

PROGRAMMING CHALLENGE#I : IMPLEMENTATION OF LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH) PROTOCOL

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Summary

In this challenge, you will first review and then, implement the traditional protocol namely Low-energy Adaptive Clustering Hierarchy (LEACH)[1]. Then, you will investigate various protocols derived from LEACH and implement a routing protocol using the programming language MATLAB™ and Python. This challenge is purely meant to refresh your programming aptitude but the accuracy of your work depends whether you read this text carefully.

Preface

This challenge is basically to implement one of my prior works in [2]. So, I recommend that you peruse through the text as it will serve as an ideal starting point. I also recommend you to search online in [Google Scholar](#), [Academia](#), and gain insights to various other protocols that are used in contemporary WSNs. You will need to submit a report (individually) explaining the design, implementation and analyses that you have conducted. Additionally, your report should answer the questions that are asked in section 2. Therefore, read through the following sections carefully.

Instruction for Cohort#1:

You will implement LEACH protocol using [MATLAB™](#). So as a starting point, I ask that you apply for an [academic license](#). You also need to be aware of the functions used for plotting graphs. In specific, I ask that you read about plotting 'boxplots' [3].

Instruction for Cohort#2:

You will implement this challenge using [Python](#). Your report needs to include graphs; therefore, I ask that you install the plotting library '[matplotlib](#)' and go through the provided functions. You should be aware of different functions to integrate multiple plots (subplots) within a figure.

1 The Challenge

Your objective is to analyze the energy consumption of the entire WSN and report which parameters influence the energy consumption. So, it is crucial that you attempt the following tasks:

- Task#1: You need to abstract your networking components (sensor nodes, sensing field, CH, etc.) and represent them in the form of primitive data-types that are supported by MATLABTM or Python. Your report should justify why your selected data-type is suitable and provide its demerits, if any. For example, if you wish to represent a WSN using `arrays`, then a natural bottleneck is that this abstraction does not allow us to model the sensing field, since `arrays` are linear data-structures.
- Task#2: You need to implement the traditional LEACH protocol and add necessary code to compute your objectives. For example, if you wish to plot the energy consumption of the network as a function of time, then your implementation should also consider the aspect of `timesteps`. Another example, if the distance between two nodes is large enough, then you need to account for '`propagation delay`', '`routing overhead`', etc., which would influence the total energy consumed.
- Task#3: You need to execute your implementation and simulate the behaviour of a WSN. Your implementation should satisfy the following:
 - Represent a sensing field of dimension `100 x 100 m`.
 - The distribution of sensor nodes should be random.
 - Model the energy consumption of individual sensor nodes.
 - Compute and extract relevant statistics related to energy consumption.

Refer to the tabulated metrics given in [2] and use it to build realistic consumption models. Your report should first identify which parameters influence the energy consumption and then analyse these parameters to draw conclusion.

- Task#4: You need to implement the algorithm proposed in [2] and gather statistics.
- Task#5: Plot the average energy consumption of a WSN as a function of time for both LEARP and LEACH.
- Task#6: Plot the average energy consumption of a WSN as a function of number of initial CHs for both LEARP and LEACH.

Report

This is not an assignment and there is no deadline, so the nature of your report should be scientific. For this purpose, I ask you that you use overleaf.com to generate a single-column report (size: 14pt) in L^AT_EX. You will publish your report in [ResearchGate](https://www.researchgate.net) and so, this shall be your first footprint in academia.

2 Questions

1. What are the parameters that influence energy dissipation in a WSN? Explain how, in a non-deterministic environment, you have attempted to model these parameters? Explain how these parameters seems to affect the energy consumption.
2. Provide remarks on the algorithmic approach that you considered while modelling?
3. Explain the dynamics of the network based on your implementation of the LEACH protocol? Do you observe stochasticity in the network after reviewing your results? If not, then craft an argument that suggests the limitation of your simulation setup.
4. Explain the dynamics of the network based on your implementation of the LEARP protocol? Are the results different?
5. How can the precision of the simulation setup be increased? Identify the major differences between high-level language simulations and discrete-event simulations?
6. What are the major disadvantages of having routing protocols with stochastic algorithm? By intuition, does every individual node receive the same (fair) opportunity to transmit data? If not, how can that lead to bottlenecks? Indicate the fairness of stochastic algorithms (for WSNs) for homogeneous and heterogeneous networks?

References

- [1] Low-Energy Adaptive Clustering Hierarchy (LEACH), Wikipedia https://en.wikipedia.org/wiki/Low-energy_adaptive_clustering_hierarchy
- [2] Banerjee, Heerok, S. Murugaanandam, and V. Ganapathy. "Low-Energy Aware Routing Mechanism for Wireless Sensor Networks." International Journal of Engineering Research in Computer Science & Engineering (IJERCSE) 5.1 (2018): 112-117. [\[link\]](#)
- [3] Boxplot, MATLAB TM <https://www.mathworks.com/help/stats/boxplot.html>