Homework 2

Due: 2/11/2026

1) Nodes A and B are within carrier-sense range of each other and both have saturated traffic destined for node C. The network uses IEEE 802.11 DCF with RTS/CTS (RTS–CTS–DATA–ACK). At time t_0, node D finishes a transmission and the channel becomes idle. After the channel has been idle for DIFS, nodes A and B start (or resume) their backoff countdown. For this problem, assume A and B both initialize their first backoff counters at $t_0$and begin counting down after DIFS according to standard DCF rules.
   Backoff sequences (in slots) for successive transmission attempts are predetermined as follows (use in order; if another attempt is needed beyond the list, stop):

   - Node A: 6, 3, 5, 6, 4
   - Node B: 6, 8, 6, 2, 7

   Assume:

   - Propagation delay is negligible.
   - No capture effect; any overlapping transmissions collide and are lost.
   - RTS frames are subject to collision. If an RTS collides, the attempt fails (no CTS is received).
   - If an RTS is received correctly at C, then the subsequent CTS, DATA, and ACK in that exchange are received correctly (i.e., ignore data corruption/bit errors).
   - 802.11a slot time = 9 μs.
   - Transmission time of RTS, CTS, and ACK is 61 μs each (use as given; ignore PHY header/preamble differences).
   - You may denote SIFS and DIFS symbolically (no numeric values required), but you must place them correctly in the sequence:
     - A successful exchange is: DIFS → backoff → RTS → SIFS → CTS → SIFS → DATA → SIFS → ACK.
   - When the medium becomes busy, other nodes freeze their backoff counters and resume counting down only after the channel has again been idle for DIFS.

- After a failed attempt (e.g., RTS collision), a node schedules a retransmission using the next backoff value in its given sequence (assume it immediately becomes eligible to contend again per normal DCF behavior).

Draw a timing diagram showing events starting at $t_0$and continuing until both A and B have successfully delivered their first DATA frame to C and received an ACK, or until one node exhausts its given backoff sequence (whichever occurs first). DATA transmission time is a fixed constant $T_{DATA}$and show it as a labeled block.

Your diagram must include:

- One timeline each for A, B, and C.
- All transmissions (RTS/CTS/DATA/ACK) on the correct timelines.
- Backoff countdown behavior (slots counted, frozen, resumed).
- Any collisions clearly marked (which frames collide).
- The instant each node achieves "first packet success" (ACK received). [25 points]

2) Repeat Problem 1 when A and B are hidden terminals: they cannot carrier-sense each other's transmissions, but both can communicate with C. The network does not use RTS/CTS, i.e., DATA–ACK only. Keep the same backoff sequences and slot time assumptions. Show collisions at C when they occur and the resulting retransmission behavior. [25 points]

3) Repeat Problem 1 when A and B are hidden terminals and RTS/CTS is enabled. Keep the same backoff sequences and timing assumptions for RTS/CTS/ACK. Indicate how NAV (if shown) and RTS/CTS affect collisions and backoff freezing/resuming. [25 points]

4) If the NAV mechanism were removed but physical carrier sensing remained, what problems would arise? Explain with at least one concrete scenario (e.g., hidden terminals, exposed terminals, or virtual carrier sense use cases). [25 points]