ECE2305
Introduction to Communications & Networks
Course Design Project:
Wireless Capture the Flag

1 Objective

The objective of this project is to implement a wireless transceiver capable of connecting to multiple low complexity "mystery" devices broadcasting on different channels and transmission patterns.

2 Technical Description

There are mystery nodes set up in AK that you are tasked with locating and communicating with. Your goal is to extract a piece of data corresponding to the "flag" as proof of communication. The mystery nodes use the HC-12 transceiver module to wirelessly communicate. It is up to you to determine the characteristics of these communication systems such as broadcasting frequency/channel, baud rate, and packet structure. Additionally, your prototype system must receive a response from the mystery nodes. The complete list of tasks is as follows:

- **Broadcasting Channel**: Determine the frequency that the mystery node is broadcasting on. This can be done using the RTL-SDR used in Mini-Project 01 to scan the frequency ranges in and around 433MHz. Once you have found the operating frequency of the node, translate that to a channel of the HC-12.
- **IP Address**: Each node has a unique IP address that can be used to communicate with it. *Hint:* You can find this by being a good wireless listener!
- **Packet Structure**: The node needs to understand *who* is communicating with it and *what* to execute. You must determine the packet structure that the nodes use. *Hint:* Sections of the packet are delimited by the '|' character. An example packet structure might be: information1|information2|information3|...
- **Authenticate**: Teams will be provided login credentials to send to the node. Upon authentication, commands can subsequently be executed.
- **Packet Filtering**: Teams will also have to receive information and ACK/NACK signals back from the node after a packet is sent. Teams will have to filter packets that do not belong to their device as multiple users might be transmitting/receiving on a channel simultaneously.

As mentioned previously, this project uses the HC-12 433MHz transceiver. These modules are inexpensive and highly versatile for LoRa (long range) communication prototyping applications. There are many clones of this board available for purchase online such as:

- `https://www.amazon.com/dp/B01MYTE1XR/ref=cm_sw_em_r_mt_dp_U_wjyJCb26HEVFW`

Some things to note when using the HC-12: You should use the 5V pin instead of the 3.3V pin to power this device. This is because as an Arduino application, the 3.3V pin can only supply a maximum current of 150mA. On the other hand, the 5V can supply a current of up to 1A. However, this module will overheat when using 5V for extended periods of time (*e.g.*, on the order of hours). Additional circuitry can be added to protect against overheating. The link below is a good source to get started using the HC-12:

- https://www.allaboutcircuits.com/projects/understanding-and-implementing-the-hc-12-wire

Additionally, with all cheap ICs on Amazon, there is a chance your board might be delivered DOA (dead on arrival). Consequently it is highly recommended that you test early in order to get replacements if need be!

The embedded portion of this assignment is relatively open-ended. Teams have the choice to implement their solution on a Raspberry Pi or Arduino device. The HC-12 will work on both platforms. Of course, if you want to get super fancy and design a serial interface for the HC-12, this is totally acceptable as well. However, the course staff will only be able to help on the Arduino / Raspberry Pi implementations.

The Internet is rich with do-it-yourself (DIY) and how-to guides/tutorials on using the various components for this course project. Listed below are a few that might be useful:

- Using the HC-12:
  - https://www.youtube.com/watch?v=vqRqtgvltOI
  - https://www.youtube.com/watch?v=PQzNO17fqYY
  - https://www.youtube.com/watch?v=0zOTvB0T5fY
  - https://www.elecrow.com/download/HC-12.pdf
  - http://statics3.seeedstudio.com/assets/file/bazaar/product/HC-12_english_datasheets
- Arduino Resources:
  - https://www.youtube.com/watch?v=d8_xXNcGYgo
  - https://www.youtube.com/watch?v=nL34zDTPkcs
  - https://www.youtube.com/watch?v=BtLwoNJ6klE
- Raspberry Pi Resources:
  - https://www.youtube.com/watch?v=wvxCNQ5AYPg
  - https://www.youtube.com/watch?v=bKHLTn_nXUM
  - https://www.youtube.com/watch?v=GJuWpBCgQPQ
- Using MATLAB with Arduino
  - https://www.youtube.com/watch?v=ymWXCPenNM4
  - https://www.youtube.com/watch?v=zzrV32z1jnU
  - https://www.youtube.com/watch?v=7tcEs0QOiBk

Warning: Although there exists numerous IoT/Wireless applications, it is expected that all teams **do not** implement or apply prototype networks that could potentially be harmful or dangerous to anyone, as well as violate the WPI Acceptable Use Policy (AUP). When in doubt, please ask Professor Wyglinski.

3 Evaluation

The design project grade will constitute 50% of the final grade for this course. Please refer to the course syllabus for the grade percentage allocated to each element of the course design project.

3.1 Design Proposal Document

A short (5 pages) design proposal (excluding cover page and appendices) is required by each student team, which outlines the approach they will employ in designing and implementing their transceiver interface capable of meeting the technical specifications described in the previous section. Note that proposed designs can change over the duration of the project since new challenges and issues are expected to arise. However, the proposed design at this stage in the project should be conceptually as close to the final design as possible, and that every effort should be taken to fully describe the entire implementation in great detail. Additionally, mention why this reverse engineering is important and what applications this can be applied in.

This document must be electronically submitted in **PDF format** (no other formats will be accepted) via the ECE2305 CANVAS website by the due date. Failure to submit the design proposal by the specified due date and time will result in a grade of "0%" for this component of the design project.

3.1.1 Proposal Document Format & Content

The format of the design proposal document should consist of a cover page, abstract, introduction to the problem statement, description of proposed solution (including rationale), brief overview of implementation, prototype evaluation strategies, and project logistics (e.g., timeline, milestones, task specification). Note that every detail about the proposed implementation should be included in this document to ensure that a complete understanding of the design is provided.

3.2 Status Updates

Each student team must conduct four weekly status update meetings with their assigned tutor. Meetings will consist of a short presentation consisting of a meeting agenda, accomplishments of the past week, any technical challenges that were encountered, proposed solutions, and plan for the upcoming week. Each of these weekly short presentation slides are to be submitted to the ECE2305 CANVAS website by the due date. Failure to submit a presentation slides will result in a grade of 0% for the submission, and no late submissions will be accepted.

3.3 Final Presentation and Final Demonstration

All students must submit a YouTube video presenting their final design that includes a real-time demonstration of their prototype. The presentation and demo should possess an overview of the

proposed implementation, a detailed description of the different elements that constitute the system as well as the integration of the prototype, and results of the prototype operating is required. No late submissions will be accepted.

3.4 Final Project Report

The final project report should contain a detailed narrative of the entire implementation process of the proposed prototype design by the student team. The goal is to provide a sufficient level of insight and details that would ultimately enable the reader to recreate from scratch the same functional prototype proposed by the student team. Additionally, describe any issues encountered and how they were overcome.

Photographs, screen captures, flow diagrams, concept diagrams, pseudocode, and other graphical means of explaining the proposed implementation are definitely encouraged in this report as they will all provide the reader with additional insight and clarity with respect to the proposed prototype design. Moreover, proper usage of the English language and grammar is a must, as numerous English and grammar errors can significantly impede readability and thus result in a negative impact on the final grade for this report.

3.4.1 Final Report Format & Content

A thoroughly documented report regarding the prototype will be reflected in the final report grade for this project. Each final project report should possess the following format:

- A cover page that includes the course number, design project title, names and WPI ID numbers of the team members, submission date.
- Table of contents.
- Abstract (250 words maximum).
- Authorship page.
- Introduction chapter.
- A description and explanation of the final prototype design, along with details of engineering decisions made during the design and implementation process, as well as any schematics and flow diagrams.
- Experimental results section containing plots as well as any relevant explanations. Note that the student team should employ a narrative approach to describing the resulting outcomes of their project, and attempt to provide the necessary insights to the reader in order to highlight the actual operations of their design and whether it is work as expected.
- Conclusion chapter.
- Bibliography (IEEE formatting only).
- Design Proposal Document (as an appendix).
- Source code (as an appendix).

This document must be electronically submitted in **PDF format** (no other formats will be accepted) via the ECE2305 CANVAS website by the due date. Failure to submit the design proposal by the specified due date and time will result in a grade of "0%" for this component of the design project.

4 Important Dates & Milestones

The following **mandatory** events (unless otherwise indicated) related to this design project will be scheduled throughout the term:

Design Project Announcement:	20 March 2019
Design Proposal Documents Due:	29 March 2019
Status Updates Deadlines: 3 April 2019, 10 April 2019, 17 April 2019, 24 April 2019	
Final Presentation and Demonstration Due:	30 April 2019
Final Reports Due:	30 April 2019