Adaptive Distributed Fuzzy Logic Routing for Energy Optimization and Uncertainty Management in Wireless Sensor and Mobile Ad-hoc Networks

[1]*P. Ravikumar*
Associate Professor, Department of Electronics and Instrumentation
K.L.N. College of Engineering, ravecumar@gmail.com

[2]*V.Aravinda Rajan*
Assistant Professor, Department of Computer Science and Engineering
School of Computing, Kalasalingam Academy of Research and Education
v.aravindarajan@klu.ac.in

[3]*M. Satheesh Kumar*
Assistant Professor, Department of Computer Science and Engineering
Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology
Satheesh.becse@gmail.com

Abstract:

In heterogeneous and dynamic wireless sensor networks (WSNs) and mobile ad-hoc networks (MANETs), optimizing energy consumption while maintaining robustness against environmental and topological uncertainties remains a critical challenge. In this paper, we propose an Adaptive Distributed Fuzzy Logic Routing (ADFLR) system that simultaneously addresses energy efficiency, load balancing, and uncertainty management. Our approach integrates dynamic fuzzy logic controllers that adaptively tune membership functions based on real-time network conditions and environmental factors. ADFLR incorporates fuzzy interval analysis to model spatial, temporal, and environmental uncertainties, ensuring stable routing cost estimation under varying conditions. The system constructs fuzzy minimum spanning trees dynamically for both unicast and multicast communication, balancing energy consumption and minimizing routing errors. Extensive simulations demonstrate that ADFLR outperforms existing solutions such as DEFL, MTE, and FMST in terms of network lifetime, energy balancing, and resilience to environmental disruptions, achieving near-optimal performance across diverse traffic and mobility scenarios.

Keywords: Mobile Ad-hoc Networks (MANETs), Energy-efficient Routing, Fuzzy Logic, Distributed Routing, Load Balancing, Uncertainty Management