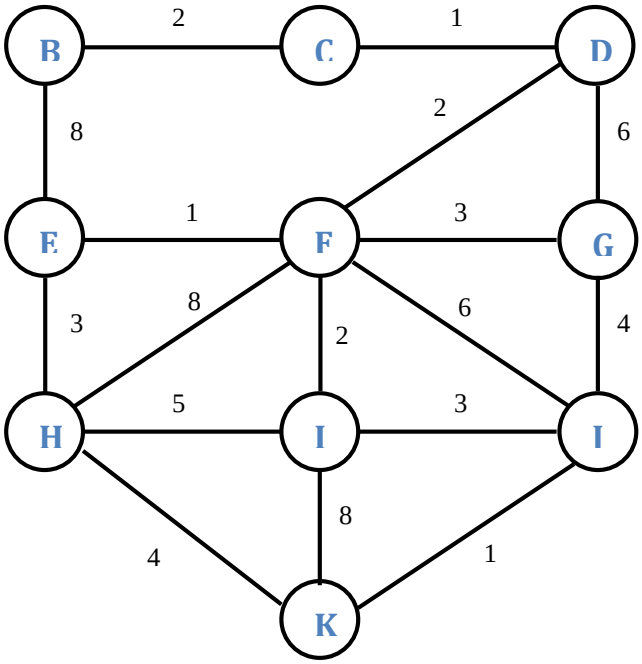
**HW#2, due June 4, 2023**

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

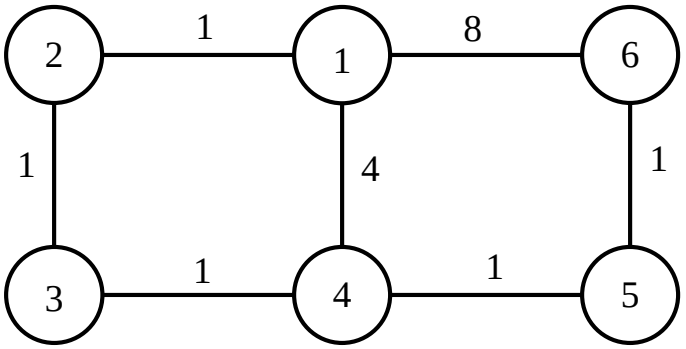
$$D_x(y) = \min_{v \in \mathrm{N}(x)} \{c(x,v) + D_v(y)\} \text{ for each possible destination } y \qquad (1)$$

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., $pc(x_1, x_2, x_3, \ldots, x_p) = c(x_1,x_2) + c(x_2,x_3) + \ldots + c(x_{p-1},x_p)$.

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 | | | | | | | | | | | | |
| 0.5 | | | | | | | | | | | | |
| 1.1 | | | | | | | | | | | | |
| 2.1 | | | | | | | | | | | | |
| 3.1 | | | | | | | | | | | | |
| 4.1 | | | | | | | | | | | | |
| 5.1 | | | | | | | | | | | | |
| 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 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |

**Second link**

| Fragment | Length | Offset | Flag |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 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 | |
| 2 | 3500 | |
| 3 | 1800 | |
| 4 | 1000 | |
| 5 | 900 | |

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 $2^{nd}$, $4^{th}$, $5^{th}$ and $10^{th}$ highest order bits are received with errors. Determine whether this error can be detected by the receiver.

7. Consider an Ethernet LAN using CSMA/CD running at 10 Mbits/sec. The propagation speed for the signal over the cable is $2x10^8$ 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 nodes that have been involved in a collision and 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.
9. Nodes A, B and C are connected to the same Ethernet and each node is trying to retransmit a frame. The collision counters are 2, 4 and 5 for nodes A, B and C, respectively. All three nodes detected the last collision simultaneously. All other nodes are currently inactive. Node C chooses 2 as the random number according to the exponential backoff algorithm.
    i. What is the probability that A will be the first node initiating a retransmission attempt?
    ii. What is the probability that B will be the first node initiating a retransmission attempt?
    iii. What is the probability that the next retransmission event will be a collision involving nodes A and B only?