University of Toronto
Faculty of Applied Science and Engineering

Final Exam, December 2010

ECE 461: Internetworking
Examiner: J. Liebeherr

- Exam Type: B
- Calculator: Type 2

- There are a total of 10 problems.
- Note the information about header formats and a binary-decimal conversion table on the last pages.
- Write your solutions into an answer book. Make sure your name is on the answer book.
- Do not write answers in this handout.

Problem 1. *(10 points)*

Below is the traffic capture of a packet in hexadecimal notation. The capture consists of an Ethernet II header, followed by an IP header, followed by a TCP header. (Hint: Each digit corresponds to 4 bits.)

```
00 13 72 30 84 8d 00 1f f3 56 8a 9f 08 00 45 00
00 34 2c 9e 40 00 40 06 1a bb 8e 96 eb 21 8e 96
eb 1c c4 e4 00 50 7a 4f 7f 03 ef 7c db 51 80 11
ff ff f3 91 00 00 01 01 08 0a 35 b9 51 3b c1 67
d1 28
```

Note: The format of headers is provided on attached sheets.

a. *(2 points)* Provide the value of the Source IP Address and the Destination IP address (Use dotted decimal notation !)

b. *(2 points)* How can you tell that the Ethernet header is followed by an IP header? How can you tell that the IP header is followed by a TCP header? Include the relevant information from the captured data in your answer.

c. *(2 points)* Provide the values of the TCP source and destination port numbers (as decimal numbers). Which application protocol has sent the above TCP segment?

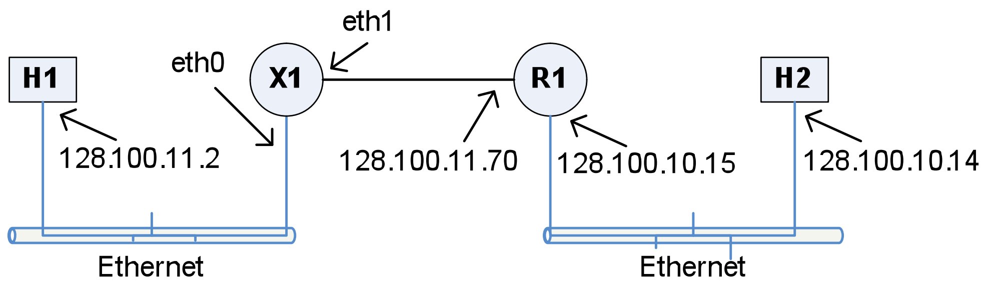
d. *(2 points)* The above segment has the ACK bit set. After receiving the segment, describe the range of sequence numbers that the receiver of the segment is allowed to transmit. (Sequence numbers can be given as hexadecimals).

e. *(2 points)* How can you tell that there is no payload following the TCP header? Since there is no payload in the above packet, what is the purpose of this packet?

Problem 2. *(10 points)*
Consider the following figure with two Ethernet segments where

- H1 and H2 are hosts;
- R1 is a router;
- X1 is a bridge.

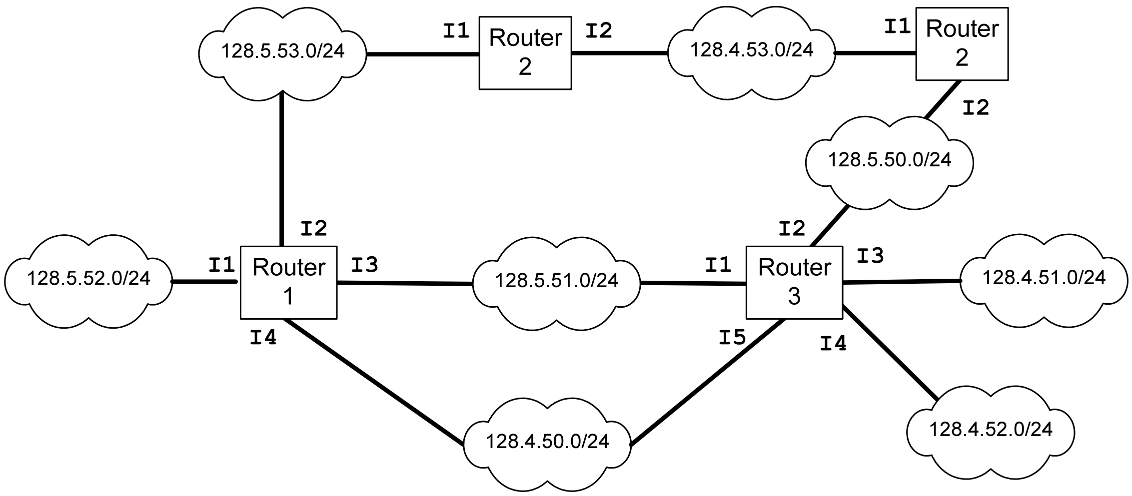
The IP addresses of the interfaces are indicated in the figure.
Proxy ARP is not available, i.e., cannot be used.



a. *(5 points)* Select subnetmasks for H1, H2, and R1. The subnetmasks should be selected so that the (extended) network prefix has maximal length.

b. *(5 points)* Suppose the configuration X1 is set to an IP router. Provide the required changes to the IP configuration in the network, so that H1 and H2 can communicate. The IP addresses of H1, H2, and R1 cannot be changed. The configuration includes:
   - IP addresses and subnetmasks for interfaces eth0 and eth1 at X1.
   - Subnetmasks at H1, H2, and R1 (If you choose the same as in part (a), state so).
   - Routing table entries at X1 and R1.

Problem 3. *(10 Points)*
Consider the interconnected IP networks as shown in the figure.



Assume that the routers run a routing protocol that minimizes the hop count to the destination (similar as RIP). If there are multiple routers with the same hop count, a router breaks the tie by picking the route which maximizes its opportunities for route aggregation. If that leaves unresolved ties, the remaining ties are broken arbitrarily.

a. *(5 points)* Provide the routing table for Router 2. The routing table should have two columns: (1) Network Address (including prefix length), and (2) Interface. The routing table must take advantage of all opportunities for route aggregation.

b. *(5 points)* Consider a routing strategy which selects routes solely on the basis of maximizing opportunities for route aggregation. Such a routing strategies should result in the smallest possible routing tables. However, there are problems with realizing this routing strategy.
Provide at least two distinct potential problems of such an approach to routing.

Problem 4. *(10 Points)*
Pretend for a moment that IP addresses are 12 bits instead of 32, and suppose you are allocated the block of addresses 1011xxxxxxxx (i.e., all addresses that start with `1011' in binary notation). Your task is to create address prefixes for four networks A, B, C, D, with the requirement that

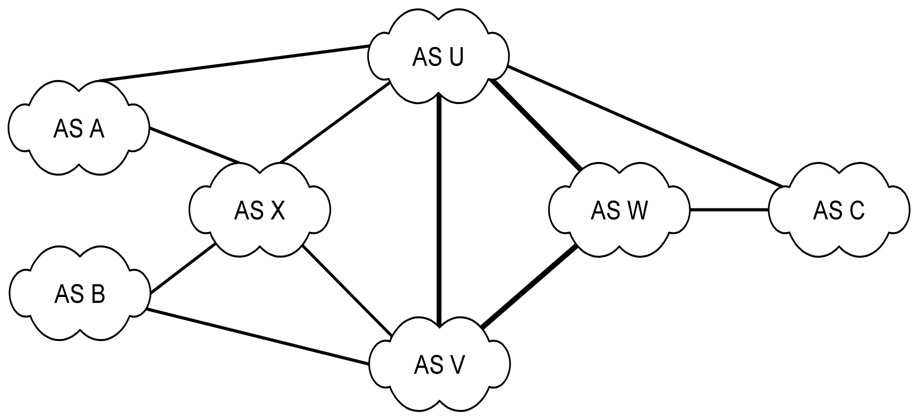
- Network A has 100 hosts;
- Network B has 50 hosts;
- Network C has 25 hosts;
- Network D has 10 hosts.

a. *(8 points)* For each network prefix, provide the IP network address in binary notation and the length of the network prefix.

b. *(2 points)* Create a network (Network E) that uses the entire unused portion of the address block. Provide the IP address and prefix length of the network, as well as the maximum number of hosts.

Problem 5. *(10 Points)*
Consider the network of autonomous systems in the figure, where AS A is a customer of AS X and AS U, and AS B is a customer of AS X and AS V. AS X, in turn, has two provider ASes U and V, while AS C is a customer AS of AS W and AS U. The three ASes U, V and W have peering relationships among themselves.

- AS C owns the prefix 128.1.0.0/16.
- AS A owns two network prefixes 64.1.10.0/24, and 128.101.34.0/24,



The inter-domain routing protocol BGP is used among the ASes to exchange routing information.

a. *(5 points)* For a packet from a host in AS A with the destination IP address 128.1.34.35, which ASes would this packet most likely traverse to reach its final destination? Explain your answer.

b. *(5 points)* Suppose AS A wants the traffic to its prefix 128.101.34.0/24 to come from AS U and the traffic to its prefix 64.1.10.0/24 to come from AS X. Which routes should AS A announce to AS U, and what routes should AS A announce to AS X? For each announcement, provide the prefix and the AS-PATH attribute. Explain your answers.

Problem 6. *(10 points)*

Consider a TCP connections between A and B. Assume that A has sent to B the sequence numbers 100 through 500 (measured in bytes).

(a) *(3 points)* Describe the difference between the advertised window and the usable window in TCP.

(b) *(3 points)* Show the advertised and usable windows at A, after A receives from B a segment with *(AckNo=500, Window size = 500)*. Which sequence numbers can A send to B?

(c) *(4 points)* After sending the segment with *(AckNo=500, Window size = 500)* in part (b), B wants to further reduce the advertised window by setting *Window size = 200.* Describe how B should proceed.

Problem 7. *(10 points)*
Assume you modify the TCP implementation on your computer as follows:

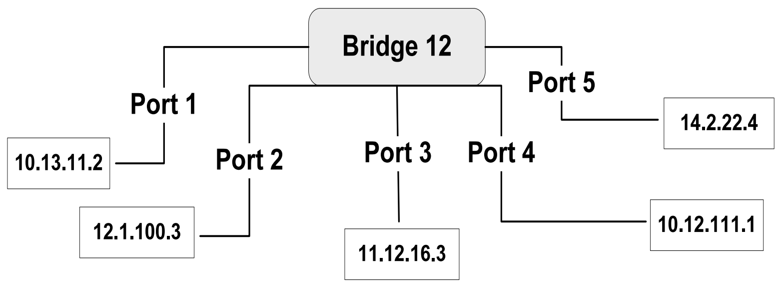
- After a retransmission timeout and subsequent retransmission, do not modify the values of the congestion window (*cwnd*) or the slow-start threshold value (*ssthresh*).
- After a retransmission timeout and subsequent retransmission, do not apply Karn's algorithm.
- Disable the round-trip time (RTT) measurements, i.e., always use the initial values of RTO.
- Do not use Fast Retransmit after a third duplicate acknowledgement (instead only retransmit using timeouts).
- Never leave the Slow-Start phase.

(a) *(5 points)* Describe the impact of each of the modifications on the maximum data rate at which your computer can transmit on a TCP connection. (Consider each modification individually).

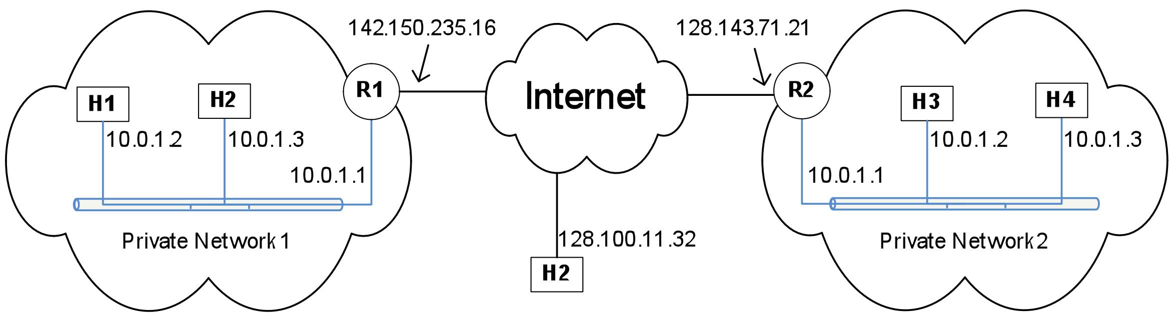
(b) *(5 points)* Describe the impact of each of the modification when all computers on the Internet are modified. (Again, consider each modification individually).

Problem 8. *(10 points)*
Consider Bridge 12 with 5 ports as shown in the figure below. The bridge is receiving configuration messages (BPDUs) as shown in the figure. Specifically, a message (R, C, B, P) where R is the value of the root ID, C is the value of the root path cost, B is the bridge ID, and P is the port ID, is interpreted as follows: "I am bridge B and I am sending from my port P. I believe R to be the root bridge, and the cost of my path to the root bridge is C."

(a) What is the root bridge of Bridge 12, and what is its Root Path Cost?
(b) What is Bridge 12's root port?
(c) What is Bridge 12's configuration message?
(d) On which ports does Bridge 12 send its configuration message?
(e) Which ports of Bridge 12 are marked as "blocked"?



Problem 9. *(10 points)*
Consider the network in the figure with two private IP networks, which are each connected to the Internet by a NAT router. Both routers R1 and R2 perform IP masquerading (Port Address Translation). R1 and R2 have public addresses, 142.150.235.16 and 128.143.71.21, respectively, which have been acquired using DHCP.



(a) *(3 points)* Suppose both H1 and H2 issue the command "ping 128.100.11.32". Describe the difficulty for the NAT router of handling these ping commands. Explain what NAT router R1 must do to handle the traffic resulting from the ping commands.

(b) *(3 points)* Suppose users on H1 and H3 want to set up a Voice-over-IP application (e.g., Skype) with each other. Describe the difficulty with setting up this application, and describe how it can be solved.

(c) *(4 points)* Suppose that H1 wants to run a web server that can be accessed from any computer on the Internet. The restriction is that the IP addresses in Private Network 1 cannot be changed. Also, NAT router R1 must continue to perform IP masquerading with a single public IP address. Describe changes to the configuration of R1, so that H1 can run a web server which can be accessed by H3, H4, and H5.

Problem 10. *(10 points)* Consider the following set of prefixes

A. 010*
B. 1100*
C. 01111*
D. 00*
E. 0111*
F. 01*
G. 1*
H. 11*

a) *(4 points)* Construct a disjoint-prefix binary trie for these prefixes.

b) *(3 points)* Construct the disjoint-prefix binary trie after adding the prefixes "X. 1111*" and "Y. 1010*".

c) *(3 points)* Construct the disjoint-prefix binary trie after removing entries for A and C.

Binary-Decimal Conversion

Last 4 bits→ **First 4 bits↓**	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0001	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0010	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
0011	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
0100	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
0101	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
0110	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
0111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
1000	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
1001	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
1010	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
1011	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
1100	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
1101	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
1110	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
1111	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

Packet Format of Ethernet, IP, and TCP header