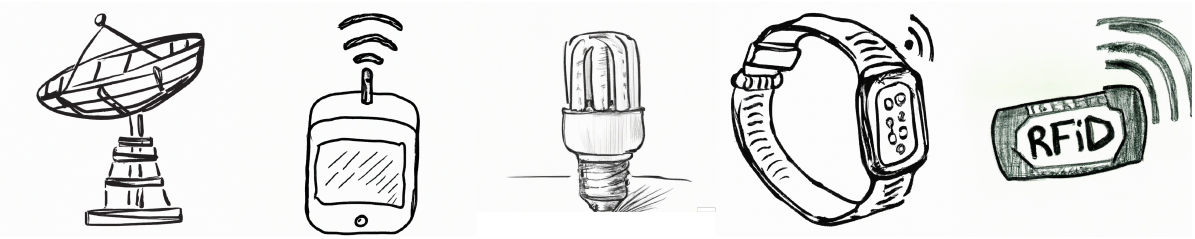

Wireless Networking aka “Wireless for IoT Class”

Course code: CS4222/CS5422

Semester 2, 2022/2023

Instructor: Professor Ambuj Varshney

Contact: ambujv@nus.edu.sg, COM3: #02-25

TUTORIAL 8 for WEEK 12 (Starting 27th March 2023)

[1] **Question 1:** (a) On the average, there are 17 students in a tutorial session. What is the probability that at least two students have the same birthday (assume 365 days)? (b) For the entire class, there are 141 students. What is the probability that no two students have the same birthday (assume 365 days)?

[2] **Question 2:** Whitespace frequencies allows wireless communication in an unused part of the television spectrum.

- Discuss the pros and cons of utilizing the TV spectrum for wireless communication.
- Identify applications that could significantly benefit from the implementation of whitespace networking.
- How does whitespace frequency availability differ between urban and rural settings?
- Explain how databases play a critical role in managing whitespace frequencies for wireless communication.
- Describe the regulatory hurdles and requirements for using whitespace frequencies.
- What are the TV frequency bands allocated in Singapore? Assuming you want to use the Bluetooth standard (Transmitting at 0 dBm, RX

Sensitivity: -100 dBm) within the whitespace frequency band, how would the range improve compared to operating at the 2.4 GHz frequency band? What could be a potential drawback?

[3] **Question 3:** In the project assignment, we are using a time-slotted neighbor discovery mechanism. For this kind of neighbor discovery mechanism, please answer and reason the following questions:

- Let's assume that time is divided into slots of duration 200ms. In each time slot, a node wakes up with a probability of 0.1. What is the average time taken for two such nodes to select a common slot to wake up?

- In the project, beacon transmissions to announce a node's presence are transmitted once at the beginning and once at the end of an active time slot. Should transmissions be performed more often to improve chances of discovery?

[4] **Question 4:** Assuming you are deploying a network of air quality sensors in a city and need to make decisions regarding the selection of wireless networks, please answer the following questions:

- What data rate should be expected for these sensors? Which wireless networks would you choose and why?

- If you are selecting between 2-FSK (narrow bandwidth transmitter) occupying 125 kHz bandwidth and the LoRa standard using the CSS modulation scheme, consider the following: You have been allocated 3 MHz of spectrum in the unlicensed frequency band. What are the pros and cons of each option? How many air quality sensors can be supported using these standards?

Note: For the sake of calculation, time division multiplexing is not considered in this question.

[5] **Question 5:** Assume you have an IoT device equipped with ZigBee, LoRa, and Wi-Fi radios, powered by a coin cell battery with a capacity of 240 mAh. Given the radio configurations below, please calculate the energy per bit for each technology. Based on the results, discuss the advantages and disadvantages of each wireless communication method.

Technology	**Bitrate**	**Transmit Current (mA) @ 3 Volts**
WiFi (802.11b)	11 Megabits/second	170 mA (at 17 dBm TX sstrength)
ZigBee	250 kilobits/second	9.1 mA (5 dBm)
LoRa	27 Kilobits/second	87 mA (at 17 dBm TX Strength)

For the following applications, which technology would you use:

- Sensor in agriculture setting (basetsation located 300 meters from soil sensor)
- Smoke alarms in home talking to each other and aHub
- Security camera