Data Communications and Networking

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Addressing

- What is an address?
- Why do we need to use addresses in network communication?

Names and Addresses

- A computer, machine or service (an entity) within a network usually requires a name – a string of bits/characters referring to it.

- To operate on such an entity, we need an access point – the access point is the address of the entity.
  - Entities may have several access points, and hence several addresses – in just the same way we might have more than one phone number.

Addresses

- The address of an entity may change over time;
  - A new IP address when you move your laptop.
- Addresses are rarely the same as the name of the entity to which they refer.
  - Machines may be reassigned leading to inappropriate naming.
  - If a machine has more than one access point, which name should be assigned?
- Entity names which are independent of their addresses are easier and more flexible to use – these names are ‘location independent’.

- Addresses are *Locators* not *Identifiers.*

Identifiers

- A different type of name is one which uniquely identifies an entity;
  - An identifier refers to at most 1 entity.
  - And identifier always refers to the same entity.
  - An identifier is unique.
- Identifiers provide a way of unambiguously referring to an entity.
  - “John Smith” would not be an identifier.
  - A telephone number would not be an identifier.
  - A passport number is an identifier

Human Friendly Names

- A final type of name is a human friendly name.
  - Names on a network are actually strings of bits – perhaps a 32 bit string.
  - These are clearly difficult for humans to remember or use.
- Human friendly names are names that are easy for humans to read, type and remember.
- Example of Human friendly names: Domain names, URLs & Email addresses.

Example Names

- Domain Names: payap.ac.th
- IP address: 64.233.187.99
- MAC address: 00-B0-D0-86-BB-F7
  - MAC addresses are sometimes called Burned In Addresses (BIA).

IP Address

- An IP address is a unique address that certain electronic devices use in order to find and communicate with each other on a computer network using the Internet Protocol (IP).
- An IP address acts as a Locator for one IP device to find another and interact with it.

IP Address

- An IP address is just a 32-bit binary number: a set of 32 ones or zeroes.

11100011010100101001101110110001

- Computers always work in binary and this also applies to networking hardware and software.
- Different meanings are ascribed to different parts of this number, but the address itself is just this 32-digit binary number.

Quick Question

Which IP address is larger?

A) 11100011010100101001100110110100

B) 11100011010100101001101110100001

Human friendly IP addresses

dot-decimal notation is a way of writing a 32bit binary IP address as 4 decimal numbers separated by dots.

11100011010100101001101110110001

is converted into octets (groups of 8)

11100011 . 01010010 . 10011011 . 10110001

octets are converted into the decimal equivalent

227.82.155.177

which is easier for us humans to read and write!

Total number of IP addresses

- IP address is 32 bits wide, this provides us with a theoretical address space of 2^{32}, or 4,294,967,296 addresses.
- This seems like quite a lot of addresses! However, as we will see, due to how IP addresses are structured and allocated, not every one of those addresses can actually be used.
- For example, IP addresses starting with “127” in the first octet are reserved for the loopback function. This makes 16,277,216 addresses, no longer available.

Internet IP Address Structure

227.82.155.177

11100011010100101001101110110001

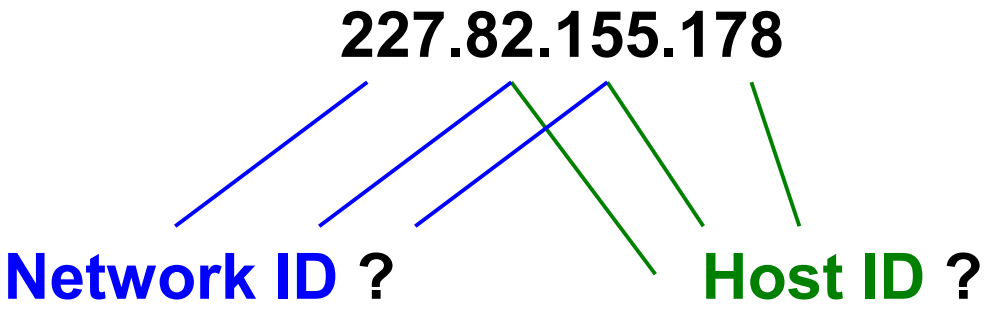
- Network Identifier (Network ID): A certain number of bits, starting from the left-most bit, is used to identify the network where the host or other network interface is located. (this can be any number of bits – including parts of an octet)

example:11100011010100101001101110110001

- Host Identifier (Host ID): The remainder of the bits are used to identify the host on the network.

Network ID – Host ID

Q. How does the computer (or a human) know which part of the IP address is the Network ID and which part is the Host ID?



Subnet Mask

- A subnet mask is a string of 32 bits that looks very similar to an IP address.
- The subnet mask is used in conjunction with the network address to determine which part of the address is the network address and which part is the host address.

IP address: 11100011 . 01010010 . 10011011 . 10110001

subnet mask: 11111111 . 00000000 . 00000000 . 00000000

- This subnet mask indicates that the first octet is used for the Network ID and the rest = Host ID

How subnet masks work

- Subnet masks work through a simple process called an “AND” operation.

Rules of ANDing

1 AND 1 = 1

1 AND 0 = 0

0 AND 0 = 0

ANDing the IP address and Subnetmask

IP address: 11100011 . 01010010 . 10011011 . 10110001

subnet mask: 11111111 . 00000000 . 00000000 . 00000000

AND result: 11100011 . 00000000 . 00000000 . 00000000

AND rules:

1 AND 1 = 1

1 AND 0 = 0

0 AND 0 = 0

Q. What is the result?

Human-friendly subnet masks

IP address: 11100011 . 01010010 . 10011011 . 10110001

subnet mask: 11111111 . 00000000 . 00000000 . 00000000

Using dot-decimal notation

IP address: 227.82.155.177

Subnet mask: 255. 0 . 0 . 0

Network ID = 227.0.0.0

Host ID = 0.82.155.177

Mid-Octet IP Address Division

IP address: 11100011 . 01010010 . 10011011 . 10110001

subnet mask: 11111111 . 11111111 . 11110000 . 00000000

or

IP address: 227.82.157.177

subnet mask: 255.255.240.0

Network ID = 227.82.144. 0

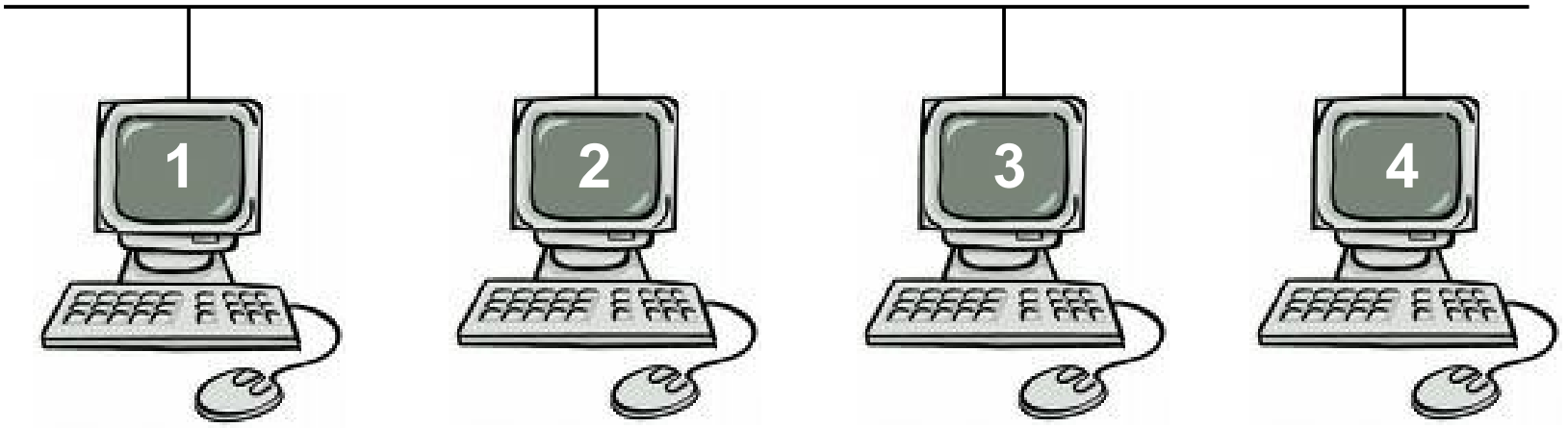
Host ID = 0 . 0 . 13 .177

Computer Networks

- For computers to communicate on the same network segment they require:
  - The same Network ID
  - A unique Host ID

- If computers have different Network IDs or a wrong subnet mask then they will not think they are on the same logical network.
- Different logical networks can be connected together using a router.

Network ID – Host ID



227.82.155.177	227.82.155.178	227.82.160.177	228.82.161.02
255.0.0.0	255.0.0.0	255.255.0.0	255.0.0.0

Q. What is the Network ID and Host ID for these computers?

Q. Which computers will have a problem communicating?

IP Classes

On the Internet there are 5 groups or Classes of IP addresses:

- Class A 1.0.0.1 to 126.255.255.254 Supports 16 million hosts on each of 127 networks.
- Class B 128.1.0.1 to 191.255.255.254 Supports 65,000 hosts on each of 16,000 networks.
- Class C 192.0.1.1 to 223.255.254.254 Supports 254 hosts on each of 2 million networks.
- Class D & E are reserved ranges.

Private IP addresses

- The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of the IP address space for private/local networks:
  - 10.0.0.0 - 10.255.255.255
  - 172.16.0.0 - 172.31.255.255
  - 192.168.0.0 - 192.168.255.255
- Also, IP addresses in the range of:
  - 169.254.0.0 -169.254.255.255

are reserved for Automatic Private IP Addressing.

- These should not be used on the Internet!

Special IP addresses

- The 127.0.0.1 address is designated for loopback and cannot be assigned to a network.

- The loopback address is used to test the network adapter attached to a device.
- Making a request to this address sends a message down the TCP/IP layers to the cable and then back up again as a received message.

IP Checking

IPCONFIG

- ipconfig is a command line tool that we can use to check the status of the IP address(s) attached to a specific device or network adapter.
- It is a windows based utility
- ipconfig /all will print out a detailed configuration report for all interfaces, including any configured serial ports.
- ifconfig is a Linux tool with a similar function.

Checking Connectivity

PING

- ping is a tool that uses the Internet Control Message Protocol (ICMP) to determine the availability and responsiveness of network hosts.
- Packet Internet Groper – I forwards data packets to check the quality of a link or verify the connection of a machine to the Internet.

Checking the network

TRACERT

- tracert - the traceroute tool is used to determine the route taken by packets across an IP network.
- tracert sends a series of packets across the network. Each host returns an ICMP message back to the original host.
- Using these messages the tracert tool can build up a list of hosts between the source and final destination.

Running out of IP addresses!

- With the current version of IP we have 3.7 billion that are usable on the Internet.
- 2.2 billion are marked as “in use” already.
- Therefore we have 1.5 billion available for new Internet users and for existing users who connect more devices.
- We’re currently putting into use about 200 million new addresses per year.

Q. How many years can we keep going like this?

IPv6

- IP version 6 expands the IP address size from 32 bits all the way up to 128 (2^{128})
- This increases the address space to a ridiculously large number and makes the entire matter of the number of devices attached to the address space not so important.
- This can give each square millimeter on the earth hundreds of thousands of IP addresses!

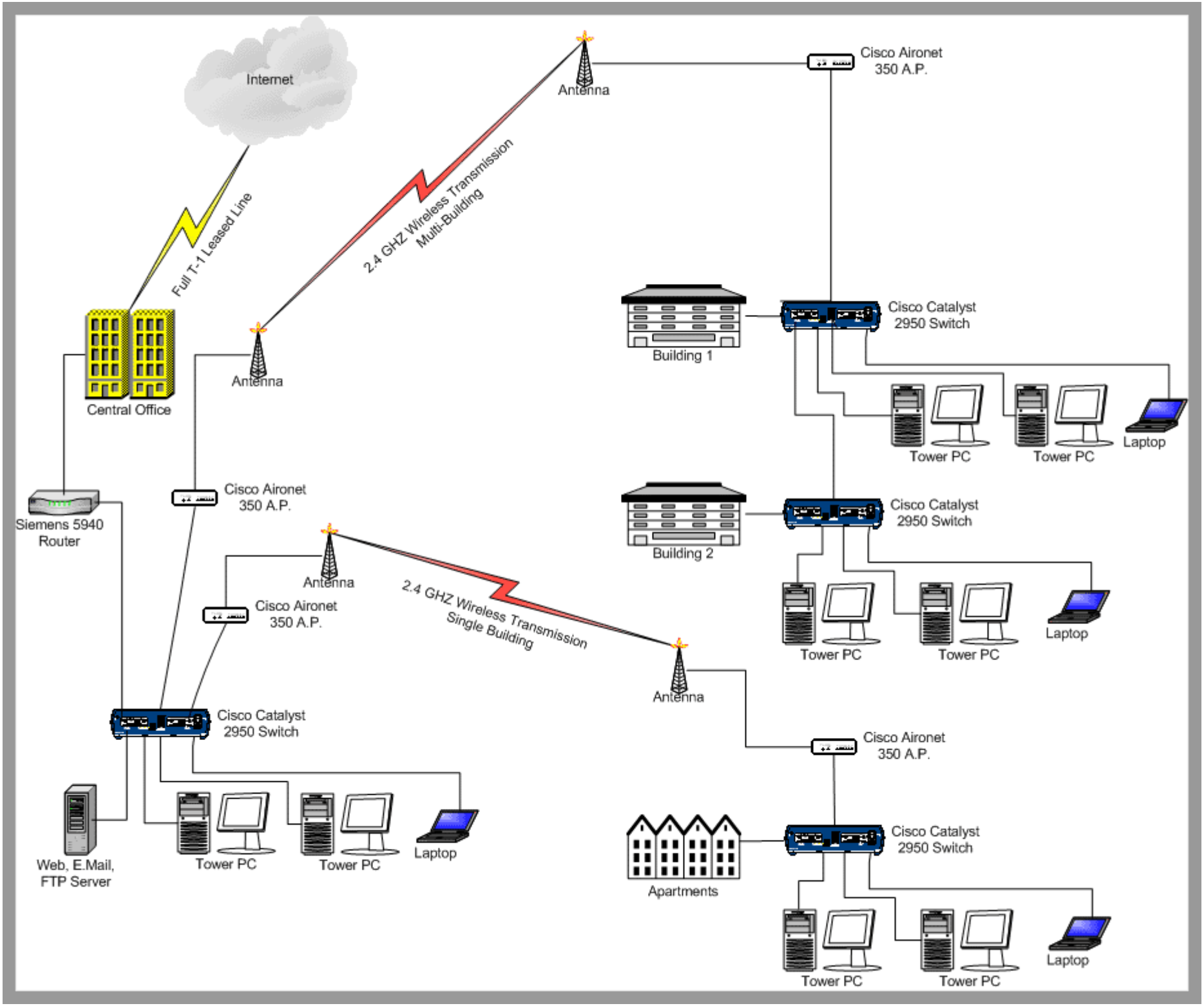
IPv6

- IPv6 Node Addresses are 128-bit records represented as eight fields of up to four hexadecimal digits.
- A colon separates each field.

FE80:0:0:0:202:B3FF:FE1E:8329

Network Diagrams

- A network diagram depicts the nodes and connections amongst nodes in a computer network.
- Network diagrams usually show the logical connection rather than a realistic picture of where the cables actually go.
- Network diagrams usually show:
  - Computer names
  - IP addresses
  - Subnet masks
  - Connection devices (hubs/switches/routers)
  - Connection types (cable/optical fibre/wireless)
  - Locations (buildings or rooms)


Internet
Full T-1 Leased Line
Central Office
Antenna
2.4 GHZ Wireless Transmission
Multi-Building
Antenna
Cisco Aironet
350 A.P.
Building 1
Cisco Catalyst
2950 Switch
Tower PC
Tower PC
Laptop
Siemens 5940
Router
Cisco Aironet
350 A.P.
Building 2
Cisco Catalyst
2950 Switch
Tower PC
Tower PC
Laptop
Antenna
Cisco Aironet
350 A.P.
2.4 GHZ Wireless Transmission
Single Building
Antenna
Cisco Catalyst
2950 Switch
Web, E.Mail,
FTP Server
Tower PC
Tower PC
Laptop
Cisco Aironet
350 A.P.
Apartments
Cisco Catalyst
2950 Switch
Tower PC
Tower PC
Laptop