

An Energy-Aware Cluster-Head Rotation Scheme for Wireless Sensor Networks

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Abstract— Battery life limits the usefulness of wireless sensor networks deployed in fields, forests and buildings. Clustering reduces energy use by letting cluster heads aggregate data, but poor head selection drains some nodes quickly. This paper proposes a cluster-head rotation scheme that considers residual energy and distance to the base station. Simulations show longer network lifetime and more even energy consumption than a widely used baseline. All values in this template are sample results.

Index Terms— *wireless sensor networks, clustering, energy efficiency, network lifetime, routing*

This is a template: all data, results and references are placeholders for the author to replace.

I. INTRODUCTION

Wireless sensor networks consist of many small battery-powered nodes that measure physical quantities and send data to a base station. Replacing batteries is often impractical, so energy efficiency determines how long a network remains useful.

Clustering protocols group nodes so that only cluster heads communicate with the base station. If heads are chosen without considering remaining energy, some nodes die early and coverage is lost.

The main contributions of this paper are as follows:

- A head-selection probability that combines residual energy and distance.
- A rotation rule that prevents low-energy nodes from becoming heads.
- A simulation study comparing lifetime and energy balance with a baseline protocol.

The rest of the paper is organised as follows. Section II reviews related work, Section III describes the proposed clustering scheme, Section IV presents the experimental setup, Section V reports and discusses the results, and Section VI concludes the paper.

II. RELATED WORK

Classic probabilistic clustering rotates heads randomly to spread energy use [1].

Energy-aware variants weight the probability by residual energy [2].

Distance-aware schemes reduce long-range transmissions [3].

Multi-hop clustering further reduces energy in large fields [4].

Ref.	Approach	Data	Limitation
[1]	Random rotation	Simulation	Ignores energy
[2]	Energy-weighted	Simulation	Ignores distance
[3]	Distance-aware	Testbed	Uneven load
[4]	Multi-hop	Simulation	Complex routing

TABLE I. Summary of related work

III. PROPOSED CLUSTERING SCHEME

In each round, a node computes a threshold that increases with its residual energy and decreases with its distance to the base station. Nodes whose energy is below a cut-off do not compete.

Elected heads advertise themselves; other nodes join the nearest head. Heads aggregate data before forwarding it.

A. Overview

Operation proceeds in rounds, each with a set-up phase (head election and cluster formation) and a steady-state phase (data transmission).

Figure placeholder — block diagram of the proposed clustering scheme

Fig. 1. Overview of the proposed clustering scheme

B. Algorithm

1. Compute the election threshold from residual energy and distance.
2. Draw a random number and become a head if it is below the threshold.
3. Advertise and form clusters.
4. Collect, aggregate and forward data.
5. Repeat in the next round.

$$T(n) = p / (1 - p (r \bmod 1/p)) \times (E_{res} / E_{init}) \times (d_{avg} / d_n)$$

IV. EXPERIMENTAL SETUP

Simulations placed 100 nodes randomly in a 100 m × 100 m field with the base station at the centre. Each result is the average of 20 runs.

Parameter	Value
Nodes	100
Field	100 m × 100 m
Initial energy	0.5 J
Packet size	4,000 bits
Head probability p	0.05
Runs	20

TABLE II. Experimental parameters

A. Evaluation Metrics

- Round when the first node dies (FND)
- Round when half the nodes die (HND)
- Standard deviation of residual energy

V. RESULTS AND DISCUSSION

The proposed scheme delays the death of the first node and spreads energy use more evenly.

Protocol	FND (round)	HND (round)	Energy std. dev. (J)
Baseline random rotation	820	1,240	0.081
Energy-weighted	960	1,330	0.064
Proposed	1,090	1,410	0.047

TABLE III. Comparison with baseline methods (sample data)

Chart placeholder — insert a graph of your results

Fig. 2. Number of alive nodes per round (sample data)

Considering distance reduced the number of heads far from the base station, which saves energy on long transmissions.

The improvement was smaller in very dense networks, where distances are short for all nodes.

A. Ablation Study

To understand the contribution of each component, we removed one component at a time and repeated the evaluation. Table IV shows that every component contributes to the final result, with the largest drop observed when the distance factor is removed.

Variant	FND (round)
Full model	1,090
Without distance factor	985
Without pre-processing	1,020
Baseline only	820

TABLE IV. Ablation results (sample data)

B. Limitations

- Results are from simulation only.
- A single-hop model was assumed.
- Node mobility was not considered.

VI. CONCLUSION AND FUTURE WORK

The proposed rotation scheme extends network lifetime and balances energy consumption in clustered sensor networks.

Future work will test the scheme on hardware and extend it to multi-hop and mobile scenarios.

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