CS4222/CS5422 Semester 2, 2020/2021

Tutorial for Week of Feb 1, 2021

Note:-

- All students must come prepared with ideas/solutions and participate in the group discussion and present the solutions to the entire class. Thinking about the solution during the solution in the tutorial class will not be of much use.
- Please note that all questions in this tutorial need not be discussed in full in the class.

1, What is the trade-off among power, data rate and range. Starting from a given design point, if you want to save power, how would data rate and range be affected?

2. Explain (briefly) if the following frequency band are suitable for used a locator device that is supposed to transmit a very short beacon periodically and this beacon should be detectable over long range. (i) 30Hz – 40Hz, (ii) 30KHz – 40KHz, or (iii) 400MHz – 500MHz? (iv) 50GHz – 60GHz.

3. What are ISM bands and what are the ISM bands used by WiFi on NUS Campus?

4. A WiFi channel with a 20MHz bandwidth in the range between 2.40GHz to 2.42GHz, has a signal to noise ratio of 63.

(a) What is the Shannon capacity of the channel?

(b) If the transmission is varied to use a 80MHz bandwidth band in the range between 5.00GHz to 5.08GHz, should the expected throughput increase or decrease? You can assume that the other parameters such as antenna gain, distance, noise etc. remain the same. (Assume path loss exponent is 3).

5. A wireless receiver with an effective radius of 100cm is receiving signals at 2 GHz from a transmitter that transmits at a power of 100W and a gain of 40dB (or 10,000). Assume path loss exponent is 2.

(a) What is the gain of the receiver antenna?

(b) What is the received power if the receiver is 1km away from the transmitter?

1, What is the trade-off among power, data rate and range. Starting from a given design point, if you want to save power, how would data rate and range be affected?

$$P = G_r G_t \left(\frac{c}{4\pi f c d}\right)^{\alpha} P_t$$

$$P_r = P_t\left(\frac{1}{d}\right)^{\alpha}$$

- Data rate & Range is dependent on the power consumption
  - ↳ Range : Higher Freq is required to propagate the signal to reach further range
  - ↳ Data rate : Higher Date rate req higher freq

- Range can limit to amt actually required for the product

- Data rate : limit → only send data when required

- Increasing range = decreasing rate
  - ↳ Base on formu

2. Explain (briefly) if the following frequency band are suitable for used a locator device that is supposed to transmit a very short beacon periodically and this beacon should be detectable over long range. (i) 30Hz – 40Hz, (ii) 30KHz – 40KHz, or (iii) 400MHz – 500MHz? (iv) 50GHz – 60GHz.

- At high freq, distance travelled decreases

  Depending on how far is the range

  i) - iii) hould be able to reach at most 9km

  iv) will not reach that far

  → Not considering env

  ⇒ Data sent cannot

- Higher freq = lower range
- Higher freq will cost power

Industual, scientific, Medical

3. What are ISM bands and what are the ISM bands used by WiFi on NUS Campus?

- WIFI
- Mobile Service
- Bluetooth
- wireless tele

NUS
- 2.4 GHz
- 5GHz

5.7 GHz

4. A WiFi channel with a 20MHz bandwidth in the range between 2.40GHz to 2.42GHz, has a signal to noise ratio of 63.

(a) What is the Shannon capacity of the channel?

(b) If the transmission is varied to use a 80MHz bandwidth band in the range between 5.00GHz to 5.08GHz, should the expected throughput increase or decrease? You can assume that the other parameters such as antenna gain, distance, noise etc. remain the same. (Assume path loss exponent is 3).

Shannon cap → internet speed is directly prop to bandwidth

a) $C = B^* \log_2(1 + SNR)$

$= 20 \times 10^6 \log_2(1 + 63)$ → $\frac{\log(1+63)}{\log(2)}$ # calculator error

$= 36123599.48 \cancel{\approx} 36M$ (120M)

b) Increase. Increase in bandwidth = increase throughtput.

$C = 80M^* \log_2(1 + \underline{0.1093} * 63)$ → SNR Ir(…

$= 240Mbps$

Even though bandwidth × 4

By increasing freq, at the same time,

line of sight path simple ← $\boxed{P_r \sim \left(\frac{d_0}{d}\right)^\alpha P_t}$ internet speed gain is only 2 times

$P_{r_1} = \beta \left(\frac{1}{2.4}\right)^3 P_t$

$P_{r_2} = \beta \left(\frac{1}{5.0}\right)^3 P_{t_1}$

Ratio : $\frac{P_{r_1}}{P_{r_2}} = \left(\frac{2.4}{5.0}\right)^3 = 0.1093$

5. A wireless receiver with an effective radius of 100cm is receiving signals at 2 GHz from a transmitter that transmits at a power of 100W and a gain of 40dB (or 10,000). Assume path loss exponent is 2.

dBW

(a) What is the gain of the receiver antenna?

1W = 90dB

(b) What is the received power if the receiver is 1km away from the transmitter?

$$P_r = G_r G_t \left(\frac{c}{4\pi f_c d}\right)^{\alpha} P_t \qquad G = \frac{4\pi A_e}{\lambda^2}$$

a)

$\alpha = 2$ $\quad P_t = 100W$

$G_T = 40dB$ $\quad d = 1Km$ $\quad f_c = 2GHz$

$$A_e = \pi r^2$$
$$= \pi(100 \times 10^{-2})^2$$

$$G = \frac{4\pi f^2 A_e}{c^2}$$

$$= \frac{4\pi \times (2 \times \overset{10^9}{G})^2 \times \pi \times (100)^2}{(3 \times 10^8)^2}$$

$$= 1754.59$$ ✓

b)

$$P_r = G_r G_t \left(\frac{\overset{\text{speed of light}}{c}}{4\pi f_c d}\right)^{\alpha} P_t$$

$$= 1754.59 \times 10000 \times \left(\frac{3 \times 10^8}{4\pi \times (2G) \times (1k)}\right)^2 \times 100$$

$$= 0.25\ W$$ ✓