Homework 1 solution

February 5, 2016

Problem 1. Suppose a new wireless technology uses phase shift modulation to encode data, there are 16 possible phase shifts available, and it takes the underlying hardware 20 nanoseconds to make a phase shift. How many bits per second can the technology transfer?

Solution:
Data rate can be computed using the following equation:

\[
\text{data rate} = \text{baud} \times \lfloor \log_2^{\text{level}} \rfloor \text{bits/second}
\]  

(1)

Baud rate is number of times signal changes per second;

\[
\frac{1}{2 \times 10^{-8}} \times \lfloor \log_2^{16} \rfloor = 200 \times 10^6 \text{bits/second} = 200 \text{Mbit/sec}
\]

(2)

Based on above result, this technology can transfer 200 Mbit/s.

Problem 2. Assume signals propagate along an optical fiber at approximately 2/3 of the speed of light. According to Google maps, the distance along highways from West Lafayette to Palo Alto is 2265 miles. If optical fiber is laid next to the highways on the Google route, what is the round-trip delay to propagate a signal from here to Palo Alto and back?

Solution:
Since the speed of light is 186282 miles/second, signals propagate along an optical fiber at approximately \( \frac{2}{3} \times 186282 = 124188 \) mile/second. Based on following equation we will have:

\[
RTT = 2 \times \frac{\text{distance}}{\text{speed}} \Rightarrow 2 \times \frac{2265}{124188} = 0.0364 \text{ sec} = 36 \text{ msec}
\]

(3)

Problem 3. Suppose a Purdue startup wants to set up an office in Palo Alto and must choose between an optical fiber connection (as in the previous question) and a Geosynchronous Earth Orbit satellite connection. How do the delays compare?

Solution The distance required for a geostationary orbit is 35785 kilometers or 22236 miles. So at the speed of light \( 3 \times 10^8 \) meters per second, the trip takes:

\[
\frac{2 \times 35.8 \times 10^6 \text{meters}}{3 \times 10^8 \text{meters/sec}} = 0.238 \text{ sec} = 238 \text{ msec}
\]

(4)
Based on previous answer, we will have:

$$\frac{238 - 36}{36} \times 100 = 561\%$$  \hspace{1cm} (5)

As we can see, optical fiber is 561% faster than GEO satellite.

**Problem 4.** If radio waves could travel directly from West Lafayette to Palo Alto, the direct distance is 1894 miles. Assuming radio waves propagate at the speed of light, how much faster would a radio link be than an optical fiber running along a highway?

**Solution**

$$\text{RTT} = 2 \times \frac{\text{distance}}{\text{speed}} = 2 \times \frac{1894 \text{ mile}}{186282 \text{ mile/sec}} = 0.0203 \text{ sec} = 20.3 \text{ msec}$$  \hspace{1cm} (6)

So based on answer of question 2, we will have:

$$\frac{36 - 20.3}{20.3} \times 100 = 77.3\%$$  \hspace{1cm} (7)

As we can see, radio waves are 77.3% is faster than optical fiber.