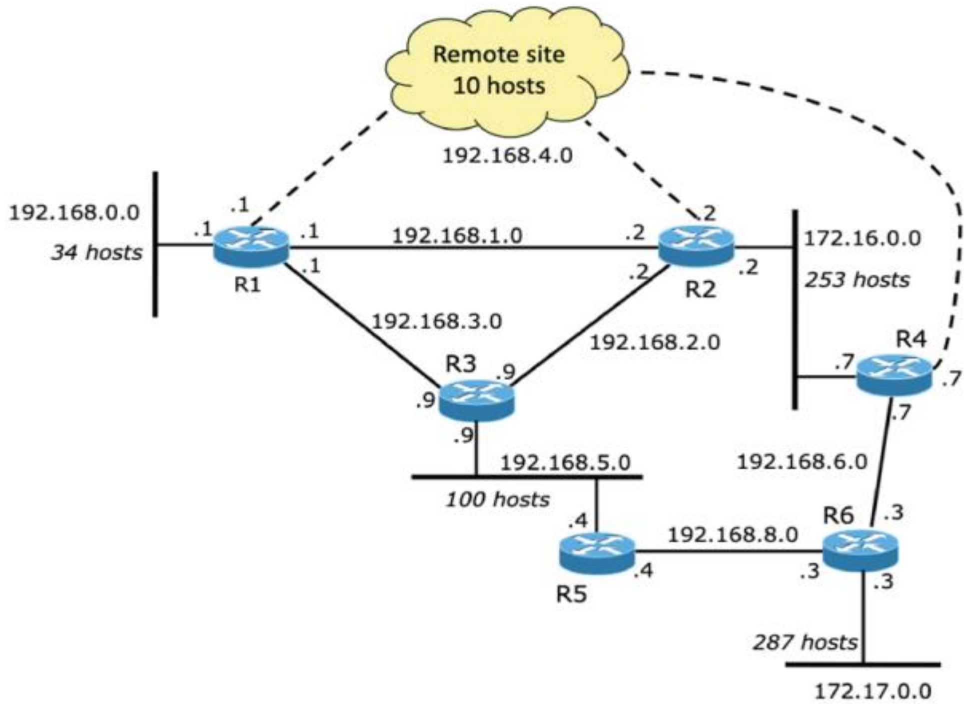
Exercise 5:

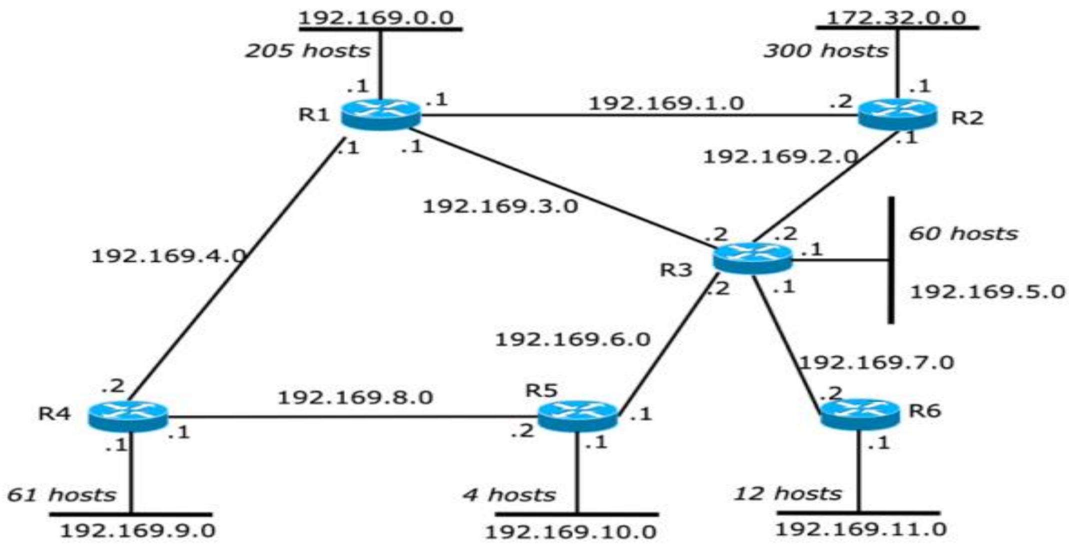
In this exercise, all the LIN but two can be configured with class C address. The first exception is the network with 253 elements, whose size exceeds the number of addresses available in a class C block because of the necessity to allocate space for the two reserved addresses (this net and broadcast) and the two routers. The second exception is the network with 287 elements. Both those networks have to be configured with class B addresses.

The solution is shown in the figure below.



Exercise 6:

The topology includes only class C networks, excluding the LIN with 300 elements that has to be handled with a class B block. The solution is shown in the figure below.



Exercise 7:

Number of hosts	Network address / prefix length	Broadcast address
2	192.168.0.0/30	192.168.0.3
27	192.168.0.32/27	192.168.0.63
5	192.168.0.64/29	192.168.0.71
100	192.168.0.128/25	192.168.0.255
10	192.168.1.0/28	192.168.1.15
300	192.168.2.0/23	192.168.3.255
1010	192.168.4.0/22	192.168.7.255
55	192.168.8.0/26	192.168.8.63
167	192.168.9.0/24	192.168.9.255
1540	192.168.16.0/21	192.168.23.255

Exercise 8:

In this exercise we need to consider a number of addresses which is three more than the number of hosts of the network, because of the two reserved addresses (this net and broadcast), and the router. For instance, a network with two 2 hosts would need 5 addresses, bringing to the necessity to use an address space of 8 addresses (/29). With respect to the assignment of the IP addresses to hosts and routers, it is worthy remember that those values are arbitrary, provided that they belong to the address range assigned to the given LIN (and that are not the reserved addresses this net and broadcast). In this solution we decided to assigne the first available address to the router and the others, following the natural order, to the hosts. The solution is the following:

Number of hosts	Address range	Network address / prefix length	Router address	Hosts addresses
2	192.168.0.0/24	192.168.0.0/29	192.168.0.1	192.168.0.2-192.168.0.3
27	192.168.0.0/24	192.168.0.0/27	192.168.0.1	192.168.0.2-192.168.0.28
30	192.168.0.0/24	192.168.0.0/26	192.168.0.1	192.168.0.2-192.168.0.31
126	192.168.0.0/24	192.168.0.0/24	192.168.0.1	192.168.0.2-192.168.0.127
140	192.168.0.0/24	192.168.0.0/24	192.168.0.1	192.168.0.2-192.168.0.141
230	192.168.0.0/24	192.168.0.0/24	192.168.0.1	192.168.0.2-192.168.0.231

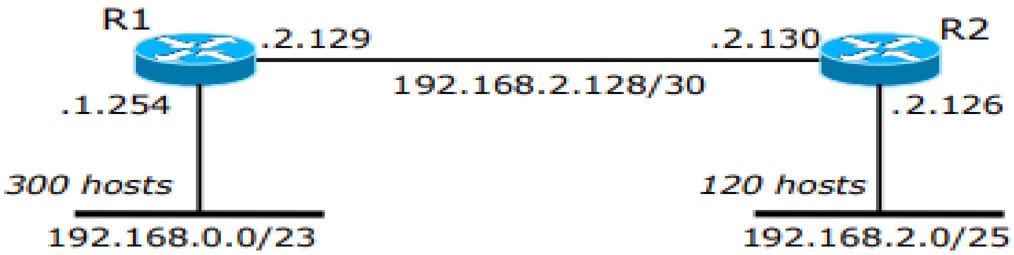
It is evident that the networks with 30, 126 and 140 hosts have a large number of unused addresses. For those networks we can propose an alternative addressing based on the splitting of the network into two distinct logical IP networks. It is worthy remember that the splitting of the hosts in two portions requires also one more address for the router, i.e., each resulting LIN must include also one address assigned the router (in addition to the two reserved addresses this net and broadcast). In other words, the router will become the so called one-arm router, i.e. a device with one interface and two IP addresses associated to it, the first that belongs to the address space of the first LIN (and that serves that LIN) while the second belongs to the address space of the second LIN. A possible solution for those networks is the following:

Number of hosts	Address range	Network	Router address	Hosts addresses
30	192.168.0.0/24	192.168.0.0/27 + 192.168.0.32/30	.1 + .33	.2-.30 + .34
126	192.168.0.0/24	192.168.0.0/25 + 192.168.0.128/30	.1 + .129	.2-.126 + .130
140	192.168.0.0/24	192.168.0.0/25 + 192.168.0.128/27	.1 + .129	.2-.126 + .130-.144

Exercise 9:

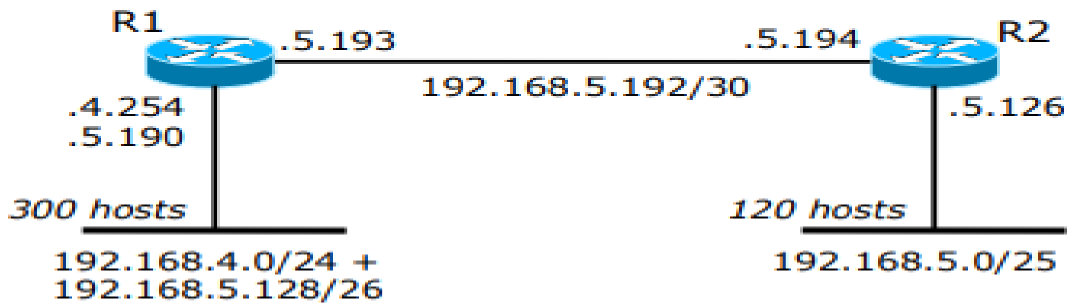
1. Address range /22

As per the first part of the exercise in which the address range 192.168.0.0/22 (i.e., 1024 addresses) has to be used, the solution is rather simple. In fact, we can use 512 addresses for the LIN with 300 hosts (a /23 network), 128 addresses for the LIN with 120 hosts (a /25 network) and 4 addresses for the point-to-point link. The total number of allocated addresses is equal to 644, which is far smaller than the total number of addresses available in our /22 range. Because of this high number of available (and not allocated) addresses, it would have been possible to allocate a /24 network to the LINs with 120 hosts; however, the text of the exercise suggest that no future expansion are needed, it should be better to stay with the /25 address blocks. The solution is shown in the figure below.



2. Address range /23

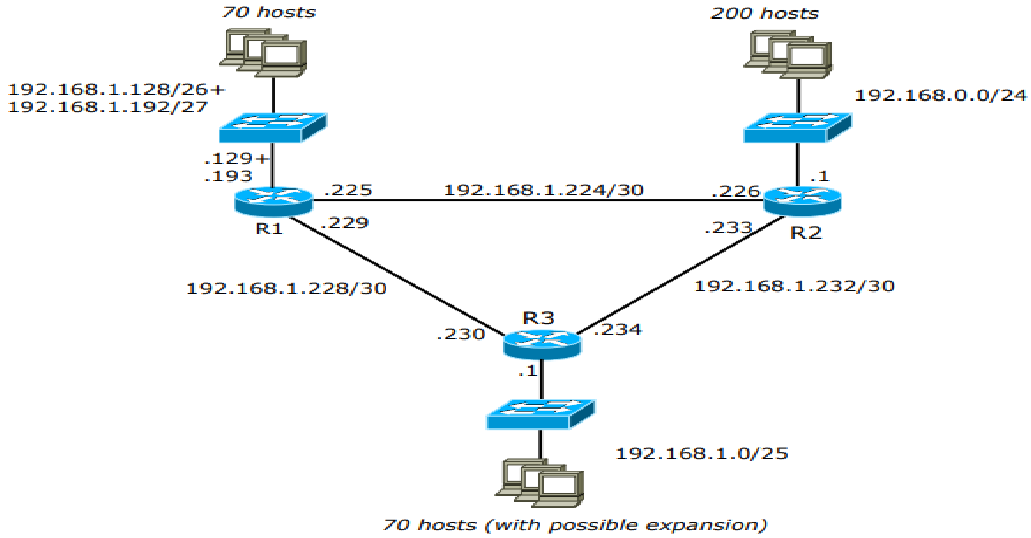
In this case the number of addresses available are not enough to handle the network with the same addressing plan defined in the previous solution. In fact, we have only 512 addresses, while the addressing plan required 644 addresses. A possible solution is to partition LIN with 300 hosts in two distinct LINs, one keeping 253 hosts and the other with the remaining 47. The first LIN will be configured with a /24 network (253 hosts, one address for the router plus the two reserved addresses). For the second LIN, we can use a /26 network (64 addresses), in which 50 addresses will be actually used (47 hosts, one address for the router and the two reserved addresses this net and broadcast). The number of addresses needed by this solution will be equal to 256+64 (for the network with 300 hosts), plus 128 (for the network with 120 hosts) and 4 (for the point-to-point link), which results in 452 addresses. Such this allocation is enough for us to be able to configure all our network with the assigned /23 address space. As the exercise requires that the total occupied address space should be contiguous, we suggest to assign the address spaces to the LINs in (inverse) order of size, starting the allocation from the biggest network firsts. The LIN with 300 hosts will thus be handled by two non contiguous blocks: the /24 block assigned to the first portion of the 300 hosts network should be followed by the /25 block assigned to the LIN with 120 hosts, further followed by the /26 block used to complete the coverage of the 300 hosts LIN. The solution, making use of the address range 192.168.4.0/23, is shown in the figure below.



It is worthy noting that, even if it would be possible to partition the original LINs into even smaller portions (for example the network with 300 hosts could be partitioned into 253 + 29 + 13 + 5, i.e., a /26 + /27 + /28 +/29 network), this is not a good idea as it adds more complexity while a coarse partitioning was enough to make everything working. In fact, the partitioning of a single LIN into multiple LINs must be seen as a last-resort technique to be used when we have an insufficient number of available addresses; however, when possible, it should be avoided. One of the problems relates to the efficiency when forwarding data from one host to another: hosts in two different LINs cannot communicate directly with data-link frames (even though they are physically located on the same LAN level), hence the IP packet from one host belonging to LIN1 has to be sent to the router, which will then forward that packet to the second host belonging to LIN2. As a consequence, the packet traverses the LAN twice, with the effect of doubling the traffic on that network segment. Another problem is that the IP broadcast address in the two LINs are different, hence services (e.g., some network discovery applications) that are based on sending IP (local) broadcast packets cannot operate across the boundary of the LIN, even if multiple LINs are in fact present on the same LAN.

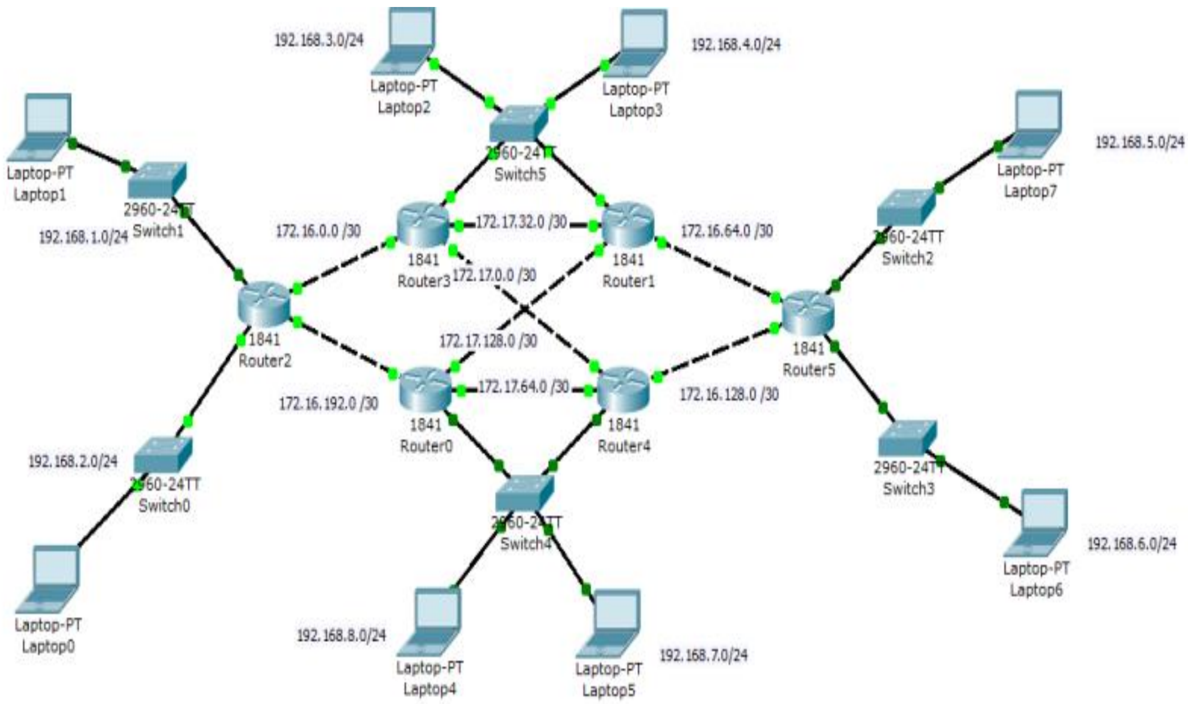
Exercise 10:

The allocated address space is not large enough to handle the network without any further partition of at least one IP network in multiple LINs in order to save addresses. The two networks with 70 hosts are the best candidate for such an operation because they "waste" a large amount of addresses (in fact, only 73 out of 128 addresses are occupied, leaving 55 addresses unused). However, the network below the router R3 may need future expansion; therefore it should be better not to partition this network in order to leave room for future expansions. For this reason we will begin with the partition of the first network with 70 host (the one attached to router R1), verifying later if this is enough or we need to implement some other partition in order to save addresses. In our case no further partition is needed, as the number of needed IP address after the above partition of the network with 70 hosts fits within the available address space. Notice that this exercise replaces the traditional shared (Ethernet) LANs with "switched" networks. This does not affect the IP addressing in any way, as the IP protocol works independently of the particular technology used in the data-link network. Therefore the solution with respect to the IP addressing plan will be the same, either with a shared or "switched" network. The solution is shown in the figure below.



Exercise 11:

a) Draw the topology according to the routing tables



Complete and corrected routing tables								
R0			R1			R2		
	@ S/Net	N. Hop		@ S/Net	N. Hop		@ S/Net	N. Hop
R	172.16.0.0 /30	172.16.192.1	R	172.16.0.0 /30	172.17.32.1	C	172.16.0.0 /30	--
R	172.16.64.0 /30	172.17.128.2	C	172.16.64.0 /30	--	R	172.17.0.0 /30	172.16.0.2
R	172.16.128.0 /30	172.17.64.2	R	172.16.128.0 /30	172.16.64.2	C	172.16.192.0 /30	--
C	172.16.192.0 /30	--	R	172.16.192.0 /30	172.17.128.1	R	172.17.32.0 /30	172.16.0.2
R	172.17.0.0 /30	172.17.64.2	R	172.17.0.0 /30	172.17.32.1	R	172.17.64.0 /30	172.16.192.2
R	172.17.32.0 /30	172.17.128.2	C	172.17.32.0 /30	--	R	172.17.128.0 /30	172.16.192.2
C	172.17.64.0 /30	--	R	172.17.64.0	172.17.128.1	C	192.168.1.0 /24	--
C	172.17.128.0 /30	--	C	172.17.128.0	--	C	192.168.2.0 /24	--
R	192.168.1.0 /24	172.16.192.1	R	192.168.3.0 /24	172.17.32.1	R	192.168.3.0 /24	172.16.0.2
R	192.168.2.0 /24	172.16.192.1	R	192.168.5.0 /24	172.16.64.2	R	192.168.4.0 /24	172.16.0.2 172.16.192.2
R	192.168.3.0 /24	172.17.128.2 172.16.192.1 172.17.64.2	R	192.168.7.0 /24	172.17.128.1 172.16.64.2 172.17.32.1	R	192.168.5.0 /24	172.16.0.2 172.16.192.2
R	192.168.4.0 /24	172.17.128.2	C	192.168.4.0 /24	--	R	192.168.6.0 /24	172.16.0.2 172.16.192.2
R	192.168.5.0 /24	172.17.64.2 172.17.128.2	R	192.168.1.0 /24	172.17.128.1 172.17.32.1	R	172.16.64.0 /30	172.16.0.2 172.16.192.2
R	192.168.6.0 /24	172.17.64.2 172.17.128.2	R	192.168.2.0 /24	172.17.128.1 172.17.32.1	R	172.16.128.0	172.16.0.2 172.16.192.2
R	192.168.7.0 /24	172.17.64.2	R	192.168.6.0 /24	172.16.64.2	R	192.168.7.0 /24	172.16.0.2 172.16.192.2
C	192.168.8.0 /24	--	R	192.168.8.0 /24	172.17.128.1	R	192.168.8.0 /24	172.16.192.2

Complete and corrected routing tables								
R3			R4			R5		
	@ S/Net	N. Hop		@ S/Net	N. Hop		@ S/Net	N. Hop
C	172.16.0.0 /30	--	R	172.16.0.0 /30	172.17.0.1	R	172.16.0.0 /30	172.16.64.1 172.16.128.1
R	172.16.64.0 /30	172.17.32.2	R	172.16.64.0 /30	172.16.128.2	C	172.16.64.0 /30	--
R	172.16.128.0 /30	172.17.0.2	C	172.16.128.0	--	C	172.16.128.0 /30	--
R	172.16.192.0	172.16.0.1	R	172.16.192.0 /24	172.17.64.1	R	172.16.192.0	172.16.64.1 172.16.128.1
C	172.17.0.0 /30	--	C	172.17.0.0 /30	--	R	172.17.0.0	172.16.128.1
C	172.17.32.0 /30	--	R	172.17.32.0 /30	172.17.0.1	R	172.17.32.0	172.16.64.1
R	172.17.64.0 /30	172.17.0.2	C	172.17.64.0 /30	--	R	172.17.64.0	172.16.128.1
R	172.17.128.0 /30	172.17.32.2	R	172.17.128.0 /30	172.17.64.1	R	172.17.128.0	172.16.64.1
R	192.168.1.0 /24	172.16.0.1	R	192.168.1.0 /24	172.17.64.1 172.17.0.1	R	192.168.1.0	172.16.64.1 172.16.128.1
R	192.168.2.0 /24	172.16.0.1	R	192.168.2.0 /24	172.17.64.1 172.17.0.1	R	192.168.2.0	172.16.64.1 172.16.128.1
C	192.168.3.0 /24	--	R	192.168.3.0 /24	172.17.0.1	R	192.168.3.0	172.16.64.1 172.16.128.1
R	192.168.4.0 /24	172.17.32.2	R	192.168.8.0 /24	172.17.64.1	R	192.168.4.0	172.16.64.1
R	192.168.5.0 /24	172.17.32.2 172.17.0.2	R	192.168.5.0 /24	172.16.128.2	C	192.168.5.0	--
R	192.168.6.0 /24	172.17.32.2 172.17.0.2	R	192.168.6.0 /24	172.16.128.2	C	192.168.6.0	--
R	192.168.7.0 /24	172.17.0.2	C	192.168.7.0 /24	--	R	192.168.7.0	172.16.128.1
R	192.168.8.0 /24	172.17.32.2 172.17.0.2 172.16.0.1	R	192.168.4.0 /24	172.16.128.2 172.17.64.1 172.17.0.1	R	192.168.8.0	172.16.64.1 172.16.128.1

b) Give the network interface addresses: addresses are shown in the figure above

c) The optimal mask is /30.

d) The answer is above

e) The answer is above

f) We have 8 subnetworks, so we'll need 3 bits to calculate s/network addresses. The new mask will be /30,

The addresses:

1- 10.0.255.128 /30

2- 10.0.255.132 /30

3- 10.0.255.136 /30

4- 10.0.255.140 /30

5- 10.0.255.144 /30

6- 10.0.255.148 /30

7- 10.0.255.152 /30

8- 10.0.255.156 /30

Exercise 12:

Routing tables of R1 and R2

R1 routing table		
	Destination address	Next hop
C	123.1.2.0 /23	--
C	123.1.0.0 /23	--
C	101.0.1.0 /30	--
R	111.3.2.0 /23	101.0.1.1
R	200.4.4.0 /30	101.0.1.1
R	0.0.0.0 /0	101.0.1.1

R2 routing table		
	Destination address	Next hop
C	200.4.4.0 /30	--
C	111.3.2.0 /23	--
C	101.0.1.0 /30	--
R	123.1.2.0 /23	101.0.1.2
R	123.1.0.0 /23	101.0.1.2
R	0.0.0.0 /0	200.4.4.2