PATUAKHALI SCIENCE AND TECHNOLOGY UNIVERSITY

Assignment Name: Assignment on Chapter 05 Exercises

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Exercises

1. **What is the address space in each of the following systems?**

   a. a system with 8-bit addresses => 2^{8} = 256
   b. a system with 16-bit addresses => 2^{16} = 65536
   c. a system with 64-bit addresses => 2^{64} = 18446744073709600000

2. **An address space has a total of 1,024 addresses. How many bits are needed to represent an address?**

   Answer: 10 bits

3. **An address space uses three symbols: 0, 1, and 2 to represent addresses. If each address is made of 10 symbols, how many addresses are available in this system?**

   Answer: 3^{10} = 59049

4. **Change the following IP addresses from dotted-decimal notation to binary notation:**

   a. 114.34.2.8 => 01110010 00100010 00000010 00001000
   b. 129.14.6.8 => 10000001 00001110 00000110 00001000
   c. 208.34.54.12 => 11010000 00100010 00110110 00001100
   d. 238.34.2.1 => 11101110 00100010 00000010 00000001

5. **Change the following IP addresses from dotted-decimal notation to hexadecimal notation:**

   a. 114.34.2.8 => 0x72220208
   b. 129.14.6.8 => 0x810E0608
   c. 208.34.54.12 => 0xD022360C
   d. 238.34.2.1 => 0xEE220201

6. **Change the following IP addresses from hexadecimal notation to binary notation:**

   a. 0x1347FEAB => 19.71.254.171
   b. 0xAB234102 => 171.35.65.2
   c. 0x0123A2BE => 1.35.162.190
   d. 0x00001111 => 0.0.17.17

7. **How many hexadecimal digits are needed to define the netid in each of the following classes?**

   a. Class A => 2
   b. Class B => 4
   c. Class C => 6

8. **Change the following IP addresses from binary notation to dotted-decimal notation:**

a. 01111111 11110000 01100111 01111101 => 127.230.103.125
b. 10101111 11000000 11111000 00011101 => 175.192.248.29
c. 11011111 10110000 00011111 01011101 => 223.176.31.93
d. 11101111 11110111 11000111 00011101 => 239.247.199.29

9. **Find the class of the following IP addresses:**

a. 208.34.54.12 => Class C
b. 238.34.2.1 => Class D
c. 242.34.2.8 => Class E
d. 129.14.6.8 => Class B

10. **Find the class of the following IP addresses:**

a. 11110111 11110011 10000111 11011101 => Class E
b. 10101111 11000000 11110000 00011101 => Class B
c. 11011111 10110000 00011111 01011101 => Class C
d. 11101111 11110111 11000111 00011101 => Class D

11. **Find the netid and the hostid of the following IP addresses:**

a. 114.34.2.8 => Class A, netid = 8, hostid = 24
b. 132.56.8.6 => Class B, netid = 16, hostid = 16
c. 208.34.54.12 => Class C, netid = 24, hostid = 8
d. 251.34.98.5 => Class E, netid = n/a, hostid = n/a

12. **Find the number of addresses in the range if the first address is 14.7.24.0 and the last address is 14.14.34.255.**

Last address = 14.14.34.255
First address = 14.7.24.0
Difference = 0.7.10.255

Number of addresses = $(0*256^3 + 7*256^2 + 10*256^1 + 255*256^0) + 1$
= 461568

13. **If the first address in a range is 122.12.7.0 and there are 2048 addresses in the range, what is the last address?**

$n = 32 - \log_2 N = 32 - \log2\ 2048 = 32 - \log_2 2^{11} = 32 - 11 = 21$

Network Mask = 255.255.248.0
!(Network Mask) = 0.0.7.255

Alternative,
Block needed = 2048/256 = 8
In 256-base format = 0.0.7.255

```
First address     = 122.12.7.0
!(Network Mask)   = 0.0.7.255

Last address      = 122.12.14.255
```

14. Find the result of each operation:

a. NOT (22.14.70.34) = 233.241.185.221
b. NOT (145.36.12.20) = 110.219.243.235
c. NOT (200.7.2.0) = 55.248.253.255
d. NOT (11.20.255.255) = 244.235.0.0

15. Find the result of each operation:

a. (22.14.70.34) AND (255.255.0.0) = 22.14.0.0
b. (12.11.60.12) AND (255.0.0.0) = 12.0.0.0
c. (14.110.160.12) AND (255.200.140.0) = 14.72.128.0
d. (28.14.40.100) AND (255.128.100.0) = 28.0.32.0

16. Find the result of each operation:

a. (22.14.70.34) OR (255.255.0.0) = 255.255.70.34
b. (12.11.60.12) OR (255.0.0.0) = 255.11.60.12
c. (14.110.160.12) OR (255.200.140.0) = 255.238.172.12
d. (28.14.40.100) OR (255.128.100.0) = 255.142.108.100

17. In a class A subnet, we know the IP address of one of the hosts and the subnet mask as given below:

IP Address: 25.34.12.56	Subnet mask: 255.255.0.0

What is the first address (subnet address)? What is the last address?

```
IP Address          = 25.34.12.56   AND
Subnet Mask    = 255.255.0.0

First IP Address    = 25.34.0.0     OR
!(Subnet Mask) = 0.0.255.255

Last IP Address     = 25.34.255.255
```

18. In a class B subnet, we know the IP address of one of the hosts and the subnet mask as given below:

IP Address: 131.134.112.66	Subnet mask: 255.255.224.0

What is the first address (subnet address)? What is the last address?

```
IP Address          = 131.134.112.66         AND
Subnet Mask    = 255.255.224.0

First IP Address    = 131.134.96.0       OR
!(Subnet Mask) = 0.0.31.255

Last IP Address     = 131.134.127.255
```

19. In a class C subnet, we know the IP address of one of the hosts and the subnet mask as given below:

IP Address: 202.44.82.16	Subnet mask: 255.255.255.192

What is the first address (subnet address)? What is the last address?

IP Address = 202.44.82.16 AND
Subnet Mask = 255.255.255.192

First IP Address = 202.44.82.0 OR
!(Subnet Mask) = 0.0.0.63

Last IP Address = 202.44.82.63

20. Find the subnet mask in each case:

a. 1024 subnets in class A
Class A => netid = 8, hostid = 24
1024 = 2^{10}, hostid = 24 – 10 = 14 and netid = 8 + 10 = 18
So, Subnet Mask = 255.255.192.0

b. 256 subnets in class B
Class B => netid = 16, hostid = 16
256 = 2^{8}, hostid = 16 – 8 = 8 and netid = 16 + 8 = 24
So, Subnet Mask = 255.0.0.0

c. 32 subnets in class C
Class C => netid = 24, hostid = 8
32 = 2^{5}, hostid = 8 – 5 = 3 and netid = 24 + 5 = 29
So, Subnet Mask = 255.255.255.248

d. 4 subnets in class C
Class C => netid = 24, hostid = 8
4 = 2^{2}, hostid = 8 – 2 = 6 and netid = 24 + 2 = 26
So, Subnet Mask = 255.255.255.192

21. In a block of addresses, we know the IP address of one host is 25.34.12.56/16. What is the first address (network address) and the last address (limited broadcast address) in this block?

n = 16, Subnet Mask = 255.255.0.0

Host Address = 25.34.12.56 AND
Subnet Mask = 255.255.0.0

First Address = 25.34.0.0 OR
!(Subnet Mask) = 0.0.255.255

Last Address = 25.34.255.255

22. In a block of addresses, we know the IP address of one host is 182.44.82.16/26. What is the first address (network address) and the last address (limited broadcast address) in this block?

n = 26, Subnet Mask = 255.255.255.63

```
Host Address       = 182.44.82.16 AND
Subnet Mask        = 255.255.255.63

First Address          = 182.44.82.16 OR
!(Subnet Mask)     = 0.0.0.192

Last Address       = 182.44.82.208
```

23. In fixed length subnetting, find the number of 1s that must be added to the mask if the number of desired subnets is _______.

a. 2 => $\log_2$ 2 = 1, Number of 1’s = 1, Subnets = 2
b. 62 => $\log_2$ 62 = 5.954, Number of 1’s = 6, Subnets = 64
c. 122 => $\log_2$ 122 = 6.93, Number of 1’s = 7, Subnets = 128
d. 250 => $\log_2$ 250 = 7.96578, Number of 1’s = 8, Subnets = 256

24. An organization is granted the block 16.0.0.0/8. The administrator wants to create 500 fixed-length subnets.

$\log_2$ 500 = 8.96578, n’ = 8 + 9 = 17

a. Find the subnet mask.
n’ = 17, Subnet Mask = 255.255.128.0

b. Find the number of addresses in each subnet.
$2^{32-17} = 2^{15}$ = 32768 addresses in each subnet

c. Find the first and the last address in the first subnet.

```
n’ = 17, Number of Address = 0.0.127.255
First Subnet,
First Address         = 16.0.0.0          OR
Number of Address     = 0.0.127.255
Last Address          = 16.0.127.255
```

d. Find the first and the last address in the last subnet (subnet 500).

```
Last Subnet,
Network Address           = 16.0.0.0          OR
Address (499th)       = 0.249.128.0
First Address (500th)     = 16.249.128.0 OR
Number of Address     = 0.0.127.255
Last Address (500th) = 16.249.255.255
```

25. An organization is granted the block 130.56.0.0/16. The administrator wants to create 1024 subnets.

$\log_2$ 1024 = 10, n’ = 16 + 10 = 26

a. Find the subnet mask.
n’ = 26, Subnet Mask = 255.255.255.192

b. Find the number of addresses in each subnet.
$2^{32-26} = 2^6 = 64$ addresses in each subnet

c. Find the first and the last address in the first subnet.
n’ = 26, Number of Address = 0.0.0.63
First Subnet,
First Address = 130.56.0.0 OR
Number of Address = 0.0.0.63
Last Address = 130.56.0.63

d. Find the first and the last address in the last subnet (subnet 1024).
Last Subnet,
Network Address = 130.56.0.0 OR
Address (1023) = 0.0.255.192
First Address (1024) = 130.56.255.192 OR
Number of Address = 0.0.0.63
Last Address (1024) = 130.56.255.255

26. An organization is granted the block 211.17.180.0/24. The administrator wants to create 32 subnets.

$\log_2 32 = 5$, n’ = 24 + 5 = 29

a. Find the subnet mask.
n’ = 29, Subnet Mask = 255.255.255.248

b. Find the number of addresses in each subnet.
$2^{32-29} = 2^3 = 8$ addresses in each subnet

c. Find the first and the last address in the first subnet.
n’ = 29, Number of Address = 0.0.0.7
First Subnet,
First Address = 211.17.180.0 OR
Number of Address = 0.0.0.7
Last Address = 211.17.180.7

d. Find the first and the last address in the last subnet (subnet 32).
Last Subnet,
Network Address = 211.17.180.0 OR
Address (499th) = 0.0.0.217
First Address (500th) = 211.17.180.217 OR
Number of Address = 0.0.0.7
Last Address (500th) = 211.17.180.224

27. Write the following mask in slash notation (/*n*):

a. 255.255.255.0
11111111 11111111 11111111 00000000 → /24

b. 255.0.0.0
11111111 00000000 00000000 00000000 → /8

c. 255.255.224.0

11111111 11111111 11100000 00000000 → /19

d. 255.255.240.0

11111111 11111111 11110000 00000000 → /20

28. Find the range of addresses in the following blocks:

a. 123.56.77.32/29

n = 29, N = 2^{32-29} = 2^{3} = 8
Network Mask = 255.255.255.248
Network Address = 123.56.77.32
First Address = 123.56.77.32
Number of Address = 0.0.0.7
Last Address = 123.56.77.39
Range : 123.56.77.32 – 123.56.77.39

b. 200.17.21.128/27

n = 27, N = 2^{32-27} = 2^{5} = 32
Network Mask = 255.255.255.224
Network Address = 200.17.21.128
First Address = 200.17.21.128
Number of Address = 0.0.0.31
Last Address = 200.17.21.159
Range : 200.17.21.128 – 200.17.21.159

c. 17.34.16.0/23

n = 23, N = 2^{32-23} = 2^{9} = 512
Network Mask = 255.255.254.0
Network Address = 17.34.16.0
First Address = 17.34.16.0
Number of Address = 0.0.1.255
Last Address = 17.34.17.255
Range : 17.34.16.0 – 17.34.17.255

d. 180.34.64.64/30

n = 30, N = 2^{32-20} = 2^{2} = 4
Network Mask = 255.255.255.252
Network Address = 180.34.64.64
First Address = 180.34.64.64
Number of Address = 0.0.0.3
Last Address = 180.34.64.67
Range : 180.34.64.64 – 180.34.64.67

29. In classless addressing, we know the first and the last address in the block. Can we find the prefix length? If the answer is yes, show the process and give an example.

If we know the first and last address of a block, then we can calculate the number of addresses, N in that block. Then we can calculate prefix, $n = 32 - \log_2 N$.

Example:

First Address = 17.24.12.64
Last Address = 17.24.12.127

So, N = 64
Hence, $n = 32 - \log_2 64 = 32 - 6 = 26$

The block is then 17.24.12.64/26.

30. In classless addressing, we know the first address and the number of addresses in the block. Can we find the prefix length? If the answer is yes, show the process and give an example.

If we know the first address and number of address, then we can calculate the prefix, $n = 32 - \log_2 N$.

Example:

Number of Address, N = 64

So,
prefix length, $n = 32 - \log_2 64 = 32 - 6 = 26$

31. In classless addressing, can two blocks have the same prefix length? Explain.

Many blocks can have the same prefix length. The prefix length only determines the number of addresses in the block, not the block itself. Two blocks can have the same prefix length but start in two different point in the address space. For example,

127.15.12.32/27	174.18.19.64/27

the following two blocks have the same prefix length, but they are definitely two different blocks. The length of the blocks are the same, but the blocks are different.

32. In classless addressing, we know the first address and one of the addresses in the block (not necessarily the last address). Can we find the prefix length? Explain.

Calculate the difference between A_2 and A_1 in binary representation. This will give us the number of bits that differ between the two addresses.

Let's call this difference Δ (delta).

Since A_1 is the first address in the block, it means that all addresses in the block share a common prefix with A_1. We can find the common prefix length by counting the number of leading zeros in Δ.

Let's call the common prefix length n.

The prefix length is the number of bits that are fixed in the block. Since we know the common prefix length n, we can calculate the prefix length as:

```
Prefix length = 32 (IPv4) - n
```

Example:

Suppose we know the first address A_1 = 192.168.1.0 and one of the addresses in block A_2 = 192.168.1.12.

In binary representation, A_1 = 11000000 10101000 00000001 00000000 and A_2 = 11000000 10101000 00000001 00001100.

The difference Δ = 00000000 00000000 00000000 00001100.

The common prefix length n is 22 (counting the leading zeros in Δ).

The prefix length = 32 - 22 = 10.

So, the prefix length is 10, and the block can be represented as 192.168.1.0/10.

In classless addressing, if we know the first address and one of the addresses in the block, we can try to find the prefix length by calculating the difference between the two addresses, finding the common prefix length, and then calculating the prefix length. However, this method assumes a contiguous range of addresses and a whole number prefix length.

33. An ISP is granted a block of addresses starting with 150.80.0.0/16. The ISP wants to distribute these blocks to 2600 customers as follows:

- **a.** The first group has 200 medium-size businesses; each needs approximately 128 addresses.
- **b.** The second group has 400 small businesses; each needs approximately 16 addresses.
- **c.** The third group has 2000 households; each needs 4 addresses.

Design the subblocks and give the slash notation for each subblock. Find out how many addresses are still available after these allocations.

Group 1

For this group, each customer needs 128 addresses. This means the suffix length is $\log_2 128 = 7$. The prefix length is then 32 − 7 = 25. The range of addresses are given for the first, second, and the last customer. The range of addresses for other customers can be easily found:

1st customer: 150.80.0.0/25 to 150.80.0.127/25

2nd customer: 150.80.0.128/25 to 150.80.0.255/25

... ...

200th customer: 150.80.99.128/25 to 150.80.99.255/25

Total addresses for group 1 = 200 × 128 = 25,600 addresses.

Group 2

For this group, each customer needs 16 addresses. This means the suffix length is $\log_2 16 = 4$. The prefix length is then 32 − 4 = 28. The addresses are:

1st customer: 150.80.100.0/28 to 150.80.100.15/28

2nd customer: 150.80.100.16/28 to 150.80.100.31/28

... ...

400th customer: 150.80.124.240/28 to 150.80.124.255/28

Total addresses for group 2 = 400 × 16 = 6400 addresses.

Group 3

For this group, each customer needs 4 addresses. This means the suffix length is $\log_2 4 = 2$. The prefix length is then 32 − 2 = 30. The addresses are:

1st customer: 150.80.125.0/30 to 150.80.125.3/30

2nd customer: 150.80.125.4/30 to 150.80.100.7/30

... ...

64th customer: 150.80.125.252/30 to 150.80.125.255/30

65th customer: 150.80.126.0/30 to 150.80.126.3/30

... ...

2048th customer: 150.80.156.252/30 to 150.80.156.255/30

Total addresses for group 3 = 2048 × 4 = 8192 addresses.

Number of allocated addresses: 40,192

Number of available addresses: 25,344

34. An ISP is granted a block of addresses starting with 120.60.4.0/20. The ISP wants to distribute these blocks to 100 organizations with each organization receiving 8 addresses only. Design the subblocks and give the slash notation for each subblock. Find out how many addresses are still available after these allocations.

The block 120.60.4.0/20 has a subnet mask of 255.255.240.0 (20 bits for the network part and 12 bits for the host part). This means there are 2^{12} = 4096 addresses in the block.

Each organization needs 8 addresses, which means we need to borrow 3 bits from the host part (2^3 = 8).

The new subnet mask for each subblock will be 20 (original) + 3 (borrowed) = 23 bits.

The subnet mask for each subblock is 255.255.254.0 (23 bits for the network part and 9 bits for the host part).

The ISP needs to distribute blocks to 100 organizations, so we need 100 subblocks.

We can calculate the starting address of each subblock by incrementing the last byte of the original block by 2^3 = 8 for each subblock.

Here are the first few subblocks:

- Subblock 1: 120.60.4.0/23
- Subblock 2: 120.60.4.8/23
- Subblock 3: 120.60.4.16/23
  …
- Subblock 100: 120.60.7.232/23

We've allocated 100 subblocks, each with 8 addresses, so we've used 100 x 8 = 800 addresses.

There are 4096 addresses in the original block, so the number of addresses still available is:

4096 - 800 = 3296 addresses

Therefore, there are 3296 addresses still available after these allocations.

35. An ISP has a block of 1024 addresses. It needs to divide the addresses to 1024 customers. Does it need subnetting? Explain your answer.

There are two choices. If the ISP wants to use subnetting (a router with 32 output ports) then the prefix length for each customer is $n_{sub} = 32$. However, there is no need for a router and subnetting. Each customer can be directly connected to the ISP server. In this case, the whole set of the customer can be taught addresses in one single block with the prefix length n (the prefix length assigned to the ISP).