



## Wireless Networking aka “Wireless for IoT Class”

Course code: CS4222/CS5422

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## TUTORIAL 1 for WEEK3 (Starting 23rd of January 2023)

All the students should come prepared with ideas, solutions, and suggestions to participate in the group discussion.

[1] **Question 1:** What are the ISM frequency bands used for wireless communication? In residential and campus settings, such as National University of Singapore, which frequency bands support Wi-Fi communication? Lastly, do TV, and FM radio transmissions occur on ISM frequency bands?

[2] **Question 2:** Can you elaborate on the relationship between power consumption, data rate, and range in various wireless standards? If tasked with designing the following applications, what range and frequency of operation would you target for them? How would these choices impact the data rate?

Application	Description
Temperature sensor	This device allows measuring temperature inside the house. The sensor (temperature) readings are then

Application	Description
	wirelessly transmitted to a smartphone
Soil sensor	This device measures the humidity levels and quality of soil on farms, transmitting this information to a central basestation located at the farm's center
IoT camera	Deployed in urban areas, this device captures images and short videos for surveillance purposes. The gathered information is wirelessly transmitted to the cloud for anomaly detection and processing

[3] **Question 3:** : When designing a beacon device, such as an Apple AirTag or a Wiliot sticker, that is powered by small batteries or harvested energy from the environment, what wireless frequencies and data rate would you choose for the device to transmit small periodic information?

- When the device transmits to short distances (few meters)
- When the device transmit to large distances (hundreds of meters)

Possible frequencies for wireless communication: 30Hz - 40Hz, (ii) 30KHz - 40KHz, or (iii) 400MHz - 500MHz (iv) 800-950 MHz, (v) 2400-2480 MHz, (vi) 50GHz - 60GHz.

[4] **Question 4:** A communication channel using a 20MHz spectrum in the range between 2.40GHz to 2.42GHz, has a signal to noise ratio of 63.

- What is the Shannon capacity of the channel?
- If the transmission is varied to use a 80MHz spectrum in the range between 5.00GHz to 5.08GHz (instead of 2.40GHz to 2.42GHz), explain why the throughput can drop even though the bandwidth used has increased from 20MHz to 80MHz (for the same distance between transmitter and receiver). Please note that the transmit power also remains the same as when 20 MHz of spectrum was used.

[5] **Question 5:** Recently, there has been a growing interest in connecting Internet of Things (IoT) devices through a network of small satellites. One example of this is the service offered by [Space X's Swarm](#). Lets put you in the role of a designer building these satellites, if the goal is to transmit small amounts of information from the satellite swarm to IoT devices on the ground.

- What should be the antenna on the IoT device and satellite? What would be the ideal gain and type of the transmit and receive antenna?
- What should be the maximum transmit power of the radio on the satellite to support a sufficient link budget? Please note that energy conservation on the satellite should also be considered.
- Finally, what frequency would you want to use for communication? Can you estimate path loss ( $G_t, G_r = 6 \text{ dBi}$ )? Minimum sensitivity of a receiver for transmit power of 30 dBm?