Homework 1
Due: 11:59pm, 23 Feb 2022

1 Getting to 640 Mbps

You are tasked with creating a wireless transmission scheme that achieves at least 640Mbps. The radio you are given is using the 5.8GHz unlicensed spectrum (similar to many WiFi specs), uses an 80MHz bandwidth, and can use one of the modulation schemes given by the table below.

<table>
<thead>
<tr>
<th>Modulation</th>
<th>$M$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPSK</td>
<td>2</td>
</tr>
<tr>
<td>QPSK</td>
<td>4</td>
</tr>
<tr>
<td>8PSK</td>
<td>8</td>
</tr>
<tr>
<td>16-QAM$^2$</td>
<td>16</td>
</tr>
<tr>
<td>256-QAM$^2$</td>
<td>256</td>
</tr>
</tbody>
</table>

Table 1: Modulation scheme choices.

a. Assuming no noise, what is the simplest modulation scheme required to achieve 640Mbps ($640 \times 10^6$ bits/s)?

b. Signal strength is often measured in dBm, which is decibels (dB) relative to a 1 milliwatt reference point. Thus, for a given signal power ($P$, in watts):

$$1dBm = 10 \times \log_{10}\left(\frac{P}{0.001W}\right)$$

Under real (noisy) conditions, you measured the noise level of your system to be -95dBm, and the signal power at the receiver to be -78dBm. What is the ratio of signal to noise power (S/N, NOT in dB)?

c. What is the highest bitrate you can achieve on this channel, given the signal to noise power you found in part (b)? What is the best among the modulation schemes above that you can use, and what rate does it achieve?

d. If that is not enough to transmit 640Mbps, by what factor should the radio’s transmit power increase in order to achieve the desired rate of 640Mbps?

$^2$BPSK: Binary Phase-shift keying
$^2$QAM: Quadrature Amplitude Modulation (varies both phase and frequency)
2 Don’t shout at the same time!

a. What does it mean to say that all packets on an Ethernet network are in the same broadcast domain?

b. True or False: Using a learning switch increases throughput by isolating each host-switch link in its own broadcast domain. Explain your reasoning.

c. Explain one advantage and one disadvantage of Ethernet’s randomized exponential backoff scheme for Ethernet, compared to a time-based scheme in which each node has a designated time slot to send data.

3 Layering

In Lecture 2, we discussed layering as a form of organizing the required functions for communicating across a network. One challenge in designing a layered architecture is to decide where to place functionality.

We have (broadly, for now) discussed how TCP provides reliable data transmission between two hosts. Let’s say you are designing a new, fully-reliable wireless protocol to connect your laptop to the campus network.

a. If your new link-layer protocol is fully-reliable, would you still need TCP’s reliable delivery to, e.g., upload a file to Google Drive? Explain why or why not.

b. Is there a reason to have reliable delivery provided at both the link layer and the transport layer (TCP)?