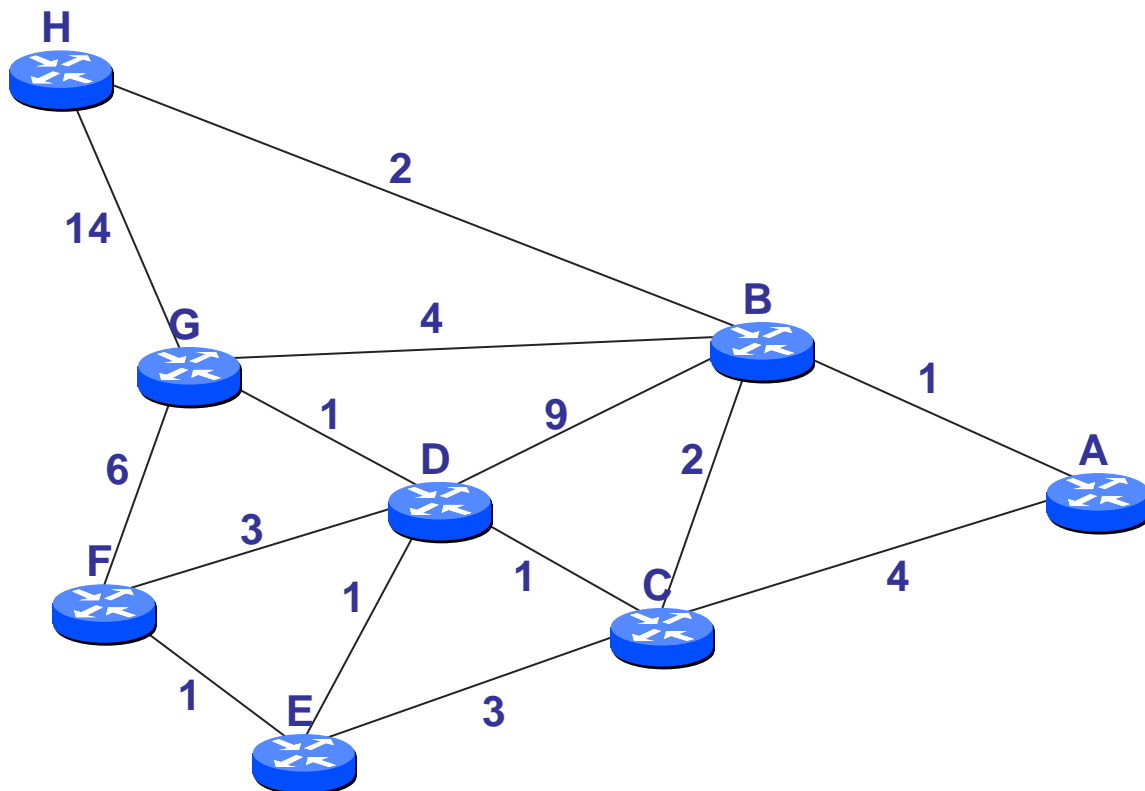


Due Dec 1st at the **beginning** of class

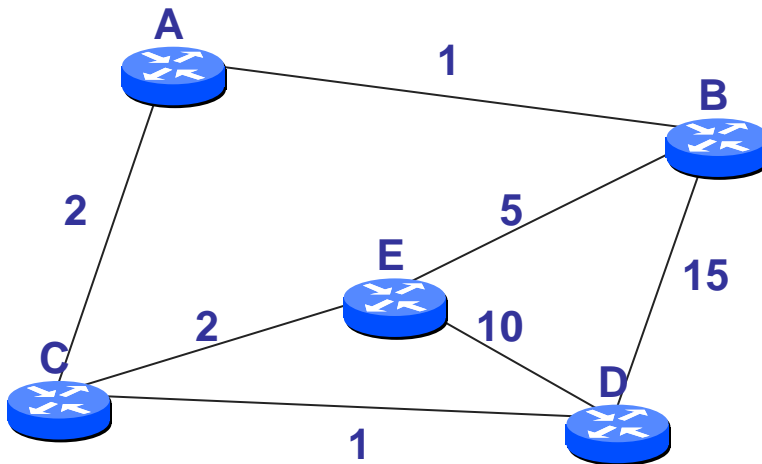
1. Consider a network path with a 100ms round-trip time and a 100Mbps bottleneck link between two hosts, A and B. At time t_1 , host A connects to host B using TCP (including its connection management and congestion control protocols) and then sends 60Kbytes of data to it, sending the last byte of data at time t_2 . Assume the packet size available for carrying data is 1500bytes (ignore header overhead), there are no packet losses and there is sufficient buffering at the receiver. What is the average data throughput delivered between times t_1 and t_2 ?
2. Explain why TCP excludes retransmitted packets when estimating the round-trip time. Give an example that demonstrates the problem with using these packets for RTT estimation.
3. Consider the following network. With the indicated link costs, use Dijkstra's shortest-path algorithm to compute the shortest path from F to all network nodes.



Show how the algorithm works by filling in a table with columns for step, N and $D(x), p(x)$, where step is the iteration through Dijkstra's algorithm, N is the set of nodes whose least-cost path from the source is definitively known, $D(x)$ is the cost of the path from the source to destination x that currently (as of this iteration of the algorithm) has the least cost and $p(x)$ is the previous node (neighbor of x) along the current least-cost path from the source to x . The first two rows in this table are filled out below. Fill out the remaining entries.

step	N	D(A),p(A)	D(B),p(B)	D(C),p(C)	D(D),p(D)	D(E),p(E)	D(G),p(G)	D(H),p(H)
0		∞	∞	∞	3,F	1,F	6,F	∞
1	E	∞	∞	4,E	2,E		6,F	∞

4. Consider the following network. Assume that each node initially knows the costs to each of its neighbors. Consider the distance vector algorithm and show the distance table entries at node E (this is a table showing the cost to reach each destination via each neighbor).



5. Consider a general topology (**any** potential network) and the distance vector algorithm (updates happen periodically and at the same time at all routers – in particular, no triggered updates). Suppose that at each interaction, a node exchanges its minimum costs with its neighbors and receives their minimum costs. Assuming that the algorithm begins with each node knowing on the costs to its immediate neighbors, what is the maximum number of iterations required from this point before the algorithm converges (i.e. that all nodes agree on the shortest path to all destinations)? Justify your answer. *Hint: it may help to think of the network in terms of its diameter d (the maximum number of hops between any two points in the network).*

6. Describe how loops are avoided in the Border Gateway Protocol (BGP)?