Report Date: 12/02/2022
To: ematson@purdue.edu, ahsmith@purdue.edu, lee3450@purdue.edu
From: 454P

- Seokhyeon Bang (kzrt0123@cau.ac.kr)
- Junyoung Jang (junjang99@cau.ac.kr)
- Yuseon Choi (181133@jnu.ac.kr)
- Minju Ro (romj98@cau.ac.kr)
- Doyong Kwon (doyong365@knu.ac.kr)

Summary

The main goal of this week is to find a way to maximize the efficiency of the experiment based on the results obtained from several tests. Due to unexpected variables at the experimental sites, the results were not satisfactory. Team members discussed what factors to manipulate in order to increase the completeness of the experiment by retracing the test process in a controlled environment. In addition, the task of preprocessing data and estimating meaningful statistics was carried out. The further experiments were decided for next week to measure the extent of accurate jamming attacks affecting communication between end nodes and gateways.

What 454P completed this week:

- Conduct an indoor experiment

Figure 1. The blueprint of Knoy Hall, where the indoor experiment was conducted

The four ESP32 [1] devices were located at a certain distance throughout the third floor of Knoy Hall, as shown in figure 1. In order to assess the jamming attack performance, SM, which sends communication signals from the jamming device, was placed near the gateway, and AP was placed about 20m away with doors and wall obstacles in between.
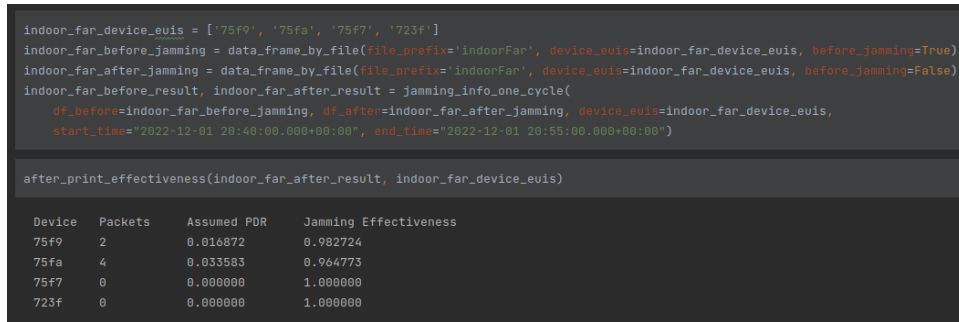
```
indoor_far_device_euis = ['75f9', '75fa', '75f7', '723f']
indoor_far_before_jamming = data_frame_by_file(file_prefix='indoorFar', device_euis=indoor_far_device_euis, before_jamming=True)
indoor_far_after_jamming = data_frame_by_file(file_prefix='indoorFar', device_euis=indoor_far_device_euis, before_jamming=False)
indoor_far_before_result, indoor_far_after_result = jamming_info_one_cycle(
    df_before=indoor_far_before_jamming, df_after=indoor_far_after_jamming, device_euis=indoor_far_device_euis,
    start_time="2022-12-01 20:40:00.000+00:00", end_time="2022-12-01 20:55:00.000+00:00")


after_print_effectiveness(indoor_far_after_result, indoor_far_device_euis)

Device  Packets    Assumed PDR    Jamming Effectiveness
75f9    2          0.016872       0.982724
75fa    4          0.033583       0.964773
75f7    0          0.000000       1.000000
723f    0          0.000000       1.000000
```

Figure 2. The result of the indoor experiment

Figure 2 shows the results of the experiment using a directional antenna. The influence of the attack was numerically calculated through the ratio of normal PDR and jamming PDR.

- Preprocess data of the JSON file for the indoor experiment received from TTN

The JSON file downloaded from The Things Network(TTN) [2],[3] was preprocessed in a Jupiter Notebook environment and schematized into diagrams and graphs using Matplotlib. After data preprocessing, in order to derive an accurate PDR value, the average time is calculated by measuring the time taken for 100 packets to be forwarded from four ESP32 sensors over three cycles. Through a proportional expression for the time taken and the number of packets, the task of predicting how many packets will be sent to each sensor device for 15 minutes was performed. PDR is obtained as a ratio of the predicted number of packets and the number of packets sent after actual jamming. Jamming effect is calculated through PDR values before and after jamming,indicating the influence of jamming attacks.
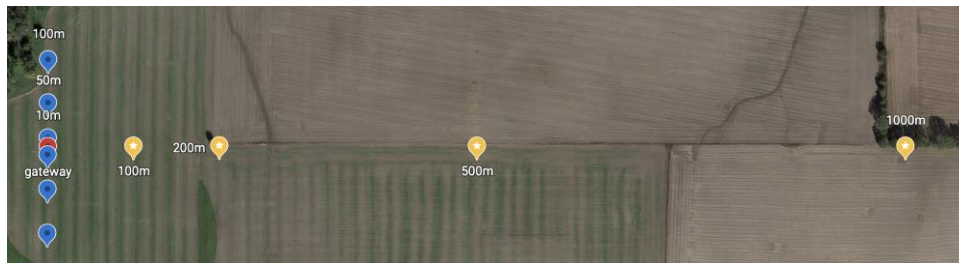
- Specifying the details for an outdoor experiment

Figure 3. The map of the location where the outdoor experiment was conducted

For the outdoor test, the location should be set to know where to drop the ESP32 and where the jamming devices should go for faster experiment settings. It was difficult to determine some details in conducting the experiment on the actual farm, such as the layout of gateways and ESP32 sensors. By referring to the experimental process of the previous studies [4]-[6], the experiment could be efficiently designed. Also, by using Google Earth, referencing the location where the outdoor experiment was conducted would be easy. Therefore, pinning the location of ESP32 devices and Canopy [7] devices on google Maps was executed.

- Write the Implementation part of the paper

  The Implementation part covers the process of the experimental setup and detailed device specifications. Packet Delivery Ratio(PDR) [8] will be used as a key metric to assess the jamming performance. Besides, this paper describes Jamming Effect, RSSI(Received Signal Strength Indication) [9], and SNR(Signal-to-noise ratio) [10].

Things to do by next week
- Conduct an indoor experiment with ESP32 on different floors
- Complete outdoor experiments of the project
- Analyze the results of outdoor and indoor experiments
- Complete the Implementation part of the paper
- Revise the Introduction part of the paper based on the feedback

Problems or challenges:

- Problems while conducting indoor test

  For the indoor test, whose environment is surrounded by walls and doors, the connection of the canopy devices was occasionally lost due to the timing issue. The suggested theory of the cause of this issue was that these canopy devices, which are made for outdoor usage, cannot interpret the packets from the hindered signals by the diffractions from the walls and doors, causing the connection to be lost. To solve the problem, the experiment location was changed to be in a line so that directional antennas could be used without walls or doors alongside the signal's way.

References

[1] ESPRESSIF, "ESP32.", *espressif.com,* [Online]. Available:
https://www.espressif.com/en/products/socs/esp32. [Accessed: 02-Dec-2022].
[2] The Things Network, "LoRaWAN® Network Server", *thethingsnetwork.org* [Online]. Available:
https://www.thethingsnetwork.org/marketplace/product/professional-network-server [Accessed: 02-Dec-2022].
[3] The Things Network, "Data Formats", *thethingsnetwork.org* [Online]. Available:
https://www.thethingsindustries.com/docs/reference/data-formats/. [Accessed: 02-Dec-2022].
[4] D. Yim et al., "An experimental LoRa performance evaluation in tree farm," 2018 IEEE Sensors Applications Symposium (SAS), 2018, pp. 1-6, doi: 10.1109/SAS.2018.8336764.
[5] M. Loriot, A. Aljer and I. Shahrour, "Analysis of the use of LoRaWan technology in a large-scale smart city demonstrator," 2017 Sensors Networks Smart and Emerging Technologies (SENSET), 2017, pp. 1-4, doi: 10.1109/SENSET.2017.8125011.
[6] A. Mdhaffar, T. Chaari, K. Larbi, M. Jmaiel and B. Freisleben, "IoT-based health monitoring via LoRaWAN," IEEE EUROCON 2017 -17th International Conference on Smart Technologies, 2017, pp. 519-524, doi: 10.1109/EUROCON.2017.8011165.
[7] Motorola, "Motorola Canopy User Manual.", *manualslib.com*, [Online]. Available:
https://www.manualslib.com/manual/1356228/Motorola-Canopy.html. [Accessed: 02-Dec-2022].
[8] IGI Global, "Packet Delivery Ratio.", igi-global.com, [Online]. Available: https://www.igi-global.com/dictionary/packet-delivery-ratio/21749. [Accessed: 02-Dec-2022].

[9] TELTONIKA, "RSSI.", *wiki.teltonika-networks.com*, [Online]. Available: https://wiki.teltonika-networks.com/view/RSSI. [Accessed: 02-Dec-2022].

[10] Cadence, "What is Signal to Noise Ratio and How to calculate it?.", *resources.pcb.cadence.com*, [Online]. Available: https://resources.pcb.cadence.com/blog/2020-what-is-signal-to-noise-ratio-and-how-to-calculate-it. [Accessed: 02-Dec-2022].