

LEACH in WSN

Software: NetSim Standard v14.0, Visual Studio 2022

Project Download Link:

<https://github.com/NetSim-TETCOS/LEACH-in-WSN-v14.0/archive/refs/heads/main.zip>

Follow the instructions specified in the following link to download and set up the Project in NetSim:

<https://support.tetcos.com/en/support/solutions/articles/14000128666-downloading-and-setting-up-netsim-fileexchange-projects>

Introduction:

Low-energy adaptive clustering hierarchy ("LEACH") is a MAC protocol that is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs). The goal of LEACH is to lower the energy consumption required to create and maintain clusters to improve the lifetime of a wireless sensor network.

This Cross-Layer Protocol is implemented in NetSim in the MAC layer which involves ZigBee Protocol and the Network layer which involves DSR protocol. The clustering of sensors happens in the Network layer and the Cluster head election involves interacting with the MAC layer to obtain the remaining power of the sensors.

Real-world Context:

In the context of Precision Agriculture in large farms, various monitoring sensors are deployed to gather data on different aspects of the agricultural environment, such as soil moisture, temperature, Weather and crop health. In this example, we consider the LEACH protocol, which is commonly used to manage clusters of sensor nodes in wireless sensor networks (WSNs). In this scenario, we consider Yield, Weather, Soil and Plant as clusters, representing different aspects of the farm's operations. By implementing the LEACH protocol, we can effectively improve the lifetime of sensors and enhancing the efficiency of data collection for precision agriculture in large farms.

Soil Monitoring Cluster: Gathers data on soil moisture, nutrient levels, and temperature.

Plant Monitoring Cluster: Collects data on plant growth and water stress.

Weather Monitoring Cluster: Measures temperature, humidity, precipitation, and wind .

Yield Monitoring Cluster: Estimates crop yield and improve agricultural productivity.

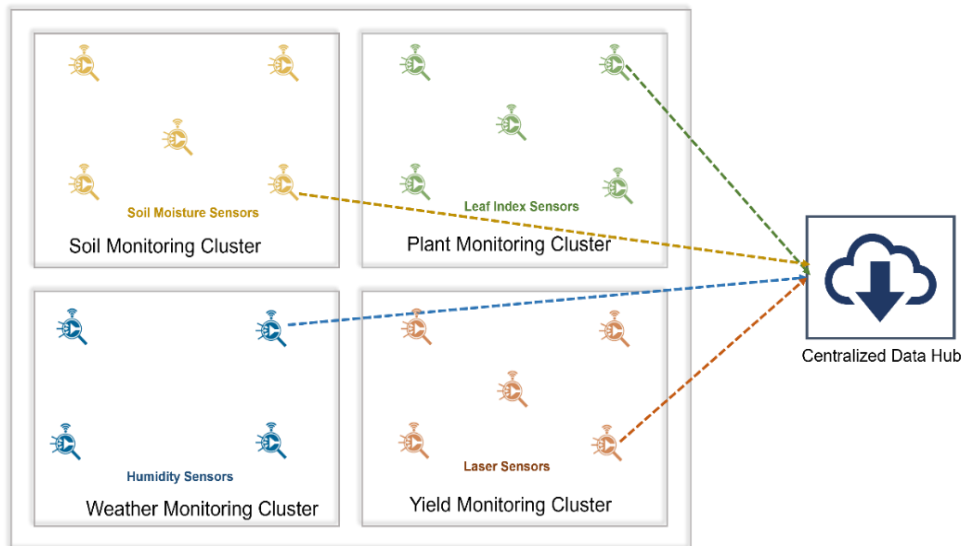


Figure 1: Real World Agriculture Monitoring System.

Implementation of Leach in WSN:

A **Leach .c** file is added to the DSR project.

1. For this implementation of Leach, the number of Clusters is fixed as 4 and all the 4 clusters are equal. If the user wants to change it, then he/she must also change the static routing for the Cluster Heads and the ClusterElement array accordingly in **Leach.c**

```

31 #include "../BatteryModel/BatteryModel.h"
32 #include "../ZigBee/802_15_4.h"
33 #define NUMBEROFCLUSTERS 4
34 #define SIZEOFCLUSTERS 16 //SIZEOFCLUSTERS can be 1,4,9,16,25
35
36 static int CHcount[NUMBEROFCLUSTERS];
37 static int prevCH[NUMBEROFCLUSTERS];
38
39
40
41 //For 100 sensors and SIZEOFCLUSTERS = 25, uncomment this
42 //int ClusterElements[NUMBEROFCLUSTERS][SIZEOFCLUSTERS] = {{1,2,3,4,5,11,12,13,14,15,21,22,23,24,25,31,32,33,34,35,41,42,43,44,45}, \
43 {6,7,8,9,10,16,17,18,19,20,26,27,28,29,30,36,37,38,39,40,46,47,48,49,50}, \
44 {51,52,53,54,55,61,62,63,64,65,71,72,73,74,75,81,82,83,84,85,91,92,93,94,95}, \
45 {56,57,58,59,60,66,67,68,69,70,76,77,78,79,80,86,87,88,89,90,96,97,98,99,100}};
46
47 //For 64 sensors and SIZEOFCLUSTERS = 16, uncomment this
48 int ClusterElements[NUMBEROFCLUSTERS][SIZEOFCLUSTERS] = { {1,2,3,4,9,10,11,12,17,18,19,20,25,26,27,28}, \
49 {5,6,7,8,13,14,15,16,21,22,23,24,29,30,31,32}, \
50 {33,34,35,36,41,42,43,44,49,50,51,52,57,58,59,60}, \
51 {37,38,39,40,45,46,47,48,53,54,55,56,61,62,63,64} };
52
53 //For 36 sensors and SIZEOFCLUSTERS = 9, uncomment this
54 //int ClusterElements[NUMBEROFCLUSTERS][SIZEOFCLUSTERS]= {{1,2,3,7,8,9,13,14,15},{4,5,6,10,11,12,16,17,18},{19,20,21,25,26,27,31,32,33},{22,23,24
55
56 //For 16 sensors and SIZEOFCLUSTERS = 4, uncomment this
57 //int ClusterElements[NUMBEROFCLUSTERS][SIZEOFCLUSTERS] = {{1,2,5,6},{3,4,7,8},{9,10,13,14},{11,12,15,16}};
58
59 //For 4 sensors and SIZEOFCLUSTERS = 1, uncomment this
60 //int ClusterElements[NUMBEROFCLUSTERS][SIZEOFCLUSTERS] = {{1},{2},{3},{4}};
61
  
```

Figure 2: Leach.c file

- To make 4 equal clusters the number of sensors must be 4,16,36,64,100. Depending on the number of sensors, the Cluster Elements array must be defined. Here, it has been defined and commented for 4,16,36,64,100 sensors. Uncomment the one you want to use.

The file contains the following functions:

fn_NetSim_LEACH_CheckDestination(); //This function is used to check whether the current device is the destination (i.e) the sink node or not. Else the packet will be forwarded to the next hop.

fn_NetSim_LEACH_GetNextHop(); //This function is used to identify the next hop in cases where the current device is either a sensor within the cluster or the cluster head. Static routes are defined in this function. It returns the Device id of the next hop.

fn_NetSim_LEACH_AssignClusterHead (); //This function is used to dynamically assign cluster heads within a cluster based on the residual energy. The sensor with higher remaining power in comparison to other sensors within the same cluster will be elected as the cluster head.

fn_NetSim_LEACH_IdentifyCluster(); //This function is used to determine the cluster to which a sensor belongs. It returns the cluster id of the cluster.

Example:

- The **LEACH-in-WSN-Workspace** comes with a sample network configuration that is already saved. To open this example, go to Your work in the Home screen of NetSim and click on the **LEACH-in-WSN-Example**. from the list of experiments.
- The network scenario consists of 64 sensors uniformly placed along with the SINKNODE as shown below.

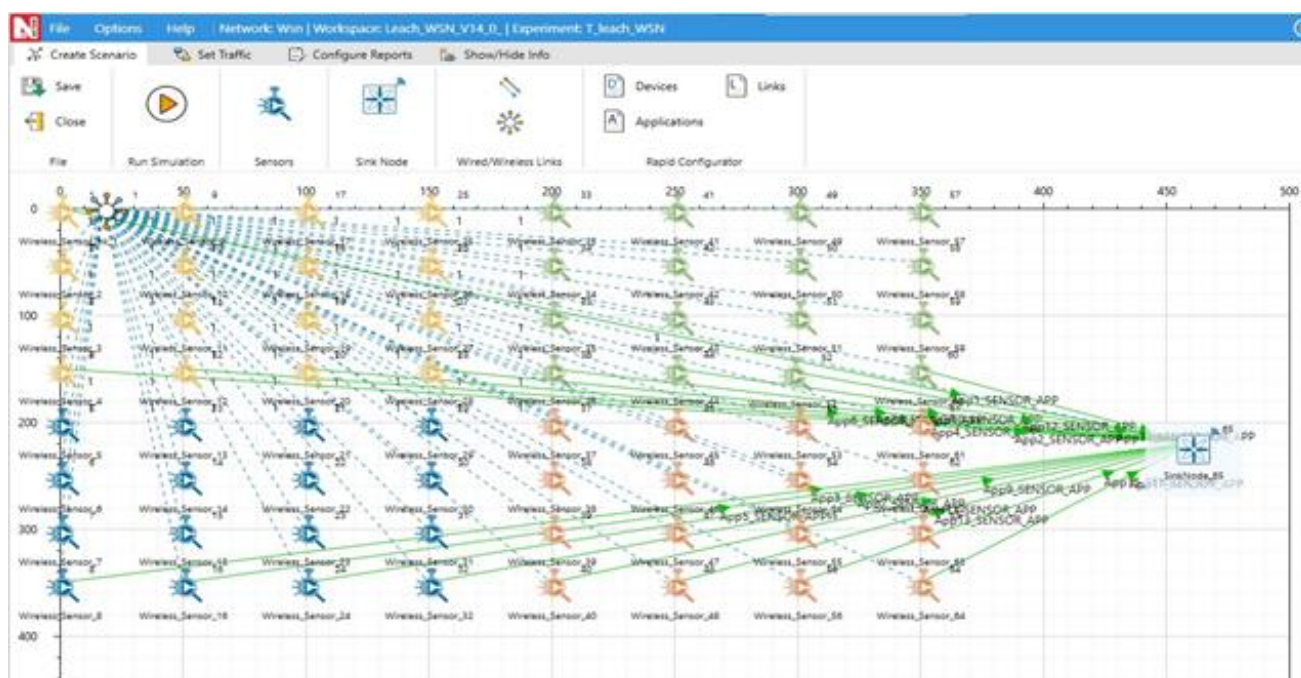


Figure 3: Network topology in this project

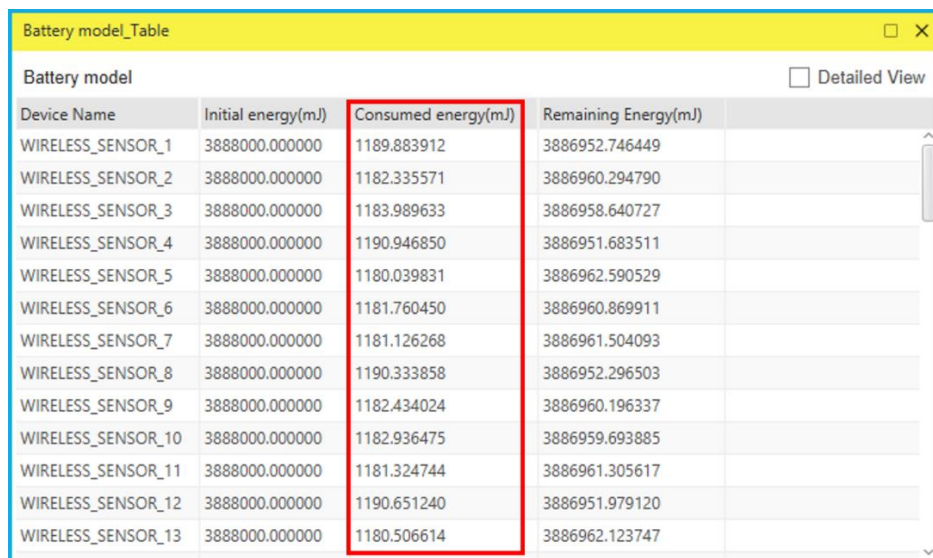
3. Run the simulation.

Results and discussion:

In packet trace, You will notice that the sensors directly start transmitting packets without route establishment since the routes are statically defined in LEACH. You will also note that the cluster heads keep changing dynamically.

The battery model table in the Result Dashboard window reveals that the consumed energy is significantly lower with LEACH protocol implementation compared to without LEACH Protocol. This can be observed in the battery model table.

With Leach Protocol Implementation:



| Device Name | Initial energy(mJ) | Consumed energy(mJ) | Remaining Energy(mJ) |
|--------------------|--------------------|---------------------|----------------------|
| WIRELESS_SENSOR_1 | 3888000.000000 | 1189.883912 | 3886952.746449 |
| WIRELESS_SENSOR_2 | 3888000.000000 | 1182.335571 | 3886960.294790 |
| WIRELESS_SENSOR_3 | 3888000.000000 | 1183.989633 | 3886958.640727 |
| WIRELESS_SENSOR_4 | 3888000.000000 | 1190.946850 | 3886951.683511 |
| WIRELESS_SENSOR_5 | 3888000.000000 | 1180.039831 | 3886962.590529 |
| WIRELESS_SENSOR_6 | 3888000.000000 | 1181.760450 | 3886960.869911 |
| WIRELESS_SENSOR_7 | 3888000.000000 | 1181.126268 | 3886961.504093 |
| WIRELESS_SENSOR_8 | 3888000.000000 | 1190.333858 | 3886952.296503 |
| WIRELESS_SENSOR_9 | 3888000.000000 | 1182.434024 | 3886960.196337 |
| WIRELESS_SENSOR_10 | 3888000.000000 | 1182.936475 | 3886959.693885 |
| WIRELESS_SENSOR_11 | 3888000.000000 | 1181.324744 | 3886961.305617 |
| WIRELESS_SENSOR_12 | 3888000.000000 | 1190.651240 | 3886951.979120 |
| WIRELESS_SENSOR_13 | 3888000.000000 | 1180.506614 | 3886962.123747 |

Figure 4: Battery model table

Without Leach Protocol Implementation:

| Battery model_Table | | | | |
|--|--------------------|---------------------|----------------------|--|
| Battery model <input type="checkbox"/> Detailed View | | | | |
| Device Name | Initial energy(mJ) | Consumed energy(mJ) | Remaining Energy(mJ) | |
| WIRELESS_SENSOR_1 | 3888000.000000 | 1213.748661 | 3886929.577444 | |
| WIRELESS_SENSOR_2 | 3888000.000000 | 1196.283876 | 3886947.042228 | |
| WIRELESS_SENSOR_3 | 3888000.000000 | 1196.283876 | 3886947.042228 | |
| WIRELESS_SENSOR_4 | 3888000.000000 | 1196.874433 | 3886946.451671 | |
| WIRELESS_SENSOR_5 | 3888000.000000 | 1196.289682 | 3886947.036422 | |
| WIRELESS_SENSOR_6 | 3888000.000000 | 1196.286779 | 3886947.039325 | |
| WIRELESS_SENSOR_7 | 3888000.000000 | 1196.289682 | 3886947.036422 | |
| WIRELESS_SENSOR_8 | 3888000.000000 | 1196.877336 | 3886946.448768 | |
| WIRELESS_SENSOR_9 | 3888000.000000 | 1196.286779 | 3886947.039325 | |
| WIRELESS_SENSOR_10 | 3888000.000000 | 1196.286779 | 3886947.039325 | |
| WIRELESS_SENSOR_11 | 3888000.000000 | 1196.283876 | 3886947.042228 | |
| WIRELESS_SENSOR_12 | 3888000.000000 | 1204.744754 | 3886938.581351 | |
| WIRELESS_SENSOR_13 | 3888000.000000 | 1196.289682 | 3886947.036422 | |

Figure 5:Battery model table

Note: You can observe slight variation in the Consumed energy with and without Leach protocol implementation.