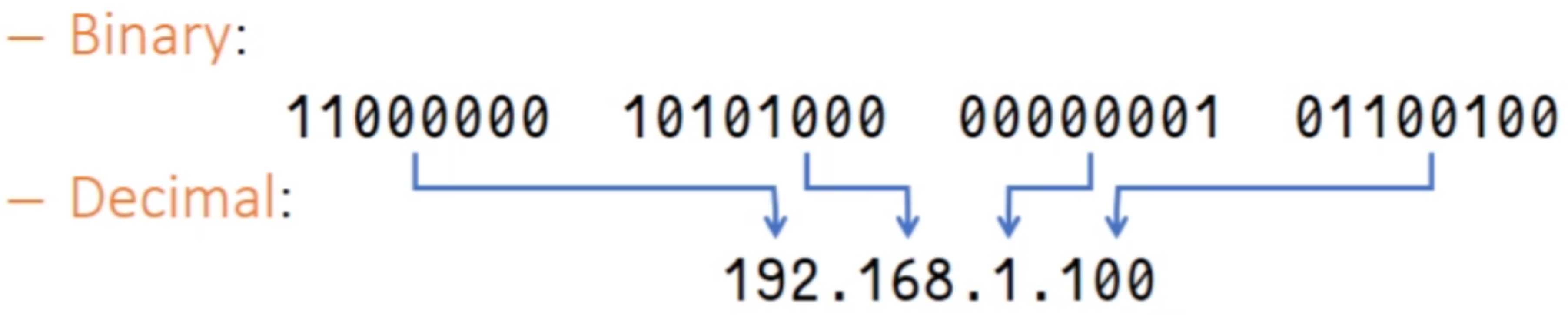
CS2105 Introduction to Computer Networks

Prepared by Clinton Law (AY19/20 Sem1)

Recap

- IP addresses
  - Bounded to a network interface
- Identify hosts/routers
- IPv4
  - 32 bit
  - Represented as binary/decimal



Recap

- Hierarchical Addressing – (IP addresses have 2 parts)
  - Host Identifier
    - Which host is this in this subnet?
  - Network(Subnet) prefix
    - **Identifies** separate networks(subnets)
    - All devices in this subnet **must have this prefix**
      - What does this tell you about communication within and out of a subnet?
      - Inter-subnet(out) messages need to pass through a router
      - Intra-subnet(within) communications doesn't need router's full functionality

Recap

- Hierarchical Addressing – (IP addresses have 2 parts)
  - Network(Subnet) prefix (cont.)
    - Represented with a **subnet mask**

Example: for IP address 200.23.16.42/23:

IP address:	11001000	00010111	00010000	00101010
Subnet mask:	11111111	11111111	11111110	00000000

– Subnet mask in dot-decimal:

255.255.254.0

- **32 – mask = $\log_2$ # IP addresses the subnet can hold ➔ Capacity$_{subnet}$ = $2^{32\text{-mask}}$**

Subnet of arbitrary length

Address format: x.x.x.x/y where y is the subnet mask

⟵ subnet prefix (23 bits) ⟶⟵ host id ⟶

11001000 00010111 00010000 00000001

200.23.16.1/23

This subnet has 2^9 IP addresses

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Recap

- Longest Prefix Match
  - Routers forward packets based on how many bits of the packet prefix tallies with the net mask.
  - This helps to differentiate between subnets!

– packet with destination IP 200.23.20.2? → R1

11001000 00010111 00010100 00000010

– packet with destination IP 200.23.19.3? → R2

11001000 00010111 00010011 00000011

Net Mask	Net mask in binary	Next hop
200.23.16.0/20	11001000 00010111 00010000 00000000	R1
200.23.18.0/23	11001000 00010111 00010010 00000000	R2
199.31.0.0/16	11000111 00011111 00000000 00000000	R2
…		…

Recap

- Dynamic Host Configuration Protocol (DHCP)
  - Servers run on UDP port 67, clients on port 68
  - Identify gateway router, IP address of local DNS, network mask
  - Allows a host to dynamically (and automatically) obtain an IP address from a DHCP server when it joins a network
  - IP addresses are "leased" to you when you obtain it from a DHCP
    - DHCP gives you an IP address for 6 hours; after 6 hours, it checks whether it needs to be renewed (extend lease?)
  - IP addresses are also reusable
    - Continuing the analogy, if you leave the network, DHCP can reassign the same IP address to another host entering the network
  - Good support for mobile users
    - Able to join different networks easily – all with different IP addresses

Recap

- Dynamic Host Configuration Protocol (DHCP)
  - **D**iscover
    - Hosts **broadcasts** a discover message
      - Message is blasted because he does not know the IP addresses (multiple) of the DHCP servers
  - **O**ffer
    - DHCP server responds with a **broadcasted** offer message
      - Host is not yet offered an IP address, hence DHCP needs to someway to address the host, which is by blasting
      - When waiting for a response after the offer, the IP address is **reserved**.
  - **R**equest
    - Host **broadcasts** a request for an IP address here
      - Multiple DHCP servers can send an offer in response to the discover message
      - Need to let the other DHCP servers know which IP address he has selected so the other servers can free the reserved IP address.
  - **A**cknowledge
    - DHCP server **broadcasts** an acknowledgement, allowing host to take on the requested IP address
      - Again this is broadcasted as the host has not yet assumed the IP address.

Recap

```
src: 0.0.0.0:68
dst: 255.255.255.255:67
yiaddr: 0.0.0.0
transaction Id: 654
```

```
src: 223.1.2.5:67
dst: 255.255.255.255:68
yiaddr: 223.1.2.4
transaction Id: 654
DHCP server: 223.1.2.5
Lifetime: 3600 secs
```

```
src: 0.0.0.0:68
dst: 255.255.255.255:67
yiaddr: 223.1.2.4
transaction Id: 655
DCHP server: 223.1.2.5
Lifetime: 3600 secs
```

```
src: 223.1.2.5:67
dst: 255.255.255.255:68
yiaddr: 223.1.2.4
transaction Id: 655
DHCP server: 223.1.2.5
Lifetime: 3600 secs
```

Tutorial Questions

Question 1

[KR, Chapter 4, R13] What is the 32-bit binary equivalent of the IP address 202.3.14.25?

11001010 00000011 00001110 00011001

Question 2a

Write down the first and last IP addresses of the subnet associated with the following IP address:

244.233.234.12/4

244 = 11110100

First IP address in this subnet = 11110000 00000000 00000000 00000000

= 240.0.0.0

Last IP address in this subnet = 11111111 11111111 11111111 11111111

= 255.255.255.255

Question 2b

Write down the first and last IP addresses of the subnet associated with the following IP address:

10.45.123.34/19

123 = 01111011

First IP address in this subnet = 00001010 00101101 01100000 00000000

= 10.45.96.0

Last IP address in this subnet = 00001010 00101101 01111111 11111111

= 10.45.127.255

Question 2 (extra!)

The questions discussed the range of all IP addresses.

What is the range of valid(usable) IP addresses for 192.168.0.0/24?

Valid(usable) = IP addresses that can be assigned.

We know that the very first address is to address the network (network address), in this case 192.168.0.0.

We also know that the very last address is the network broadcast address, ie when the destination address of a packet is 192.168.0.255, the packet is sent to all nodes of that IP network. (Reconcile this with DHCP!)

Hence, valid IP addresses for this example range from 192.168.0.1 to 192.168.0.254, although TYPICALLY, the first assignable IP address is also reserved for the router.

This means that the end hosts are assigned 192.168.0.2 to 192.168.0.254.

Question 3

Combine the following three blocks of IP addresses into a single block:

a) 16.27.24.0/26

b) 16.27.24.64/26

c) 16.27.24.128/25

From a) we get: 00010000 00011011 00011000 00000000

From b) we get: 00010000 00011011 00011000 01000000

From c) we get: 00010000 00011011 00011000 10000000

Expressing the block as a.b.c.d/x, we need to take the most binding constraint, ie maximise x, yet preserve the generality of a.b.c.d.

Observe that the first 24 digits are common → 16.27.24.0/24

Question 4a

[Modified from KR, Chapter 4, P16]

Consider a subnet with network prefix 192.168.56.128/26. Give an example IP address (of form xxx.xxx.xxx.xxx) that belongs to this network.

!!Note that the mask is 26 ➔ 128 = <u>10</u>000000, the underlined 10 must be preserved!!

Hence, answer is any IP address in the range 192.168.56.128 to 192.168.56.191

Question 4b

Suppose an ISP owns the block of addresses of the form 192.168.56.128/26. Suppose it wants to create four subnets from this block, with each block having the same number of IP addresses. What are the network prefixes (of form a.b.c.d/x) for the four subnets?

Again, we know available addresses = 192.168.56.128 - 192.168.56.191

What the question is really asking: how can I divide my subnets equally, and identify each of them uniquely?

Rephrasing, how can I uniquely identify the 4 subnets which span the range of 192.168.56.128 to 192.168.56.191?

Question 4b

How can I uniquely identify the 4 subnets which span the range of 192.168.56.128 to 192.168.56.191?

192.168.56.128 to 192.168.56.191 → 64 IP addresses → subnet of size 16

The start of these subnets should hence be 192.168.56.128, 192.168.56.144, 192.168.56.160 and 192.168.56.176.

Network Prefix	Binary Expression
192.168.56.128/28	11000000 10101000 00111000 10000000
192.168.56.144/28	11000000 10101000 00111000 10010000
192.168.56.160/28	11000000 10101000 00111000 10100000
192.168.56.176/28	11000000 10101000 00111000 10110000

Note that to delineate the different subnets, we must extend the mask. Also notice that we have to extend our mask by $\log_2 n$, where n is the number of subnets.
Rule of thumb: Check that you can differentiate your subnets with your mask.

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Question 5

[Modified from KR, Chapter 4, P12] Consider a datagram network using 8-bit addresses. Suppose a router has the following forwarding table:

Prefix Match	Interface
11	0
101	1
100	2
otherwise	3

For each of the four interfaces, give the associated range of destination host addresses and the number of addresses in the range.

Question 5

What the question is asking: How do I "span" all the possible IP addresses (0000 0000 to 1111 1111) WITHOUT allowing datagrams to face a conflict as to which interface to go to?

By longest prefix match, we know that "11" has to "take care" of 1100 0000 to 1111 1111.

Similarly, "101" has to "take care" of 1010 0000 of 1011 1111,

"100" has to "take care" of 1000 0000 of 1001 1111,

and otherwise has to "take care" of the rest of the IP not yet covered.

Prefix Match	Interface	IP Range	No. of IP
11	0	1100 0000 – 1111 1111	64
101	1	1010 0000 – 1011 1111	32
100	2	1000 0000 – 1001 1111	32
otherwise	3	0000 0000 – 0111 1111	128

Question 6

What is private IP address? Does IVLE use private or public IP? When your laptop is connected to NUS network, does it receive a private or public IP?

The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of IP address space for private networks:

10.0.0.0 - 10.255.255.255 (10/8 prefix)

172.16.0.0 - 172.31.255.255 (172.16/12 prefix)

192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

An enterprise that decides to use private IP addresses can do so without any coordination with IANA or an Internet registry. The address space can thus be used by many enterprises.

However, private IP addresses cannot have IP connectivity to any host outside of the enterprise. NAT or application layer gateways are needed to map private to public address and vice versa when traffic goes in and out private network.

Private IP is initially designed for experimentation purpose, but now used as a way to alleviate IPv4 address exhaustion. Its use is very common today.

IVLE use public IP address (137.132.10.10). Students may use ping command to check it. Laptops of students are assigned private IP addresses (e.g. 172.26.184.76).

Summary

- IP addresses
- Hierarchical Addressing
  - Subnet Masks
  - Longest Prefix Match
- DHCP

Extra Questions

Given a subnet of 222.22.22.0/27, which of the following addresses belong to the same subnet? (Pick all that apply)

A. 222.22.22.22

B. 222.22.22.23

C. 222.22.22.30

D. 222.22.22.31

E. 222.22.22.32

Extra Questions

An enterprise has been given the following IP address block: 137.132.64.0/18.

Which of the following subnet and host combinations are possible given the above address block? (Pick all that apply)

A. 6 subnets with 7000 hosts each

B. 10 subnets with 1020 hosts each

C. 20 subnets with 800 hosts each

D. 30 subnets with 500 hosts each

E. 200 subnets with 200 hosts each

Thank you!

Answers:
Q1. All but E.
Q2. B and D

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