IPv4 Subnetting Examples

Example 1

- **Given** base network: 192.168.100.0/24

- **Design** a subnetting scheme to meet the following **requirements:**

    1. The LAN with PC-A needs to hold up to 40 hosts

    2. The LAN with PC-B requires at least 89 host addresses

- **Assign** the 1st usable host address in each subnet to its default gateway, assign the 2nd usable host address in each subnet to the PC, assign the last usable host address in Subnet A to the SVI of S1
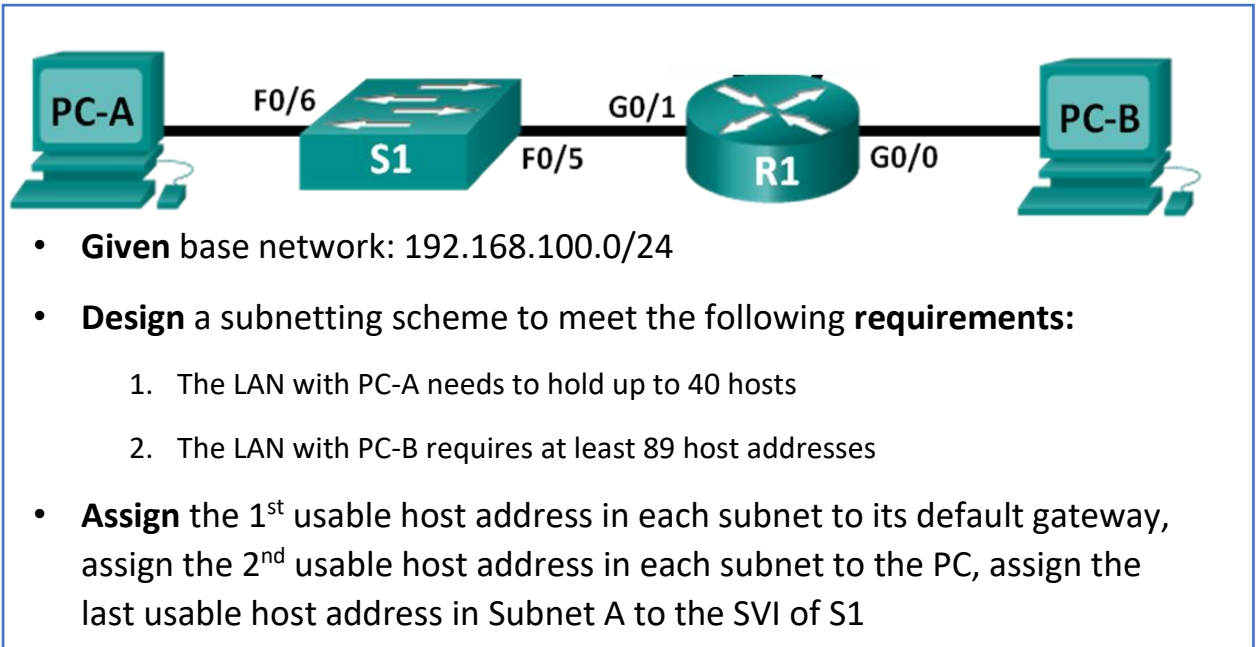
Questions to ask and answer when designing the subnetting scheme:

1. How many network bits and how many host bits in an address of the base network?

2. How many subnets are required?

3. What is the minimum number of bits to borrow in order to create the required number of subnets?

4. What is the required number of hosts in the largest subnet?

5. How many host bits are required to meet the #host requirement in the largest subnet?

6. What is the subnet mask and what is the network address for each of the subnets?

7. What is the broadcast address and what is the range of usable host addresses for each of the subnets?

1. How many network bits and how many host bits in an address of the base network?

Answer: The base network's subnet mask is given as /24 (or 255.255.255.0). Hence there are 24 network bits and 8 (=32-24) host bits in an address of the base network.

	Network portion (24 bits)			Host portion (8 bits)
Address	192.	168.	100.	hhhhhhhh
Mask	255.	255	255.	00000000

2. How many subnets are required?
   Answer: From the topology, 2 subnets are required, one for each LAN

3. What is the minimum number of bits to borrow in order to create the required number of subnets?

   Answer: 1.
   Recall that #subnets created = 2^#bits borrowed

	Network portion (25 bits)			Host portion (7 bits)
Address	192.	168.	100.	nhhhhhhh
Mask	255.	255	255.	10000000

4. What is the minimum number of hosts in the largest subnet?
   Answer: 89, based on the requirement.

5. How many host bits are required to meet the #host requirement in the largest subnet?
   Answer: 7.
   Recall that #hosts=2^#remaining host bits-2, 2^7-2=126 > 89. 6 host bits would not be enough because 2^6-2=62 <89
   Note: from the answer to question 3, after 1 bit is borrowed, 7 host bits remained, which is good – the base network is big enough to accommodate both host and subnet requirements; otherwise, we have to use a bigger base network.

6. What is the subnet mask and what is the network address for each of the subnets?
   Answer:
   a. **Subnet mask** of the new subnets: /25.
      Note that base network subnet mask is /24, i.e. there are 24 network bits in each of the addresses in the base network. After we have borrowed 1 host bit as network bit, there are 25 network bits for each of the addresses. So the subnet mask for each of the subnets is the same, which is /25)

	Network portion (25 bits)			Host portion (7 bits)
Address	192.	168.	100.	nhhhhhhh
Mask	255.	255	255.	10000000

   b. **Network addresses**
      1st subnet: Set the borrowed bit to 0 and set all the 7 host bits to 0 →
      network address of the first subnet: 192.168.100.0/25

	Network portion			Host portion
Address	192.	168.	100.	0hhhhhhh
Mask	255.	255	255.	10000000

2nd subnet: Set the borrowed bit to 1 and set all the 7 host bits to 0 →
network address of the 2nd subnet: 192.168.100.128/25

	Network portion			Host portion
Address	192.	168.	100.	1hhhhhhh
Mask	255.	255	255.	10000000

7. What is the broadcast address and what is the range of usable host addresses for each of the subnets?
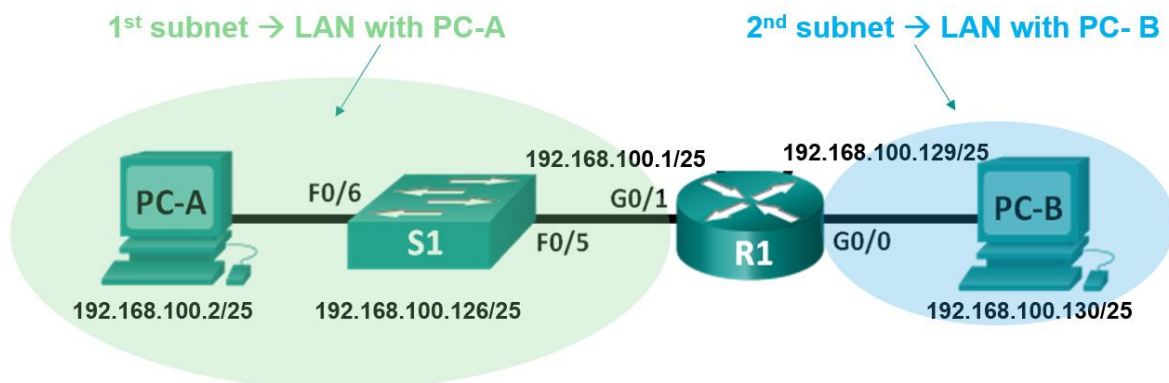
Answer:

1st subnet:
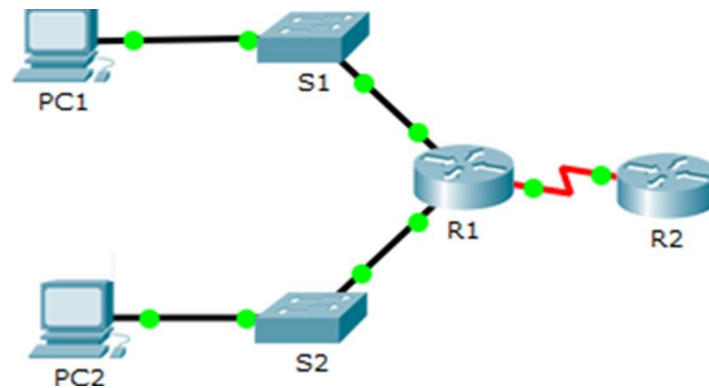
Network address: 192.168.100.0/25

Network Address	192.	168.	100.	00000000

- The 1st usable host address: 192.168.100.1 (the address immediately following the network address; or simply turn the last host bit of the network address to 1 and then convert the address to decimal)
- The broadcast address: 192.168.100.127 (set all host bits to 1 and convert the address to decimal)
- The last usable host address: 192.168.100.126 (the address immediately before the broadcast address)
- The range of usable host addresses is: 192.168.100.1 to 192.168.100.126

Assign the 1st usable host address in each subnet to its default gateway, assign the 2nd usable host address in each subnet to the PC, assign the last usable host address in Subnet A to the SVI of S1

1st subnet → LAN with PC-A   **2nd subnet → LAN with PC- B**

PC-A   F0/6   S1   192.168.100.1/25   G0/1   192.168.100.129/25   PC-B

F0/5   R1   G0/0

192.168.100.2/25   192.168.100.126/25   192.168.100.130/25

Example 2

- **Given** base network: 192.168.100.0/24

- **Design** a subnetting scheme to meet the following **requirements**:

    1. Top LAN needs to hold up to 25 hosts

    2. The bottom LAN requires at least 20 host addresses

- For each of the 2 LANs, **assign** the 1st usable host address in the subnet to its default gateway, assign the 2nd usable host address in the subnet to the PC, assign the last usable host address in the subnet to the switch SVI.

Questions to ask and answer when designing the subnetting scheme:

1. How many network bits and how many host bits in an address of the base network?

2. How many subnets are required?

3. What is the minimum number of bits to borrow in order to create the required number of subnets?

4. What is the required number of hosts in the largest subnet?

5. How many host bits are required to meet the #host requirement in the largest subnet?

6. What is the subnet mask and what is the network address for each of the subnets?

7. What is the broadcast address and what is the range of usable host addresses for each of the subnets?

1. How many network bits and how many host bits in an address of the base network?

   Answer: The base network's subnet mask is /24 (or 255.255.255.0). Therefore, there are 24 network bits and 8 (=32-24) host bits in an address of the base network.

	Network portion (24 bits)			Host portion (8 bits)
Address	192.	168.	100.	hhhhhhhh
Mask	255.	255	255.	00000000

2. How many subnets are required?

   Answer: 3, from the topology (2 LANs and **1 WAN link**)

3. What is the minimum number of bits to borrow in order to create the required number of subnets?

   Answer: 2.

   Recall that #subnets created = 2^#bits borrowed, and borrow 2 bits creates 4 subnets

	Network portion (26 bits)			Host portion (6 bits)
Address	192.	168.	100.	nnhhhhhh
Mask	255.	255	255.	11000000

4. What is the minimum number of hosts in the largest subnet?

   Answer: 25, based on the requirement.

   Note: the WAN link subnet only requires 2 addresses, for the connecting serial interfaces of R1 and R2

5. How many host bits are required to meet the #host requirement in the largest subnet?

   Answer: 5.

   Recall that #hosts=2^#remaining host bits-2, 2^5-2=30 > 25. 4 host bits would not be enough because 2^4-2=14 <25

   Note: from the answer to question 3, after the 2 bits are borrowed, there are 6 host bits remained. So we can either borrow more bits to create more subnets, or only borrow 2 bits and have 6 host bits, which gives 2^6-2=62 host addresses in each subnet. Let's take the 2nd option, i.e. create 4 subnets

6. What is the subnet mask and what is the network address for each of the subnets?

   Answer:

   Subnet mask of the new subnets: /26.

   Note that base network subnet mask is /24, i.e. there are 24 network bits in each of the addresses in the base network. After we have borrowed two host bits as network bits, there are 26 network bits for each of the addresses. So the subnet mask for each of the subnets is the same, which is /26)

	Network portion (26 bits)			Host portion (6 bits)
Address	192.	168.	100.	nnhhhhhh
Mask	255.	255	255.	11000000

Network addresses

1st subnet: the borrowed bits=00

Each of the 6 host bits =0 → network address of the first subnet: 192.168.100.0/26

	Network portion (26 bits)			Host portion (6 bits)
Address	192.	168.	100.	00hhhhhh
Mask	255.	255	255.	11000000

2nd subnet: the borrowed bits=01

Each of the 6 host bits =0 → network address of the 2nd subnet: 192.168.100.64/26

	Network portion (26 bits)			Host portion (6 bits)
Address	192.	168.	100.	01hhhhhh
Mask	255.	255	255.	11000000

3rd subnet: the borrowed bits=10

Each of the 6 host bits =0 → network address of the first subnet: 192.168.100.128/26

	Network portion (26 bits)			Host portion (6 bits)
Address	192.	168.	100.	10hhhhhh
Mask	255.	255	255.	11000000

4th subnet: the borrowed bits=11

Each of the 6 host bits =0 → network address of the 2nd subnet: 192.168.100.192/26

	Network portion (26 bits)			Host portion (6 bits)
Address	192.	168.	100.	11hhhhhh
Mask	255.	255	255.	11000000

7. What is the broadcast address and what is the range of usable host addresses for each of the subnets?

Answer:

1st subnet:

Network address: 192.168.100.0/26

Network Address	192.	168.	100.	00000000

- The 1st usable host address: 192.168.100.1
- The broadcast address is 192.168.100.63 (set all 6 host bits to 1 and convert to decimal)
- The last usable host address: 192.168.100.62
- The range of usable host addresses is: 192.168.100.1 to 192.168.100.62

2nd subnet:

Network address: 192.168.100.64/26

Network Address	192.	168.	100.	01000000

- The 1st usable host address: 192.168.100.65
- The broadcast address is 192.168.100.127 (set all 6 host bits to 1 and convert to decimal)
- The last usable host address: 192.168.100.126
- The range of usable host addresses is: 192.168.100.65 to 192.168.100.126

3rd subnet:

Network address: 192.168.100.128/26

Network Address	192.	168.	100.	10000000

- The 1st usable host address: 192.168.100.129
- The broadcast address is 192.168.100.191 (set all 6 host bits to 1 and convert to decimal)
- The last usable host address: 192.168.100.190
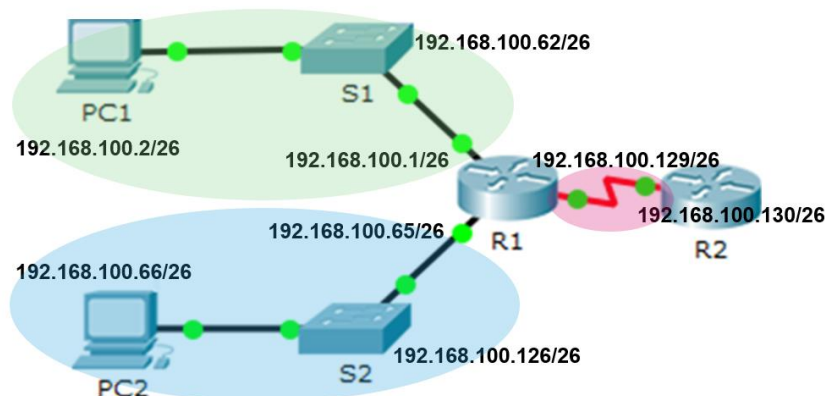- The range of usable host addresses is: 192.168.100.129 to 192.168.100.190

4th subnet:

Network address: 192.168.100.192/26

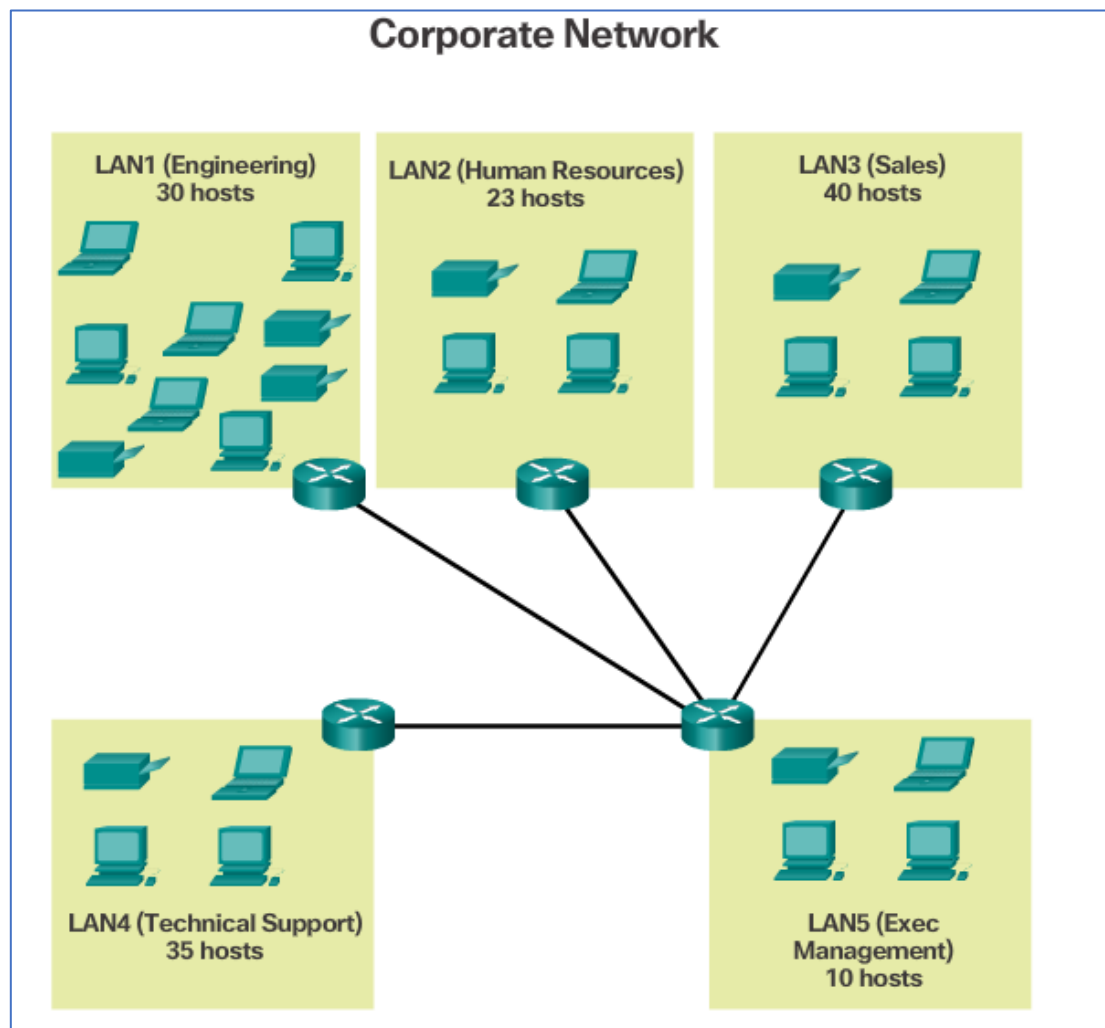| Network Address	192.	168.	100.	11000000

- The 1st usable host address: 192.168.100.193
- The broadcast address is 192.168.100.255 (set all 6 host bits to 1 and convert to decimal)
- The last usable host address: 192.168.100.254
- The range of usable host addresses is: 192.168.100.193 to 192.168.100.254

For each of the 2 LANs, assign the first usable host address in the subnet to its default gateway, assign the 2nd usable host address in the subnet to the PC, assign the last usable host address in the subnet to the switch SVI

1st subnet →top LAN;   **2nd subnet →bottom LAN**; **3rd subnet →WAN link**

Another – more complicated

Corporate Network

LAN1 (Engineering) 30 hosts
LAN2 (Human Resources) 23 hosts
LAN3 (Sales) 40 hosts
LAN4 (Technical Support) 35 hosts
LAN5 (Exec Management) 10 hosts

Analysing the question:

- Based on the topology diagram, 9 subnets required (5 LANs plus 4 links between routers) → need **borrow 4 bits**: 2^4=16
- Largest subnet needs to hold 40 hosts → must have **6 host bits** for the subnet: 2^6-2=62 hosts
- So at least a /22 base network is required, because
  - The number of host bits of a /22 network is 10
  - After 4 bits are borrowed, we still have 6 bits
- In the follow **sample answer**, let's **use 172.16.0.0/22 as the base network**

Network Portion   Host Portion   Dotted Decimal

10101100.00010000.000000 00.00 000000 172.16.0.0/22

4 bits borrowed from host portion to create subnets

0 10101100.00010000.000000 00.00 000000 172.16.0.0/26
1 10101100.00010000.000000 00.01 000000 172.16.0.64/26
2 10101100.00010000.000000 00.10 000000 172.16.0.128/26
3 10101100.00010000.000000 00.11 000000 172.16.0.192/26
4 10101100.00010000.000000 01.00 000000 172.16.1.0/26
5 10101100.00010000.000000 01.01 000000 172.16.1.64/26
6 10101100.00010000.000000 01.10 000000 172.16.1.128/26

Nets 7 – 13 not shown

14 10101100.00010000.000000 11.10 000000 172.16.3.128/26
15 10101100.00010000.000000 11.11 000000 172.16.3.192/26

4 bits borrowed from host portion to create subnets

LAN 1
172.16.0.0/26

LAN 2
172.16.0.64/26

LAN 3
172.16.1.0/26

172.16.2.64/26

172.16.2.128/26

172.16.2.192/26

172.16.2.0/26

LAN 4
172.16.0.128/26

LAN 5
172.16.0.192/26