1. (25) Consider the Clustering algorithm based on Lowest ID clusterhead election.

(a) compute the “best case” and “worst case” complexity of the algorithm (ie, number of steps required for its convergence). A step is defined as an exchange of control messages between neighbors, for simplicity assumed here to be periodic

Ans: best case O(1) (example: 1-4-2-6-3-7-5); worst case O(N) (example:1-2-3-4-5-6-7)

(b) Another approach for cluster election is to select the node with the largest number of one hop neighbors (ie, “maximum connectivity” clusterhead election). Using intuitive arguments, explain why Lowest ID is more stable (ie, lower number of cluster changes) than highest connectivity when nodes are mobile.

Ans: The lowest ID property is not as sensitive to node movements as connectivity is. So, the latter criterion triggers instability.

2. (25) In 802.11, a station upon sensing the channel idle waits a DIFS interval and then the backoff interval before transmission. Would it make a difference if the station first “counted down” the backoff interval and then waited DIFS?

Ans: suppose two stations collide. Station A pulls a backoff number = 20 minislots, station B pulls 5 minislots. Assume the DIFS is 3 minislots. When the channel becomes idle, Station B wins and starts transmission after 8 minislots. At this point, with the standard 802.11 scheme, station A has counted down 5 minislots of its countdown value. With our new scheme, it will have counted down 8 minislots. Thus, the new scheme will give a slight advantage to the losers. The scheme will still work properly.

3. (25) Consider a linear ad hoc wireless network topology with the following nodes {A, X1, X2, X3, ..XN, B}, ie, A and B are the end nodes, while X1, X2, ..XN are the intermediate nodes. The internode distance is exactly equal to the transmission range. Assume MAC protocol is CSMA. Transport layer is UDP. Moreover, assume passive (or echo) ACK is used, except for the last node in the chain, which must issue an explicit ACK. This is like the original DARPA Packet Radio protocol. Channel speed is 2Mbps; packet and explicit ACK length is 2000bits. Header O/H and propagation delays are negligible.

(a) Assume a large file is present at node A. Compute the maximum throughput (in Kbps) for a file transfer between A and B for variable number of intermediate nodes (from 0 to infinity).

Ans: for N=0, Thr = 1Mbps; for N> 0, we must wait for the first packet to cover 3 hops before the second packet goes. Thus, Thr = 2Mbps/3 = 0.666Mbps
(b) Repeat this problem assuming that you use 802.11 with RTS/CTS and explicit ACKs. For simplicity assume that data packets are very large so the O/H caused by control packets, ACK, IFS intervals and CW is negligible. Find the maximum throughput.

Ans: for N=0, Thr = 2Mbps; for N=1, Thr = 1 Mbps ; for N>1, Thr = .666Mbps

4. (25) This problem helps understand the issue of “exposed terminal” in 802.11. Consider a wireless ad hoc network with four nodes A, B, C, D arranged in a linear topology. B and C are within each other range. A can hear B but not C and D. D can hear C but not B and A. You want to transfer files simultaneously from B to A and from C to D. You have the choice of using 802.11 with or without RTS/CTS. Assume channel speed is 2Mbps. All the control packets and ACKs incur zero O/H.

Which strategy will give you the highest aggregate throughput and thus fastest transfer completion time?

Ans: use CSMA without RTS/CTS will achieve a higher aggregate throughput = 2Mbps. Perfect synchronization however is required. Without perfect synch, the throughput is 1 Mbps. RTS/CTS will force alternation of transmissions, which will cause overhead. Thus less throughput.