6.263 Data Communication Networks — October 23, 2005
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Solutions to Problem Set 5

Problem 5.1
There are two main reasons:

1) In a wireless LAN scenario, all transmissions are from or to the AP. Traffic from the AP will not collide with other traffic coming from the AP. This reduces the overall probability of a collision.

2) Given that most of Internet connections are downloads from a Web or an FTP server, most of the bytes will be from the AP to the mobile nodes. The mobile nodes usually send small packets to the server to acknowledge the reception of the downloaded data. Although these packets may collide, they are almost as small as the RTS and CTS.

Problem 5.2
The duration of the ACK transmission.

Problem 5.3
Yes, because the exposed terminal will hear the RTS but not the CTS. This indicates that the terminal is within the range of the sender but not the receiver and thus it is free to transmit. When we introduce the ACK, the ACK sent by station B might collide with station C's transmissions (see figure from lecture). MACAW addresses the problem by introducing a new packet DS, which is used to inform C that the RTS/CTS exchange was successful. As a result C will defer until the end of the transmission of DATA and ACK (see section 3.3.2 in the MACAW paper). 802.11 solves this problem using the NAV. In this case, B will send a CTS packet whose NAV value is set to the duration of the whole transmission including the ACK. Node C will hear the CTS and will defer until the end of the transmission–i.e., until B has transmitted the ACK.

Problem 5.4
In contrast to MACAW, 802.11 does not share the backoff timer used by the successful transmission. The node that was successful in transmitting does not know that other nodes are backlogged. This node has the smallest backoff, making it likely to grab the medium again. (see section 3.1 in the MACAW paper).

Problem 5.5
The maximum throughput is 1/3 because at any single point in time only one node can transmit.

Problem 5.6
Radios that are sufficiently distant can transmit concurrently; the total amount of data that can be simultaneously transmitted for one hop increases linearly with the total area of the ad hoc

network. If node density is constant, this means that the total one-hop capacity is $O(n)$, where n is the total number of nodes. However, as the network grows larger, the number of hops between each source and destination may also grow larger, depending on communication patterns. One might expect the average path length to grow with the spatial diameter of the network, or equivalently the square root of the area, or $O(\sqrt{n})$. With this assumption, the total end-to-end capacity is roughly $O(n/\sqrt{n})$, and the end-to-end throughput available to each node is $O(1/\sqrt{n})$.