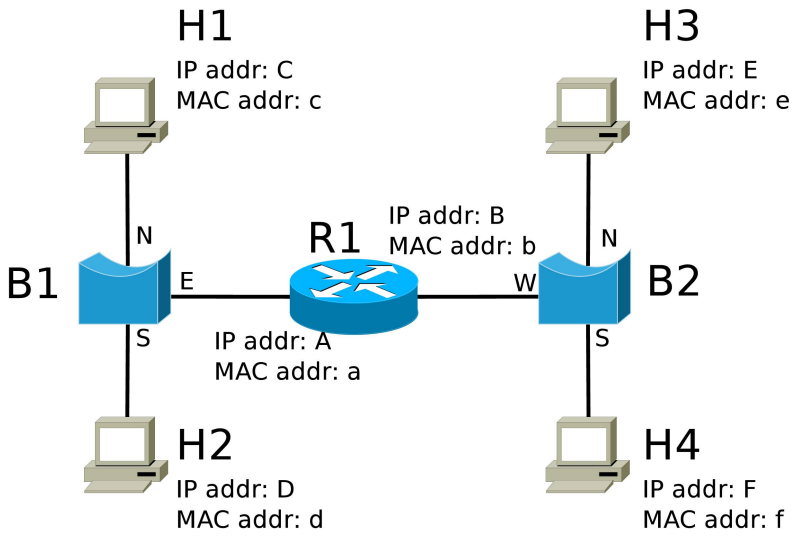
EP2120 Internetworking
IK2218 Protocols and Principles of the Internet

Homework assignment 2
(Solutions due 17:00, Wednesday, 2015.Sept.23)
(Review due 17:00, Friday, 2015.Sept.25)

1. ARP (20/100)



The figure above illustrates four hosts H_1, H_2, H_3, and H_4 connected by an inter-network running IPv4. The hosts are on two Ethernet networks, which are connected by router R_1. Note the learning bridge B_1, which connects hosts H_1, H_2, and router R_1, and the learning bridge B_2, which connects hosts H_3, H_4 and router R_1. The figure shows the IP and MAC addresses of the hosts and the router's interfaces, and the interface names of the bridges. Assume that the ARP caches of the router and of the hosts, and the MAC address tables of the bridges are initially empty and that no packets have been sent yet. The forwarding tables of all hosts and the router are correctly configured. All hosts know each others' IP addresses. ARP snooping is enabled.
Consider that host H_3 sends an IPv4 unicast datagram to host H_2.

a) Provide the state of the five ARP caches as they will appear after the IPv4 unicast datagram has been delivered to host H_2, that is, after dynamic ARP resolution has been made (16p).

b) Provide the state of the bridge B_1's MAC address table as it will appear after the IPv4 unicast datagram has been delivered to host H_2, that is, after dynamic ARP resolution has been made. (4p)

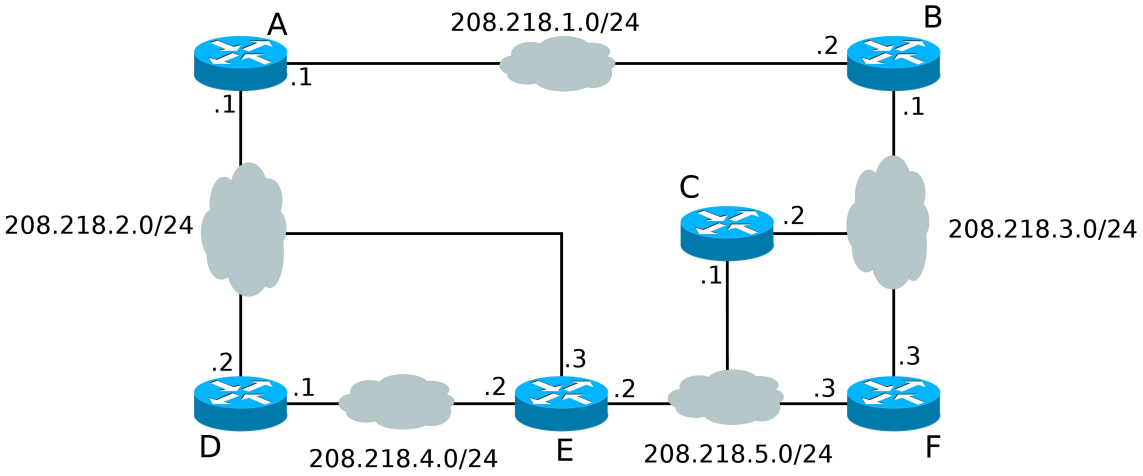
2. UDP and fragmentation (15/100)

Assume an Ethernet link with MTU 1500 bytes connects hosts A and B. An application process on Host A sends 7400 bytes of application data via UDP to a process on Host B. IPv4 is used at the network layer.

a) How many fragments are transmitted? (5p)

b) Give the values of the MF bit, the offset and the total length field of the IP header of each fragment! (10p)

3. Routing (25/100)



In the IPv4 network shown in the figure all routers A-F run RIPv2 and all link metrics are 1. The addresses of the IPv4 networks and the associated interface addresses are given in the figure. Note that the letters A-F do *not* denote addresses. Assume an initial state for all routers, where only the addresses of the directly connected networks are present in the routing tables. The destinations in the network are the /24 prefixes. Assume also that all RIP implementations support Equal-cost-multi-path (ECMP). All routers implement split-horizon and poison reverse.
Express routes as 'destination, metric, next-hop'. If the destination is a directly connected network, the route is given as 'destination, metric, -'.

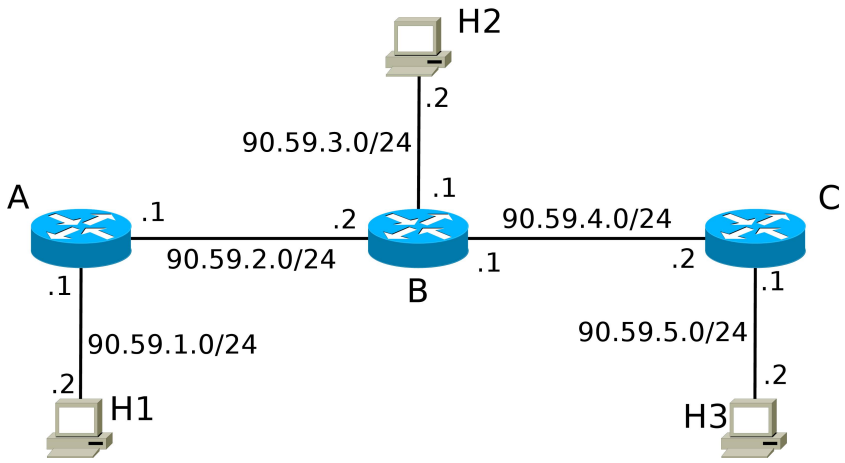
a) What is the initial routing state of D? (3p)

b) Assume that router E starts by sending a RIP response to its neighbours. What is the routing state of D after it has received the initial distance-vector from E? (5p)

c) Assume that the second event that happens in the network is that router A sends RIP responses to its neighbours. Which RIP response messages does A send, and which distance-vectors do they contain? You should indicate source and destination address of each RIP message, on which interface they are sent out (and to where) and which distance-vector (destination, metric tuples) are contained in each message. (8p)

d) What are the routing states of D and E after they have received the distance-vector from A in the previous step (c)? (9p)

4. ICMP (15/100)



The two hosts H1, H2 and H3 are connected by a network running IPv4. The forwarding tables of all hosts and connecting routers are correctly configured. Note that the letters A-C do not denote addresses.

a) H1 wants to use ping to verify that H2 is reachable. Which type of ICMP messages are exchanged between the two hosts? (5p)

b) Assume H1 performs a traceroute to host H3 relying on ICMP. Which ICMP messages does H1 send? List the packets including their destination address, the fields that differ between the subsequent packets, and the ICMP message type! What messages does H1 receive and from whom? List the received packets, assign each received packet to a sent packet and show its source address and the ICMP message type! (10p)

5. TCP (25/100)

Consider a recently established TCP connection between processes P_A and P_B on hosts A and B, respectively. The three-way handshake has been done, but no data has been sent yet. TCP on Host B announced a receiver window size of 5000 bytes to TCP on Host A, and Process P_B can read the received data from TCP as soon as they arrive. Process P_A has 15000 bytes to send via TCP. The path MTU between the two hosts is known to be 1040 bytes. The propagation time is 100ms, and the link speed is 4Mbps. It takes 1ms for TCP to generate a segment (with or without data) and this can be done in parallel with sending a previously generated segment.
The receiver uses delayed acknowledgements with a delay of 2*00ms* (or at most two full segments). The size of a segment having a TCP header only is negligible in terms of transmission time. IP options are not used. Process P_A sends the first segment at time t_0 with sequence number ISN+1. CWND is originally set to 1 MSS and the slow start threshold is 65535 bytes. Assume that the granularity G of the heartbeat timer is 0.5 seconds.

a) What is the MSS used by TCP? (2p)

b) What is the bandwidth-delay product of the communication channel? Is the advertised receiver window of *B* big enough? If not, how big should it be for *A* to be able to fully utilize the channel? (5p)

c) Provide the sequence of segments sent by TCP from host *A*. For each segment sent from host *A* provide the time it is sent, and the sequence number of the first byte it contains. For the first *four* segments sent from host A also provide the SRTT, RTTVAR and the RTO values of the sender TCP at the time the segment is sent. Assume that outgoing segments are handled before incoming segments in case more than one event happens at the same time! (15p)

d) At what time does A receive the acknowledgement for the last segment? (3p)

Hint 1: Try to first draw the sequence of segment exchanges to get the order of the segments right.

Hint 2: Consult RFC 6298 for details on how to calculate the SRTT, RTTVAR and the RTO. The description provided in the course book (3ed and 4ed) is not correct.