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Summary

The main goal of this week is to measure network performance according to jamming attacks through several experiments. Prior to testing, team members made specific plans on how to carry out indoor and outdoor experiments. Each test imitated the environment and technical specifications utilized in the real world, especially in agriculture and the medical industry. The outdoor experiment was conducted on the farm and the indoor experiment was conducted in KNOY Hall, which is structurally similar to a hospital. By working in an actual testing environment, the necessary parts were supplemented to increase the completeness of the experiment.

What 454P completed this week:

- Set the Kona Micro Lite gateway for indoor test

  For the indoor test purpose, a new gateway is needed because the RAK gateway used for previous experiments is supposed to use outside, which has more signal power to send and receive than indoor gateways. Kona Micro Lite [1] was introduced as an indoor gateway. Kona Micro Lite uses Trivial File Transfer Protocol (TFTP) [2] to upload a configuration rather than HTTP interfaces because it needs the machine's computing power. This gateway needs a LAN port that can do Dynamic Host Configuration Protocol (DHCP) [3]. With Larry's help, by sending the MAC address of the gateway to Larry, the IP address of the Kona Micro Lite was set. With that address, using TFTP, a new .bin file to change the gateway as a basic station mod, a customer.json file to configure the upload server to The Things Network (TTN) [4] server, and CUPS [5] certification files to connect it securely with TTN was uploaded [6]. Also, to use United States 902-928 MHz, FSB 2, the LoRaWAN.json file was uploaded to configure the frequency the gateway will use [7]. As a result, the Kona Micro Lite gateway was ready for experiments.

- Conduct an outdoor experiment on the farm

  Outdoor experiments are designed to analyze whether jamming attack affects network performance in the real world, especially in agricultural environments. First, the distance was measured using a golf laser on the farm, and the locations for ESP32 devices [8] were specified as 100m, 200m, and 500m. After placing the ESP32 devices in place, the experimental environment was set by connecting the Canopy and RAK gateway. There was a problem that the gateway could not connect to the Internet smoothly. However, it was solved by operating local LoRaWAN using ChripStack rather than TTN, as local LoRaWAN does not need an internet connection. The experiment was conducted with a total of 1 set of Canopy, including Subscriber Module(SM) 81 serving as a client and Access Point(AP) 80 serving as a server. The results confirmed that the distance between jamming devices is able to jam the data transmission up to 55m away from each other, and the communication between the gateway and end nodes was successfully jammed up to 500m at the farthest distance. In the case of the close-in experiment conducted on the roof of KNOY Hall last week, there were external obstructions due to gateways placed in other buildings [9]. In

contrast, the farm is an open environment with few obstacles and there is no interference from other gateways. For this reason, the jamming attack was more effective than expected, so team members planned to locate ESP32 devices up to 1km.

- Conduct an indoor experiment in KNOY Hall

  Indoor experiments are designed to observe network performance that depends on the internal structure of the building and to analyze how the valid distance of jamming devices affects Packet Delivery Rate(PDR).

  In the first test, the location of two Canopys(SM and AP) was fixed at the experimental site(Knoy Hall, laboratory 376), and a Kona gateway was located between them. One ESP32 device was placed right next to the gateway, and the other three were placed at a certain distance from the site. The results showed that the ESP32 device next to the Kona gateway and the farthest from the gateway was not jammed. Team members concluded that Interference from other external gateways prevented the canopy communication.

  In the second test, one Canopy(SM) was placed next to the gateway and the other Canopy(AP) was placed around the ESP device, which is the third closest to the gateway. The jamming attack failed since two Canopys were not connected. Further experiments will be conducted to compensate for this result.

- Write Methodology part of the paper

  Detailed experimental processes were designed based on prior studies [10]-[12] that cover cases of analyzing wireless network performance indoors and outdoors. The methodology includes planning, architecture, and objectives for three experiments: close-in, outdoor, and indoor.

Things to do by next week

- Conduct an outdoor experiment complementing the experiment of this week.
- Conduct an indoor experiment with ESP32 on different floors.
- Preprocessing data of the json file for indoor experiment received from TTN.
- Write the Implementation part of the paper

Problems or challenges:

- Problems while conducting outdoor test

  First, there was no LAN cable on the farm, so the platform used for the gateway, TTN, could not be used. So, instead of using the cloud server, local LoRaWAN with Chirpstack platform was decided to use for the outdoor experiment. Second, there were battery and Canopy device issues. Some Canopy devices were not able to connect to the laptop because of cable issues. Also, there were canopies that could not connect well due to low battery. After returning to K-Square and checking all the canopies, it was confirmed that only one Canopy out of 7 canopies had a problem itself, and the other six canopies were set again. As for the battery problem, the professor would give an additional power supply. In addition, it was decided to connect the canopies after all the ESP32 devices were installed in the following experiment to save the batteries.

- Problems while conducting experiment for close-in attack

Since the currently used ESP32 device is connected to TTN, the application server is able to receive data by other gateways installed in the Purdue university when conducting the experiment for close-in jamming attack on the rooftop of KNOY Hall. Therefore, the PDR of the gateway needs to be measured to verify whether the gateway we installed is jamming.

- Problems while conducting indoor test

Since the Canopy antenna is directional, the signal is weak when there are obstacles, especially in the building, since diffraction of the wall caused timing issues for packets. These Canopy devices are supposed to use in the outdoor environment; a single timing issue closed the current session. By using an omnidirectional antenna and a Yagi antenna, canopies were able to communicate with each other. However, in the ranged distance, packet losses occurred; thus, the jamming power was reduced.

References

[1] TEKTELIC, "Kona Micro Lite Gateway," *tektelic.com*, [Online]. Available: https://www.tektelic.com/products/gateways/kona-micro-lite-iot-gateway/. [Accessed: 18-Nov-2022].
[2] K. Sollins, "The TFTP protocol (Revision 2)," *rfc-editor.org*, [Online]. Available: https://www.rfc-editor.org/rfc/rfc1350. [Accessed: 18-Nov-2022].
[3] R. Droms, "Dynamic Host Configuration Protocol," *rfc-editor.org*, [Online]. Available: https://www.rfc-editor.org/rfc/rfc2131.txt. [Accessed: 18-Nov-2022].
[4] The Things Network, "LoRaWAN® Network Server", *thethingsnetwork.org* [Online]. Available: https://www.thethingsnetwork.org/marketplace/product/professional-network-server [Accessed: 18-Nov-2022].
[5] Apple Incorporation, "Managing Encryption," *cups.org*, [Online]. Available: https://www.cups.org/doc/encryption.html. [Accessed: 18-Nov-2022].
[6] TEKTELIC communications incorporation, "Configuration of Basic Station for Kona Micro Lite Gateway on TTNv3," *supprot.tektelic.com* [Online]. Available: https://support.tektelic.com/portal/api/kbArticles/27469600002569113 2/locale/en/attachments/3beg5dd72f4908a5744a18edade11689e76f5/content?portalId=edbsn03c2c0f3d55c454c5ea69c8ffe71f7394795528efce27af0067754e2fe440f68&inline=true. [Accessed: 18-Nov-2022].
[7] TEKTELIC communications incorporation, "Kona Micro Lite Configuration User Guide," *supprot.tektelic.com*, [Online]. Available: https://support.tektelic.com/portal/api/kbArticles/27469600001461717 9/locale/en/attachments/oge0o27afaf40f2864321b0af2f22d2f2af98/content?portalId=edbsn03c2c0f3d55c454c5ea69c8ffe71f7394795528efce27af0067754e2fe440f68&inline=true. [Accessed: 18-Nov-2022].
[8] ESPRESSIF, "ESP32.", *espressif.com*, [Online]. Available: https://www.espressif.com/en/products/socs/esp32. [Accessed: 18-Nov-2022].
[9] LoRa Alliance, "LoRaWAN™ Backend Interfaces 1.0 4 Specification", *lora-alliance.org*, [Online]. Available: https://lora-alliance.org/wp-content/uploads/2020/11/lorawantm-backend-interfaces-v1.0.pdf. [Accessed: 18-Nov-2022].
[10] 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.
[11] 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.
[12] 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.