

ENERGY-EFFICIENT PROTOCOLS FOR WIRELESS SENSOR NETWORKS

A thesis submitted in partial fulfilment of the requirements
for the degree of

Doctor of Philosophy

by

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May 2026

DECLARATION

The thesis entitled **Energy-Efficient Protocols for Wireless Sensor Networks** is a presentation of my original research work done under the guidance of my thesis supervisor. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

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CERTIFICATE

This is to certify that the work contained in the thesis entitled **Energy-Efficient Protocols for Wireless Sensor Networks** by Rahul Deka has been carried out under my supervision, and that it has not been submitted elsewhere for a degree.

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Acknowledgements

I thank my thesis supervisor, Dr. Nandita Baruah, for her guidance and constant encouragement, the members of my Doctoral Committee for their valuable suggestions, and my labmates for their help with the testbed deployment.

Abstract

Wireless sensor networks deployed for environmental and structural monitoring run on batteries that are hard to replace, so the network's useful life is set by how carefully it spends energy on communication. This thesis designs routing and medium-access protocols that extend network lifetime without sacrificing data delivery. It proposes a clustering protocol that rotates cluster heads according to residual energy and link quality, and a duty-cycling scheme that aligns sensor wake-up times with the cluster head's schedule. In simulation and on a 48-node testbed, the combined protocols extend the time until the first node dies by 37% compared with the LEACH protocol at a packet delivery ratio above 98%.

Keywords: wireless sensor networks, clustering, duty cycling, network lifetime, energy efficiency

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Chapter 1

Introduction

A sensor network monitoring a bridge or a tea garden may need to run for years on the batteries it was deployed with. Radio communication dominates energy use, so protocols decide the network's life: which nodes forward data, how often they wake, and how evenly the burden is shared [1].

Chapter 2

Background

In the first-order radio model, transmitting k bits over distance d costs

$$E_{\text{Tx}}(k, d) = E_{\text{elec}} k + \varepsilon_{\text{amp}} k d^2, \quad (2.1)$$

and receiving costs $E_{\text{elec}} k$. LEACH organizes nodes into clusters whose heads aggregate data and forward it to the base station, rotating the head role at random to spread the load [2].

Chapter 3

Residual-Energy Clustering with Aligned Duty Cycles

Our protocol elects cluster heads with a probability weighted by residual energy and by the expected transmission count of their links, so that weak nodes and poor links rarely become heads. Members wake only in slots announced by their head, which removes idle listening.

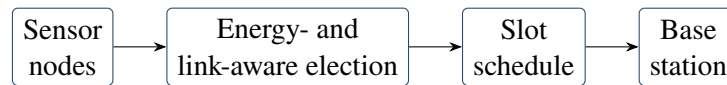


Figure 3.1: Cluster-head election and aligned wake-up schedule.

Chapter 4

Results

Table 4.1 reports lifetime and delivery on the 48-node testbed.

Table 4.1: Network lifetime and delivery on a 48-node testbed.

Protocol	First node death (days)	Delivery ratio (%)
LEACH	41	96.2
Energy-aware election	49	97.5
Proposed protocols	56	98.4

Chapter 5

Conclusion

Choosing cluster heads by residual energy and link quality, and waking members only when their head listens, extends network lifetime while improving delivery. Energy harvesting nodes, whose budget changes over time, are a natural extension.

Appendix A

Testbed Configuration

The testbed used 48 nodes with 2.4 GHz radios at 0 dBm transmit power, deployed over a 60 m by 40 m area, reporting one reading per minute.

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