EP2120 Internetworking/Internetteknik
IK2218 Internets Protokoll och Principer

Homework Assignment 1

(Solutions due 17:00, Wednesday, 2015. Sept.9)

(Review due 17:00, Friday, 2015. Sept.11)

1. IPv4 Addressing (30/100)

a) What is the best fit netmask (i.e., resulting in as few host addresses as possible) for a network with 255 hosts in it? (5p)
You need 255 IP addresses for the hosts, plus a network address plus a directed broadcast address = 257 addresses required. Additionally, you might need one more IP address for the router, but the router could be one of the hosts. Whether or not the router is a host, you still need at least 257 addresses, and 9 bits are needed .Thus the netmask is 255.255.254.0.

b) What is the maximum number of hosts can you have in a /14 network? (5p)
/14 means that you have 32-14=18 bits for host addresses, which means 2^{18}=262144 addresses in the net, out of which one is the network address, and one is the directed broadcast address, so there can be up to 262142 hosts. If the router needs its own IP address then 262141 hosts.

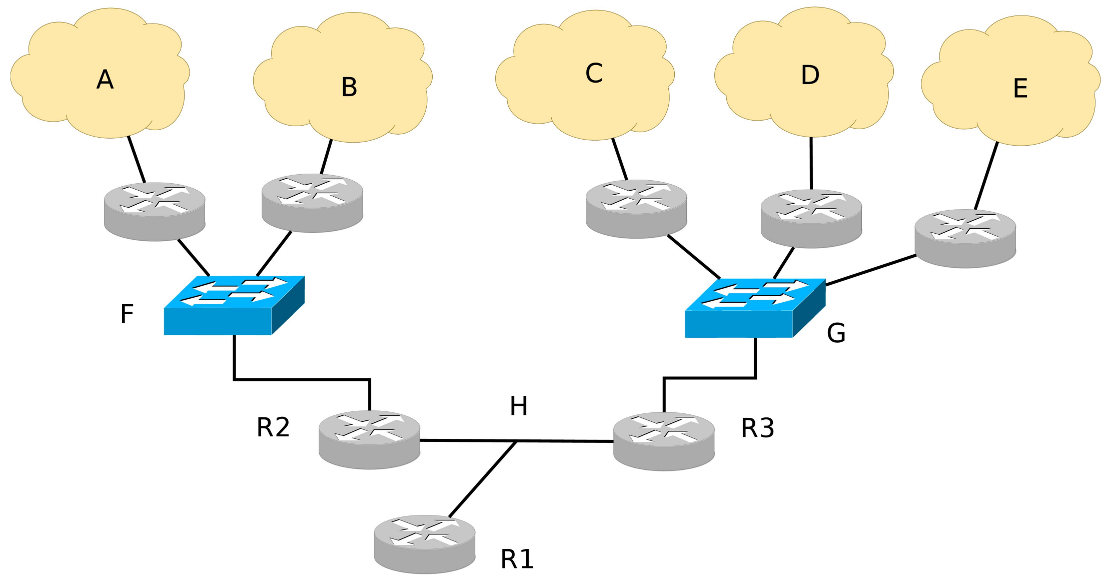
c) Split up the network 93.113.245.224/27 into four equally sized /29 networks! (5p)
/27 means that the first 27 bits of the address are the network address. Hence the first 27 bits of the four /29 networks will have to be 01011101.01110001.11110101.111
The 4 networks will differ in the following two bits (bits 28 and 29), which will be 00,01,10 and 11. The first network in binary format will be 01011101.01110001.11110101.11100000/29, the second network 01011101.01110001.11110101.11101000/29, etc.
In dotted decimal format the networks are 93.113.245.224/29, 93.113.245.232/29, 93.113.245.240/29, and 93.113.245.248/29.

d) What is the directed broadcast address of the network 84.129.75.0/24? (5p)
The directed broadcast address of this network is the address with all bits set to 1 between positions 25 and 32. That is, 84.129.75.255

e) What is the limited broadcast address of the network 84.129.75.0/24? (5p)
The limited broadcast address is the address with all bits set to 1. Consequently, it is 255.255.255.255.

f) Use the services of IANA and a regional registry to figure out to whom the IP network 195.74.160.0/19 belongs. Provide the name of the organization and the AS number. (5p)
Based on the RIPE whois database (http://apps.db.ripe.net/search/query.html) the network is ESA-OPSNET, that is, it is the Europen Space Agency Mission Operations and Support Network. The AS number is AS8519.

2. Address allocation (30/100)



Consider the network above, a routed network in an organization's enterprise network. The organization built a core network connected to a central router R1 (network H), and connected their edge/access routers with (long-haul) switched Ethernet (networks F and G). The access routers are connected to a set of local offices (networks A to E). All networks use Ethernet on the link layer. The enterprise allocated prefix 72.33.144.0/20 for its internal addresses.
Make an *address allocation* using 72.33.144.0/20 in the network by assigning a sub-block to each network A-E in the following way:

1) The networks A and B require 500 hosts each, while networks C, D, and E require 300 hosts each. Create a minimal block for each local office A through E. Start with the lowest address for network A.
2) There are no unnumbered point-to-point links: all Ethernet networks have IP sub-networks and all nodes (routers and hosts) have an IP address on all their network interfaces. All nodes need to be reachable from any other host.
3) The address allocation should be such that the sub-networks can be *aggregated*. The forwarding table of R1 must not have more than 3 entries (not counting the entry towards the 'rest of the network').

Based on your address allocation, provide the required entries of the forwarding table of router R1! Give a sketch of your reasoning to support your solution. (30p)

Any solution should be accepted that is correct in the sense that packets destined to ANY of the subnets and to any of the IP addresses assigned to actual nodes (host or router) can be forwarded.
The solution does not necessarily have to give a detailed explanation, but a good explanation is a merit, of course.

Observe that networks A-E need 9 bits for host ID, thus a /23 block each (as both 300 and 500 exceed 2^8-2). Networks F,G and H require 3 bits for Host ID, thus /29 blocks. It is convenient to split the /20 block into two /21 blocks for (A,B,F,H) and for (C,D,E,G) respectively, and allocate consecutive blocks.
The solution following this approach is as follows:
A: 72.33.144.0/23 – up to 510 hosts
B: 72.33.146.0/23 – up to 510 hosts
C: 72.33.152.0/23 – up to 510 hosts
D: 72.33.154.0/23 – up to 510 hosts
E: 72.33.156.0/23 – up to 510 hosts

F: 72.33.148.0/29 – up to 6 hosts
G: 72.33.158.0/29 – up to 6 hosts
H: 72.33.148.8/29 – up to 6 hosts

We assume that within the subnet allocated to network H the IP address assigned to R1 is 72.33.148.9, the IP address assigned to the router R2 (connecting to F) is 72.33.148.10, and the IP address assigned to the router R3 (connecting to G) is 72.33.148.11.

R1 Forwarding table (not including the forwarding rule for the 'rest of the network'):

Destination	*Next hop*	*Flags*	*Interface*
72.33.144.0/21	*72.33.148.10*	*UG*	*m0 (net H)*
72.33.152.0/21	*72.33.148.11*	*UG*	*m0 (net H)*
72.33.148.8/29	*–*	*U*	*m0 (net H)*

3. IPv4 forwarding (20/100)

A router has the forwarding table shown below. Determine the next-hop address and the outgoing interface for the packets arriving to the router with destination addresses as given in points (a)-(e).

Destination	Next hop	Flags	Interface
139.106.160.0/21	249.21.113.236	UG	m2
249.21.0.0/17	–	U	m2
223.180.128.0/17	249.21.118.102	UG	m2
81.148.167.80/28	19.197.72.163	UG	m1
220.142.218.32/27	7.255.85.122	UG	m0
7.255.85.64/26	–	U	m0
19.197.72.160/29	–	U	m1
0.0.0.0/0	7.255.85.90	UG	m0

a) 223.180.160.79 (4p)
249.21.118.102 on m2, indirect delivery

b) 220.142.218.41 (4p)
7.255.85.122 on m0, indirect delivery

c) 249.21.44.19 (4p)
249.21.44.19 on m2, direct delivery

d) 13.57.197.137 (4p)
7.255.85.90 on m0, default route

e) 19.197.72.162 (4p)
19.197.72.162 on m1, direct delivery

4. IPv4 options (20/100)

In the IPv4 header, options are included as a variable length field of up to 40 bytes at the end of the header, before the data field. The idea is to keep the overhead low when no options are needed.

a) How are the 1 byte options no-operation and end-of-option used in IPv4? Why are they needed? (5p)

No-operation is used as a buffer, for example to align subsequent options to the next 32-bit boundary. 32 bit alignment is desirable to enable fast processing.
End-of-option is used to mark the end of a list of options. It is only necessary to include the end-of-option option when the end of the options does not coincide with the end of the header. This is meant to avoid processing data that were not initialized (and may be invalid).

b) The record-route option can be used for recording the route a datagram travels. As the datagram is forwarded, the outgoing address of the router will be recorded in the record-route option. Why is there a limitation on the number of hops that can be recorded using this option? (5p)

The limitation is due to the length of the header of an IPv4 datagram being limited to 60 bytes. Of these 60 bytes, the base header occupies the first 20 bytes, thus only 40 bytes remain for options. After the type, length, and pointer fields of the record-route option there is only enough space left in the header for 9 addresses.

c) When an IPv4 datagram is fragmented, only certain options need to be copied to every fragment. Give an example of an option that is copied to every fragment and explain why it is copied. (5p)

Any option, for which the copy flag equals 1, is a good example. For example, the strict source route option must be copied to every fragment. This ensures that all fragments follow the same route, specified by the option.

d) In IPv6 options have been replaced by extension headers. What are the advantages of the way IPv6 extension headers are encoded? (5p)

The way extension headers are encoded removes the 40 byte limitation. Another advantage is almost all extension headers need only be processed at the destination node (the exception is the ‘hop-by-hop options’ extension header).