

Grace Meredith
CPE 400 Final Project
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Introduction

WSNs are known for balancing two problems: the lifetime of the network and its energy. In this project, I implemented the LEACH (low energy adaptive clustering hierarchy) protocol, which is a protocol that utilizes cluster routing, of which, LEACH identifies one (or many) cluster head according to the lowest degree of distance from the base station[1], and then divides sensor nodes into clusters to schedule data transmissions and reduce energy consumption between the WSNs. Transmitting data in clusters, rather than the network as a whole, results in an increase of the wireless sensor network's total lifetime.

Algorithm and Protocols

To explain the simulation, we will go in chronological order of function calls. First, the program is given x amount of nodes. It then creates a sensor object for each node, complemented with an id number, randomized Mac address, battery, position, etc. Then, while the WSN is still alive, the program will go through four stages per each round of transmissions. As each round completes, a summary will be generated on a graph. The points represent each node that is still alive, lines represent the edges for each cluster graph, and the values represent the packet sent from the sensor to the cluster head. As the rounds progress and nodes begin to run out of battery

life, the nodes will disappear from the graph and new cluster graphs will be formed.

```
SENSOR 3 BATTERY: 88.47385057643476  
HEAD 4 BATTERY: -20.678009351211408  
SENSOR 3 BATTERY: 88.47385057643476  
HEAD 7 BATTERY: -2.5322558123897707  
SENSOR 3 BATTERY: 88.47385057643476  
HEAD 10 BATTERY: -18.874906621767657
```

Fig 1. Battery statuses after a round of transmissions.
(Negative numbers means the sensor is or has been dead)

Choose Cluster Head

The first stage of LEACH determines which of the nodes will be a "cluster head" or the nodes that broadcast to the base station from their assigned clusters of node sensors. After checking if the sensor has battery life, and hasn't already been assigned as a cluster head, then we perform a simple probability test to determine whether the node qualifies (there is roughly a 30% chance it does) to be a cluster head.

```
Round: 1  
Sensor 1 with MAC address of 0:22:62:9:125:228 has been chosen to be a cluster head  
Sensor 2 with MAC address of 0:22:62:113:123:156 has been chosen to be a cluster head  
Sensor 5 with MAC address of 0:22:62:108:239:139 has been chosen to be a cluster head  
Sensor 6 with MAC address of 0:22:62:107:122:02 has been chosen to be a cluster head  
Sensor 8 with MAC address of 0:22:62:77:197:13 has been chosen to be a cluster head  
Sensor 9 with MAC address of 0:22:62:92:86:30 has been chosen to be a cluster head  
Cluster heads are broadcasting advertisements....
```

Fig 2. Cluster heads being assigned.

Advertise Signal

The second stage of LEACH performs a broadcast of the cluster heads to each of the sensors. Through the RSSI protocol [3], we compare the signal strength between the CH's

and the sensors, assigning each sensor a cluster head. This results in the formation of clusters, or sub graphs. Each Sensor transmits data to their respective CH, and the CH's transmit all the data to the base station.

```
Cluster heads are broadcasting advertisements....
Sensor 3 at position 8,73 is responding to cluster head 0:22:62:100:206:177's advertisement
Schedule Creation Time Division Multiple Access
Creating Schedule....
Cluster Heads are now Collecting Data...
0:22:62:0:234:40 is transmitting to 00:00:00:00:00:00
0:22:62:0:234:40 is transmitting to 00:00:00:00:00:00
```

Fig. 3. Cluster heads broadcasting to the sensors

Set Schedule

The Third stage takes place when creating the schedules for each cluster. The cluster head is responsible for determining the order of transmissions from its sensors.

Collect Data

In the Final stage of LEACH protocol, each cluster head receives the transmissions from it's nodes and consumes energy. Once all the packets are received, the cluster heads transmit the data to the base station at 00:00:00:00:00:00.

Results and Analysis

As the number of nodes increased, the number of clusters formed increased, resulting in only a subtle increase in the number of rounds the WSNs survived. Another note is there is an exponential growth in the number of nodes dying per each round of the simulation, due to the increased distances from nodes to their assigned cluster heads.

Below is a sample simulation of the LEACH protocol with 20 Sensor Nodes.

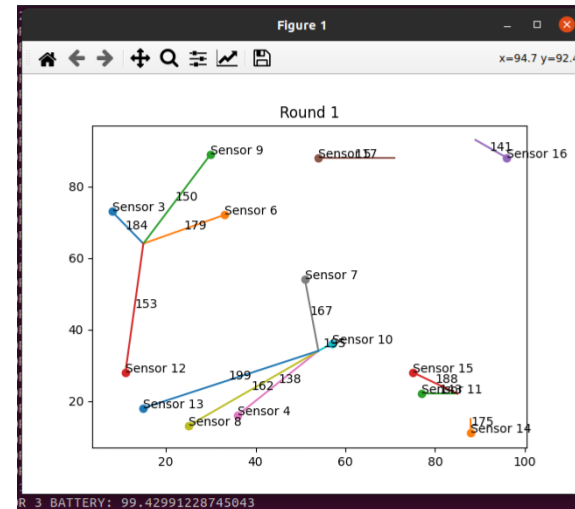


Fig. 4 Summary of clusters after Round 1 of Transmissions.

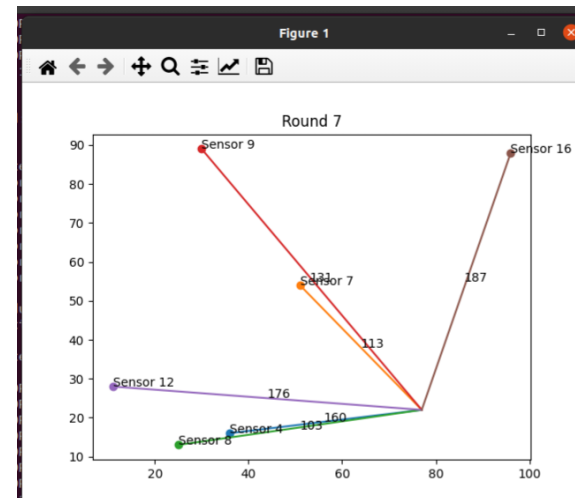


Fig. 5 A summary of the clusters after 7 rounds of transmissions.

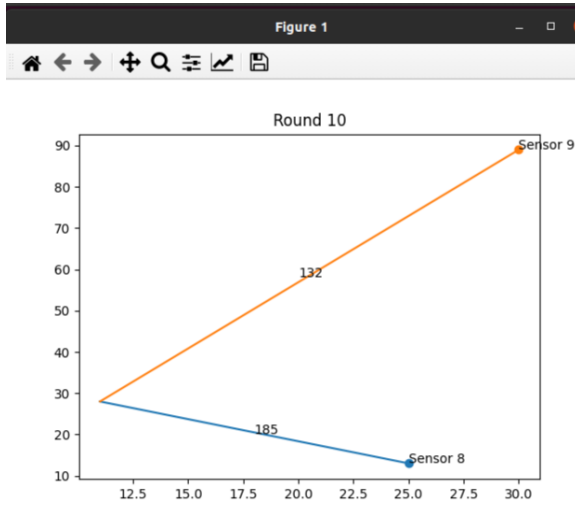


Fig. 6 A summary of the Clusters after the 10th round of transmissions.

Number of Nodes	Number of Rounds before Network Died
5	5
10	6
20	11
50	16
100	18

Table 1. A summary of results after several simulations.

References

- [1] Abu Salem, & Shudifat, N. (2019). Enhanced LEACH protocol for increasing a lifetime of WSNs. *Personal and Ubiquitous Computing*, 23(5-6), 901–907.
<https://doi.org/10.1007/s00779-019-01205-4>
- [2] Arumugam, & Ponnuchamy, T. (2015). EE-LEACH: development of energy-efficient LEACH Protocol for data gathering in WSN. *EURASIP Journal on Wireless Communications and Networking*, 2015(1), 1–9.
<https://doi.org/10.1186/s13638-015-0306-5>
- [3] Jung, & Han, K. (2017). Maximum Power Plus RSSI Based Routing Protocol for Bluetooth Low Energy Ad Hoc Networks. *Wireless Communications and Mobile Computing*, 2017, 1–13.
<https://doi.org/10.1155/2017/9843825>