Implementation and Performance Analysis of the Link Expiration Time (LET) Clustering Algorithm

CENG797 Term Project

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Problem Definition

- MANETs lack fixed infrastructure; nodes move constantly.
- Traditional algorithms (e.g., Lowest-ID) are **Reactive**.
- They wait for links to break before selecting a new leader.

Consequences

- Frequent Link Breakages
- Packet Loss & High Latency
- "Broadcast Storms" due to excessive control messages

Core Idea: Change from Reactive to **Proactive**.

The **Link Expiration Time (LET)** metric predicts the future:

- Instead of random selection, we calculate the **connection duration**.
- We choose the leader that will stay connected the longest.

Inputs for Prediction:

- Relative Velocity (v)
- Relative Position (x, y)
- Transmission Range (r)

The exact link duration (t) is calculated using kinematic parameters:

$$\text{LET} = \frac{-(ab + cd) + \sqrt{(a^2 + c^2)r^2 - (ad - bc)^2}}{a^2 + c^2} \tag{1}$$

Where:

- **a, c**: Relative Velocity vector components
- **b, d**: Relative Distance vector components

This formula gives us the precise time remaining until disconnection.

Distributed Election

Each node calculates a **Stability Weight (W_i)**:

$$W_i = \sum_{j \in Neighbors} \text{LET}_{ij}$$

Score Mechanism (Loop Prevention)

To break ties and prevent loops, we use a composite score:

$$\text{Score}_i = W_i + \frac{1}{\text{ID}_i}$$

The node with the strictly highest score becomes the **Cluster Head**.

Environment:

- **Simulator:** OMNeT++ 6.2.0
- **Framework:** INET 4.5.4
- **Area:** $1000m \times 1000m$

Scenarios:

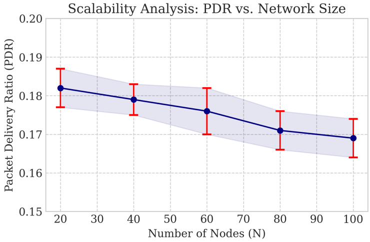
1. Scalability: $20 \rightarrow 100$ nodes
2. Mobility: $5 \rightarrow 35$ m/s

Parameters:

- **Mobility:** Random Waypoint (High Stress)
- **MAC:** IEEE 802.11
- **Traffic:** UDP Applications

Live Demo

Switching to Simulation Environment...



(Visualization of Cluster Head selection under 35 m/s mobility)

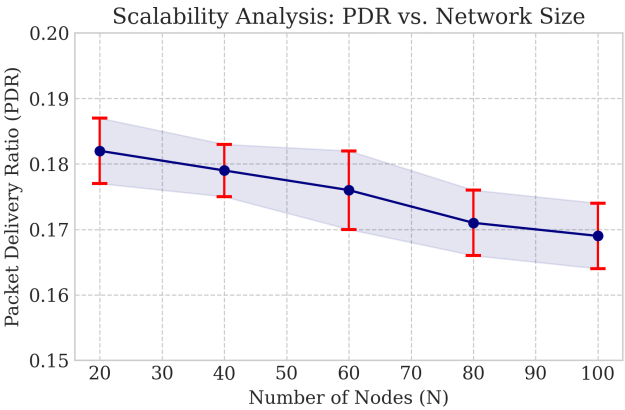


Figure: PDR vs. Network Size. Degradation is less than 2%.

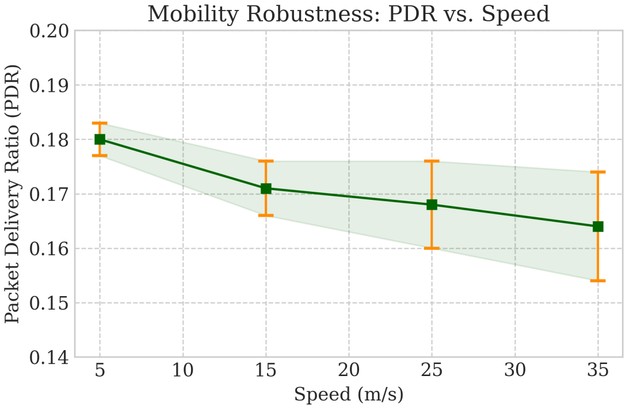


Figure: PDR vs. Speed. Connectivity maintained at highway speeds.

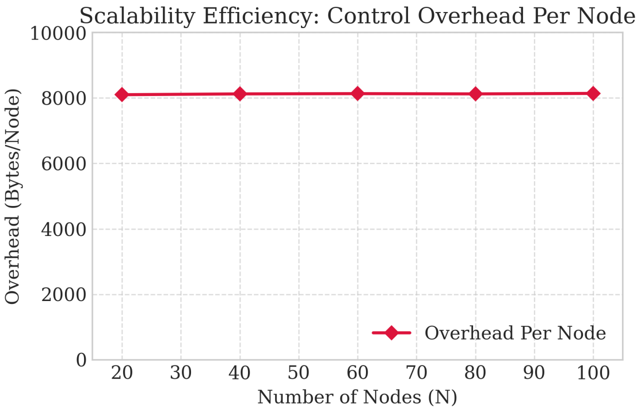


Figure: Control Overhead per Node. **O(1)** complexity demonstrated.

- **Success:** LET algorithm successfully predicts link breaks.
- **Scalability:** Proven O(1) overhead ensures scalability.
- **Robustness:** Works effectively under high-mobility.
- **Future Work:**
  - Integrate TCP for reliability.
  - Implement Energy-Aware Cluster Head rotation.

Thank You