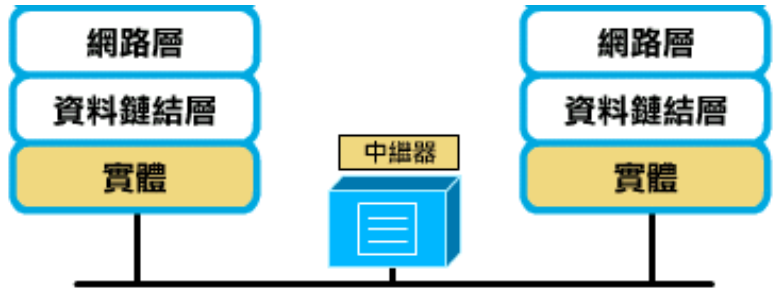
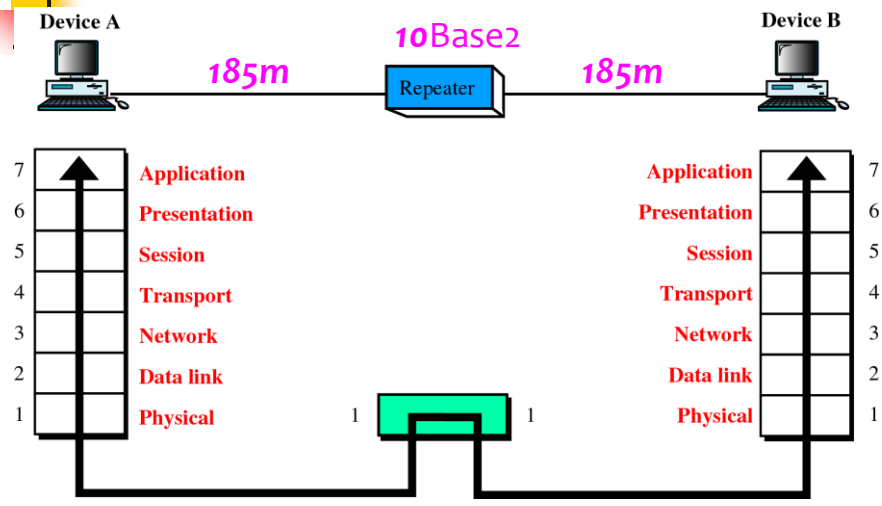
中繼器(Repeater): Layer 1 device

- Coax.同軸電纜最大長度限制185, 500m
- UTP 纜線的最大長度限制100 公尺
- 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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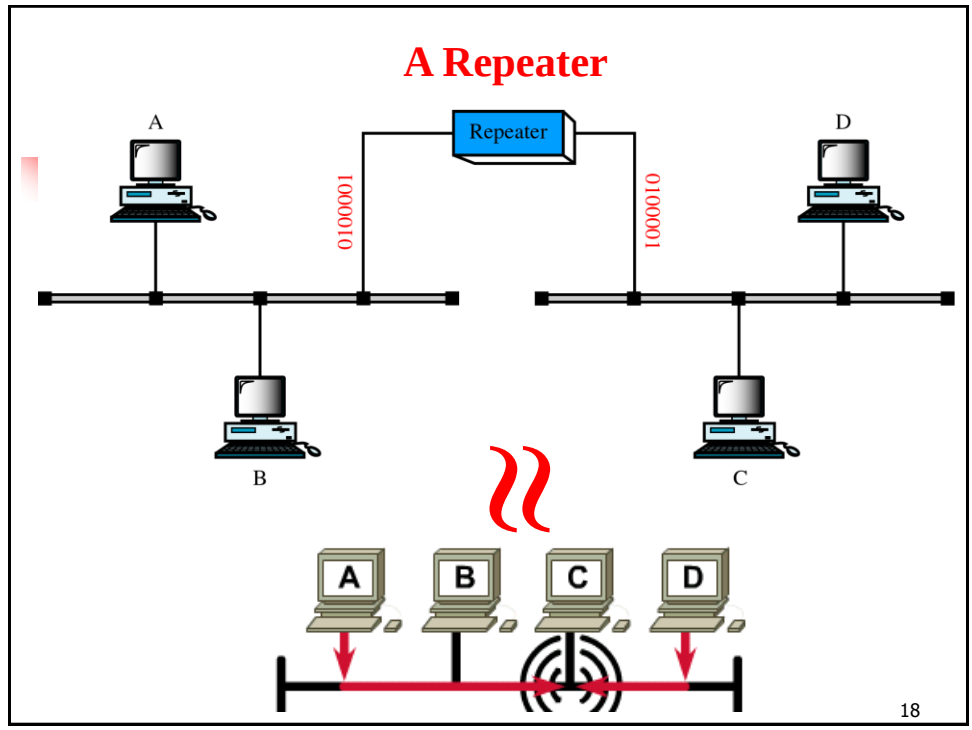
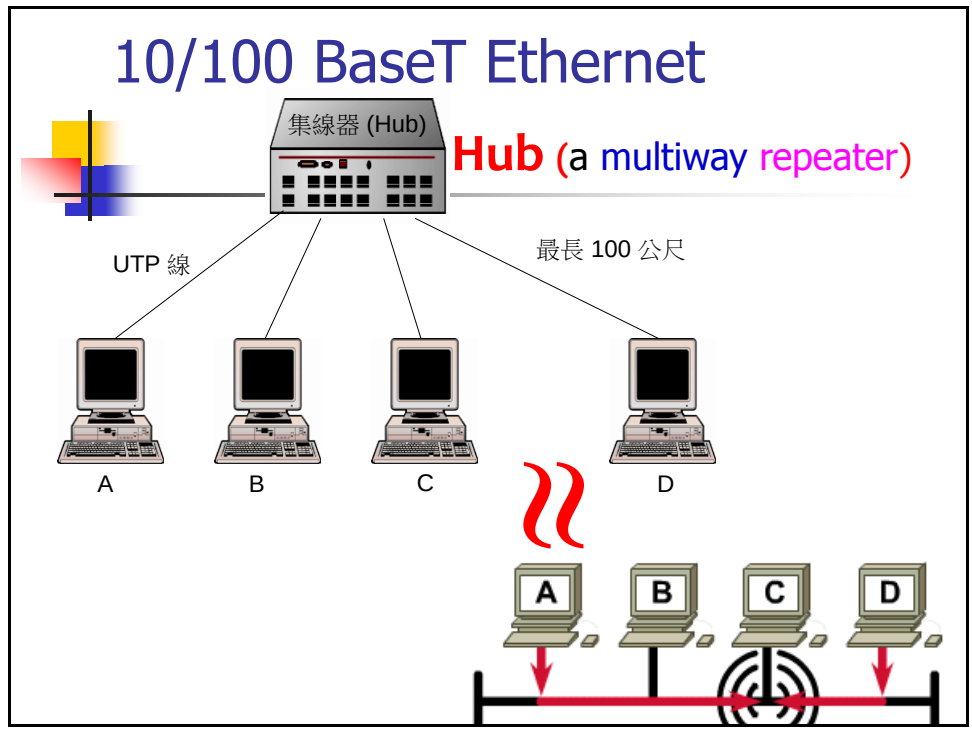

A Repeater
A
Repeater
D
0100010
1000010
B
C
A
B
C
D
18


10/100 BaseT Ethernet
集線器 (Hub)
Hub (a multiway repeater)
UTP 線
最長 100 公尺
A
B
C
D
A
B
C
D

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(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)

- 僅由第一層設備所連結之網路屬相同碰撞領域。
- 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)
- 10Mbps Ethernet同一碰撞領域任兩節點距離需<2500公尺, 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<250公尺

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橋接器(Bridge): Layer 2 device

- 為連接兩個 LAN 區段而設計
- 根據MAC位址過濾 LAN 的資料流量
- 碰撞領域之分割(頻寬不分享)

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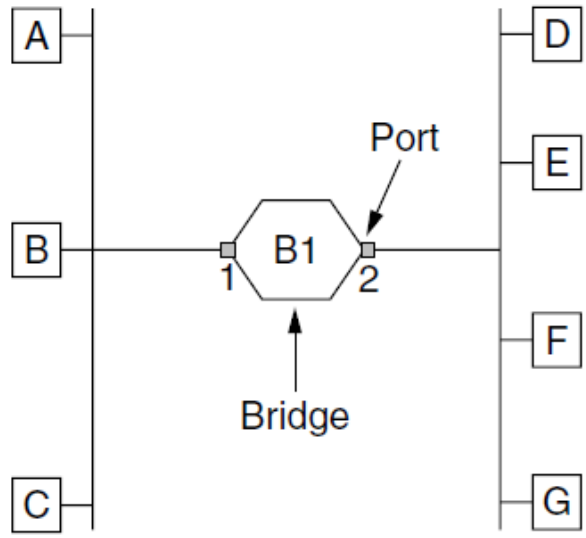
Bridge (1)



Bridge connecting two multidrop LANs

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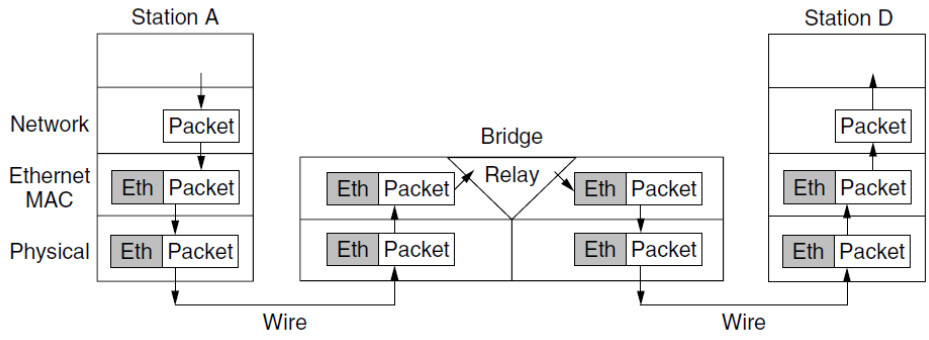
Bridge (2)



Protocol processing at a bridge.

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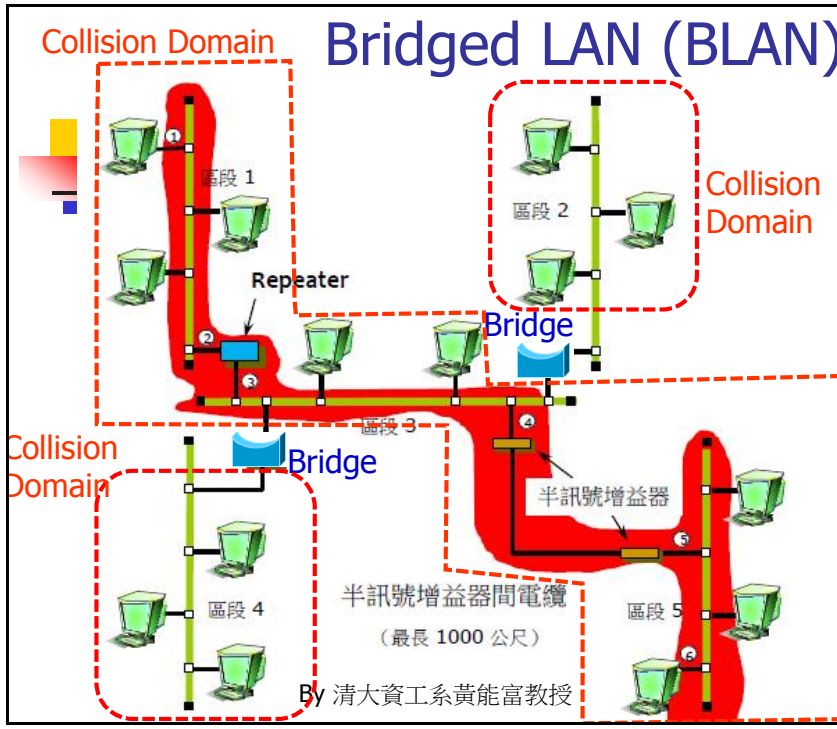
Bridged LAN (BLAN)



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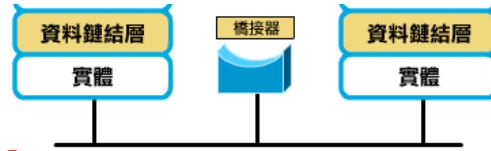
Basic Functions of a Bridge



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

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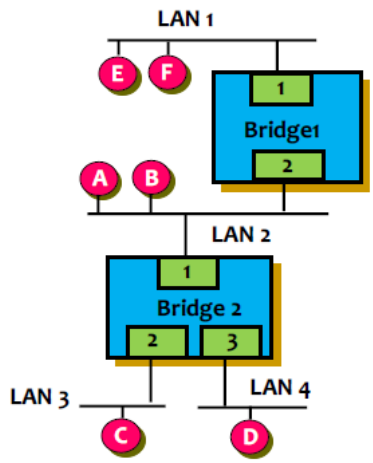
Bridge Table Examples

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

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

300 sec.

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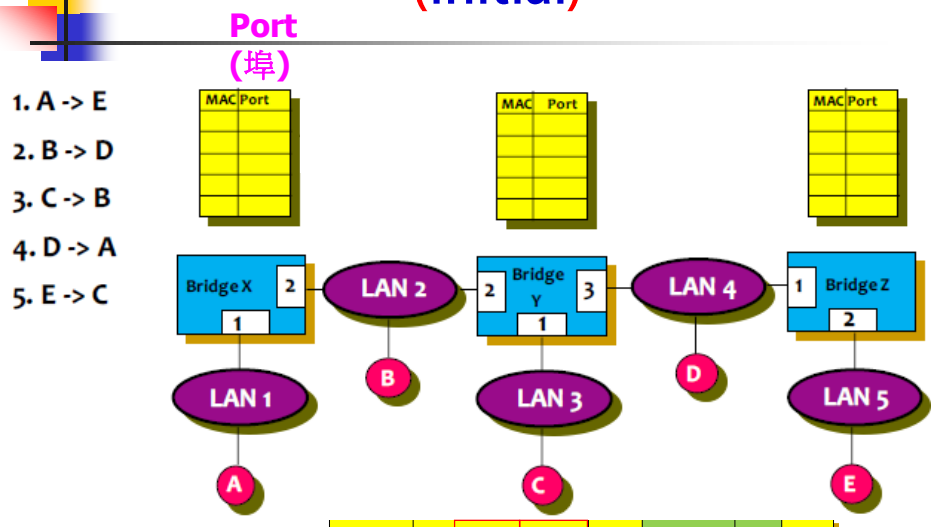
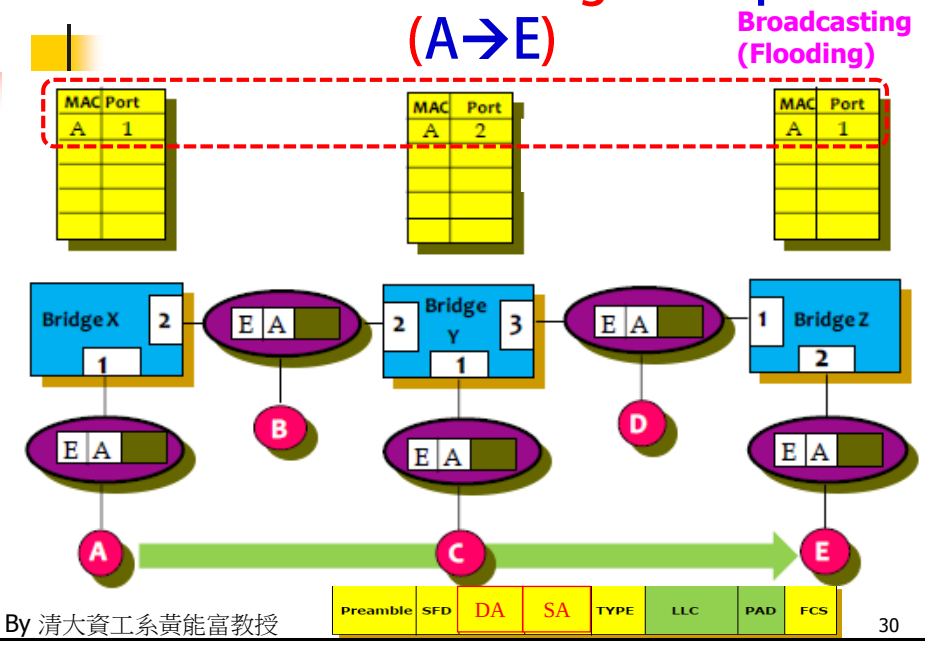
Addresses Learning Example (Initial)

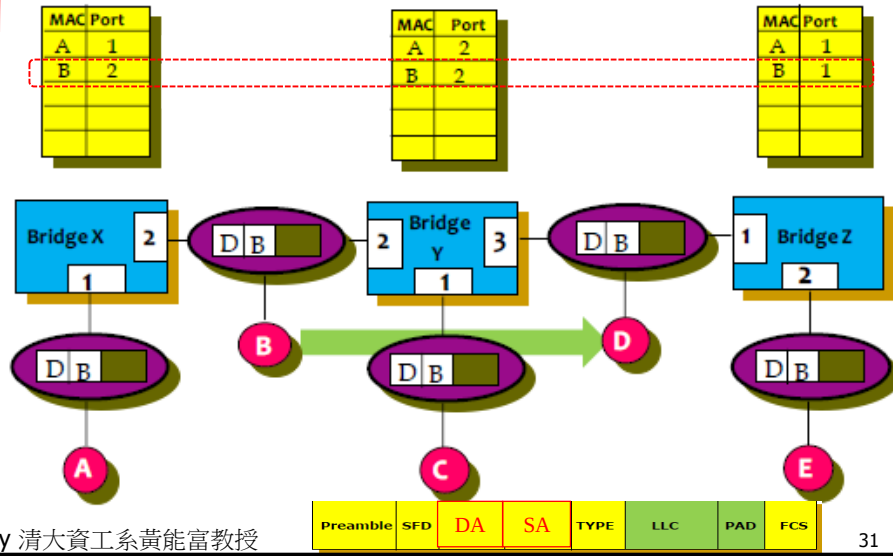


Addresses Learning Example (A→E)



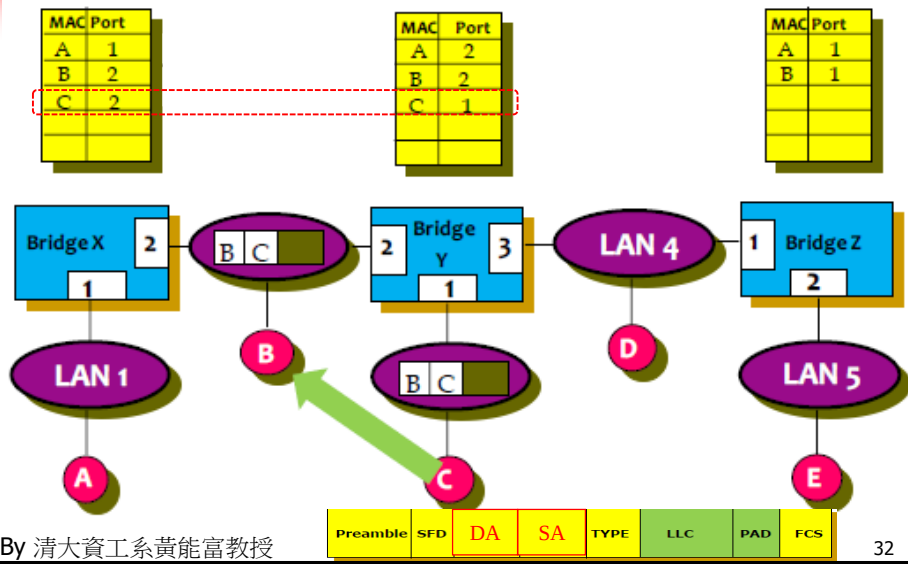
Addresses Learning Example (B→D)

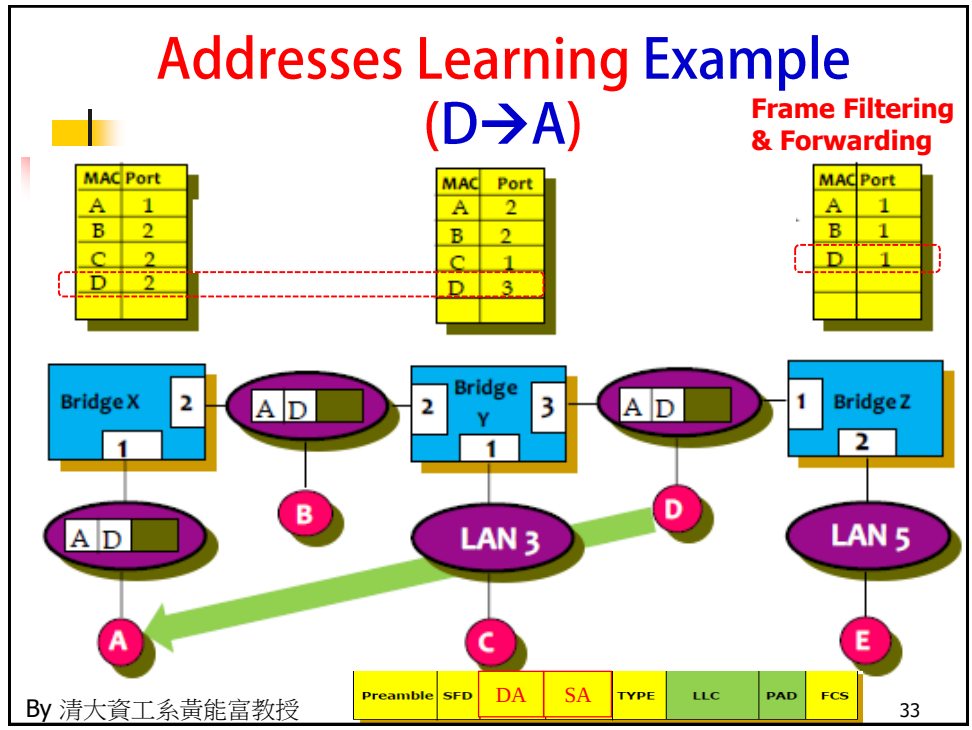
Broadcasting (Flooding)



Addresses Learning Example (C→B)

Frame Filtering & Forwarding




Addresses Learning Example
(D→A)
Frame Filtering
& Forwarding
MAC Port
A 1
B 2
C 2
D 2
MAC Port
A 2
B 2
C 1
D 3
MAC Port
A 1
B 1
D 1
Bridge X
Bridge Y
Bridge Z
A D
LAN 3
LAN 5
A
B
C
D
E
Preamble SFD DA SA TYPE LLC PAD FCS
By 清大資工系黃能富教授
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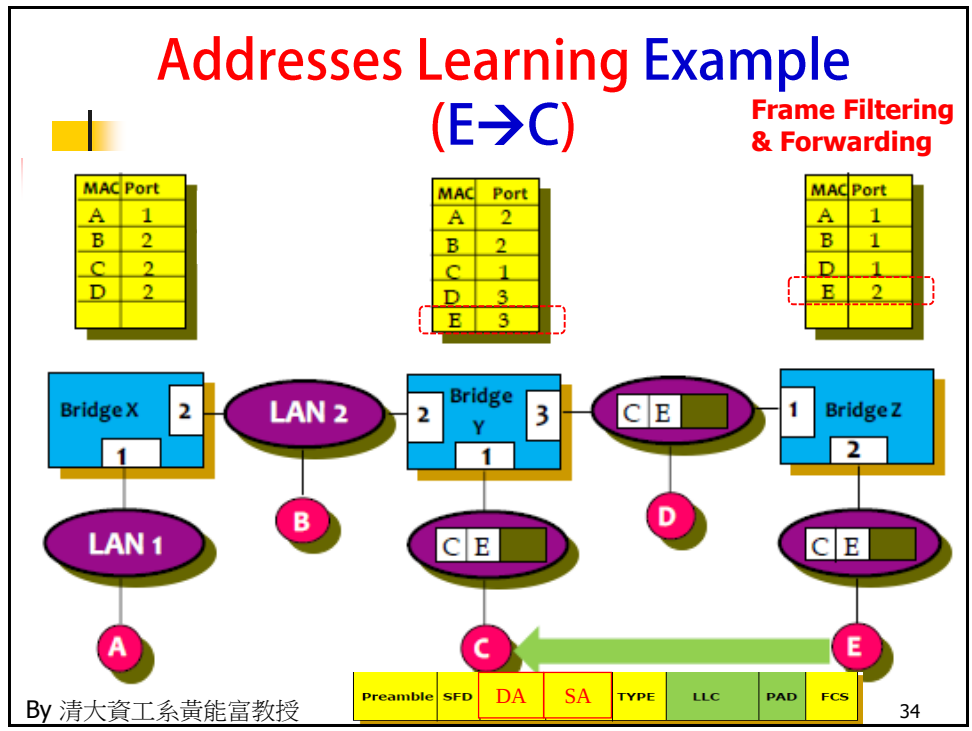
Addresses Learning Example
(E→C)
Frame Filtering
& Forwarding
MAC Port
A 1
B 2
C 2
D 2
MAC Port
A 2
B 2
C 1
D 3
E 3
MAC Port
A 1
B 1
D 1
E 2
Bridge X
Bridge Y
Bridge Z
LAN 1
LAN 2
C E
A
B
C
D
E
Preamble SFD DA SA TYPE LLC PAD FCS
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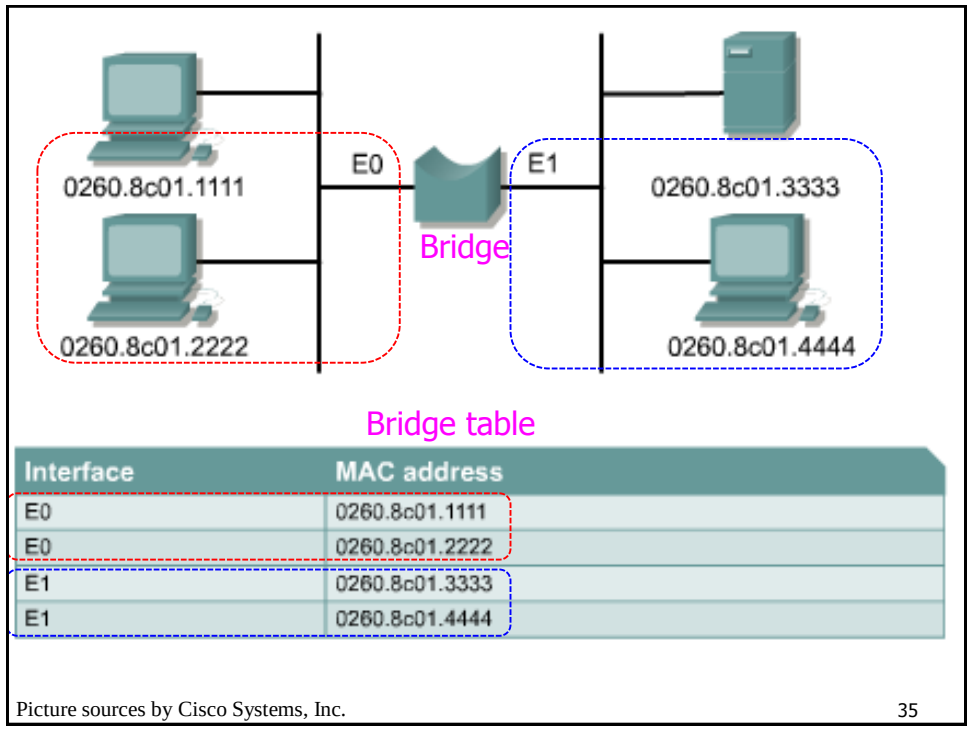
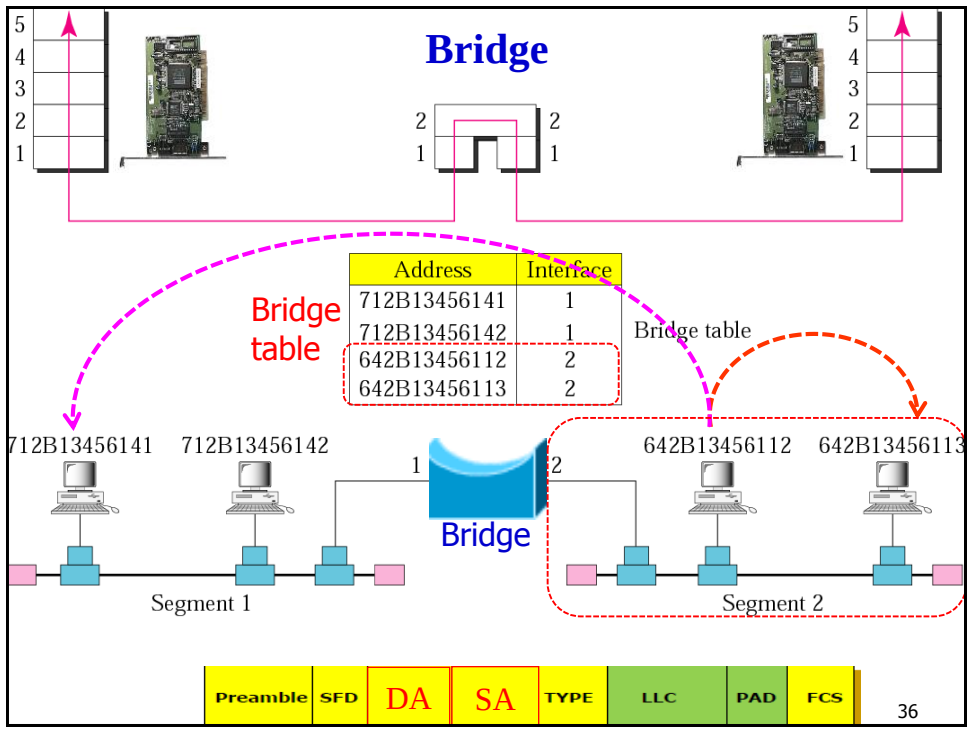


Bridge table

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. 35



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碰撞領域之分割

- 使用第二層設備(橋接器、交換器)
  - 過濾MAC位址(**Frame Filtering**)
- 可解決以下問題:
  - 頻寬分享(不浪費)
  - 安全議題(Security)

Bridge

Switch

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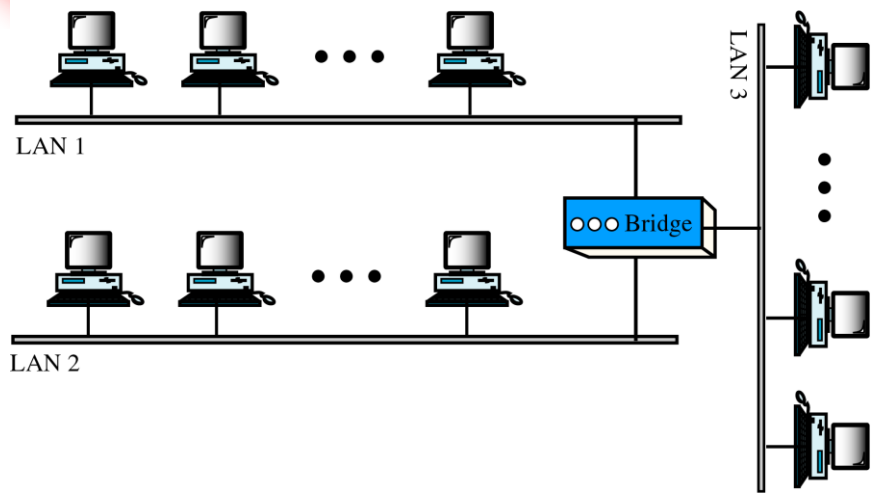
Multiport Bridge (Switch)



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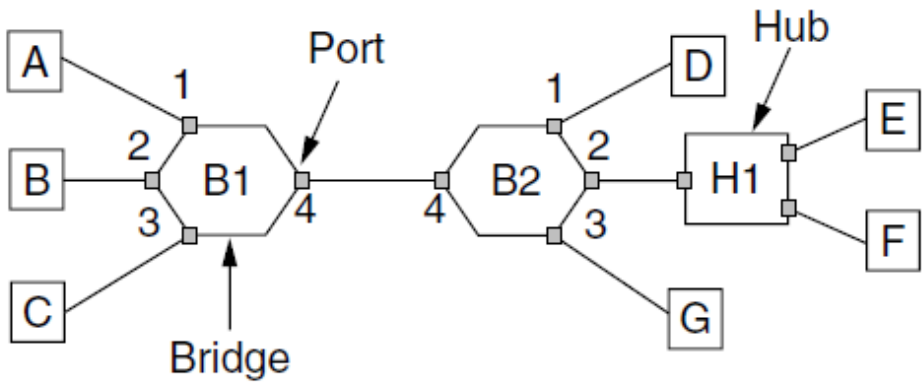
Bridges (2)

Multiport Bridge



Bridges (and a hub) connecting seven point-to-point stations.

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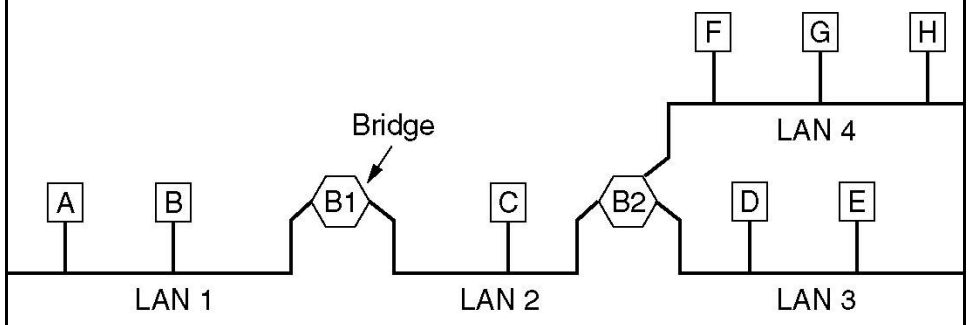
Local Internetworking

A configuration with four LANs and two bridges.



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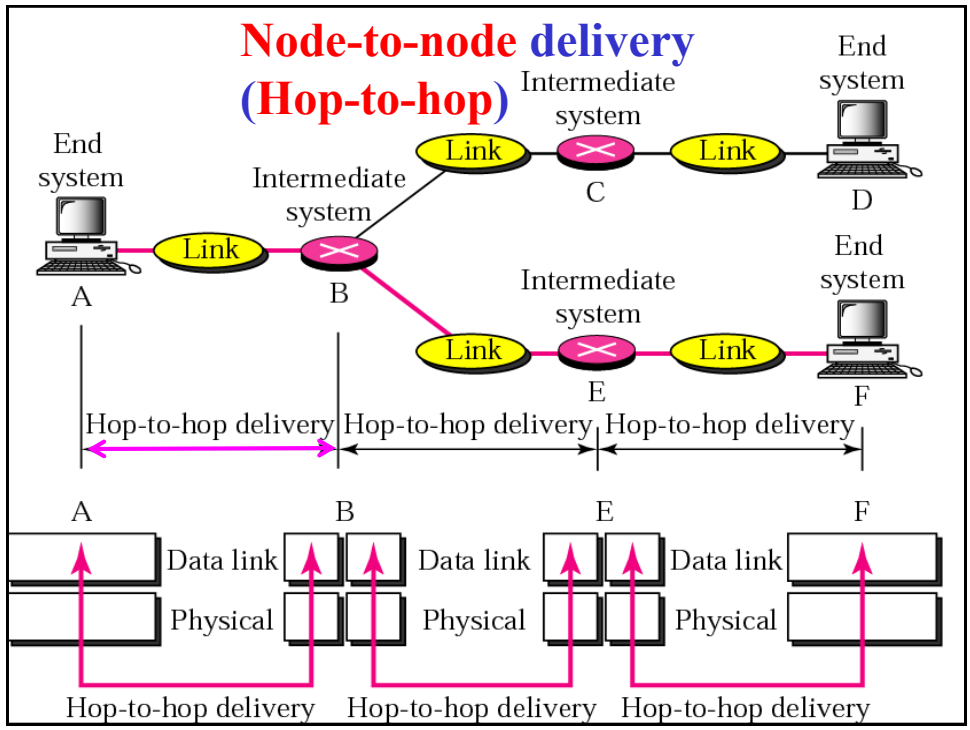

交換器(Switch): Layer 2 device

- 多埠式橋接器(A **Multiport Bridge**)
- **碰撞**領域之分割(頻寬不分享)
- 提高區域網路效率

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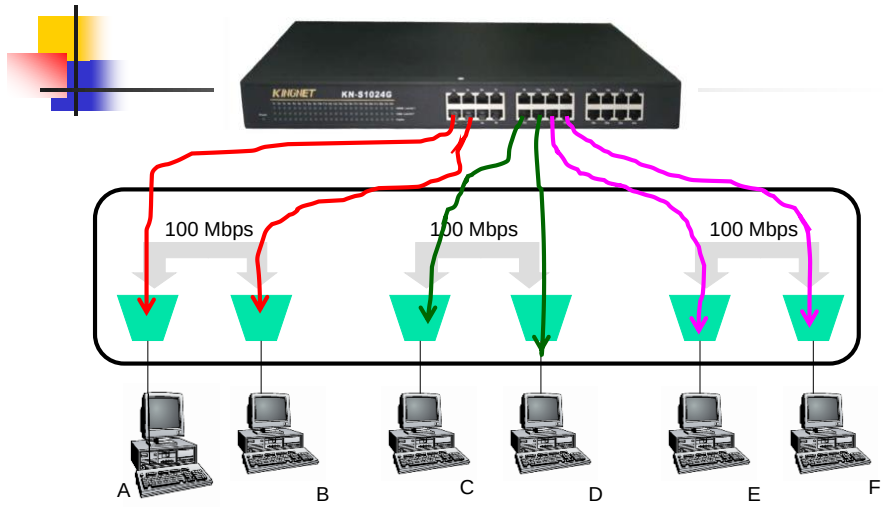
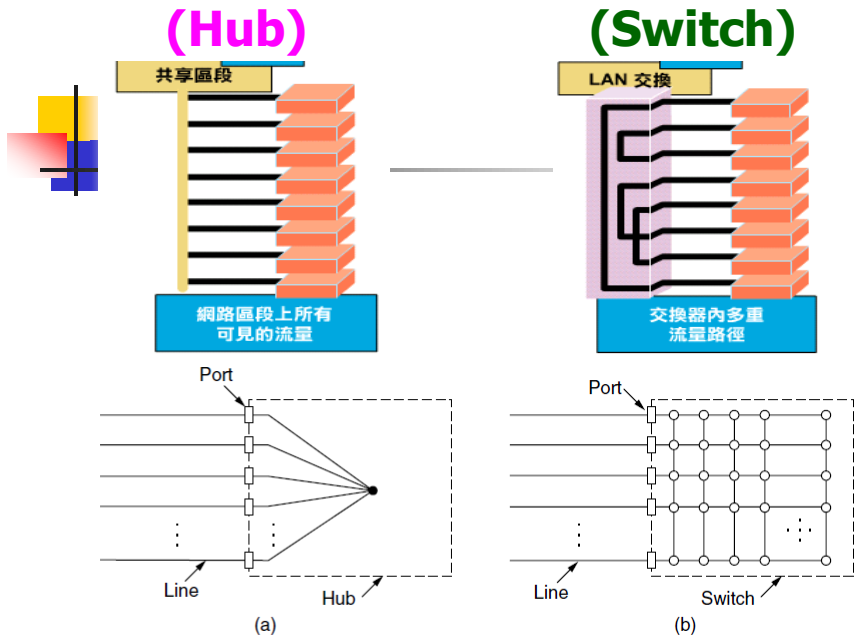
認識第 2 層交換器



6 Port 100 Mbps 交換器最多可擁有 300 Mbps 的頻寬

43



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

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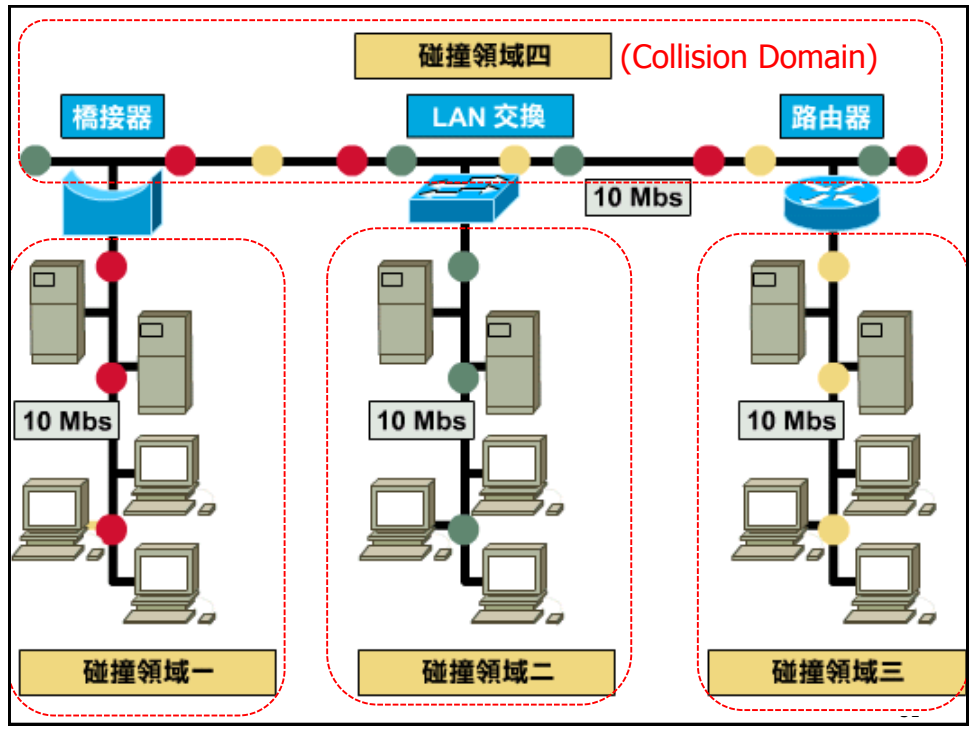

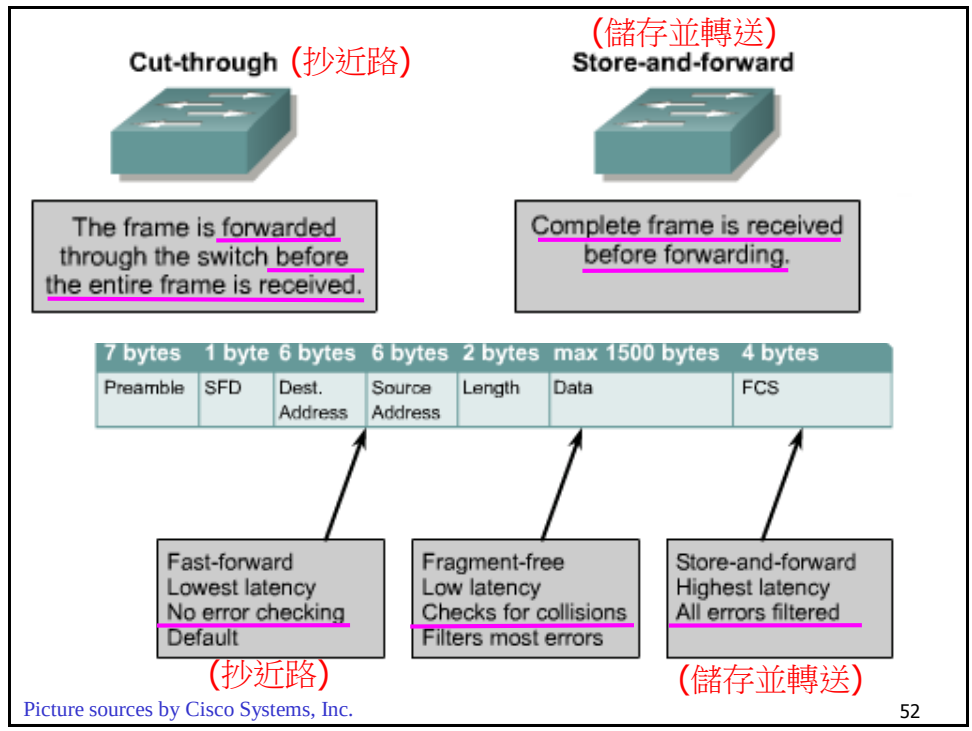

Picture sources by Cisco Systems, Inc.

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網路規劃

- **碰撞**領域(Collision Domain)
  - 僅由第一層設備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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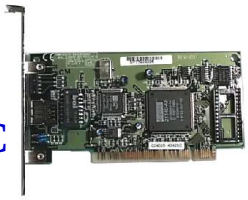
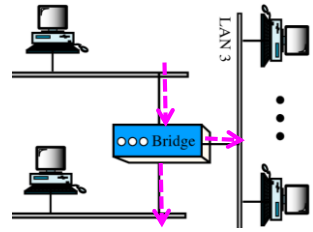
Ethernet Addresses



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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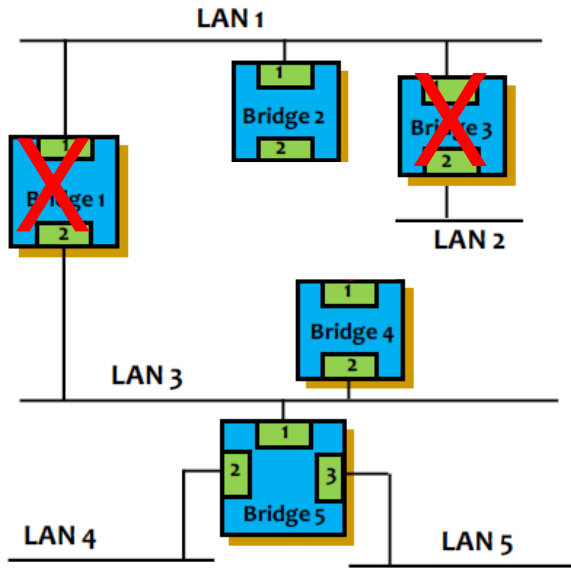
Network reliability

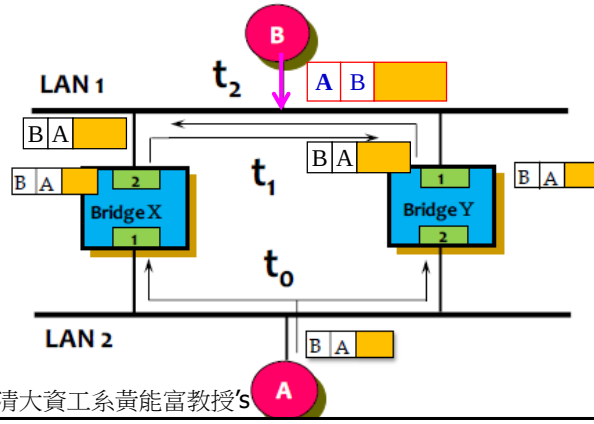


Loops!

By 清大資工系黃能富教授

Loop Problems and Resolution

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



Bridge table (Switch table)

MAC	Port
A	2
B	2

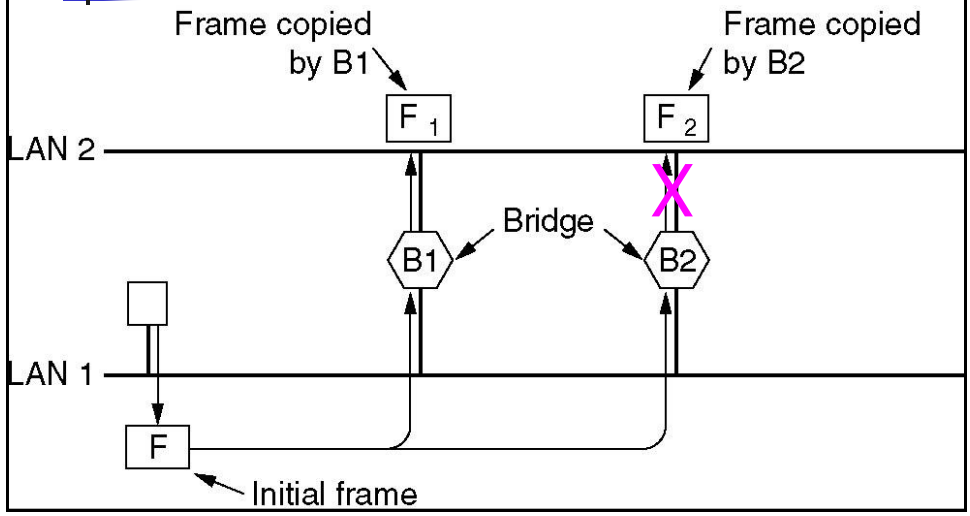
Bridge table (Switch table)

MAC	Port
A	1
B	1

Adapted from 清大資工系黃能富教授's

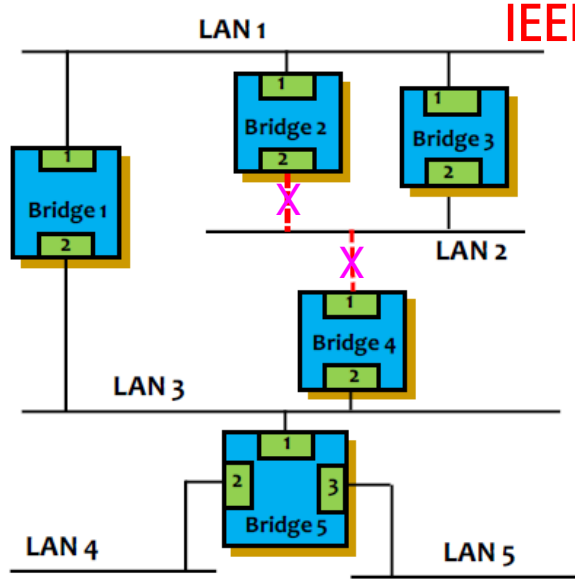
Spanning Tree Bridges

Two parallel transparent bridges.



Spanning Tree Algorithm

IEEE 802.1D



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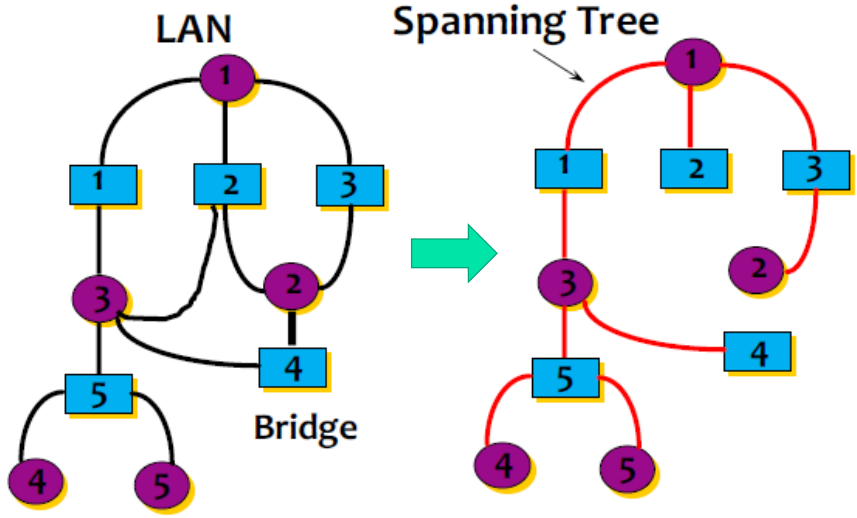
Spanning Tree Algorithm

IEEE 802.1D



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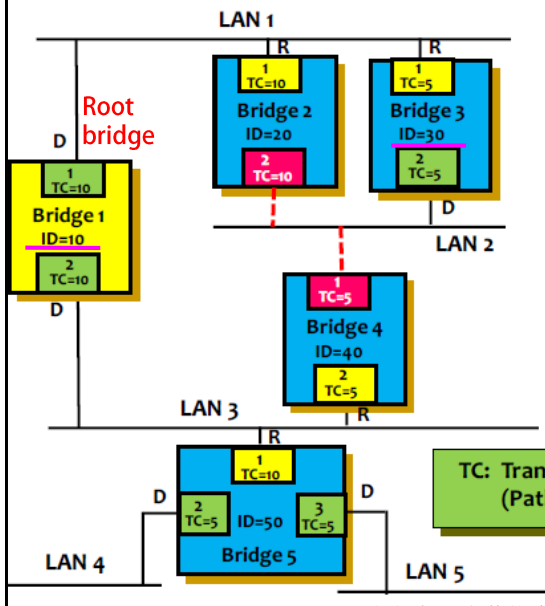
IEEE 802.1D



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

TC: Transmission Cost (Path cost) PC

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

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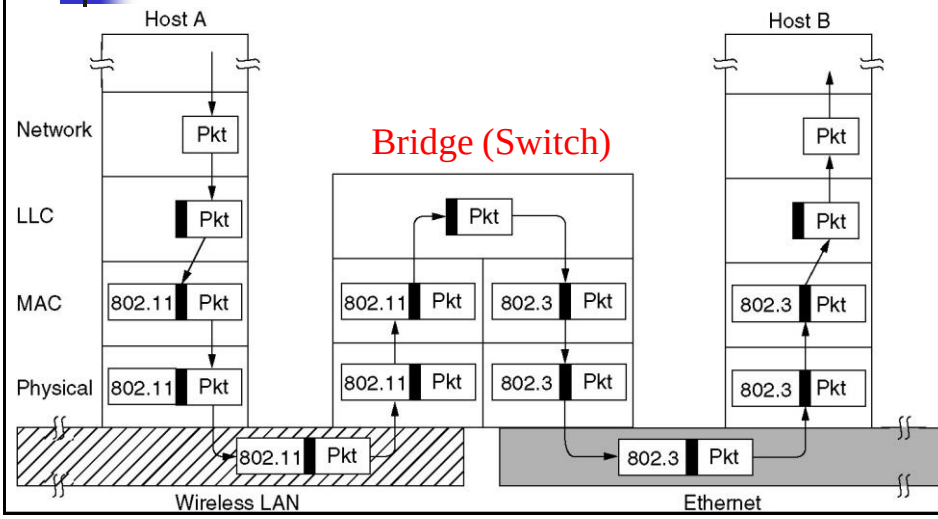
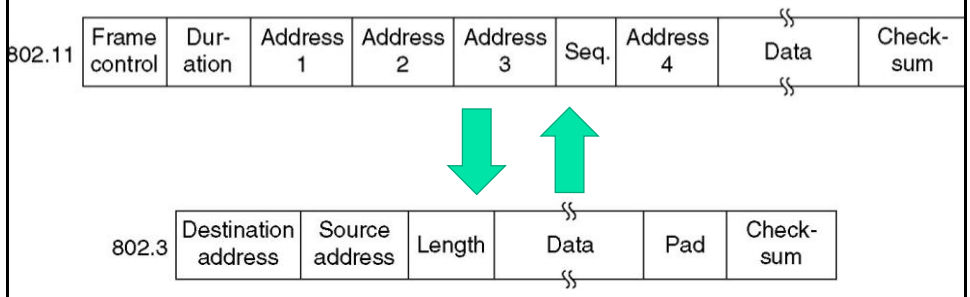
Bridges from 802.x to 802.y

Operation of a LAN bridge from 802.11 to 802.3.



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

The IEEE 802 frame formats. The drawing is not to scale.



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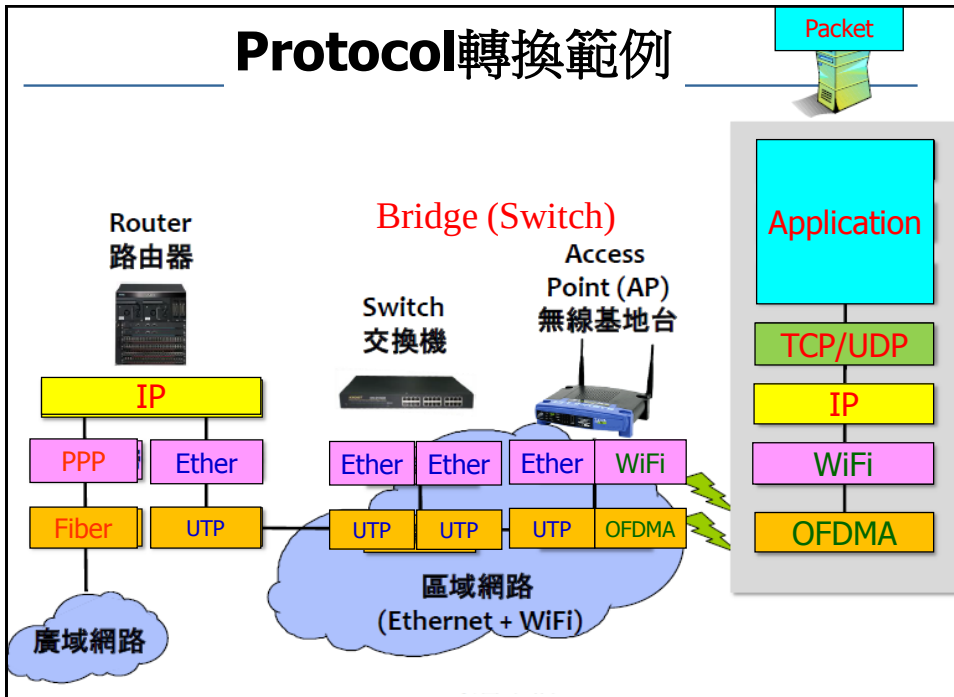
Protocol轉換範例



Adapted from 清大資工系黃能富教授's

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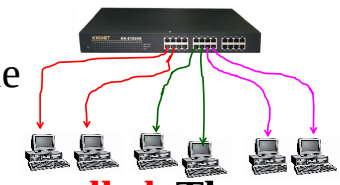
Virtual LAN (VLAN, 虛擬區域網路)

- **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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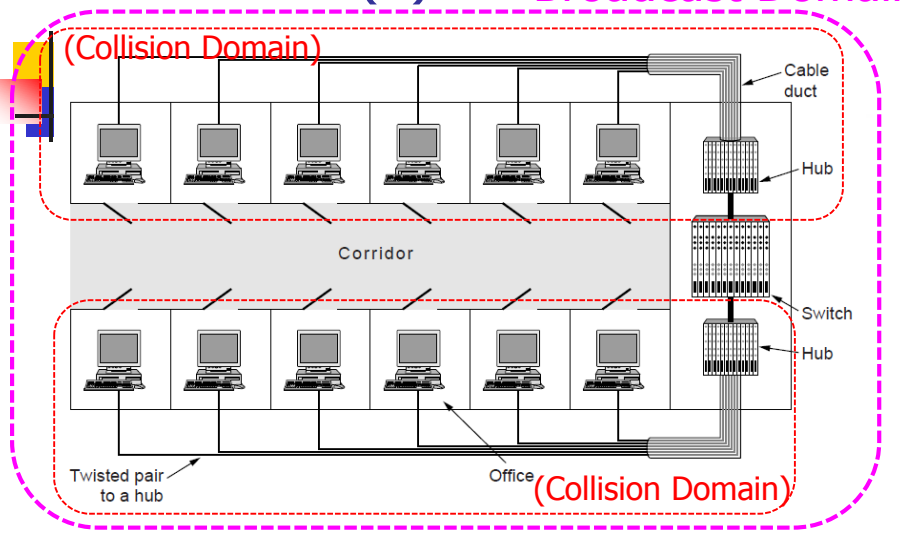
Virtual LANs (1)



A building with centralized wiring using hubs and a switch.

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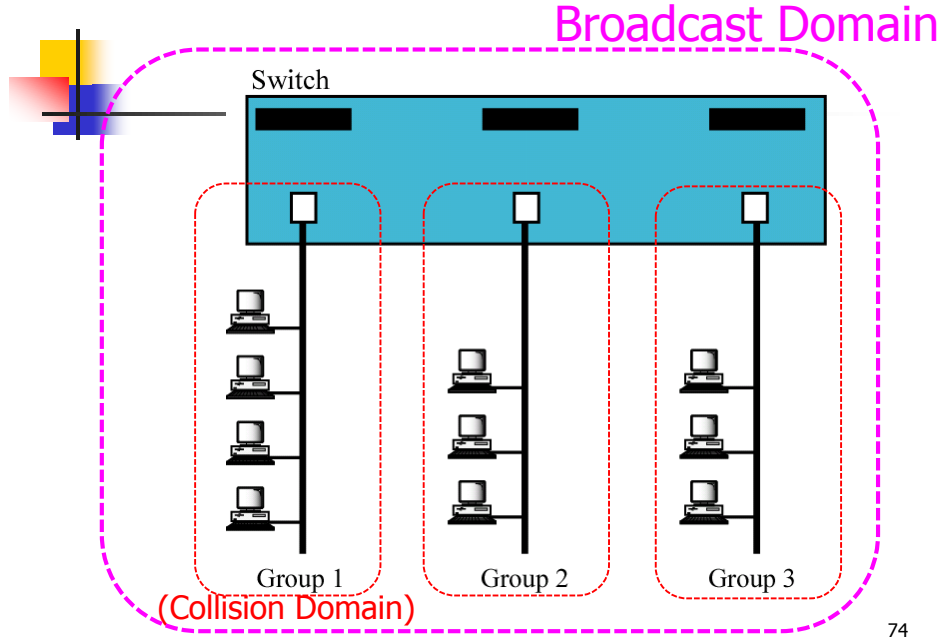
A switch connecting three segments



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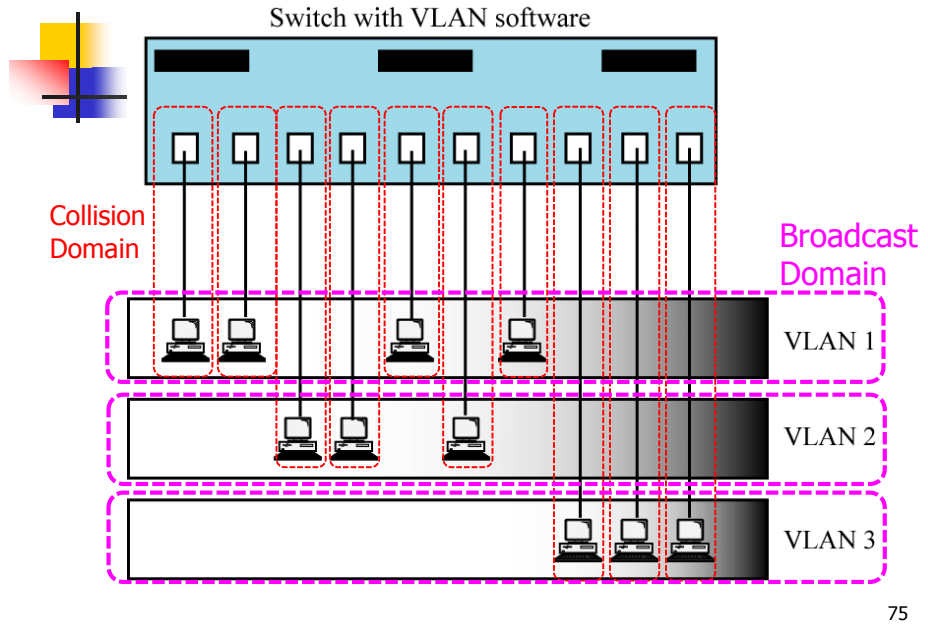
A switch using VLAN software



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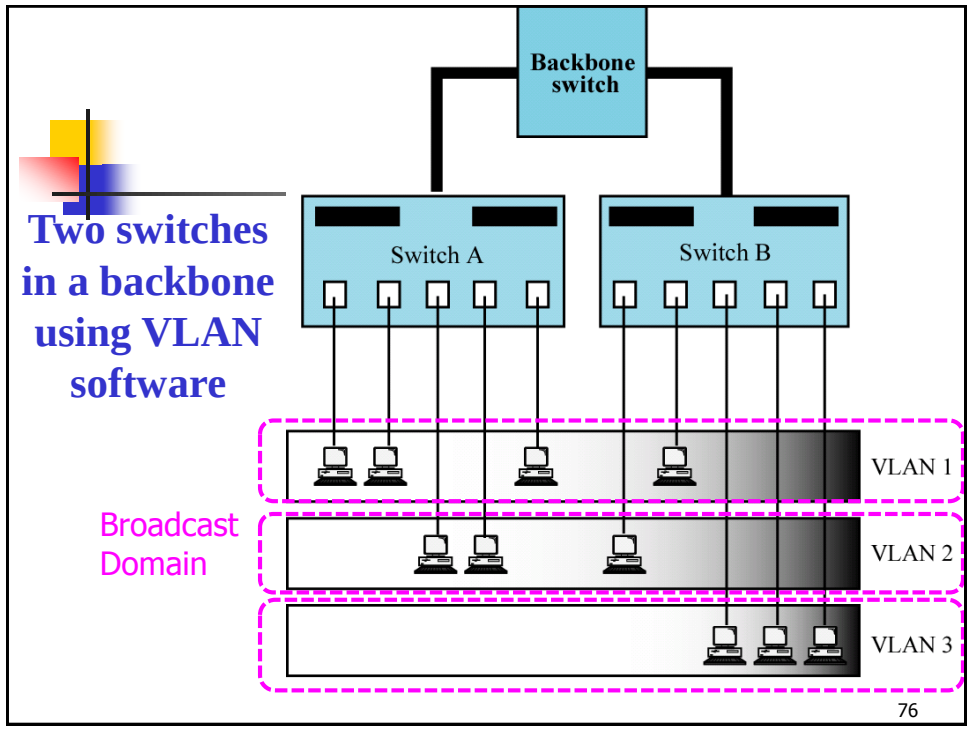
Two switches in a backbone using VLAN software
Backbone switch
Switch A
Switch B
VLAN 1
VLAN 2
VLAN 3
Broadcast Domain
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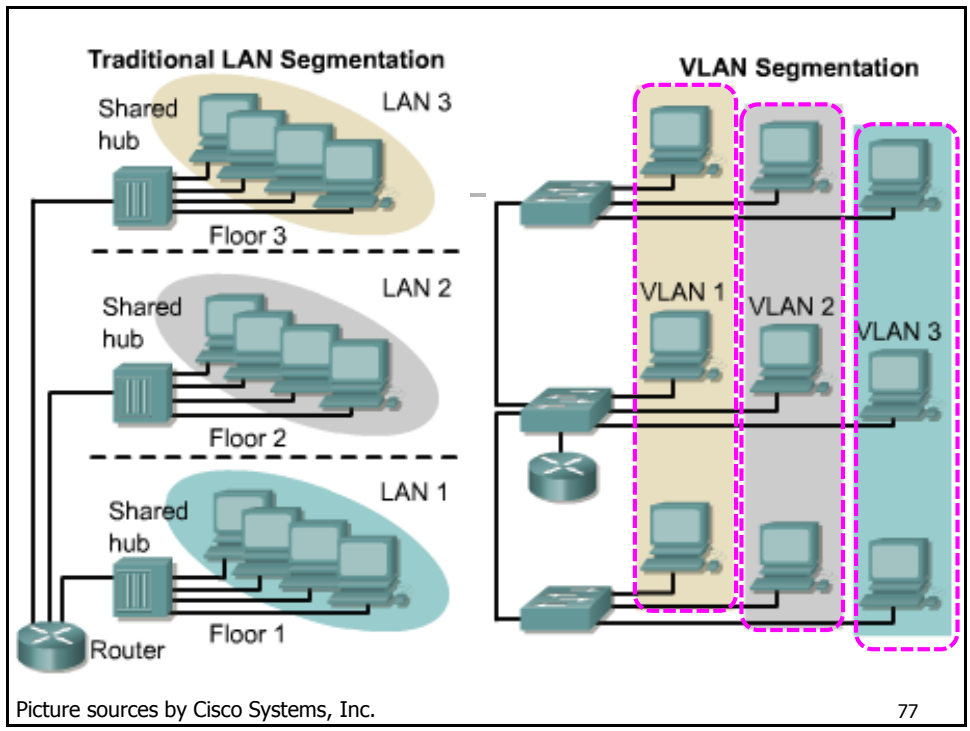
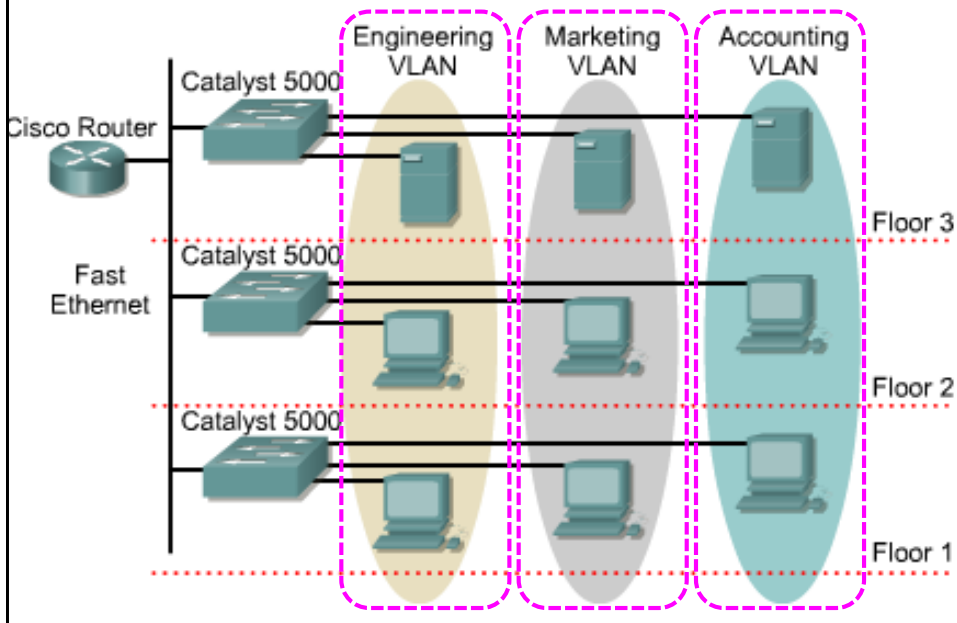

Traditional LAN Segmentation
VLAN Segmentation
Shared hub
LAN 3
Floor 3
LAN 2
Shared hub
Floor 2
LAN 1
Shared hub
Floor 1
Router
VLAN 1
VLAN 2
VLAN 3
Picture sources by Cisco Systems, Inc.
77



Picture sources by Cisco Systems, Inc.

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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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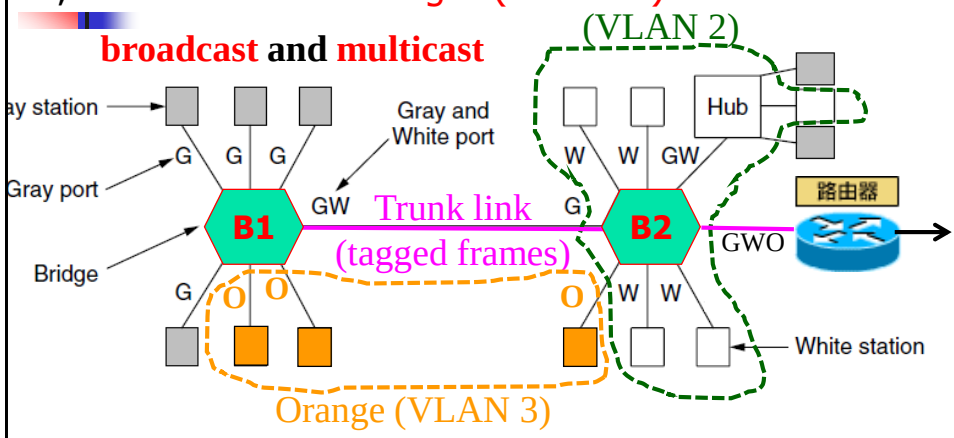
Bridged VLANs

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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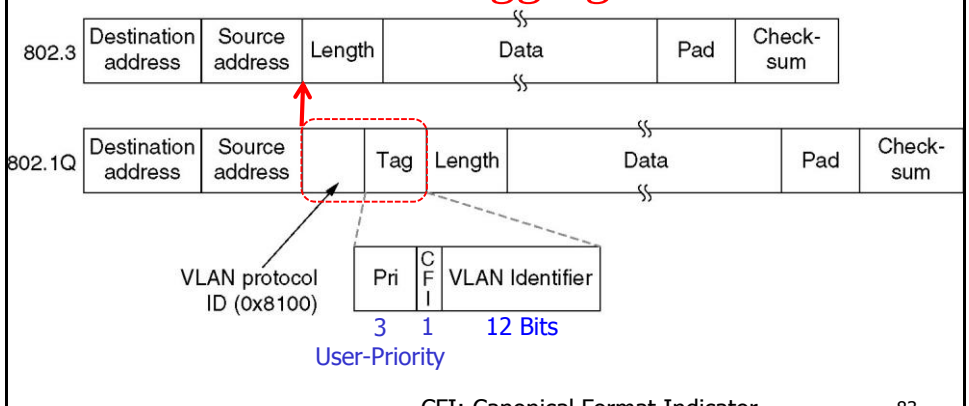
The IEEE 802.1Q Standard (2)

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

Frame tagging



CFI: Canonical Format Indicator

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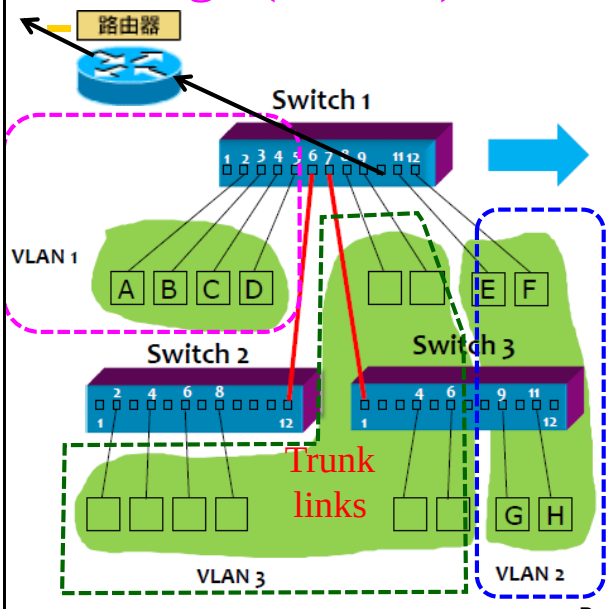
Bridge (Switch) Tables of VLAN 1



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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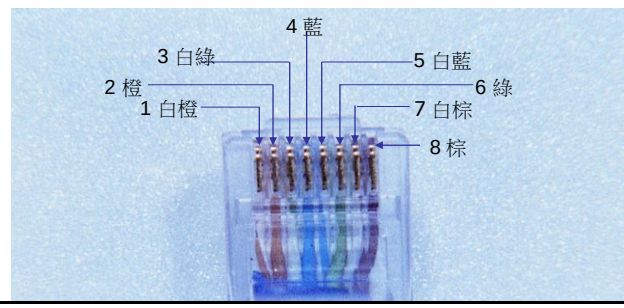
主控台纜線(Rollover) for switches/routers

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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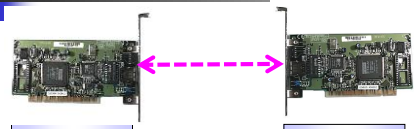
Crossover UTP cable

- 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	1 Tx+
Tx- 2	2 Tx-
Rx+ 3	3 Rx+
Rx- 6	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	1 Tx+
Tx- 2	2 Tx-
Rx+ 3	3 Rx+
Rx- 6	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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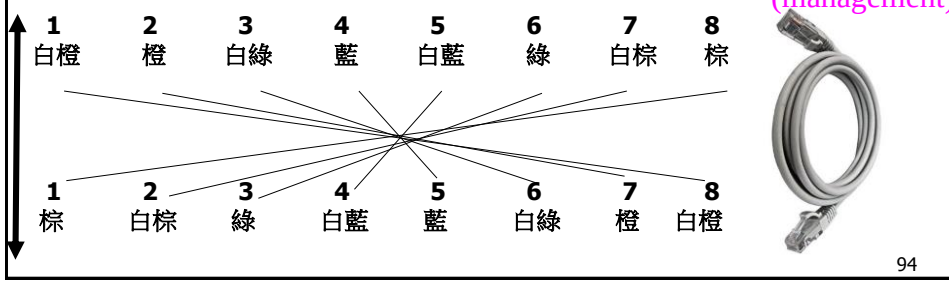
主控台纜線(Rollover)

- 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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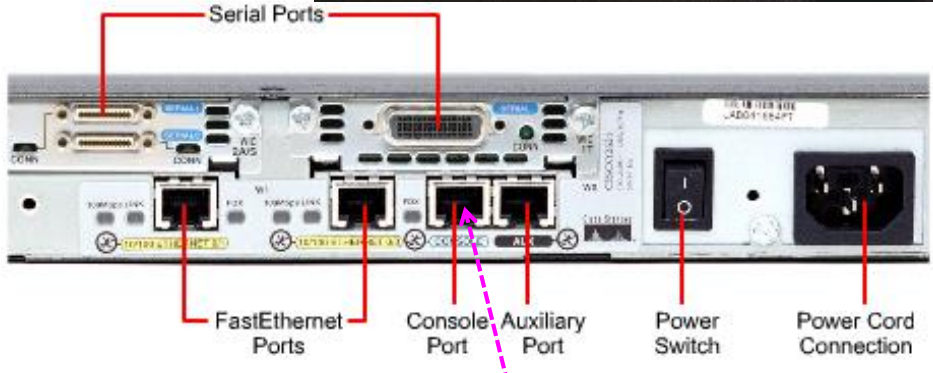
Cisco 2600 router



Picture sources by Cisco Systems, Inc.

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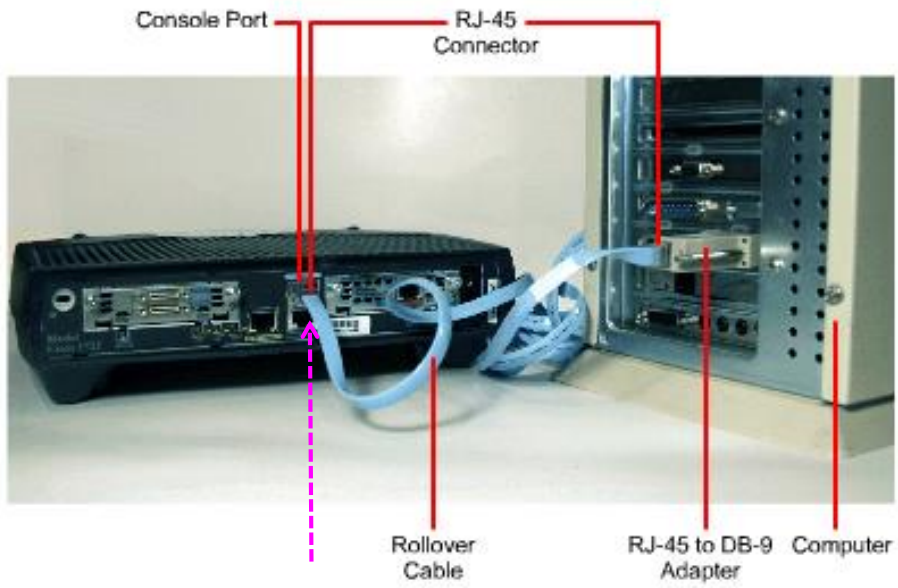
Terminal console connection



Picture sources by Cisco Systems, Inc.

The Data Link & Physical Layers

IEEE 802.1D Spanning Tree Algorithm
IEEE 802.1Q Virtual LAN

7	Application	data
6	Presentation	AH data
5	Session	PH AH data
4	Transport	SH PH AH data
3	Network	TH SH PH AH data
2	Data Link	NH TH SH PH AH data
1	Physical	DH NH TH SH PH AH data DT
		bit stream

H: header
T: trail
Each may be empty.

OSI Reference Model

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End of Chapter 4-2

Questions?

Thank you!