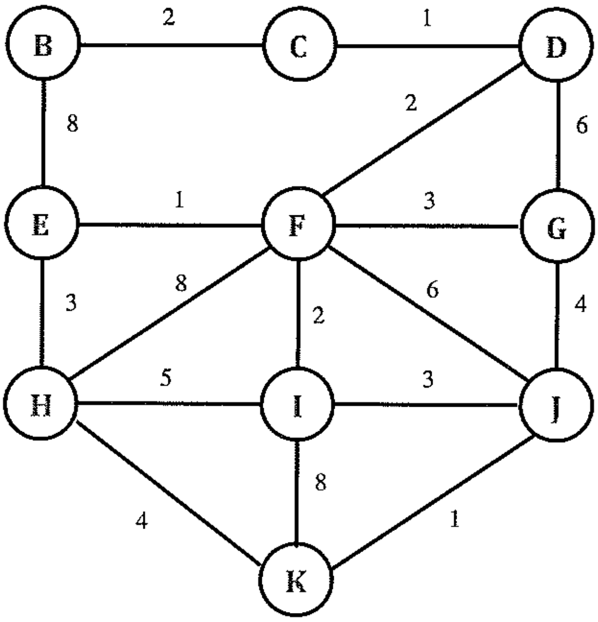
Solutions to HW#2

1. Execute the Dijkstra algorithm **at node B** for the network shown below by filling in the following table. In the table, you need to give both the distance $D(v)$ and the previous node $p(v)$.



Step	*N'*	*D(C), p(C)*	*D(D), p(D)*	*D(E), p(E)*	*D(F), p(F)*	*D(G), p(G)*	*D(H), p(H)*	*D(I), p(I)*	*D(J), p(J)*	*D(K), p(K)*
0	B	2,B	∞	8,B	∞	∞	∞	∞	∞	∞
1	B,C		3,C							
2	B,C,D				5,D	9,D				
3	B,C,D,F			6,F		8,F	13,F	7,F	11,F	
4	B,C,D,F,E						9,E			
5	B,C,D,F,E,I								10,I	15,I
6	B,C,D,F,E,I,G									
7	B,C,D,F,E,I,G,H									13,H
8	B,C,D,F,E,I,G,H,J									11,J
9	B,C,D,F,E,I,G,H,J,K									

2. In the distributed Bellman-Ford algorithm, node x which receives distance vectors from its neighboring nodes $v \in N(x)$, where $N(x)$ is the set of neighboring nodes of x, updates its own distance vector according to the following equation:

$$D_x(y) = \min_{v \in N(x)} \{c(x,v) + D_v(y)\} \text{ for each possible destination } y \qquad (1)$$

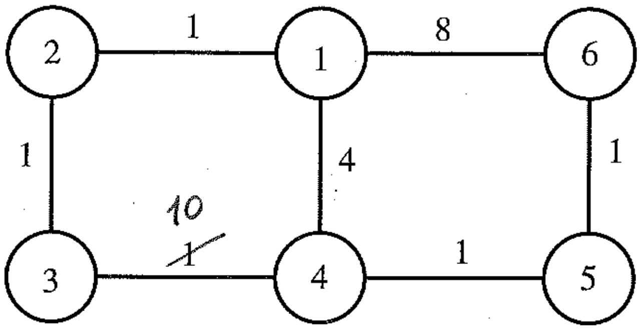
where $c(x,v)$ is the cost of the link between x and v.

Suppose that we make the following modification on the definition of the path cost: the cost of a path $(x_1, x_2, x_3, \ldots, x_p)$, denoted as $pc(x_1, x_2, x_3, \ldots, x_p)$, is given by the maximum of all the link costs along the path, i.e., $pc(x_1, x_2, x_3, \ldots, x_p) = \max\{c(x_1,x_2), c(x_2,x_3), \ldots, c(x_{p-1},x_p)\}$, instead of the definition that we used in the class where the path cost is the sum of all the link costs along the path, i.e., $pc(x_1, x_2, x_3, \ldots, x_p) = c(x_1,x_2) + c(x_2,x_3) + \ldots + c(x_{p-1},x_p)$.

$$D_x(y) \doteq \min_{v \in N(x)} \left\{ \max\left\{ c(x,v), D_v(y) \right\} \right\}$$

Modify the above equation (1) so that the distributed Bellman-Ford algorithm using this modified equation can be used to obtain the least cost paths..

3. The network below uses the distance-vector routing algorithm. Assume the following:
   - Links have the same cost in both directions.
   - Nodes exchange their routing info once every second, in perfect synchrony and with negligible transmission delays. Specifically, at every t = i, i = 0, 1, 2, 3,..., each node sends and receives routing info instantaneously, and updates its routing table; the update is completed by time t=i+0.1.
   - At time t = 0, the link costs are as shown below and the routing tables have been stabilized. At time t = 0.5, the cost of the link (3,4) becomes 10. There are no further link cost changes.
   - Route advertisements are **only exchanged periodically**, i.e., there are no immediate route advertisements after a link cost change. Hence the first route advertisement after the link cost change at t = 0.5 sec occurs at t = 1.0 sec. *Note:* However, whenever a link cost change occurs, the two nodes at the endpoints of this link immediately make corresponding changes in their distance tables.
   - Assume that the distance vector algorithm **does not use poisoned reverse.**



Give the evolution of the distance tables with respect to destination 6. Specifically, give the distance table entries for destination 6 at nodes 1-5, for t = 0.1, 0.5, 1.1, 2.1, ..., **until** all distance vectors stabilize. Present your final answer in the table given below where $D^i(j)$ is the distance vector element denoting the distance from i to j.

Time, t	$D^1(6)$ via			$D^2(6)$ via		$D^3(6)$ via		$D^4(6)$ via			$D^5(6)$ via	
	2	4	6	1	3	2	4	1	3	5	4	6
0.1	5	6	8	6	4	5	3	9	4	2	3	1
0.5	5	6	8	6	4	5	12	9	13	2	3	1
1.1	5	6	8	6	6	5	12	9	15	2	3	1
2.1	7	6	8	6	6	7	12	9	15	2	3	1
3.1	7	6	8	7	8	7	12	10	17	2	3	1
4.1	8	6	8	7	8	8	12	10	17	2	3	1
5.1	8	6	8	7	9	8	12	10	18	2	3	1
6.1												
7.1												
8.1												

4. Suppose host A transmits a 5000 Byte IP packet (including the 20 Byte IP header) over a 2-hop path to host B. The MTU of the first link (A to router) is 1500 Bytes (IP header plus data), and the MTU of the second link (router to B) is 1100 Bytes (IP header plus data). Assuming that IP header does not contain any options, indicate the length (in Bytes), more flag, and offset field values **(specify the offset values in units of 8 bytes)** of the fragment(s) transmitted over each link in the tables below.

First link

Fragment	Length	Offset	Flag
1	1,500	0	1
2	1,500	185	1
3	1.500	370	1
4	560	555	0
5			
6			
7			
8			

Second link

Fragment	Length	Offset	Flag
1	1,100	0	1
2	420	135	1
3	1,100	185	1
4	420	320	1
5	1,100	370	1
6	420	505	1
7	560	555	0
8			

5. You are given the assignment of setting subnet addresses for 5 departments of your company. The number of Internet connected PCs in each department is given in the following table. Assume that the 139.179.128.0/18 address block is given to you for this purpose. Use the following table to show the addresses of the five subnets that you created.

Campus	# of PCs	Subnet address (CIDR format)	
1	5000	139.179.128.0 /19	$8{,}192 = 2^{13}$
2	3500	139.179.160.0 /20	$4{,}096 = 2^{12}$
3	1800	139.179.176.0 /21	$2{,}048 = 2^{11}$
4	1000	139.179.184.0 /22	$1{,}024 = 2^{10}$
5	900	139.179.188.0 /22	$1{,}024 = 2^{10}$

6. Suppose the data sequence 11001101 is transmitted using the generator sequence 1100101. Compute the CRC bits and the transmitted bit sequence. Assume that the 2nd, 4th, 5th and 10th highest order bits are received with errors. Determine whether this error can be detected by the receiver.

D = 11001101

$G = \underbrace{1100101}_{r+1=7 \Rightarrow r=6 \text{ bits}}$

$2^6 . D = 11001101\,000000$

$$\begin{array}{l|l} x^{13}+x^{12}+x^{9}+x^{8}+x^{6} & x^6+x^5+x^2+1 \\ \hline x^{13}+x^{12}+x^{9}+x^{7} & x^7+x^2+1 \\ \hline x^{8}+x^{7}+x^{6} & \\ x^{8}+x^{7}+x^{4}+x^{2} & \\ \hline x^{6}+x^{4}+x^{2} & \\ x^{6}+x^{5}+x^{2}+1 & \\ \hline x^{5}+x^{4}+1 & \end{array}$$

$\Rightarrow R = 110001$

D ⋮ R = 11001101 ⋮ 110001

$D' \vdots R' = 10010101 \vdots 100001$

2nd 4th 5th 10th

$$
\begin{array}{l|l}
x^{13}+x^{10}+x^{8}+x^{6}+x^{5}+1 & x^{6}+x^{5}+x^{2}+1 \\ \cline{2-2}
\underline{x^{13}+x^{12}+x^{9}+x^{7}} & x^{7}+x^{6}+x^{5}+x^{3}+x^{2}+x+1 \\
x^{12}+x^{10}+x^{9}+x^{8}+x^{7}+x^{6}+x^{5}+1 & \\
\underline{x^{12}+x^{11}+x^{8}+x^{6}} & \\
x^{11}+x^{10}+x^{9}+x^{7}+x^{5}+1 & \\
\underline{x^{11}+x^{10}+x^{7}+x^{5}} & \\
x^{9}+1 & \\
\underline{x^{9}+x^{8}+x^{5}+x^{3}} & \\
x^{8}+x^{5}+x^{3}+1 & \\
\underline{x^{8}+x^{7}+x^{4}+x^{2}} & \\
x^{7}+x^{5}+x^{4}+x^{3}+x^{2}+1 & \\
\underline{x^{7}+x^{6}+x^{3}+x} & \\
x^{6}+x^{5}+x^{4}+x^{2}+x+1 & \\
\underline{x^{6}+x^{5}+x^{2}+1} & \\
x^{4}+x \quad \neq 0 \Rightarrow \text{error is detected} &
\end{array}
$$

7. Consider an Ethernet LAN using CSMA/CD running at 10 Mbits/sec. The propagation speed for the signal over the cable is 2×10^8 m/sec. The distances between the nodes in this Ethernet are given in the following table. Compute the minimum frame size in bytes so that the CSMA/CD algorithm will work properly for this LAN.

Distance (m)	A	B	C	D
A	-	100	350	600
B	100	-	250	500
C	350	250	-	250
D	600	500	250	-

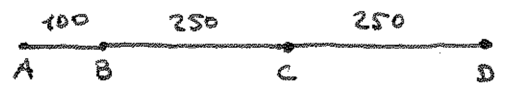
8. Assume that there are five active nodes competing for access to a channel using the Slotted-Aloha protocol. Assume that each node has just one packet to transmit. Each node attempts to transmit in each time slot with probability p as long as it has a packet to send.

   i. Calculate the probability that any one of the five nodes makes a successful transmission in the first time slot.

   ii. Calculate the probability of a collision in the first time slot.

   iii. Calculate the probability that there are successful transmissions in each of the first three time slots.

7.



$d_{max} = 600$ m

max RTT

$$\frac{F_{min}}{10^7 \text{ bps}} > \frac{2 \times 600 \text{ m}}{2 \times 10^8 \text{ m/s}}$$

$F_{min} > 60$ bits $\simeq 8$ bytes

but preamble + addresses + type + CRC = 26 bytes

8. 5 nodes using slotted Aloha with Xmission attempt probability of p in the next slot

i) Probability that any one node makes a successful Xmission in 1st slot

$= \binom{5}{1} p^1 (1-p)^4$

ii) Probability of no Xmission in 1st slot $= \binom{5}{0} p^0 (1-p)^5$

Probability of collision in 1st slot $= 1 - \binom{5}{1} p^1 (1-p)^4 - \binom{5}{0} p^0 (1-p)^5$

iii) Probability of successful Xmission in each of the first 3 slots =

$\binom{5}{1} p^1 (1-p)^4 \binom{4}{1} p^1 (1-p)^3 \binom{3}{1} p^1 (1-p)^2 = 3! \binom{5}{3} p^3 (1-p)^9$

9. $K_A \in \{0,1,2,3\}$, $K_B \in \{0,1,\ldots,15\}$, $K_C = 2$

i) $Pr\{K_A < \min\{K_B, K_C\}\} = \frac{1}{4} \cdot \frac{15}{16} + \frac{1}{4} \cdot \frac{14}{16} = \frac{29}{64}$.

ii) $Pr\{K_B < \min\{K_A, K_C\}\} = \frac{1}{16} \cdot \frac{3}{4} + \frac{1}{16} \cdot \frac{2}{4} = \frac{5}{64}$.

iii) $Pr\{K_A = K_B < K_C\} = \frac{1}{4} \cdot \frac{1}{16} + \frac{1}{4} \cdot \frac{1}{16} = \frac{1}{32}$.