FACTOR – BASED LEACH (FLEACH) PROTOCOL FOR EXTENDING WIRELESS SENSOR NETWORKS' LIFETIME

AMODU OLUWATOSIN AHMED

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FACTOR – BASED LEACH (FLEACH) PROTOCOL FOR EXTENDING WIRELESS SENSOR NETWORKS' LIFETIME

By

AMODU OLUWATOSIN AHMED

Supervisor. Mrs Raja Azlina Raja Mahmood

Faculty. Computer Science and Information Technology

The improvement of sensor networks' lifetime has been a major research challenge in recent years. This is because sensor nodes are battery powered and may be difficult to replace when deployed. Low Energy Adaptive Clustering Hierarchical (LEACH) routing protocol was proposed to prolong sensor nodes' lifetime by dividing the network into clusters. In each cluster, a cluster head (CH) node receives and aggregates data from other nodes. However, CH nodes in LEACH are randomly elected which leads to a rapid loss of network energy. This energy loss occurs when the CH has a low energy level or when it is far from the BS. LEACH with Two Level Cluster Head (LEACH-TLCH) protocol deploys a secondary cluster head (2CH) to relieve the cluster head burden in these circumstances. However, in LEACH-TLCH the optimal distance of CH to BS, and the choicest CH energy level for the 2CH, to be deployed for achieving an optimal network lifetime was not deployed. In this thesis, we have improved on LEACH-TLCH by investigating the conditions set to deploy the 2CH for an optimal network lifetime. We also conduct experiments to indicate how the 2CH impacts on the network at different CH energy levels and (or) CH distance to BS. Our improvement on LEACH-TLCH in this thesis is referred to as Factor-based LEACH (FLEACH) protocol. Investigations in FLEACH shows that as CH gets farther from the BS, the use of a 2CH extends the network lifetime. Similarly, an increased lifetime also results as the CH energy decreases while the 2CH is deployed. The best case considered in FLEACH shows an improvement of over 670% in network lifetime as compared to LEACH-TLCH and improves LEACH by over 700%.

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APPROVAL SHEET

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Mrs Raja Azlina Raja Mahmood.

Department of Communication Technology and Network

Faculty of Computer Science and Information Technology

Universiti Putra Malaysia

Date

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LIST OF ABBREVIATIONS

BS	Base Station
CH	Cluster Head
CM	Cluster Member
DCA	Distributed Clustering Algorithm
DEEC	Deterministic Energy Efficient Clustering protocol
DT	Direct Transmission
FLEACH	Factor-based LEACH Protocol
FND	First (sensor) Node Dies
GPS	Global Positioning System
HEN / 2CH	Highest Energy Node in a cluster / Secondary Cluster Head
HCC	Hierarchical Control Clustering protocol
HND	Half (of sensor) Nodes Dies
ID	Identification number
LEACH	Low Energy Adaptive Clustering Hierarchical protocol
LEACH-C	LEACH-Centralized Protocol
LND	Last (of sensor) Nodes Die
MATLAB	Matrix Laboratory
MTE	Minimum-Transmission-Energy routing protocol.
NN	Normal Node
QoS	Quality-of-Service
RN	Relay Node
SEP	Stable Election Protocol
SN	Sensor Node
TDMA	Time Division Multiple Access
WSN	Wireless Sensor Network

All Praise is due to Allah who guided me from LEACH to FLEACH

CHAPTER 1

INTRODUCTION

1.1 MOTIVATION

Wireless sensor networks has recently attracted researchers' attention due to its diverse application and unharnessed potential to solve a huge variety of human problems. Its application involves its use in disaster prediction; such as detection of fire outbreaks, surveillance of the enemy; as used in the military [1], environmental monitoring; in detecting air pollution[1], [2], fire detection, agriculture; to monitor several factors affecting plant and animal life such as water levels and temperature, and in medicine; to assist the aged [3]. However, one major challenge faced by researchers is extending the lifetime of these networks due to the resource constrained nature of the nodes.

1.2 BACKGROUND

1.2.1 WIRELESS SENSOR NETWORKS

A sensor network involves the use of sensor nodes to gather data to be conveyed to the intended user for appropriate actions to be taken. Wireless sensor networks (WSNs) are characterized by sensor nodes of different sizes depending on the area and desired aim for which they are deployed. Another major component of WSN is an energy-efficient routing protocol. For an energy-efficient routing protocol, its most crucial characteristic is its ability to extend the network lifetime and reduce its consumption of energy [3]. This helps to ensure that communication

of sensed data within the network is properly co-ordinated while sustaining the energy of sensor nodes.

Although, sensor networks have very huge prospects in the future of data communication, it is still faced with the challenge of a limited network lifetime. This is because nodes are quite many, battery operated, and may not be recharged. As such, it is expensive [4] and impracticable [5] to replace the large number of batteries in the sensors; especially when they are deployed in a harsh environment.

In order to ensure that the energy constrained nodes have its energy maximized while delivering quality data transfer to the intended information user, various algorithms and protocols have emerged. One major approach used for reducing energy consumption in WSN is through clustering. Clustering is an approach were sensed data is fused together to produce a more meaningful information [6] before sending to the end user.

Clustering has the potential of prolonging the lifetime of the network and increasing its scalability [6] while being fault-tolerant and achieving load balance [2]. A prominent clustering protocol in WSN is Low Energy Adaptive Clustering Hierarchical (LEACH) [7], [8] routing protocol. LEACH separates the network into clusters with a cluster head (CH). The cluster head collects, aggregates and sends data within its cluster to the base station (BS). However, in LEACH, the CH elected may be unsuitable due to its low energy-level or a far distance to the BS. This has led to the development of routing protocols such as LEACH-TLCH [9].

LEACH-TLCH protocol was proposed to balance the energy in the network by electing a secondary cluster head to support the role of the cluster head. Although,

this protocol improves LEACH protocol, it underutilizes the secondary cluster head for data aggregation within the cluster. This limits the network lifetime achieved.

In order to solve this problem, we have conducted simulation experiments in this thesis to determine how the secondary cluster head can be properly utilized for a maximal network lifetime. We deploy energy and distance-based thresholds to observe the impact of the secondary cluster head at different network situations. This we have referred to as Factor-based LEACH (FLEACH) protocol. Results indicate that the use of the secondary cluster head in FLEACH highly conserves the energy consumed in the network and extends the network stability and lifetime.

We have referred to the node with the highest energy level (HEN) in the cluster as secondary cluster head (2CH) whenever it is deployed for data aggregation. In the rest of this thesis work, these two terms would be used interchangeably.

1.3 PROBLEM STATEMENT

Data aggregation and transmission from cluster member (CM) nodes to the base station (BS) consumes the energy of the LEACH cluster head (CH). As a result, when the CH residual energy is low, it dies quickly. Similarly, when CH is very far from the BS, it dissipates a lot of energy due to long-distance transmissions.

The use of a secondary cluster head proposed to solve this problem in LEACH-TLCH protocol is also inadequate. This is because the choicest use of the secondary cluster head was not considered. Thus, the average network energy and the average node distance to the BS as used in LEACH-TLCH produces sub-optimal results.

This research thesis is aimed at investigating the capacity of the secondary cluster head for a sustained network energy and prolonged network lifetime

1.4 RESEARCH OBJECTIVES

The main objective of this research work are.

1. To investigate the problems with the LEACH protocol cluster head.
2. To investigate LEACH-TLCH protocol for reducing the energy burden of the LEACH protocol cluster head.
3. To develop FLEACH protocol which enhances LEACH-TLCH protocol for conserving network energy and improving the network lifetime of LEACH protocol.

1.5 RESEARCH SCOPE

This research work evaluates the FLEACH protocol by deploying two network performance metrics; network life time and total energy consumed in the network. In evaluating FLEACH, a homogenous network model[1] consisting of 200 nodes on a 200 x 200 field dimension would be used. Simulation experiments would be used to determine how the use of the node with the highest energy in the cluster as a secondary cluster head affects the network performance. Thus various cluster head (CH) energy-levels and CH distances to base station (BS) would be considered as thresholds for selecting the secondary cluster head.

[1] In this model, all nodes are deployed with same initial energy

THESIS ORGANIZATION

This thesis is divided into five chapters. The structure and overall content of the thesis is shown below.

Chapter I. This chapter introduces Wireless Sensor Networks (WSN), the research domain, problem statement, objectives and finally, the scope of this research work.

Chapter II. Introduces the reader to Wireless Sensor Networks (WSN) its application and constituents, energy in WSN, classification of routing techniques in literature which is further narrowed down to Clustering routing protocol, LEACH protocol and a review of various improvement on the LEACH protocol.

Chapter III. Provides a detailed description of how this research was carried out (Methodology). This consists of the network model and algorithm, the radio model used, assumptions, the simulation platform, simulation parameters which includes the metrics used for evaluation.

Chapter IV. This chapter focuses on the results obtained after this research was carried out. Graphs and discussions are also included in this chapter.

Chapter V. This chapter concludes the thesis giving the reader an overall view of what was accomplished during the course of this research as it relates to the problem. It also includes future research directions.

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