Wireless Networking

Course code: CS4222/5422, Assignment #3

Important Instructions: This assignment must be completed collaboratively by all members of the group. A statement of work detailing the contributions of each member to the assignment, along with the source code, must be uploaded to Canvas.

Objective of the assignment

This assignment facilitates the application of concepts learned in the lectures that focus on wireless communication. In particular, this assignment will help you understand the signal propagation, estimating the link quality metrics, programming of the wireless stack on the Contiki operating system.

Introduction to the assignment

We can characterize the wireless signal using different parameters. These include frequency, the type of modulation used to encode baseband information, and signal strength. Signal strength is an important metric as it can help understand the device's communication range. It also serves other purposes, such as estimating the distance between devices, inferring link quality, and even helping with person localization.

Radio transceivers, such as those present in the system-on-chip CC2650 used in Sensor Tag, allow you to understand the strength of the received radio wave. Typically, this is denoted through a parameter called RSSI, which stands for Received Signal Strength Indicator.

In this assignment, you will use RSSI to estimate distances between devices, determine if an obstacle blocks the link between devices by observing RSSI, and estimate if RSSI is a good indicator for measuring the distance between sender and receiver. You will also use RSSI to estimate another metric called ETX, often used to understand the quality of the link between devices.

Initial configuration and tasks for conducting assignment

We need to set up the networking stack for the Contiki operating system.
Please download the Makefile and unicast_communication.c.

Important note: When sending at fast rates, i.e., send packets with short interval, you encounter errors. The solution is to replace log_info with printf. Please make these changes in the program before doing the tasks.

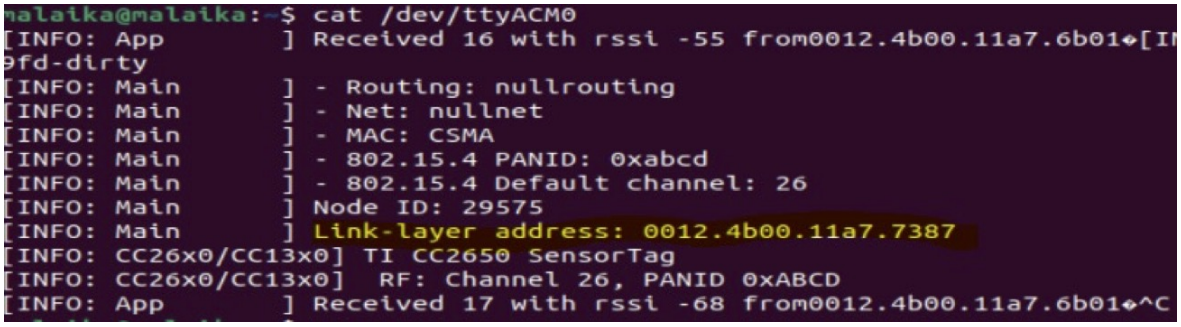
Steps for setting up the Contiki operating system for communication

1. Create a folder named "unicast" in the contiki-ng/examples directory.
2. Copy unicast_communication.c and Makefile into the folder above.
3. The same file, unicast_communication.c, is responsible for both conducting transmissions and receptions. It has been modified appropriately with comments to explain its functioning.

You will need two nodes for conducting the assignment. Choose one as a transmitter and use the other as a receiver.

Please make and compile the unicast_communication program. Next, flash the compiled code using uniflash onto the SensorTag (receiver).

Once the node starts, it will print the receiver's link-layer address among other device configuration information. Please refer to the screenshot below.



Next, replace the variable called "static linkaddr_t dest_addr" given in unicast_communication.c with the link-layer address you found above. Also, modify the program to send 4 packets every second for at least 10 seconds.

Finally, compile and flash unicast_communication to the transmitter SensorTag. Now, the transmitter will start transmitting packets destined for the receiver (with the link-layer address found above), and the receiver will print the received data with the RSSI value.

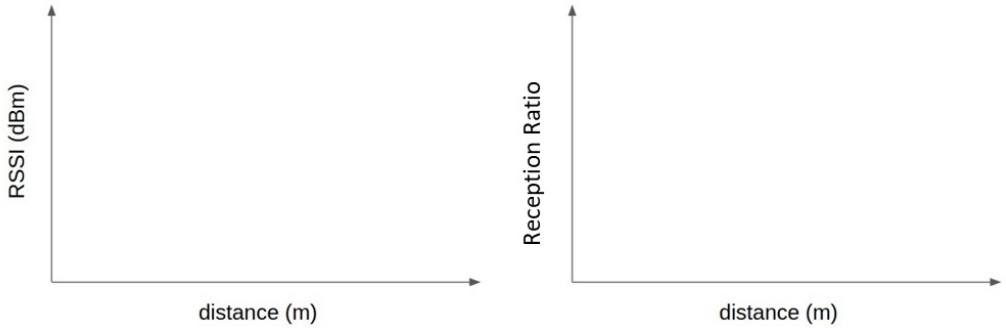
Task 1: Observing radio waves signal strength with increasing distance
In this task, you would observe the strength of the received signals as you vary the distance between the transmitter and receiver (between 1 meter and 30 meters). The experiment is conducted in the line-of-sight, i.e., there are no obstacles between the transmitter and receiver. Furthermore, please repeat the experiment in two different environments; Indoors and outdoor.

As you change the distance between receiver and transmitter, observe how the RSSI varies. Please also estimate the packet reception ratio.

Packet reception rate = Number of packets received in a time period / Number of sent packet in a time period

```
received packets: 0, message: Hi, RSSI: -40
received packets: 1, message: Hi, RSSI: -40
received packets: 2, message: Hi, RSSI: -41
received packets: 3, message: Hi, RSSI: -39
received packets: 4, message: Hi, RSSI: -39
```

You can take time period to be 60 seconds.
Please plot your observation as graphs below.



NOTE: You can decide appropriate number of readings to take between. Please justify the reason for the same in the report.

Task 2: Observing radio waves signal strength with orientation change
You would observe the signal strength as you change the orientation of the devices. This causes a change in polarisation impacting the strength of the received signal. Please conduct this experiment with a similar setting as Task 1. You can fix the distance between transmitter and receiver.

Please make a table with different orientation (aligned, 90 degrees, …) with RSSI and PRR for different distances between the two devices.

Oritentation	RSSI	PRR

Task 3: Observing radio waves signal strength with obstacles
Next, you will observe what happens to radio signals when there is an obstacle between the transmitter and receiver, i.e., when they are not exactly in a line-of-sight propagation environment. You can fix the distance between the transmitter and receiver. Next, place different obstacles between the devices, such as a chair, metallic objects, etc.

Please find the link metrics, i.e., PRR and RSSI and note them as a table.

Obstacle	RSSI	PRR

Task 4: Estimating link quality metric Expected Transmission Count (ETX)
Estimating the quality of the wireless link is important for wireless communication. It finds its application in building routing trees and other tasks. One important metric used for estimating the quality of the wireless link is the Expected Transmission Count (ETX). It captures the quality of the link in both directions (from transmitter to receiver and the other way).

In this experiment, you will estimate the ETX of the link. You will need to start by estimating the PRR from the transmitter to the receiver (forward direction) and then the PRR from the receiver to the transmitter (reverse direction), i.e., the roles of the devices change.

ETX = 1 / (PRR(Forward Direction) * PRR(Reverse Direction))

Please calculate the ETX for three distances between the transmitter and receiver. Write these values, and other details of experiments in the report.

Demonstration, Submission Guidelines and Deadline
The deadline for submission of the assignment is **April 8th, 2024.** This assignment needs to be done with members of the designated group.

Please also answer the following questions and include them in the report.

Question 1: Are there any other factors that impacts the quality of link other than distance, obstacle, and orientation? What kind of obstacles cause the most change (attenuation) in the radio signal strength?

Question 2: Is it possible to estimate distance using RSSI values? Is it a reliable metric for communication?

Question 3: What was the radiated signal strength (in dBm) in your experiments? From the values provided in data sheet, what would be the peak power consumption for transmissions and reception?

Please submit a readme file, source code, statement of work, detail report including the results from the various tasks on the CANVAS. They need to be submitted onto the canvas portal. The statement of work should describe the contribution made by every member of the group to the assignment. Only one member of the group should submit the assignment on the canvas.

There will be a penalty of 10% per day after 8th April 2024.