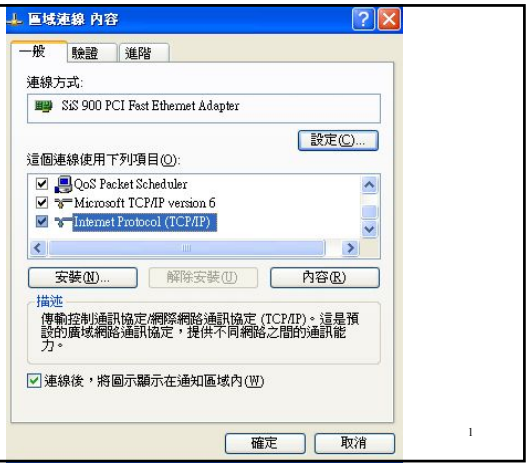

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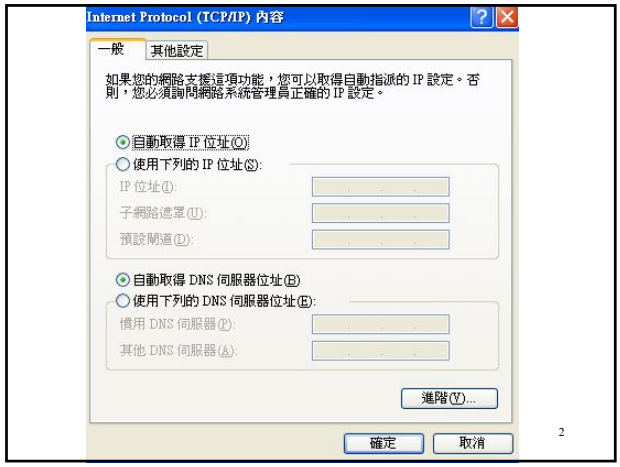

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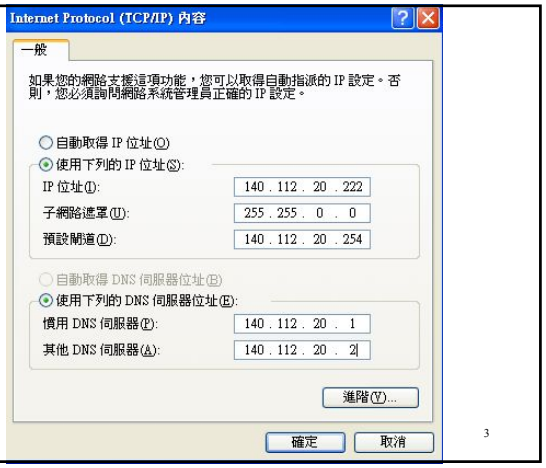

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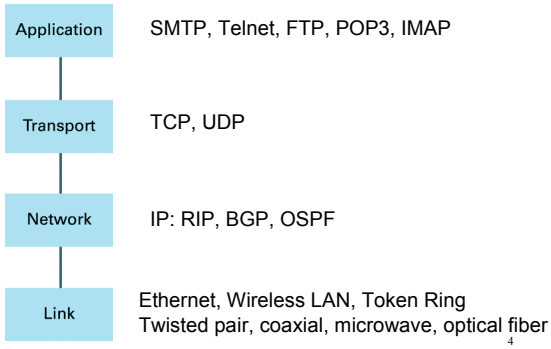
The Internet software layers



4

Ethernet

- 1973 Xerox's researcher **Bob Metcalfe**
- Communication over a single cable shared by all devices originally
- DEC, Intel, and Xerox (DIX) drawing up a standard for 10-Mbps Ethernet
- Forming the basis for 802.3
  - 802.X (IEEE standardizing network technologies in February, 1980)
- CSMA/CD

5

Ethernet Terminology

- **Medium** - Ethernet devices attach to a common medium that provides a path along which the electronic signals will travel. Historically, this medium has been coaxial copper cable, but today it is more commonly a twisted pair or fiber optic cabling.
- **Segment** - We refer to a single shared medium as an Ethernet segment.
- **Node** - Devices that attach to that segment are stations or nodes.
- **Frame** - The nodes communicate in short messages called frames, which are variably sized chunks of information.

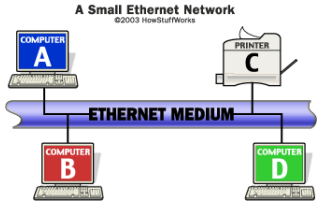
6

- Frames
  - Analogous to sentences in human language
  - **Ethernet protocol:** specifies a set of rules for constructing frames
  - Explicit minimum and maximum lengths for frames
  - Including **destination address** and a **source address** (IP address will be addressed later.)

Broadcast address: A frame with a destination address equal to the broadcast address (simply called a broadcast, for short) is intended for every node on the network, and every node will both receive and process this type of frame.

7

- When computer B transmits to printer C, computers A and D will still receive and examine the frame. However, when a station first receives a frame, it checks the destination address to see if the frame is intended for itself. If it is not, the station discards the frame without even examining its contents.



8

CSMA/CD

- **C**arrier **S**ense **M**ultiple **A**ccess with **C**ollision **D**etection
- Multiple access
  - Several computers intend to send data
- Carrier sense
  - Computers sense the carrier to determine whether it's OK to send
- Collision detection
  - Computers detect collision in case of simultaneous transmissions

9

The Mechanisms

- Each computer listens on the Ethernet
  - If not sensing data on the carrier, OK to send its own data
  - If sensing data on the carrier, check whether the data is addressed for itself
- In case of simultaneous transmissions, (collisions)
  - The computer waits a random period of time before re-send

10

Properties

- Simple
- Cheap
- The more computers on the LAN, the higher the chance of data colliding

11

Similar to Having a Polite Conversion

- One speaks at a time
- So each listens and waits until it's quiet
- In case speaking out at the same time, stop and try again

12

Annoying Person

- Do not listen
- Speak whenever he/she likes
- Refuse to back off

13

Singapore

- Pretty, clean, organized, efficiency …
- Everything is fine.
- It is also famous for
  - Rules are strictly enforced.
  - Everything is fine.
- It's a FINE city.

14

Annoying Person

- Do not listen
- Speak whenever he/she likes
- Refuse to back off

15

Where would the conversation go?

16

No Where

- The majority of well-behaving people will not be able to communicate with the **misbehaving people**
- The majority of well-behaving people will not be able to communicate with **other well-behaving people** either

17

Solution

- Kick the annoying guy out

18

Think This Way

- All participants must follow the same set of rules

19

Protocol :

Common rules obeyed by all parties, i.e. The rules that govern the communication between different components within a computer system.

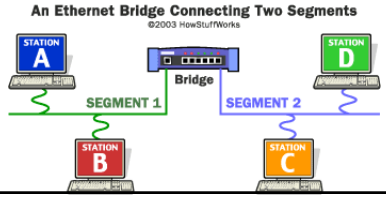
20

Mechanisms of CSMA/CD

- Each computer listens on the Ethernet
  - If not sensing data on the carrier, OK to send its own data
  - If sensing data on the carrier, check whether the data is addressed for itself
- In case of simultaneous transmissions, (collisions)
  - The computer waits a random period of time before re-send

21

- **Collision domain**: A single Ethernet segment is sometimes called a collision domain.
- **Repeater**: Repeaters connect multiple Ethernet segments, listening to each segment and repeating the signal heard on one segment onto every other segment connected to the repeater.
- **Bridges**
  - Extend the network diameter like a repeater
  - Reduce unnecessary traffic by filtering: e.g. A->B, confining the traffic in segment 1, not in segment 2



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Switched Ethernet

- a **dedicated** segment for each station => dedicated bandwidth.
- **Switch**
  - like bridges (multi-port bridge) for single-station segments
  - The switch then forwards the frame over the appropriate segment, just like a bridge, but since any segment contains only a single node, the frame only reaches the intended recipient. This **allows many conversations to occur simultaneously on a switched network**. Max. Bandwidth may be N/2 x (Individual Bandwidth). E.g. N/2*100Mbps
- **Hub**: **share** the same segment/bandwidth
- It is **full-duplex（雙工）**
  - send and receive data at the same time

(Legacy Ethernet uses shared medium. It is half duplex. ⇒information can move in only one direction at a time)
Note: simplex(單工): one way, like radio or TV broadcasting

23

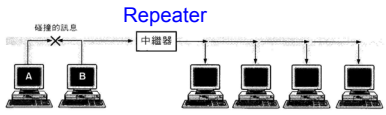


圖 5-08 使用中繼器可延長碰撞領域

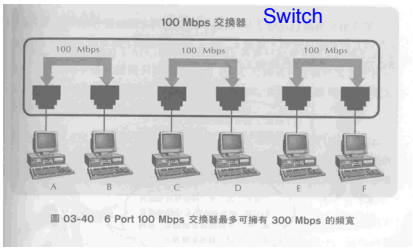
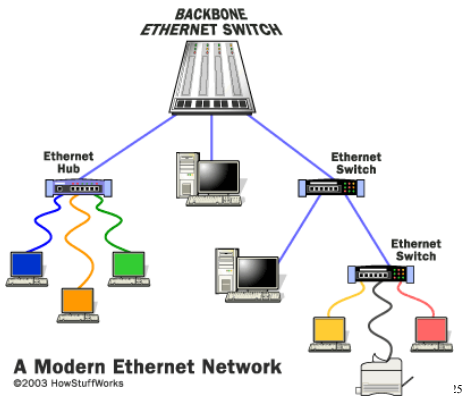


圖 03-40 6 Port 100 Mbps 交換器最多可擁有 300 Mbps 的頻寬

24



25

Ethernet

- Port hub – bus
  - Collision
  - 100Mbps shared — Collision avoidance
  - Security problem, harder to manage possibly
  - Cheap
- IP switch - star
  - **No collision**
  - 100Mbps each (Max. = N/2 *100 Mbps)
  - Easier to manage
  - Expensive

26

Item	10 Base2	10 BaseT	100BaseTX
Medium	Coaxial cable	Twisted pair	Twisted Pair
Plug	BNC	RJ-45	RJ-45
Max Segment L	185 m	100 m	100 m
Topology	bus	star	star

27

Ethernet is the most popular medium access control protocol.

28

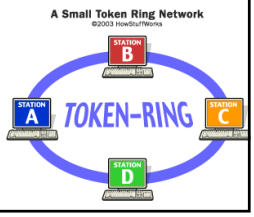
MAC

- **M**edium **A**ccess **C**ontrol
- The class of protocols that handle medium access problems
- Example
  - Ethernet (IEEE 802.3)
  - Token Bus (IEEE 802.4)
  - Token Ring (IEEE 802.5)
  - Wireless LAN (IEEE 802.11)
  - Bluetooth (IEEE 802.15),
- MAC addressing
  - e.g. 00:A0:C9:14:C8:29, where 00:A0:C9 for Intel

29

Token Ring

- The ring initializes by creating a **token**, which is a special type of frame that gives a station permission to transmit.
- The token circles the ring like any frame until it encounters a station that wishes to transmit data.
- This station then "captures" the token by replacing the token frame with a data-carrying frame, which encircles the network.
- Once that data frame returns to the transmitting station, that station removes the data frame, creates a new token and forwards that token on to the next node in the ring.



Questions?

31

WAN

- **W**ide **A**rea **N**etwork
- A large number (usually) of connected computers spreading across a wide area
- Connecting LANs
  - A LAN connects to a WAN via a router

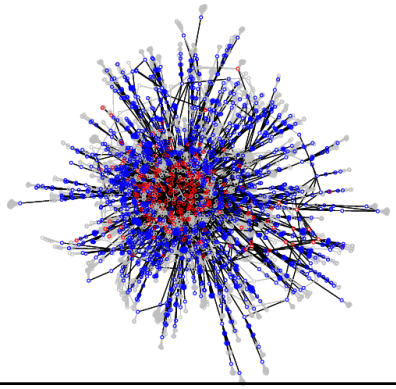
32

Constructing a WAN

- Star, ring, bus?
- A **large number** (usually) of connected computers spreading across a **wide area**
- Large number – not efficient
- Wide area – not economical

33

Any Shape You Like



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How to get the data to go where you want them to be?

35

Routing

Finding a route
from the source to the destination

36

Internet Protocol (IP)

- IP address: a 32-bit number, e.g. 140.112.1.6
  - About 4.3 billion possible combinations
- ICANN (Internet Corporation for Assigned Names and Numbers) http://www.icann.org
- TWNIC (Taiwan Network Information Center) http://www.twnic.net
- Personal or company addresses => ISPs
- IP routing
  - How to get the data to go where you want them to be?

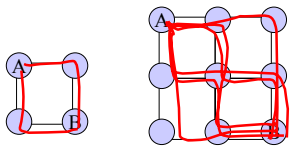
37

Routing

Finding a route
from the source to the destination

38

A to B



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Not That Easy….

Don't have the view of entire network

40

I tell my neighbors.
You tell yours

41

The Rules - Initial

- Determine initial table
  - Route and distance to itself and the neighbors
- Select one router to start telling its table to the neighbors

42

The Rules - Propagation

- Upon receiving a table,
- Check if there exists a shorter path to any destination
- If yes, update table and tell the neighbors of the updated table
- If not, do nothing (already the shortest path table)

43

Distance Vector Routing

- RIP
- BGP (strictly, path vector)

- Distance Vector – the table in the example

44

RIP

- **R**outing **I**nformation **P**rotocol
- Works exactly the way above

- Example - campus networks

45

BGP

- **B**order **G**ateway **P**rotocol
- Slightly more complicated
- Taking policies into consideration
- Propagating paths to prevent loops

- Example - backbone networks

46

RIP and BGP are two popular routing protocols.

47

IP Routing

- **I**nternet **P**rotocol Routing
- The class of protocols that handle routing problems
- Example
  - RIP (IETF RFC 1058)
  - BGP (IETF RFC 1771)
  - OSPF (IETF RFC 2328)

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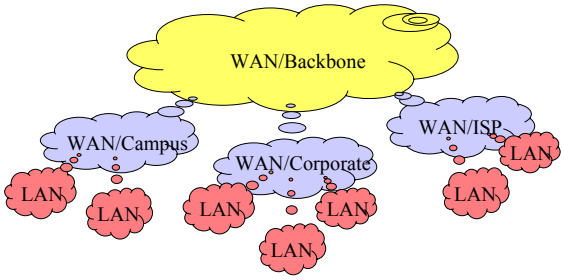
Internet – Structural View



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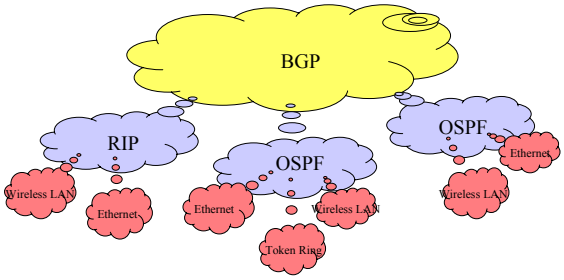
Internet - Protocol View



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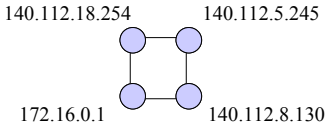
IP Address



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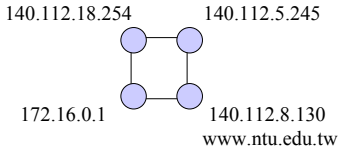
Domain Name Service



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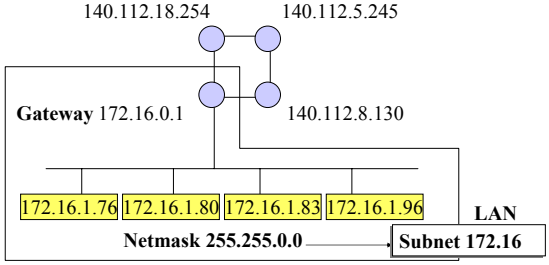
Subnet Concept



TCP/IP Network Setting

- IP Address
  - The address used to route data around the network
- DNS Server
  - Find the IP address from a computer's name (hostname)
- Gateway
  - The default router to forward data out from the local subnet
- Netmask
  - To determine the size of a subnet

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Summary

- The principle
  - Transmission
  - Media and access
- Interconnection
  - LAN and Ethernet
  - WAN and DV routing
- TCP/IP Network Configuration

55

Review

- Hub, bridge, switch, repeater, router, gateway
- DNS (Domain Name Server)
- DHCP (Dynamic Host Configuration Protocol)

56

Some Solutions to Shortage of IP Numbers

- DHCP
  - Not every node is online at the same time
  - Dynamic IP number
  - N nodes share P numbers (N>P)
  - Hard to locate due to dynamic IP number
- Local IP
  - NAT, same IP (but different ports) to outside
  - Need forwarding
- IPv6
  - 32bits => 128 bits

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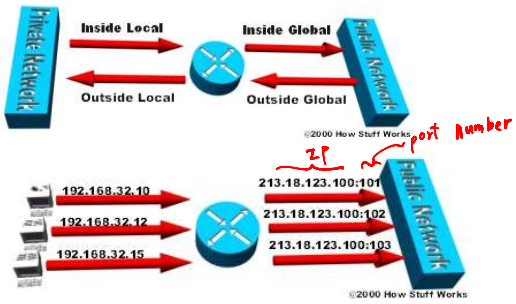
Network Address Translation (NAT) -- IP sharing



http://computer.howstuffworks.com/nat.htm/printable

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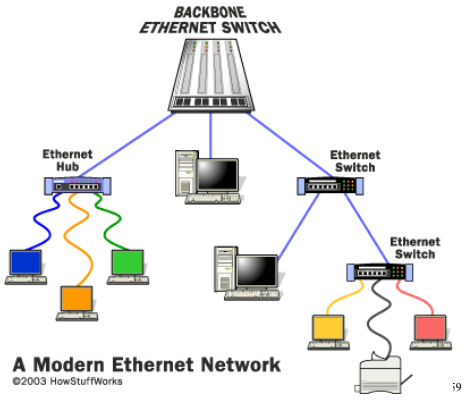

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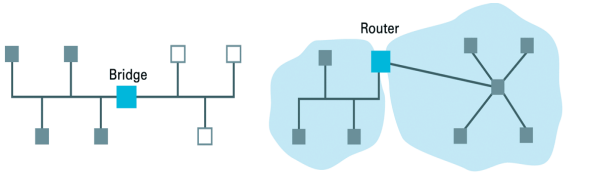
The distinction between a bridge and a router



a. A bridge connecting two bus networks to form one large network

b. A router connecting a bus network to a star network to form an Internet consisting of two networks

60

Repeater

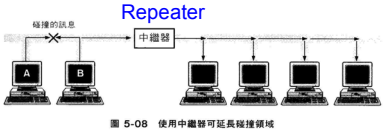


圖 5-08 使用中繼器可延長碰撞領域

Switch

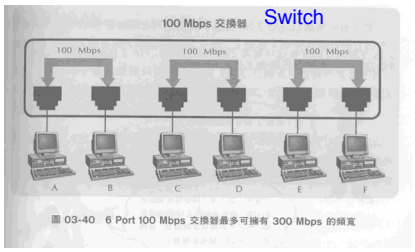


圖 03-40 6 Port 100 Mbps 交換器最多可擁有 300 Mbps 的頻寬

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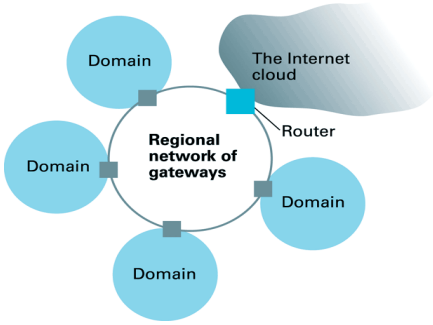
A typical approach to connecting to the Internet



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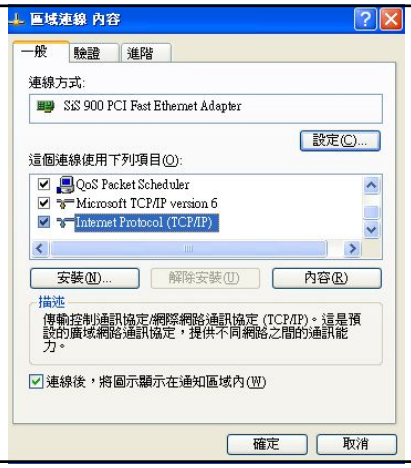

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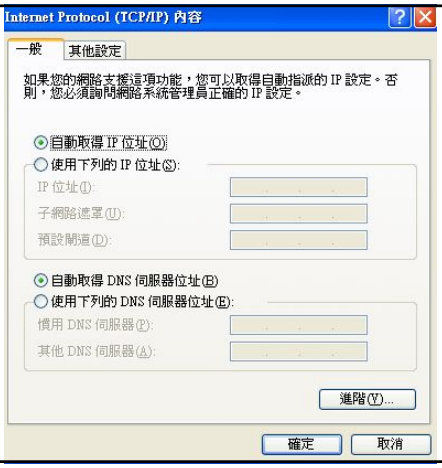

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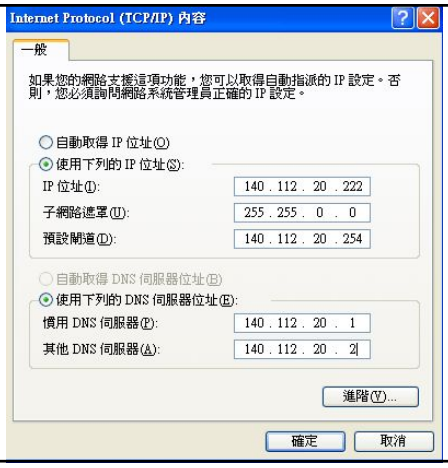

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Questions?

66