

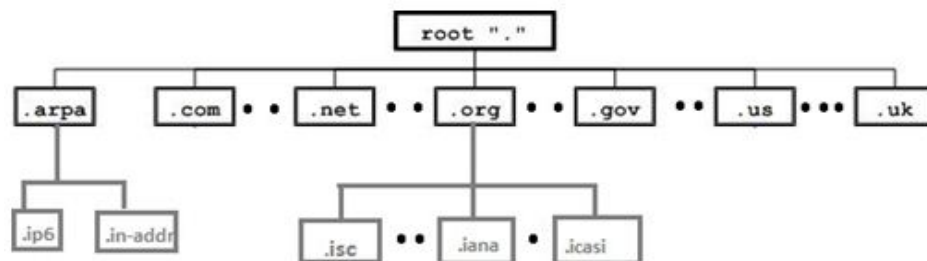


Sheet 3 Solution

Problem1:

Assume there are 10^9 names in the Internet.

Case 1: Two Level Decomposition: Domains and Subdomains



As shown in the above figure:

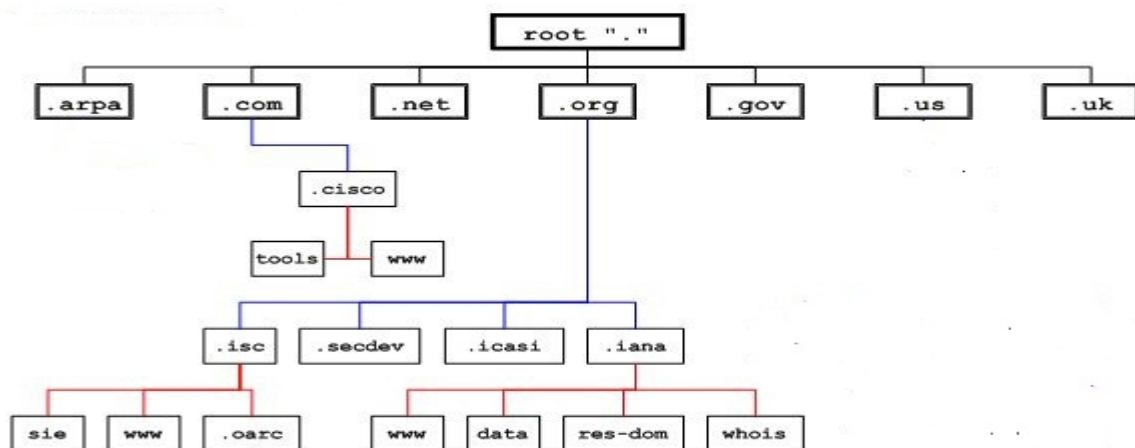
Let there be 1000 Domains (as com,.org, .gov,..., etc)

Assume each Domain has 100 Subdomain (.isc, .iana,..., etc).

For example, everything below the ".org" domain name space is in the "org" domain and everything below ".isc.org" Subdomain name space is in the "isc.org" Subdomain.

Thus, each Domain has 100 entries and each Subdomain has 10000 entries.

Case 2: Three Level Decomposition: Domains, Subdomains, and Sub-Subdomains.



As shown in the above figure:

Let there be 1000 Domains (as com,.org, .gov,..., etc)

Assume each Domain has 100 Subdomain (.isc, .iana,..., etc)

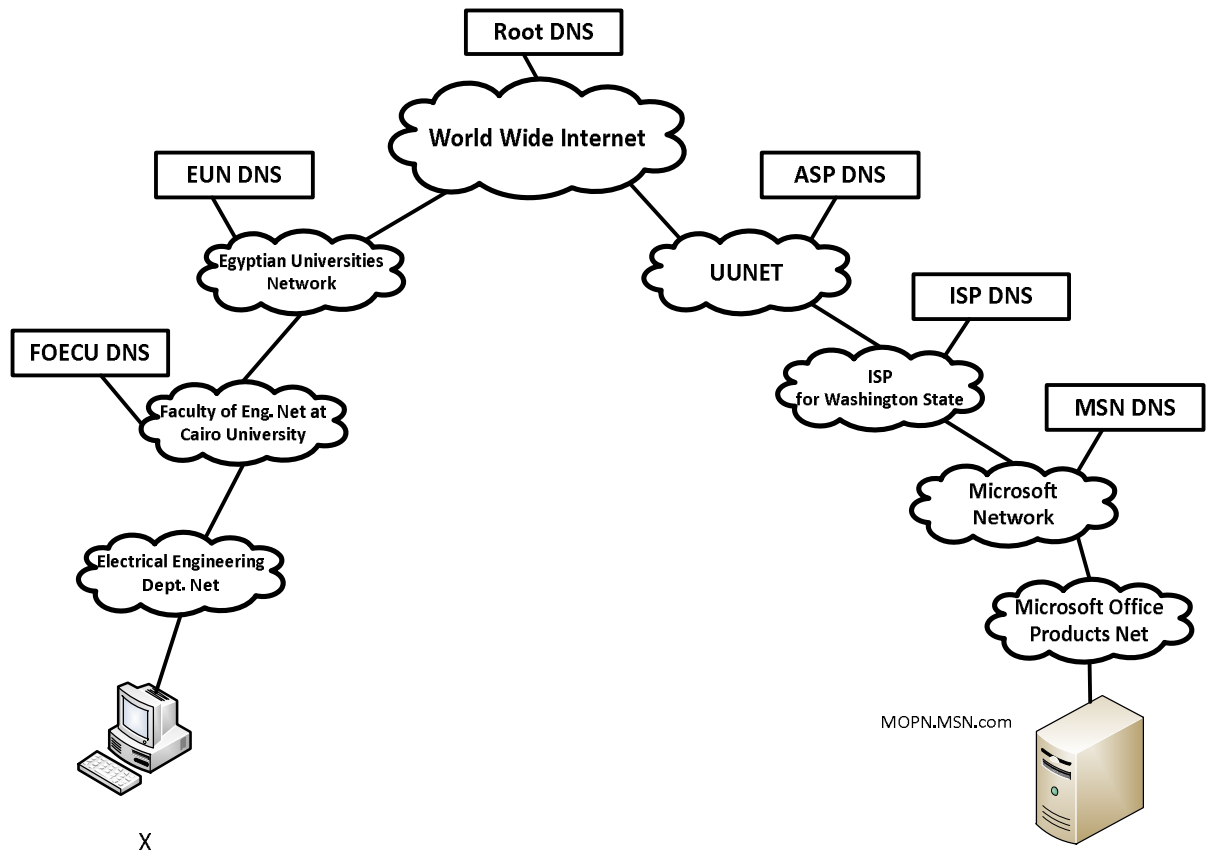
Assume further that each Subdomain has 100 Sub-Subdomains (sie, www, ..., ect)



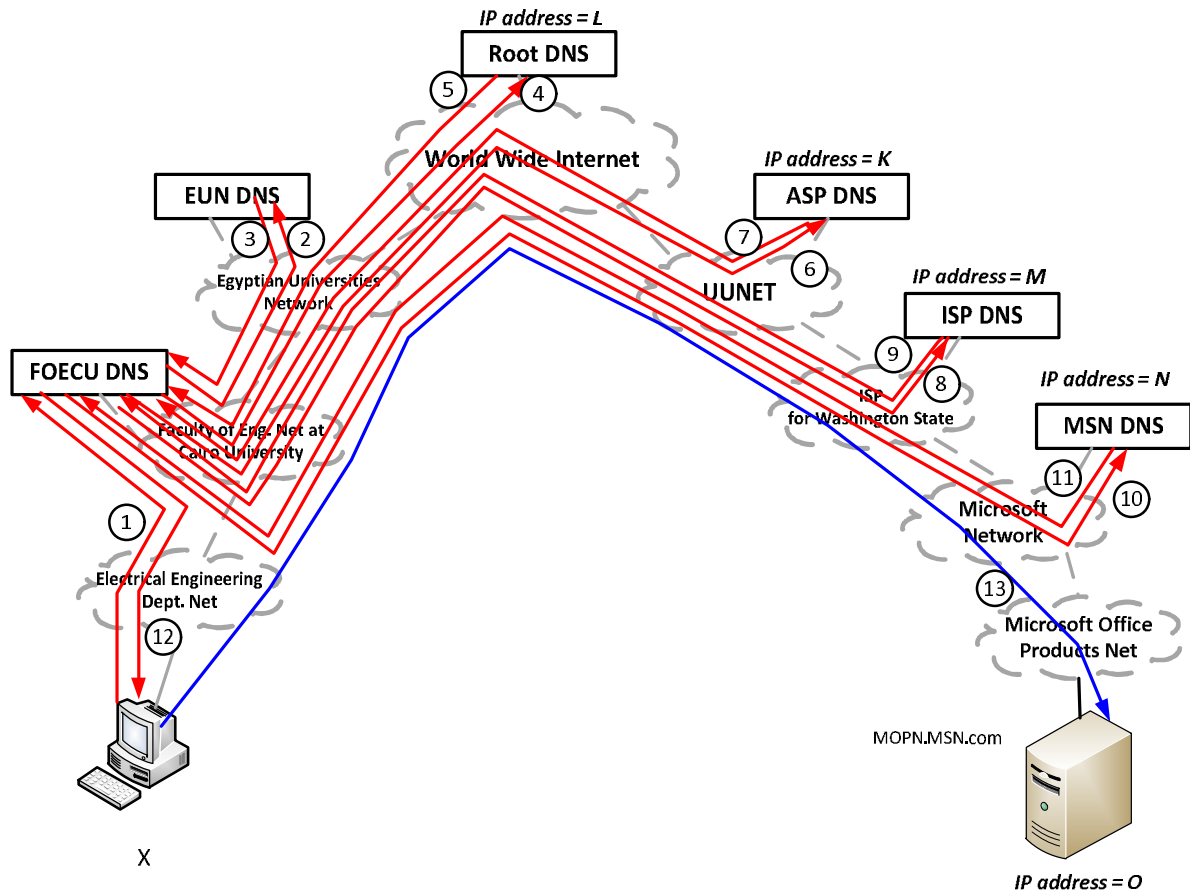
Thus, each Domain has 100 entries and each Subdomain has 100 entries, and each Sub-Subdomain has 100 entries..

Problem2:

a) A layout for DNS's :



b)_Steps that are followed in order to deduce the IP address of the server at MOPN starting from a PC X at EEN:



- 1) X searches its cache for MOPN.MSN.COM IP address. It does not find it. So, it asks FOECU.EUN DNS (Local DNS) about MOPN.MSN.COM IP address.
- 2) .FOECU DNS does not know MOPN.MSN.COM IP address, so .FOECU.EUN DNS asks EUN DNS about MOPN.MSN.COM IP address.
- 3) EUN DNS does not know MOPN.MSN.COM IP address, so .EUN DNS replies to FOECU.EUN DNS by Root IP address.
- 4) FOECU.EUN DNS asks Root about MOPN.MSN.COM IP address.
- 5) Root “.”replies to FOECU.EUN DNS by ASP DNS IP address.
- 6) FOECU.EUN DNS asks ASP DNS about MOPN.MSN.COM IP address.
- 7) ASP DNS replies to FOECU EUN DNS by ISP DNS IP address.
- 8) FOECU.EUN DNS asks ISP DNS about MOPN.MSN.COM IP address.
- 9) ISP DNS replies to FOECU EUN DNS by MSN.COM DNS IP address.
- 10) FOECU.EUN DNS asks .MSN.COM DNS about MOPN.MSN.COM IP address.
- 11).MSN.COM DNS replies to .FOECU.EUN DNS by MOPN.MSN.COM IP address.
- 12) FOECU.EUN DNS replies to X by MOPN.MSN.COM IP address.
- 13) X sends a query to MOPN.MSN.COM server



c. Information has a time to live after which it is deleted due to :

- 1) Dynamic IP change.
- 2) Have a free space for other names IP's.

Problem3:

- Have 30,000 Schools in 30 Governorates.
- Will assume that each Governorate has 1000 schools.

a) Using Class B without subnetting :

- Each Governorate is assigned one class B IP, so we will need a total of 30 class B.

	Subnet ID	Mask	IP Range (used)
Gov#1	128.32.0.0	255.255.0.0	128.32.0.1-128.32.3.232
Gov#2	128.33.0.0	255.255.0.0	128.33.0.1-128.33.3.232
Gov#3	128.34.0.0	255.255.0.0	128.34.0.1-128.34.3.232
.	.	.	.
.	.	.	.

$$\text{So, Utilization} = \frac{1000}{65534} \approx 1.5\%$$

b) Using Class B with subnetting:

- All Governorates are assigned one class B IP, so we will need a total of 1 class B.

	Subnet Number	Mask	IPs range
Gov#1	128.32.0.0	255.255.252.0	128.32.0.1-128.32.3.232
Gov#2	128.32.4.0	255.255.252.0	128.33.4.1-128.33.7. 232
Gov#3	128.32.8.0	255.255.252.0	128.32.8.1-128.32.11.232
.	.	.	.
.	.	.	.

$$\text{So, Utilization} = \frac{1000*30}{65534} \approx 45\%$$

c) Using CIDR

- Each Governorate has a different prefix (24-bit).

	Subnet Number	IPs range
Gov#1	128.32.0.0/24	128.32.0.1-128.32.3.232
Gov#2	128.32.4.0/24	128.33.4.1-128.33.7. 232
Gov#3	128.32.8.0/24	128.32.8.1-128.32.11.232
.	.	.
.	.	.

$$\text{So, Utilization} = \frac{1000}{1024} \approx 97.65\%$$



Problem (4)

(This example is a part of IP Networking lectures by Giuseppe Bianchi)

VLSM stands for “Variable Length Subnet Mask”. To be able to use VLSM, routers should support CIDR for routing. So, VLSM and CIDR are the two sides of the same coin.

Variable Length Subnet Mask

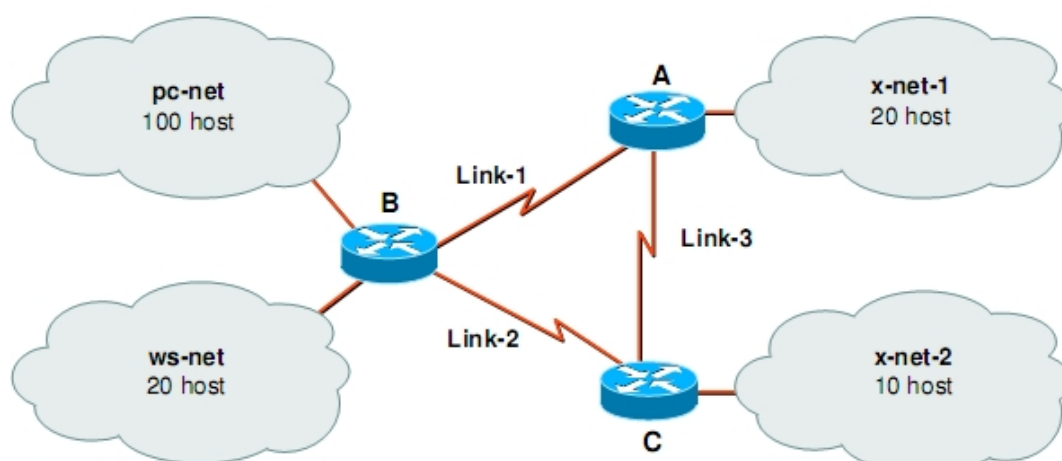
→ allows more than one subnet mask in the same network

- ⇒ A) more efficient use of organization's IP address space
 - Subnets may significantly vary in relative size (computer room = 200 hosts, secretary = 4 hosts...)
 - consider a 4 host network with mask 255.255.255.0: wastes 250 IP addresses!
- ⇒ B) allows route aggregation, thus reducing routing information needed

→ Needs further support by routing protocol

- ⇒ e.g. RIP1 doesn't support VLSM

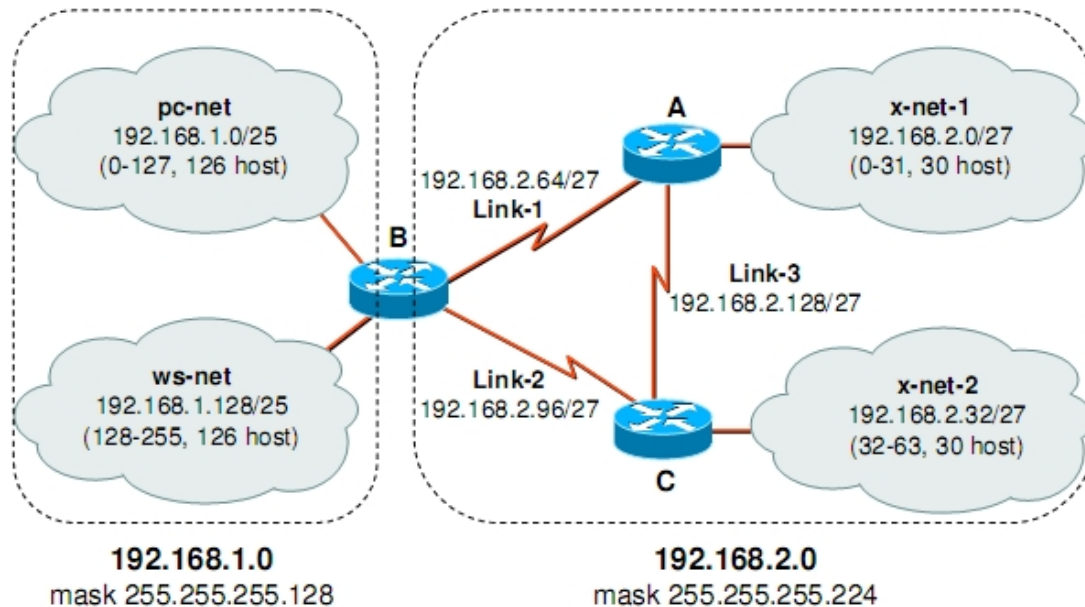
A typical problem



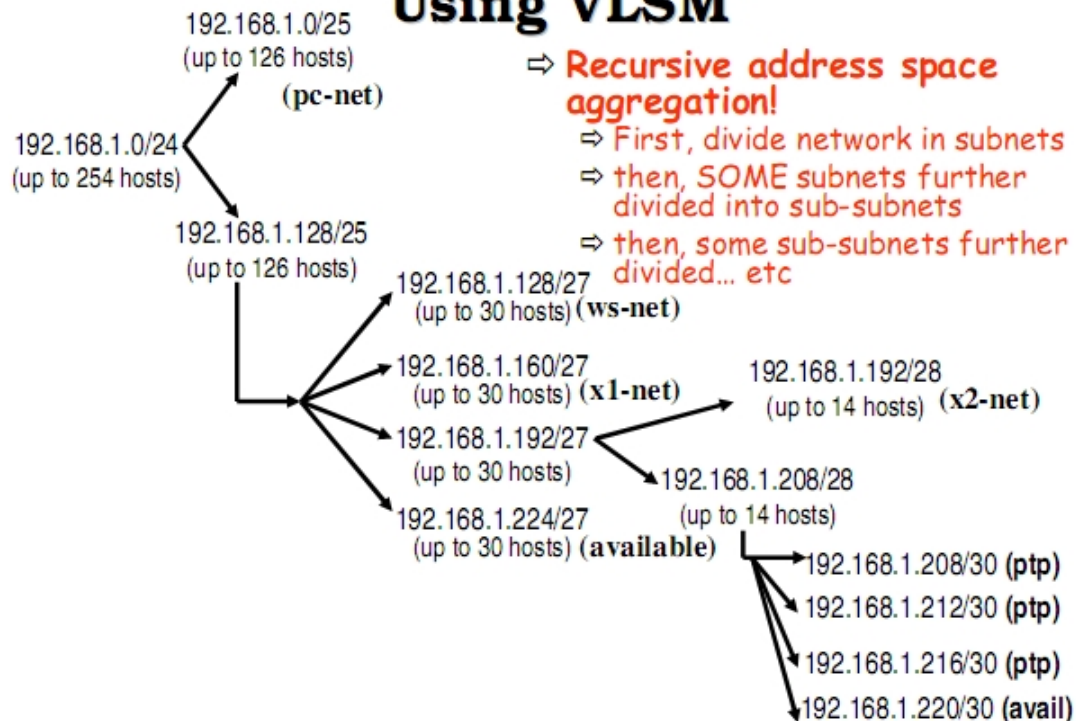
100+20+20+10 = 150 total hosts: 1 class C enough (including growth projections).
7 subnets (4 LANS + 3 point to point links): 3 bit subnet ID (= up to 8 subnets)
BUT then max 30 host per subnet: no way to accommodate pc-net!!



Solution without VLSM need 2 class C address!



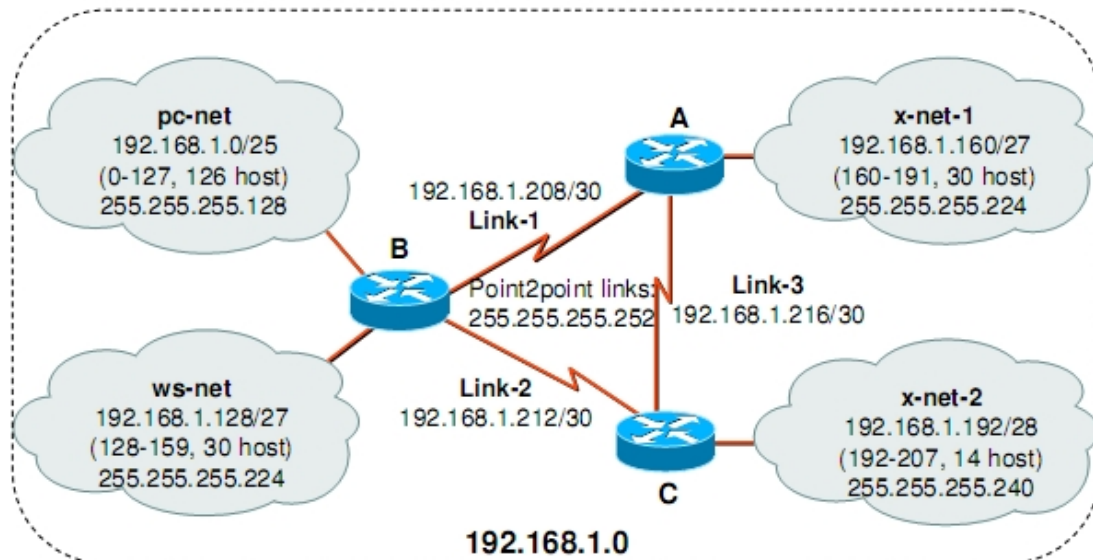
Using VLSM



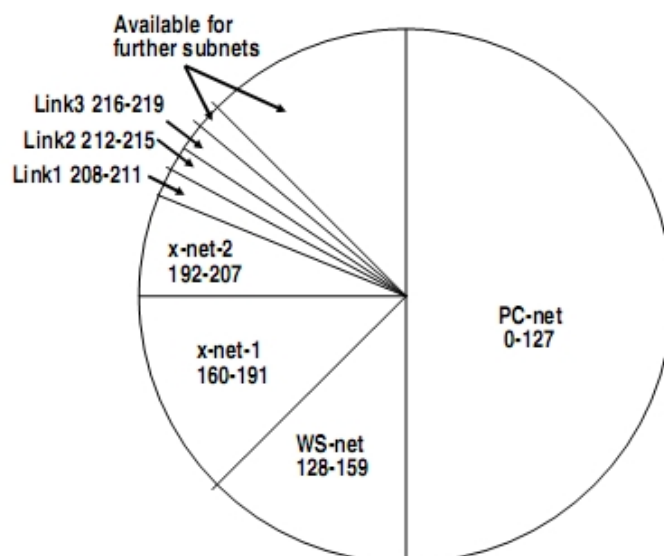


Final solution with VLSM

1 C address is enough



address pie for our sol.





Problem5:

-Router 1 Table:

SubnetNumber	SubnetMask	NextHop
128.96.39.0	255.255.255.128	Interface 0
128.96.39.128	255.255.255.128	Interface 1
128.96.40.0	255.255.255.128	R2
192.4.153.0	255.255.255.192	R3
(Default)		R4

-Steps to know the next Hop:

- 1) Perform IP (AND) Mask.
- 2) Compare result with Subnet Number to find Next Hop.

IP	Next Hop
128.96.39.10	Interface 0
28.96.40.12	R2
128.96.40.151	R4
192.4.153.17	R3
192.4.153.90	R4

Problem (6)

- a) This part is the same as Problem (7) – Sheet (2)
- b) We have 3 LANs and 2 Point-to-Point links.

Case (1) → Class-based addressing:

We need 5 Class C IP's.

	IP Class	IP Range	
HQ	192.168.16.0	192.168.16.1	192.168.16.180
Branch #1	192.168.17.0	192.168.17.1	192.168.17.60
Branch #2	192.168.18.0	192.168.18.1	192.168.18.40
Link (HQ→ Branch#1)	192.168.19.0	192.168.19.1	192.168.19.2
Link (HQ→ Branch#2)	192.168.20.0	192.168.20.1	192.168.20.2

$$\text{Efficiency} = \frac{180+60+40+2+2}{5*254} = 22.36\%$$

Case (2) → Sub-netting addressing



We can use either 1-Class B or 2-Class C IP's. I will use 2-Class C IP's for the solution.

	IP Class	IP Range	
HQ	192.168.16.0/24	192.168.16.1	192.168.16.180
Branch #1	192.168.17.0/26	192.168.17.1	192.168.17.60
Branch #2	192.168.17.64/26	192.168.17.65	192.168.17.104
Link (HQ→ Branch#1)	192.168.17.128/26	192.168.17.129	192.168.17.130
Link (HQ→ Branch#2)	192.168.17.192/26	192.168.17.193	192.168.17.194

$$\text{Efficiency} = \frac{180+60+40+2+2}{2*254} = 55.9\%$$

Case (3) → CIDR addressing

	IP Class	IP Range	
HQ	192.168.16.0/24	192.168.16.1	192.168.16.180
Branch #1	192.168.17.0/26	192.168.17.1	192.168.17.60
Branch #2	192.168.17.64/26	192.168.17.65	192.168.17.104
Link (HQ→ Branch#1)	192.168.17.128/30	192.168.17.129	192.168.17.130
Link (HQ→ Branch#2)	192.168.17.132/30	192.168.17.193	192.168.17.194

$$\text{Efficiency} = \frac{180+60+40+2+2}{254+62+62+2+2} = 74.3\%$$

Problem7:

-IP addresses and subnetwork masks for the various components:

	IP	Mask
Station#1(E1)	196.146.12.1	255.255.255.0
Station#2(E2)	196.146.12.2	255.255.255.0
Station#3(E3)	196.146.12.3	255.255.255.0
Station#4(E6)	196.146.12.6	255.255.255.0
Station#5(E5)	196.146.12.5	255.255.255.0
E4	196.146.12.4	255.255.255.0
Station#6	210.30.17.3	255.255.255.0
W1	210.30.17.1	255.255.255.0
W2	210.30.17.2	255.255.255.0
Station#7(E8)	193.227.31.8	255.255.255.0
Station#8(E9)	193.227.31.9	255.255.255.0
Station#9(E10)	193.227.31.10	255.255.255.0
E7	193.227.31.7	255.255.255.0



-station 1 sends a frame to station 4 and then to station 8. Assume that stations have knowledge of only the IP address.

Steps:

- 1) Station #1 makes [(**Station#4 IP**=196.146.12.6) **AND** 255.255.255.0 =196.146.12.0], so it knows that Station #1 and Station #4 are in the same Subnet.
- 2) Station #1 sends ARP request to know Station #4 MAC Address.
- 3) Station #4 replies to station #1 ARP request.
- 4) Station #1 sends Data Packets to Station #4.
- 5) Station #1 makes [(**Station#8 IP**=193.227.31.9) **AND** 255.255.255.0 =193.227.31.0], so it knows that Station #1 and Station #8 are in two different Subnet.
- 6) Station #1 sends ARP request to know Router 1 MAC Address for (E4=196.146.12.4).
- 7) Router 1 replies to station #1 ARP request.
- 8) Station #1 sends Data Packets to Router 1.
- 9) Router 1 checks its routing table entries, and decides that next hop for packet is Router 2 and it send the packet via Port W1.
- 10) Router 1 sends ARP request to know Router 2 MAC Address for (W2=196.146.12.4).
- 11) Router 2 replies to Router 1 ARP request.
- 12) Router 1 sends Data Packets to Router 2 after changing the MAC address of the source and the MAC address of the destination.
- 13)) Router 2 checks its routing table entries, and decides that lies in the same subnet and will exit via port E7.
- 14) Router 2 sends ARP request to know Station#8 MAC Address.
- 15) Station#8 replies to Router 2 ARP request.
- 16) Router2 sends Data Packets to Station#8 after changing the MAC address of the source and the MAC address of the destination.

-Total number of fragments received by station 6 from station 2 if the last one transmits message of 30000 bytes:

Given :

- 1) MTU (Subnet#1) = 1500 bytes = 1480 bytes (payload) + 20 bytes (header).
- 2) MTU (Subnet#2) = 512 bytes = 492 bytes (payload) + 20 bytes (header).

-Number of packets (Subnet#1) = $\frac{30000}{1480} = 20.27 \rightarrow 21$ packet. Where first 20 packets size =1500 bytes and Last packet =420 bytes.

-Number of fragments (Subnet#2) for 1500 bytes packet = $\frac{1480}{492} = 3.008 \rightarrow 4$ fragment.

-Number of fragments (Subnet#2) for 420 bytes packet = $\frac{400}{492} = 0.813008 \rightarrow 1$ fragment.

So, Total number of fragments = $20 * 4 + 1 = 81$ fragments



Problem (8)

- a) The packet passes three different nets with different MTU's:

Net 1: No fragmentation as $(TL = 40020) < (MTU = 64535)$.

Net 2: Number of fragments = $\left\lceil \frac{40000}{1520-20} \right\rceil = 27$ fragments, where 26 fragments have size 1500 B and 1 fragment has size 1000 B.

$(40000 = 26 \times 1500 + 1 \times 1000)$.

Net 3: Number of fragments = $26 * \left\lceil \frac{1500}{512-20} \right\rceil + \left\lceil \frac{1000}{512-20} \right\rceil = 107$ fragments, where $26 \times 3 + 2 = 80$ fragments have size 492 B and 26 fragments have size 24 B and 1 fragment has size 16 B.

$(40000 = 26 * (3 * 492 + 24) + (2 * 492 + 16))$

\Rightarrow Total number of fragments at destination = 107

In the IP header, there are 4 fields that are affected by fragmentation:

ID (Identification): used to identify fragments that belong to the same original packet

TL (Total Length): IP header length + data payload

FO (Fragment Offset): used to arrange different fragments and it equals the number of the first byte of data payload in the fragment.

MF (More Fragments): one bit flag to indicate that there are more fragments when it is one.

The following table indicates how these fields change when packets pass through different nets:

	ID	TL	FO	MF
Net 1	10	40020	0	0
Net 2	10	1520	0	1
	10	1520	1500	1
	:	:	:	:
	10	1520	37500	1
	10	1020	39000	0
Net 3	10	512	0	1
	10	512	492	1
	10	512	984	1
	10	44	1476	1
	:	:	:	:
	10	512	39000	1
	10	512	39492	1
	10	36	39984	0



- b) From the given table we can deduce the IP header fields of the original fragment that is secondly fragmented in these 3 fragments:


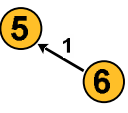
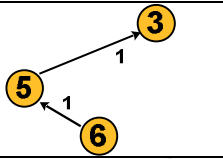
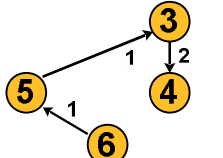
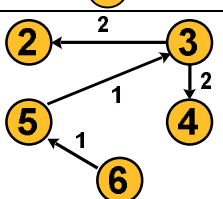
ID = 10 (same as the ID of the fragments)

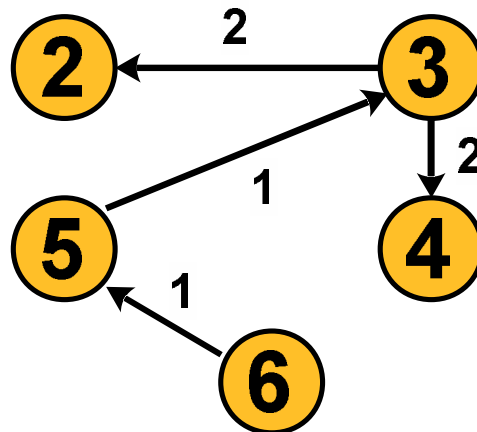
TL = 1020 (substitute 20 B of the header from TL of each fragment to get payload → sum up all payloads = 1000 → add 20 B for the header)

FO = 39000 (number of the first byte of the original fragment is the same as that of the first fragment in the given table)

MO = 0 (the last fragment is the last fragment of the original packet, so the original fragment is also the last fragment of the original packet)

Problem(9):

Step	U(n)			F(n)			N(n)			Topology
	i	di(n)	pi(n)	i	di(n)	pi(n)	i	di(n)	pi(n)	
0				1 2 3 4 5 6	∞ ∞ ∞ ∞ ∞ 0		6 6	0 	6 	
1	6	0	6	1 2 3 4 5	∞ ∞ ∞ ∞ 1		5 6	1 	6 	
2	6 5	0 1	6 6	1 2 3 4	∞ 4 2 5	 5 5 5	2 3 4	4 2 5	5 5 5	
3	6 5 3	0 1 2	6 6 5	1 2 4	∞ 4 4	 3 3	2 4	4 4	3 3	
4	6 5 3 4	0 1 2 4	6 6 5 3	1 2	∞ 4	 3	2	4	3	
5	6 5 3 4 2	0 1 2 4 4	6 6 5 3 3	1	∞					



Problem (10):

(a) each department expects the growth in the number of machines as follows

- Engineering expects machine number increase by one per week, thus by 52 per year. Note that we need 5 machines initially.
- Sales expects client number increase by $(-1) \cdot 0.20 + (+1) \cdot 0.60 + 0 \cdot 0.20 = 0.40$, thus machine number increase by $0.40 \cdot 1/2 = 0.20$ per week, so by $0.20 \cdot 52 = 10.4$ per year. Note that we do not need any machines in the first year, but at the beginning of the second year, we need 3 machines since we have 6 clients then.
- Marketing expects no increase.

To guarantee addresses for at least seven years, we need $(5 + 52 \cdot 7) + (3 + 10.4 \cdot 6) + 16 = 450.4$ addresses. Therefore, the new company needs a slash 23 address range to accommodate 512 addresses.

- (b) To determine how long the 512 addresses allocation would last: suppose it would last n years, $(5 + 52 \cdot n) + (3 + 10.4 \cdot (n - 1)) + 16 = 13.96 + 62.4 \cdot n = 512$. Thus, $n = 7.98$. The address assignment would be, for engineering, $5 + 52 \cdot n = 419.98 \sim 420$, for sales, $(3 + 10.4 \cdot (n - 1)) = 75.592 \sim 76$, for marketing, 16.
- (c) Since class B supports 65534 host addresses and class C supports 254 addresses (note that two addresses are always reserved in each network class), the company could get one class B range or two class C ranges.