FACULTY OF INFORMATION TECHNOLOGY
DEPARTMENT OF NETWORKS AND INFORMATION SYSTEMS

CHAPTER 3 – EXERCISES

IPv4 Subnetting

OBJECTIVES

- Understand clearly about IPv4 addresses
- Master the IPv4 address representation formats
- Practice subnetting IPv4 addresses

KEY WORDS

- Binary format
- Dotted-decimal format
- CIDR format
- IPv4 subnetting

CONTENTS

Exercise Form 1

Description

You are given a IPv4 address in CIDR notation

Determine the following:

- Number of network bits
- Number of host bits
- Number of host addresses
- Subnet mask in binary format
- Subnet mask in dotted-decimal
- Network address in CIDR notation
- Address of first host in CIDR notation
- Address of second host in CIDR notation
- Address of last host in CIDR notation
- Broadcast address in CIDR notation

Exercise Form 1

Example 01 – Question

CIDR IPv4 address: 152.43.78.69/24

Determine the following:

- Number of network bits
- Number of host bits
- Number of host addresses
- Subnet mask in binary format
- Subnet mask in dotted-decimal
- Network address in CIDR notation
- Address of first host in CIDR notation
- Address of second host in CIDR notation
- Address of last host in CIDR notation
- Broadcast address in CIDR notation

Exercise Form 1

Example 01 – Answer

CIDR IPv4 address: 152.43.78.69/24 = A.B.C.D/n (A.B.C.D = 152.43.78.69 and n = 24)

• Number of network bits (= n):	**24**			
• Number of host bits (= 32 – n = m):	**8 (= 32 - 24)**			
• Number of host addresses (= 2^m – 2):	**254 (= 2^8 – 2)**			
• Subnet mask in binary format = "24 bits 1" (n = 24):	**11111111 11111111 11111111 00000000**			
• Convert each byte from binary to decimal:	255	255	255	0
• Subnet mask in dotted-decimal:	**255.255.255.0**			
• A.B.C.D part from CIDR (=152.43.78.69):	152	43	78	69
• A.B.C.D part in binary format:	10011000	00101011	01001110	01000101
• Subnet mask in binary format:	11111111	11111111	11111111	00000000
• Apply Bitwise operator to the above two lines:	10011000	00101011	01001110	00000000
• Network address in binary format (as above):	10011000	00101011	01001110	00000000
• Network address in dotted-decimal (=152.43.78.0):	152	43	78	0
• Network address in CIDR notation:	**152.43.78.0/24**			

Exercise Form 1

Example 01 – Answer

CIDR IPv4 address: 152.43.78.69/24 = A.B.C.D/n (A.B.C.D = 152.43.78.69 and n = 24)

• Network address in binary format:	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
• Address of first host in binary format:	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1
• Address of first host in dotted-decimal:	152							43							78								1								
• Address of first host in CIDR notation:	**152.43.78.1/24**																														
• Address of second host in binary format:	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0
• Address of second host in dotted-decimal:	152							43							78								2								
• Address of second host in CIDR notation:	**152.43.78.2/24**																														
…	…																														
• Address of last host in binary format:	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0
• Address of last host in dotted-decimal:	152							43							78								254								
• Address of last host in CIDR notation:	**152.43.78.254/24**																														
• Broadcast address in binary format:	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1
• Broadcast address in dotted-decimal:	152							43							78								255								
• Broadcast address in CIDR notation:	**152.43.78.255/24**																														

Exercise Form 1

Example 02 – Question

CIDR IPv4 address: 205.15.37.39/28

Determine the following:

- Number of network bits
- Number of host bits
- Number of host addresses
- Subnet mask in binary format
- Subnet mask in dotted-decimal
- Network address in CIDR notation
- Address of first host in CIDR notation
- Address of second host in CIDR notation
- Address of last host in CIDR notation
- Broadcast address in CIDR notation

Exercise Form 1

Example 02 – Answers

CIDR IPv4 address: 215.108.79.39/28

• Number of network bits:	28
• Number of host bits:	4
• Number of host addresses:	14
• Subnet mask in binary format:	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0
• Subnet mask in dotted-decimal:	255.255.255.240
• Network address in CIDR notation:	215.108.79.32/28
• Address of first host in CIDR notation:	215.108.79.33/28
• Address of second host in CIDR notation:	215.108.79.34/28
. . .	...
• Address of last host in CIDR notation:	215.108.79.46/28
• Broadcast address in CIDR notation:	215.108.79.47/28

Exercise Form 2

Description

You are given an IPv4 address with the original subnet mask and the number of subnets need to create.

Determine the following:

- Calculate network address of current IP address (the original subnet mask) ?
- Find the number of "borrowing" bits to create new subnets
- Identify a new subnet mask
- List the new network IDs of subnets in CIDR notation (in order from small to large)

Exercise Form 2

Example 01 – Form 2a: Question

Given IPv4 address (123.45.167.98/23) and subnetting that network to four subnetworks.

Determine the following:

- Calculate network address of current IP address ?
- Find the number of "borrowing" bits to create new four subnets
- Identify a new subnet mask
- List the four network IDs of subnets in CIDR notation (in order from small to large)

Note:

- 2^(c-1) < The number of subnets ≤ 2^c;
- c is number of "borrowing" bits, it is an positive integer number

Exercise Form 2

Example 01 – Form 2a: Answer

CIDR IPv4 address: 123.45.167.98/23, devide that network to 4 subnetworks

Given IPv4 address	123	45	167	98	/23
Step 1: Calculate the Network address (Network ID or Net ID)					
• IP address in binary format (a)	01111011	00101101	10100111	01100010	/23
• Original subnet mask: /23 (b)	11111111	11111111	11111110	00000000	
• Apply foumular: (a) AND (b)	01111011	00101101	10100110	00000000	/23
• **The Network ID**	**123**	**45**	**166**	**0**	**/23**
Step 2: Find the number of "borrowing" bits to create four subnets:					
• 2 ^ (2-1) < 4 (four subnets) ≤ 2 ^ 2					
• 2 is "borrowing" bits					
Step 3: Identify a new subnet mask					
• New subnet mask (from /23 to /25)	11111111	11111111	11111111	10000000	(= /25)
• **New subnet mask in dotted-decimal**	**255**	**255**	**255**	**128**	

Exercise Form 2

Example 01 – Form 2a: Answer

CIDR IPv4 address: 123.45.167.98/23, devide that network to 4 subnetworks

Step 4: Calculate the subnet ID in binary format					
• The original network ID	1111011	101101	10100110	00000000	/23
• Subnet ID 1	1111011	101101	10100110	00000000	/25
• Subnet ID 2	1111011	101101	10100110	10000000	/25
• Subnet ID 3	1111011	101101	10100111	00000000	/25
• Subnet ID 4	1111011	101101	10100111	10000000	/25
Step 5: Show the subnet ID in CIDR notation					
• **Subnet ID 1**	**123**	**45**	**166**	**0**	**/25**
• **Subnet ID 2**	**123**	**45**	**166**	**128**	**/25**
• **Subnet ID 3**	**123**	**45**	**167**	**0**	**/25**
• **Subnet ID 4**	**123**	**45**	**167**	**128**	**/25**

Example 02 – Form 2b: Question

Given IPv4 address (89.145.73.107/23), devide that network to some subnetworks.

Each subnet has 28 PCs (one IP per PC).

Determine the following:

- Calculate network address of current IP address
- Find the number of "borrowing" bits to create new four subnets
- Identify a new subnet mask
- List the network IDs of subnets in CIDR notation (in order from small to large)

Exercise Form 2

Example 02 – Form 2b: Answer

CIDR IPv4 address: 89.145.73.107/23, devide that network to 16 subnetworks

Given IPv4 address	89	145	73	107	/23
Step 1: Calculate the Network address (Network ID or Net ID)					
• **The Network ID**	**89**	**145**	**72**	**0**	**/23**
Step 2: Find the number of "borrowing" bits to create subnets:					
• [2 ^ (d - 1)] - 2 < 28 (number of hosts in each subnet) ≤ [2 ^ d] - 2					
• d is number of bits for host part. Here d is 5 (or /27). **"Borrowing" bits are 4** (= 27 - 23)					
Step 3: Identify a new subnet mask					
• New subnet mask (from /23 to /27)	11111111	11111111	11111111	11100000	(= /27)
• **New subnet mask in dotted-decimal**	**255**	**255**	**255**	**224**	

Exercise Form 2

Example 02 – Form 2b: Answer

CIDR IPv4 address: 89.145.73.107/23, devide that network to 16 subnetworks

Step 4: Calculate the subnet ID in binary format					
• The original network ID	01011001	10010001	01001000	00000000	/23
• Subnet ID 1	01011001	10010001	01001000	00000000	/27
• Subnet ID 2	01011001	10010001	01001000	00100000	/27
			...		
• Subnet ID 15	01011001	10010001	01001001	11000000	/27
• Subnet ID 16	01011001	10010001	01001001	11100000	/27
Step 5: Show the subnet ID in CIDR notation					
• **Subnet ID 1**	**89**	**145**	**72**	**0**	**/27**
• **Subnet ID 2**	**89**	**145**	**72**	**32**	**/27**
			...		
• **Subnet ID 15**	**89**	**145**	**73**	**192**	**/27**
• **Subnet ID 16**	**89**	**145**	**73**	**224**	**/27**

Exercise Form 3

Description

You are given an IPv4 address with the original subnet mask and some information of subnets (of units or departments) need to create. Each subnet has its own prefix, which is not necessarily equal

Determine the following:

- Calculate network address of current IP address (the original subnet mask) ?
- Find the number of "borrowing" bits to create each subnet
- Subnetting the network according to the identified prefixes (big part first), then allocate to units (or departments)
- List the new network IDs of subnets in CIDR notation

Exercise Form 3

Example 01 – Question

- Given IPv4 address (158.99.225.193/22), devide that Network to 6 subnetworks (for 6 units in the company under the University of Transport and Communications). Each person has one PC with one IP address.
- Determine the network range for units with the number of people as below.
  - Business Department: 31 people
  - Factory: 127 people
  - Administration Office: 20 people
  - Information Security Department: 63 people
  - R&D Department: 72 people
  - Technical Department: 100 People

Exercise Form 3

Example 01 – Answer

Implementation Guide

- Calculate Network address (Net ID): 158.99.224.0/22
- Find the network/host part for each subnet (= Find the number of bits for host part of each subnet)
  - Arrange the departments by number of people (many people are ranked first; if the number of people is equal, the unit above in the question will be ranked first)
  - Use the inequation: (2^m - 2) ≥ (people) with m = the number of bits for host part

Net ID in dotted-decimal format	158.	99.	224.	0	/22
Net ID in binary format	10011110	01100011	11100000	00000000	/22
Step 1: Find the network/host part for each subnet (= Find the number of bits for host part)					
• Factory: 127	(2^m - 2) ≥ 127 → m = 8 → 32 - m = 32 - 8 = 24				/24
• Technical Department: 100	(2^m - 2) ≥ 100 → m = 7 → 32 - m = 32 - 7 = 25				/25
• R&D Department: 72	(2^m - 2) ≥ 72 → m = 7 → 32 - m = 32 - 7 = 25				/25
• Information Security Department: 63	(2^m - 2) ≥ 63 → m = 7 → 32 - m = 32 - 7 = 25				/25
• Business Department: 31	(2^m - 2) ≥ 31 → m = 6 → 32 - m = 32 - 6 = 26				/26
• Administration Office: 20	(2^m - 2) ≥ 20 → m = 5 → 32 - m = 32 - 5 = 27				/27

Exercise Form 3

Example 01 – Answer

Implementation Guide

- Subnetting the network, then allocate to departments

Step 2: Subnetting the Net ID (/22) to 4 subnets (/24)					
• Subnet 1 (Allocate to the Factory)	158.	99.	224.	0	/24
• Subnet 2 (subnetting to 2 subnets /25)	158.	99.	225.	0	/24
• Subnet 3 (subnetting to 2 subnets /25)	158.	99.	226.	0	/24
• Subnet 4 (not used)	158.	99.	227.	0	/24
Step 3: Subnetting the subnet 2, 3 (/24) to subnets (/25)					
• Subnet 2.1 (Allocate to Technical Dept)	158.	99.	225.	0	/25
• Subnet 2.2 (Allocate to R&D)	158.	99.	225.	128	/25
• Subnet 3.1 (Allocate to Information Security)	158.	99.	226.	0	/25
• Subnet 3.2 (subnetting to 2 subnets /26)	158.	99.	226.	128	/25
Step 4: Subnetting the subnet 3.2 (/25) to 2 subnets (/26)					
• Subnet 3.2.1 (Allocate to Business)	158.	99.	226.	128	/26
• Subnet 3.2.2 (subnetting to 2 subnets /27)	158.	99.	226.	192	/26
Step 5: Subnetting the subnet 3.2.2 (/26) to 2 subnets (/27)					
• Subnet 3.2.2.1 (Allocate to Administration)	158.	99.	226.	192	/27
• Subnet 3.2.2.2 (not used)	158.	99.	226.	224	/27

Exercise Form 3

Example 01 – Answer

Result:

/22	/24	/24	/24	Factory: 158.99.224.0/24
	/24	/25	/25	Technical Department: 158.99.225.0/25
		/25	/25	R&D Department: 158.99.225.128/25
	/24	/25	/25	Information Security Dept: 158.99.226.0/26
		/25	/26	Business Department: 158.99.226.128/26
			/27	Administration Office: 158.99.226.192/27
			/27	(not used): 158.99.226.224/27
	/24	/24	/24	(not used): 158.99.227.0/24

Exercise Form 1 – Question

Determine the following:

- Number of network bits
- Number of host bits
- Number of host addresses
- Subnet mask in binary format
- Subnet mask in dotted-decimal
- Network address in CIDR notation
- Address of first host in CIDR notation
- Address of second host in CIDR notation
- Address of last host in CIDR notation
- Broadcast address in CIDR notation

Form 1 - Exercise 1: CIDR IPv4 address is 231.58.197.46/23

Form 1 - Exercise 2: CIDR IPv4 address is 14.75.189.236/25

Exercise Form 2 – Question

Determine the following:

- Calculate network address of current IP address
- Find the number of "borrowing" bits to create new four subnets
- Identify a new subnet mask
- List the network IDs of subnets in CIDR notation (in order from smallest to largest)

Form 2a - Exercise 1: CIDR IPv4 address is 203.185.207.99/25, devide that Network to 7 subnetworks.

Form 2b - Exercise 1: CIDR IPv4 address is 105.93.219.235/22, devide that Network to some subnetworks. Each subnet has 15 PCs (one IP per PC)

Homework

Exercise Form 3 – Question

- Given IPv4 address (139.199.205.47/23), devide that Network to 6 subnetworks (for 6 units in the company under the University of Transport and Communications). Each person has one PC with one IP address.
- Determine the network range for units with the number of people as below.
  - Marketing department: 15 people
  - Teaching block: 128 people
  - Administrative block: 126 people
  - Training department: 38 people
  - Admissions consulting department: 54 people
  - System implementation department: 108 people

Questions and Answers