CSCE 464 Wireless and Mobile Systems Fall 2019

Homework 1
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Remove all highlights before typing your answer.

1 Signal Encoding

(a) (3) Lower frequencies have a much longer reach so it makes sense to regulate them so they can be used across countries and among different applications. Higher frequencies have a much lower reach making them less usable and thus less important to regulate.

(8) Problems of signal propagation included, attenuation, diffraction, scattering, refraction and reflection. Since signal propagation is unpredictable it will not always travel in a straight line. For example, the transmitter and receiver could be moving, or the signal could degrade over distance or terrain. Reflection is useful in propagation because there is almost never a clear line of sight between the source and destination. Reflection is harmful because it is the main reason for multi-path propagation causing ISI.

(9) ISI can be mitigated by large guard times between symbols, calculation of the strongest transmission paths and having the receiver use those paths, and lower data rates. ISI is less problematic with higher carrier frequencies. The higher the symbol rate the shorter the transmission time so ISI effects become worse. The more movement the more recalculation of the path is needed, creating more problems for ISI. In a TDM scheme ISI sets the number of users of a channel, and the maximum data rate allowed for each user.

(12) For a recieved signal the point in the phase diagram is compared to the surrounding points. The received point is corrected to the closest allowed point. Adding more and more points increases the risk to correct a received point incorrectly if the average distance to the correct point becomes more than half the distance between allowed points.

(b)
- -9.03 dBm
- -6.2 dBm
- -3.1 dBm
- 0 dBm
- 3.01 dBm
- 6.02 dBm
- 9.03 dBm

The conversion follows a logarithmic function specifically $P(dBm) = 10 * log(P(W)) + 30$

(c) $S(t) = (1.0 + 0.1\cos 5t)\cos 100t$:
$= \cos 100t + 0.1\cos 100t \cos 5t$
$= \cos 100t + \frac{0.1}{2}(\cos(100+5)t + \cos(100-5)t)$
$= \cos 100t + 0.05\cos(100+5)t + 0.05\cos(100-5)t$

$= \cos 100t + 0.05 \cos 105t + 0.05 \cos 95t$
$= \cos 2\frac{50}{\pi}t + 0.05 \cos 2\frac{105}{2\pi}t + 0.05 \cos 2\frac{95}{2\pi}t$
$= \sin 2\frac{50}{\pi}t + 0.05 \sin 2\frac{105}{2\pi}t + 0.05 \sin 2\frac{95}{2\pi}t$

Answer:
$\sin 2\frac{50}{\pi}t$: Amplitude $= 1$, frequency $= \frac{50}{\pi}$, phase $= \frac{\pi}{2}$
$0.05 \sin 2\frac{105}{2\pi}t$: Amplitude $= 0.05$, frequency $= \frac{105}{2\pi}$, phase $= \frac{\pi}{2}$
$0.05 \sin 2\frac{95}{2\pi}t$: Amplitude $= 0.05$, frequency $= \frac{95}{2\pi}$, phase $= \frac{\pi}{2}$

(d) Binary values are represented by two different amplitudes of carrier frequencies in ASK. Vulnerability to sudden gain changes and inefficiency at handling noise are the primary limitations of this approach.

(e)

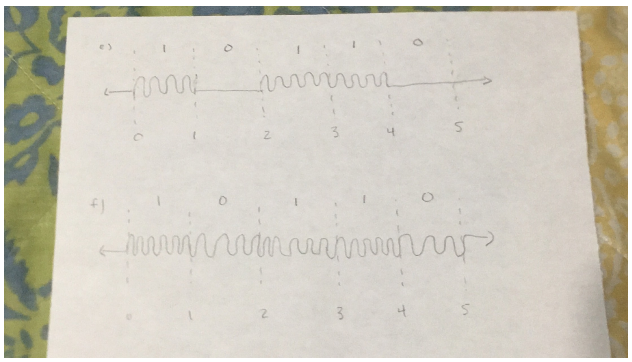

Figure 1: part (e) and (f)

(f)

(g) For ASK and FSK a signal to noise ratio of $13.5dB$ is needed for a bandwidth efficiency of 1.0

2 Channel Capacity, Models

(a) $PL(d_0)$ is the frequency dependent component and α is the path loss gradient. The value of α determines how quickly the received signal strength (RSS) falls with distance so the formula $PL(d) = PL(d_0) + 10 * \alpha * log_{10} d/d_0$ makes sense.

(b)
- For $d = 2d_0$:

$PL(d) = 40 + 10 * 2.4 * log_{10}(2d_0/d_0) = 40 + 10 * 2.4 * 0.0301 = 47.2247$

- For $d = 4d_0$:

$PL(d) = 40 + 10 * 2.4 * log_{10}(4d_0/d_0) = 40 + 10 * 2.4 * 0.0602 = 54.4494$

- Path loss = 64dB:

Since $40 + 10 * 2.4 = 63$ and $log_{10}10 = 1$ **then** $d = 10d_0$

(c) - A → B:

$10 * log_{10}10^{-3} - P_{Rx}(dB) = 20dB + (10 * 3)log_{10}30 - 30 - P_{Rx}(dB) = 64.3dB$
Answer: $P_{Rx}(dB)$ a + b = $-94.3dB$

- B → C:

$-94.3dB - P/a + c = 20dB + 30 * log20 = 59.03$
Answer: P a+c(dB) = $-153.33dB$

(d) Using the equation: $C = Blog_2(1 + SNR)$
$20 * 10^6 = 3 * 10^6 * log_2(1 + SNR)$
$log_2(1 + SNR) = 6.67$
$1 + SNR = 2^{6.67}$
$1 + SNR = 102$
Answer: $SNR = 101$

3 Spread Spectrum and OFDM

(a) A spread spectrum system is robust against interference making it beneficial in providing security. It also serves as the basis for CDMA technology. Spreading is achieved through frequency hopping. Guard spaces are replaced by the orthogonality of the hopping patterns. Multi-path propagation can be benefited by DSSS systems through recombination which results in a stronger signal.

(b) It has orthogonality. Which means the frequency spacing is $\frac{1}{T}$, and if the bit time is T then the base frequency should be a multiple of $\frac{1}{T}$

(c) Main strengths of OFDM include, efficient use of the spectrum through overlap, resistance to frequency selective fading, and the elimination of ISI and IFI through the use of a cyclic prefix.

(d) In OFDM the users are allocated only on the time domain. On the other hand OFDMA allows users to be allocated both time and frequency. Thus in OFDMA users will get the best frequencies with the least amount of noise.

(e) - Adjacent subcarriers: requires measurements to find the best channels but ICI (inter-carrier interference) is reduced
- Regularly spaced subcarriers: Provides diversification of SNR
- Randomly spaced subcarriers: Offers all the benefits of regularly spaced subcarriers as well as reduced adjacent cell interference

(f) (1) Resiliency against narrow band interface
(2) Relatively high security

(3) Receiver can separate each user based on code

(g) Spread spectrum encodes the signal and then the bandwidth of the signal is increased to reduce jamming of the signal. Thus, the bandwidth is wider after the signal has ben encoded.

(h) The bandwidth of the signal increases proportionally with the bit rate

(i) CDMA is "Code Division Multiple Access" and is a spread spectrum technique that allows for signals with a higher bandwidth as well as multiple users to be multiplexed over the same channel.

(j) Subcarrier spacing: $\frac{1}{T} = \frac{1}{16.67\mu S} = 14.999kHz$
Number of required subcarriers: $\frac{bitrate}{subcarrierspacing} = \frac{20\times10^6}{10\times10^3} = 1333.333$,
approximating to **1334 subcarriers**

(k) $C = B\log_2 1 + SNR$

- For $SNR = 0.1$
  $B = 0.4MHz$
- For $SNR = 0.01$
  $B = 3.9MHz$
- For $SNR = 0.001$
  $B = 38.84MHz$

4 Coding and Error Control

(a) $0110111 = 0110$

(b) $1010101 = 1010$

(c) $1110011 = 1110$

(d) $1110110 = 1110$

(e) $1111100 = 1111$

5 Wireshark

(a) (1) Host IP: 192.168.86.38
Destination IP: 74.6.228.140

(2) ICMP packets have a type and a code because it communicates network layer information, not application layer. The type and code identify the message being received. The network software interprets the messages so no port numbers are needed to direct the messages to a process.

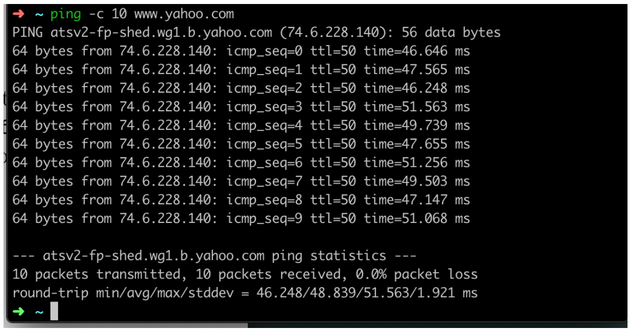

Figure 2: ping yahoo.com

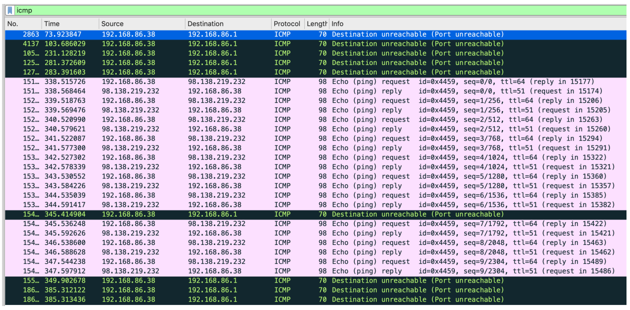

Figure 3: icmp output

(3) ICMP Type: 8 Echo (ping) request
Code: 0
Checksum: 16-bit
Sequence number: 16-bit
Identifier: 16-bit

Other fields are the timestamp from the icmp data plus the data itself.

(4) ICMP Type: 0 Echo (ping) reply
Code: 0
Checksum: 16-bit
Sequence number: 16-bit
Identifier: 16-bit

Other fields are the timestamp from the icmp data plus the data itself.

(b) (5) Host IP: 192.168.86.38
Destination IP: 129.187.255.151

(6) The protocol number would be 0x11 for UDP instead of 01

(7) The ICMP traceroute echo packet has the same fields as the ping packets

(8) The error packet has a different type than the query packets. It also contains the IP header and the first 8 bytes of the ICMP packet that it is describing.

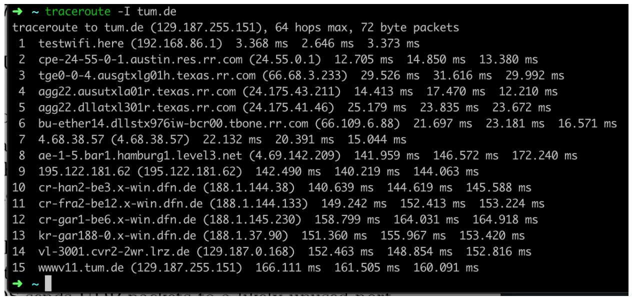

Figure 4: traceroute output

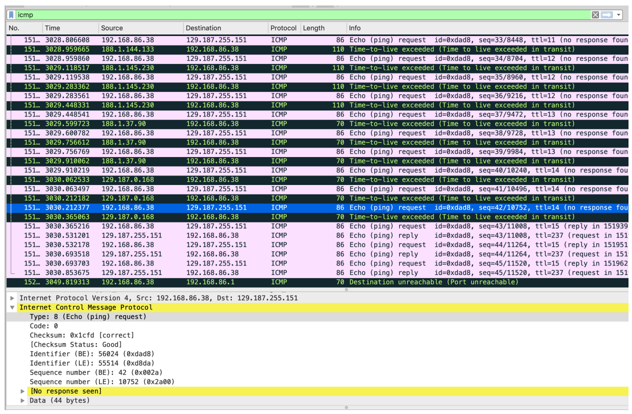

Figure 5: traceroute wireshark output

(9) The last three ICMP packets are of type 0 (echo (ping) reply). They are different because the datagrams made it all the way to the destination host before the TTL expired.

(10) The longest delay link is between steps 7 and 8. This is a link between US and Hamberg.

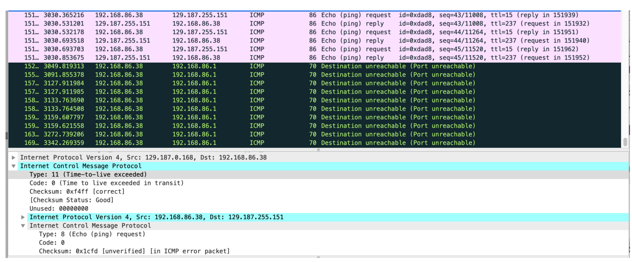

Figure 6: traceroute error wireshark output