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RESEARCH ARTICLE

GTD-CER: Game-Theoretic Dynamic Clustering for Enhanced Efficiency and Reliability in Wireless Sensor Networks

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ABSTRACT

Efficient cluster formation is a significant issue in wireless sensor networks (WSNs) for optimizing energy consumption, enhancing data reliability, and prolonging network lifetime. This paper proposes a dynamic cluster formation scheme modeled as a noncooperative game, where each sensor node acts as a player making strategic decisions on whether to become a cluster head (CH) or remain a member node (MN). In this role selection decision-making phase, nodes evaluate their potential utility function, which incorporates energy consumption, data reliability, and data forwarding efficiency. Nodes dynamically switch roles based on their utility to achieve an optimal network configuration. Simulations conducted using the NS-3 network simulator demonstrate that the proposed game theory-based clustering scheme significantly improves network performance. We analyze key measures like energy consumption, packet delivery ratio (PDR), and data forwarding, and the results shows that the proposed scheme reduces energy consumption by 25%, improves PDR by 15%, and extends the network lifetime by 20%, compared to traditional methods. The dynamic role-switching mechanism prolongs network lifetime by preventing the rapid depletion of node energy, ensuring stable and