1. (a) To prevent unfairness caused by some nodes being starved.
   (b) To prevent the capture effect, in which one node dominates the medium for several packets in a row.
   (c) The utilization will be (much) lower than the theoretical maximum (e.g., much lower than $1/e$ for slotted Aloha). The reason is that the collision rate will be very high.

2. See PSet.

3. See PSet.

4. (a) True; e.g., if one node is backlogged and the others aren’t, Aloha’s utilization will be 1, while TDMA will be $1/N$.
   (b) False; $p$ will change dynamically with successes and collisions, and will not converge to any particular value in general.
   (c) False; $U = 3 \cdot (1/3) \cdot (1 - 1/3)^2 = 4/9 \neq 1/e$.
   (d) False; TDMA can achieve 100% utilization, but slotted Aloha will converge to an expected value of $1/e$.
   (e) False; contention windows guarantee a transmission attempt within a bounded time, but there’s no guarantee of success.

5. (a) $U = p(1 - 2p)^2 + 2(2p)(1 - p)(1 - 2p) = 0.384$.
   (b) Note that $p < 0.5$ because $p_B$ and $p_C$ must be smaller than 1.


   The maximum value of $U$ is 0.456, occurring when $p = 0.202$ (the other extremum of 0.687 is not valid because $p < 0.5$.)

6. See PSet.

7. See PSet.

8. (a) All four nodes positioned so they can hear each other perfectly.
   (b) A and B can hear each other well; A and C can hear each other well; B and D can hear each other well. But D can’t hear A and C can’t hear B. A now sends to C and B to D. This is also called an “exposed terminal” situation.

9. See PSet.

10. See PSet.

11. See PSet.

12. See PSet.

Hari Balakrishnan