ASSIGNMENT 5

CSCI 6704 – Advanced Topics In Networks

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Example 1: VSLM Problem 1

Given a class C network address 201.45.68.0 and the following subnet requirements:

a. Subnet A: must support 14 hosts
b. Subnet B: must support 28 hosts
c. Subnet C: must support 2 hosts
d. Subnet D: must support 10 hosts
e. Subnet E: must support 45 hosts

Draw the topology of the internetwork showing the main gateway router at the exit point of the internetwork, routers at the exit point of each subnet, and each of these routers connecting to the main gateway router (similar to the examples from the lectures). The above requirement does not include router interfaces or the extra networks created by router interconnections (that is, you have to add them and account for them).

Design the subnetting scheme using VLSM. You need to account for all the extra addresses required by the routers. Show all steps. In the final solution table, indicate the subnet number, host ranges, broadcast address and mask for each subnet. Also indicate the total number and ranges of free addresses.

Answer

Figure 1 displays the screenshot of an internetwork with an IP address of **201.45.68.0**. Multiple routers (i.e., Routers R2 to R6) are connected to a primary router (i.e., Router R1) called gateway router. The gateway router connects to the internet. Further, routers R2 to R6 connect subnets A to E.

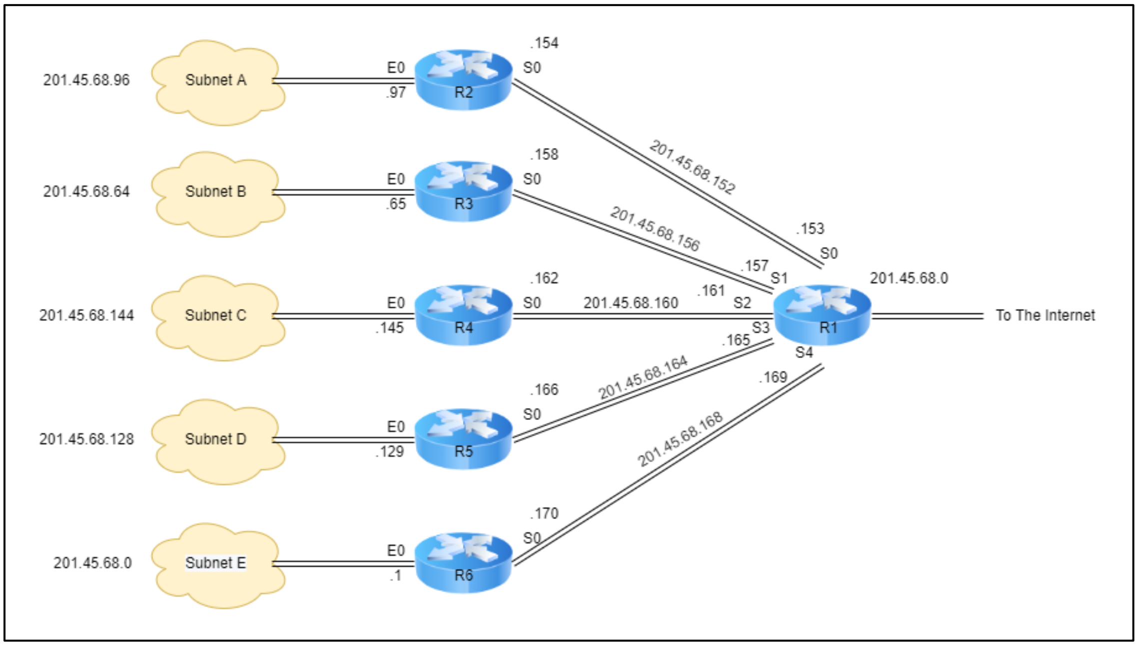


Figure 1 - Internetwork topology with network address 201.45.68.0

Step 1: Calculate total addresses required by each subnet to check whether the requirement fits under the Class C network (i.e., Total addresses required must be less than **256**).

Table 1 - Total addresses calculation

Subnet Name	Total Addresses Required
Subnet A	14 hosts + 1 + 2 = 17
Subnet B	28 hosts + 1 + 2 = 31
Subnet C	2 hosts + 1 + 2 = 5
Subnet D	10 hosts + 1 + 2 = 13
Subnet E	45 hosts + 1 + 2 = 48
R1 – R2	2 + 2 = 4
R1 – R3	2 + 2 = 4
R1 – R4	2 + 2 = 4
R1 – R5	2 + 2 = 4
R1 – R6	2 + 2 = 4
Total	**134**

The additional **1** added to host address spaces accounts for the subnet interface address.

Value 2 added to each entry in **Table 1** indicates the use of two addresses (i.e., subnet address and broadcast address). Since the total is **134** which is less than **256,** we can create given subnets.

Step 2: Calculate the number of host bits (i.e., H) and the number of subnet bits (i.e., S) for each subnet. Since subnets are to be created for Class C address space, only the last octet (i.e., last 8 bits) is to be used. The process to be followed is as below:

a. Start with the largest subnet.
b. Allocate the required number of Host ID bits.
c. Use the remaining bits for Subnet ID.

Table 2 - Subnet ID and Host ID bits allocation

Subnet Name	Total Addresses Required	Host ID bits required	Subnet ID bits required (8 – host id bits)	Subnet and Host bits
Subnet E	48	2^6 = 64 => 6 bits	8 – 6 = 2 bits	201.45.68.SS**HHHHHH**
Subnet B	31	2^5 = 32 => 5 bits	8 – 5 = 3 bits	201.45.68.SSS**HHHHH**
Subnet A	17	2^5 = 32 => 5 bits	8 – 4 = 3 bits	201.45.68.SSS**HHHHH**
Subnet D	13	2^4 = 16 => 4 bits	8 – 4 = 4 bits	201.45.68.SSSS**HHHH**
Subnet C	5	2^3 = 8 => 3 bits	8 – 3 = 5 bits	201.45.68.SSSSS**HHH**
R1 – R2	4	2^2 = 4 => 2 bits	8 – 2 = 6 bits	201.45.68.SSSSSS**HH**
R1 – R3	4	2^2 = 4 => 2 bits	8 – 2 = 6 bits	201.45.68.SSSSSS**HH**
R1 – R4	4	2^2 = 4 => 2 bits	8 – 2 = 6 bits	201.45.68.SSSSSS**HH**
R1 – R5	4	2^2 = 4 => 2 bits	8 – 2 = 6 bits	201.45.68.SSSSSS**HH**
R1 – R6	4	2^2 = 4 => 2 bits	8 – 2 = 6 bits	201.45.68.SSSSSS**HH**

Step 3: The solution shows the final table with entries subnet number, host ranges, broadcast address, and mask for each subnet.

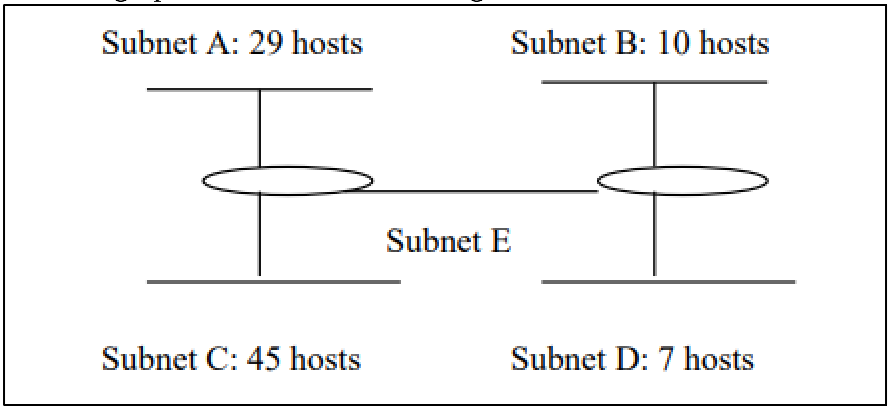
Table 3 - Solution Table

Subnet Number	Subnet Name	Subnet Assign	Subnet Address	Host Ranges	Broadcast Address	Mask
1	Subnet E	00000000	201.45.68.0	201.45.68.1 – 201.45.68.62	201.45.68.63	/26
2	Subnet B	01000000	201.45.68.64	201.45.68.65 – 201.45.68.94	201.45.68.95	/27
3	Subnet A	01100000	201.45.68.96	201.45.68.97 – 201.45.68.126	201.45.68.127	/27
4	Subnet D	10000000	201.45.68.128	201.45.68.129 – 201.45.68.142	201.45.68.143	/28
5	Subnet C	10010000	201.45.68.144	201.45.68.145 – 201.45.68.150	201.45.68.151	/29
6	R1 – R2	10011000	201.45.68.152	201.45.68.153 – 201.45.68.154	201.45.68.155	/30
7	R1 – R3	10011100	201.45.68.156	201.45.68.157 – 201.45.68.158	201.45.68.159	/30
8	R1 – R4	10100000	201.45.68.160	201.45.68.161 – 201.45.68.162	201.45.68.163	/30
9	R1 – R5	10100100	201.45.68.164	201.45.68.165 – 201.45.68.166	201.45.68.167	/30
10	R1 – R6	10101000	201.45.68.168	201.45.68.169 – 201.45.68.170	201.45.68.171	/30

Step 4: Free addresses remaining are as below:
Range: 201.45.68.172 – 201.45.68.255
(Since the last address in **Table 3** is 201.45.68.171, the free addresses range starts from 201.45.68.172)

Example 2: VLSM Problem 2

Repeat the VLSM design problem for the following scenario:



The class C address allocated to the network is 209.78.32.0. The router interfaces must also be assigned with addresses – these are not included in the number of hosts given.

Answer

Figure 2 displays the screenshot of an internetwork with an IP address of **209.78.32.0**. Routers R1 and R2 are connected to form a subnet **E**. Also, subnets **A** and **C** are connected to router R1 and subnets **B** and **D** are connected to router R2.

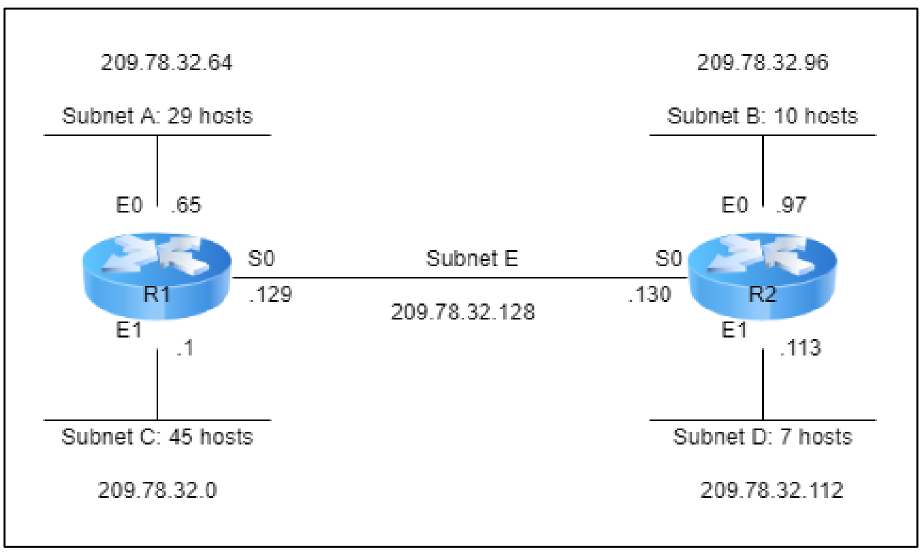


Figure 2 - Internetwork topology with network address 201.78.32.0

Step 1: Calculate total addresses required by each subnet to check whether the requirement fits under the Class C network (i.e., Total addresses required must be less than **256**).

Table 4 - Total addresses calculation

Subnet Name	Total Addresses Required
Subnet C	45 hosts + 1 + 2 = 48
Subnet A	29 hosts + 1 + 2 = 32
Subnet B	10 hosts + 1 + 2 = 13

Subnet D	7 hosts + 1 + 2 = 10
R1 – R2	2 + 2 = 4
Total	107

The additional **1** added to host address spaces accounts for the subnet interface address. Value 2 added to each entry in **Table 4** indicates the use of two addresses (i.e., subnet address and broadcast address). Since the total is **107** which is less than **256,** we can create given subnets.

Step 2: Calculate the number of host bits (i.e., H) and the number of subnet bits (i.e., S) for each subnet. Since subnets are to be created for Class C address space, only the last octet (i.e., last 8 bits) is to be used. The process to be followed is as below:

a. Start with the largest subnet.
b. Allocate the required number of Host ID bits.
c. Use the remaining bits for Subnet ID.

Table 5 - Subnet ID and Host ID bits allocation

Subnet Name	Total Addresses Required	Host ID bits required	Subnet ID bits required (8 – host id bits	Subnet and Host bits
Subnet C	47	2^6 = 64 => 6 bits	8 – 6 = 2 bits	209.78.32.SS**HHHHHH**
Subnet A	31	2^5 = 32 => 5 bits	8 – 5 = 3 bits	209.78.32.SSS**HHHHH**
Subnet B	12	2^4 = 16 => 4 bits	8 – 4 = 4 bits	209.78.32.SSSS**HHHH**
Subnet D	09	2^4 = 16 => 4 bits	8 – 4 = 4 bits	209.78.32.SSSS**HHHH**
R1 – R2	4	2^2 = 4 => 2 bits	8 – 2 = 6 bits	209.78.32.SSSSSS**HH**

Step 3: The solution shows the final table with entries subnet number, host ranges, broadcast address, and mask for each subnet.

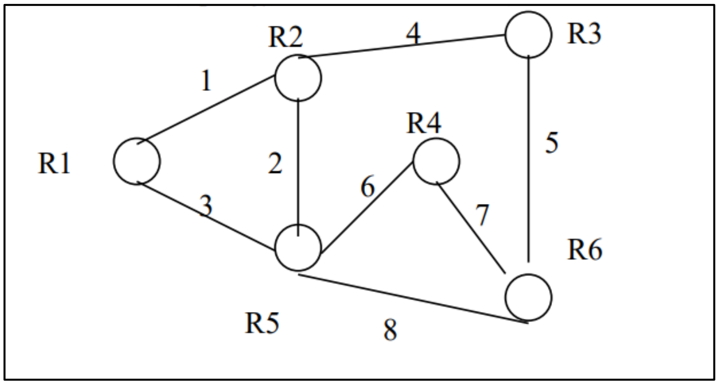
Table 6 - Solution Table

Subnet Number	Subnet Name	Subnet Assign	Subnet Address	Host Ranges	Broadcast Address	Mask
1	Subnet C	00000000	209.78.32.0	209.78.32.1 – 209.78.32.62	209.78.32.63	/26
2	Subnet A	01000000	209.78.32.64	209.78.32.65 – 209.78.32.94	209.78.32.95	/27
3	Subnet B	01100000	209.78.32.96	209.78.32.97 – 209.78.32.110	209.78.32.111	/28
4	Subnet D	01110000	209.78.32.112	209.78.32.113 – 209.78.32.126	209.78.32.127	/28
5	R1 – R2	10000000	209.78.32.128	209.78.32.129 – 209.78.32.130	209.78.32.131	/30

Step 4: Free addresses remaining are as below:
Range: 209.78.32.132 – 209.78.32.255
(Since the last address in **Table 3** is 209.78.32.131, the free addresses range starts from 209.78.32.132)

Example 3: Link State Database

The following figure shows a network of routers running the link-state routing algorithm. The numbers on the links represent costs. Assume that R1 is directly connected to a network N1 with a cost of 0, R2 to N2, etc. Write the link-state database (topology information database) that will be stored in each router after flooding.



<u>Answer</u>

The **Link State Database** stored in each router after flooding is as below:

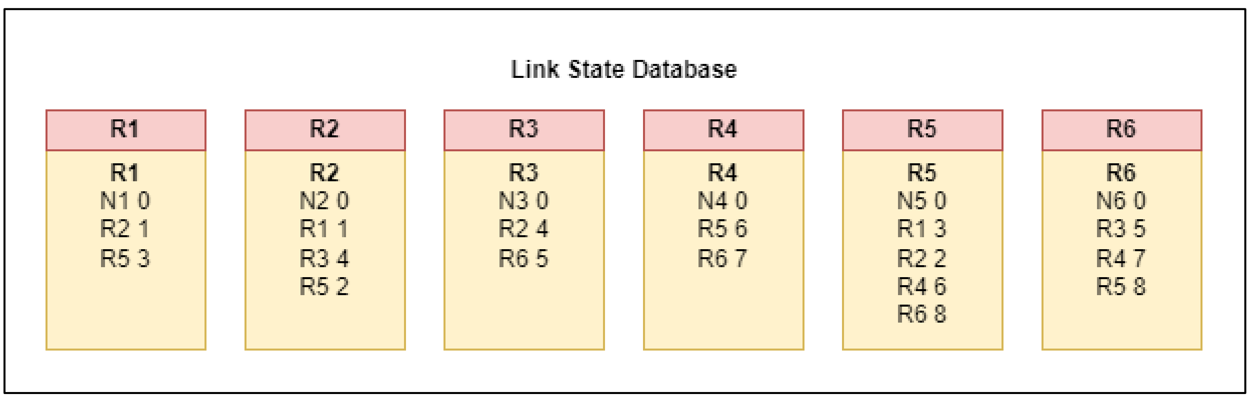


Figure 3 - Link State Database stored in all the routers

Example 4: IPv6 (Short Snappers)

4. What is the original (unabbreviated) form of the following IPv6 addresses:
- 0::0
- 0:AA::0
- 0:1234::3
- 123::1:2

Answer
Table 7 shows the short and original IPv6 addresses.

Table 7 – Short and Original IPv6 Addresses

Short IPv6 Address	Original IPv6 Address
0::0	0000:0000:0000:0000:0000:0000:0000:0000
0:AA::0	0000:00AA:0000:0000:0000:0000:0000:0000
0:1234::3	0000:1234:0000:0000:0000:0000:0000:0003
123::1:2	0123:0000:0000:0000:0000:0000:0001:0002

5. Identify the type (such as a provider-based unicast address, loopback reserved address, etc.) of each of the following
IPv6 addresses:
- 0::0
- 0::FFFF:0:0
- 582F:1234::2222
- 4821::14:22

Answer
Table 8 shows the short and original IPv6 addresses along with the address IPv6 address type.

Table 8 – Short and Original IPv6 Addresses along with Address Type

Short IPv6 Address	Original IPv6 Address	Address Type
0::0	0000:0000:0000:0000:0000:0000:0000:0000	Unspecified Address (Reserved Address)
0::FFFF:0:0	0000:0000:0000:0000:0000:FFFF:0000:0000	Mapped IPv4 Address
582F:1234::2222	582F:1234:0000:0000:0000:0000:0000:2222	Global/Provider-based Unicast Address
4821::14:22	4821:0000:0000:0000:0000:0000:0014:0022	Global/Provider-based Unicast Address

6. An IPv6 packet consists of the base header and a TCP segment. The length of the payload is 320 bytes. The packet carries HTTP data. The flow label is 2342. The destination and source addresses are 582F:1234::2222 and 4821::14:22, respectively. The hop limit is set to 64. Draw the base header and enter a value for each field in HEX in the base header. The source and destination IPv6 addresses must be written in the expanded form (un-abbreviated)

<u>Answer</u>

Figure 4 displays the base header with values entered in hexadecimal format.

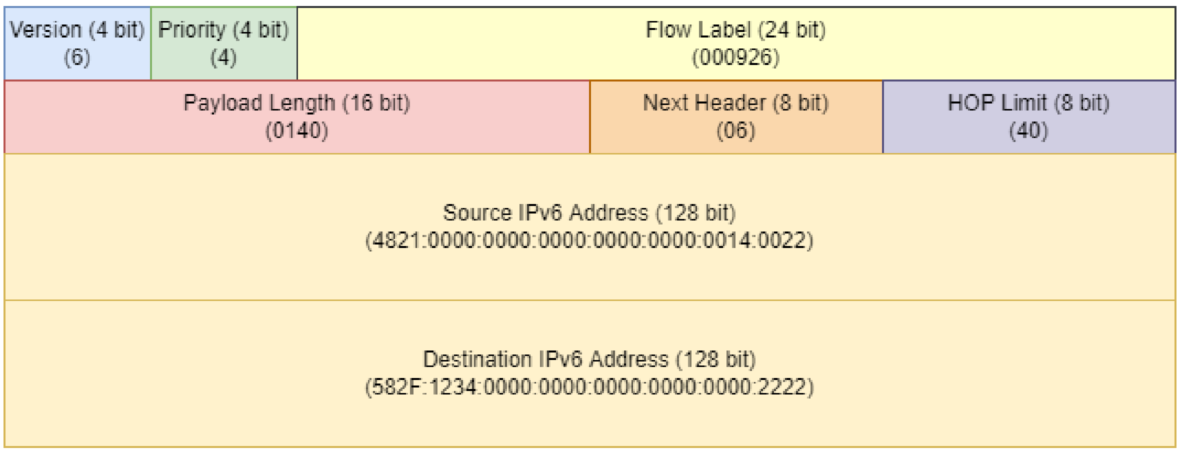


Figure 4 - IPv6 base header

7. Write the mapped IPv6 address format of the IPv4 address 129.6.12.34 in hexadecimal colon notation.

<u>Answer</u>

The format of the mapped IPv6 address is as below:

- The first 80 bits are set to 0.
- The next 16 bits are set to 1.
- The last 32 bits appended is the IPv4 decimal notation address.

Table 9 shows the mapped IPv6 address for the given IPv4 address.

Table 9 – Ipv6 mapped address

16 bits	16 bits	16 bits	16 bits	16 bits	16 bits	32 bits
All bits 0	All bits 0	All bits 0	All bits 0	All bits 0	All bits 1	IPv4 Address
0000	0000	0000	0000	0000	FFFF	129.6.12.34

The hexadecimal value for IPv4 address 129.6.12.34 is **8106:0C22**.

Mapped IPv6 address notations for IPv4 address 129.6.12.34 are as below:

- **Notation 1:** 0000:0000:0000:0000:0000:FFFF:129.6.12.34
- **Notation 2:** ::FFFF:129.6.12.34
- **Notation 3:** ::FFFF:129.6.12.34/96
- **Notation 4:** 0000:0000:0000:0000:0000:FFFF:8106:0C22
- **Notation 5:** ::FFFF:8106:0C22
- **Notation 6:** ::FFFF:8106:0C22/96

8. Write the IPv6 loopback address in hexadecimal colon notation

Answer

The IPv6 loopback address is denoted as below:

- **Notation 1:** ::1/128
- **Notation 2:** 0:0:0:0:0:0:0:1/128
- **Notation 3:** 0000:0000:0000:0000:0000:0000:0000:0001/128