Real Time Systems, CprE 558
Project Proposal

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Due date: 10/28/24

1. Project Information

1.1. Project Title

Efficient Networking: Simulating Optimal Network Coding for Arbitrary Mesh Networks

1.2. Project Type

The project will primarily be type III (simulation), but if time allows I would like to implement basic network coding using a pair of ESP32 microcontrollers.

1.3. Team Members

- Ethan Ruchotzke (ethanr@iastate.edu) - CprE 558

2. Project Objectives

The primary focus of the project is on network coding; specifically, I'd like to write a simulator capable of taking an arbitrary mesh network and identifying the best network coding opportunity available. This includes thinking about power consumption.

The objectives are:

- Quantify the impact of a network without network coding and with different types of network coding (linear, randomized)
- Identify optimal nodes and connections (which nodes are good relays)
- Simulate power consumption of network nodes/transmissions

3. Solution Approach

I will use either Rust or C# to code my simulator, which will be built from scratch. While not focused on a UI (I will allow the simulator to run from the command line) I will likely include a GUI to display the constructed network with network coding opportunities.

The input to my simulator will be an arbitrary mesh network, where each node has a given set of constraints (available modulation, power supply). The total network will also have an objective, like maximizing network lifetime or throughput.

I am experienced with writing simulation code, so I believe I have the technical ability to write the underlying infrastructure.

I will investigate a few things:

- First, for an arbitrary network and set of transmissions/receptions, how can the network be organized (in terms of linking between neighbors) to minimize the power consumption
- Then, I will look for basic linear network coding opportunities; this will be automated, and test possibilities to find the best option.
- I will compare (and research) two types of network coding. Linear (using a preset coding algorithm, like reed-solomon or XOR) or randomized. These techniques will be compared to see if either has an advantage.

I have found a few interesting resources. For general network coding, ComNets has a series of lectures posted publicly [1]. For more specific network coding information, there is a paper/primer from 2006 I plan to utilize [2]. Finally, for a more comprehensive investigation and analysis, I plan to read a 2003 implementation paper by Li et. al. [3].

4. Expected Outcomes

I plan to provide the following deliverables for a successful project:

- A set of at least 10 mesh networks (either randomly generated or manually created) to display metrics
- For each network, an energy-minimizing communication layout (based on distance and modulation)
- A quantitative discussion of network codings impact on power, latency, or both

I know we will be doing more real-time networking later this semester, so if I find those topics interesting, I may try to find a way to incorporate them.

References

[1] ComNets Lectures. L3 - 02 - NetCod - Random Linear Coding, May 2019.

[2] Christina Fragouli, Jean-Yves Le Boudec, and Jörg Widmer. Network coding: an instant primer. *SIGCOMM Comput. Commun. Rev.*, 36(1):63–68, January 2006.

[3] S.-Y.R. Li, R.W. Yeung, and Ning Cai. Linear network coding. *IEEE Transactions on Information Theory*, 49(2):371–381, February 2003.