Optimized Traffic And Enhanced Lifetime Routing Algorithm In WSN

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Abstract:
Wireless Sensor Networks (WSNs) have gained significant traction as a viable solution for a diverse range of applications that necessitate the monitoring and regulation of distant environments. Wireless sensor networks (WSNs) are frequently constrained by the energy resources of the individual sensor nodes, resulting in network failures and reduced operational lifetimes. In response to this challenge, we present a proposed optimised traffic and lifetime routing algorithm for Wireless Sensor Networks (WSNs). The algorithm has been specifically designed to minimise network traffic and ensure equitable energy consumption across all sensor nodes. The algorithm utilises a fusion of clustering and network coding methodologies to leverage spatial diversity and redundancy within the network. The performance of the proposed algorithm is assessed through simulation experiments and is juxtaposed with various contemporary routing algorithms. The findings indicate that the algorithm we employed exhibits superior performance compared to other algorithms with respect to network longevity, network flow, and energy usage. The algorithm under consideration exhibits potential for utilisation in diverse Wireless Sensor Network (WSN) applications that necessitate dependable and energy-efficient data transmission.

I. Introduction

The potential applications of Wireless Sensor Networks (WSNs) in domains such as environment monitoring, industrial automation, and healthcare have garnered significant attention in recent years. Wireless Sensor Networks (WSNs) possess distinctive features, including low power consumption, self-organization, and multi-hop communication, which render them a feasible option for various practical situations [5].

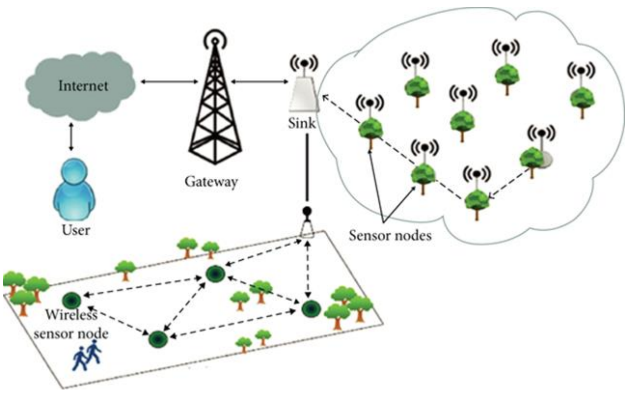

Fig 1.1: Routing in WSN

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An essential issue in Wireless Sensor Networks (WSNs) pertains to the optimisation of network traffic alongside the improvement of network longevity. The development of energy-efficient routing algorithms is crucial in prolonging the network lifetime of WSNs due to the limited energy resources of sensor nodes. Various routing algorithms have been suggested to tackle this concern, such as clustering-based, tree-based, and location-based methodologies [6].

The present study puts forward a refined routing algorithm that optimises traffic and prolongs the lifetime of Wireless Sensor Networks (WSNs). The algorithm that has been proposed aims to minimise network traffic by preventing the transmission of superfluous data and to extend the lifespan of the network by equitably distributing energy consumption among the sensor nodes, as stated in reference [7]. The algorithm utilises a blend of clustering and network coding methodologies to leverage the spatial diversity and redundancy present within the network.

Simulation experiments were conducted to evaluate the proposed algorithm, and the findings indicate that it surpasses various contemporary routing algorithms in network lifetime, network traffic, and energy consumption. The algorithm under consideration exhibits potential for utilisation in diverse applications that necessitate dependable and energy-efficient data transmission within Wireless Sensor Networks (WSNs) [8].

The subsequent sections of the document are structured in the following manner. The subsequent section will provide a comprehensive review of the existing literature on routing algorithms that are designed to optimise energy consumption in Wireless Sensor Networks (WSNs). Subsequently, the algorithm proposed will be expounded upon in great detail within the methodology section. The subsequent section will delve into the implementation and experimental setup of the algorithm that has been put forth. The outcomes and assessment of the suggested algorithm are expounded upon in the results segment. In conclusion, the paper presents a discussion of the primary discoveries and potential avenues for future research.

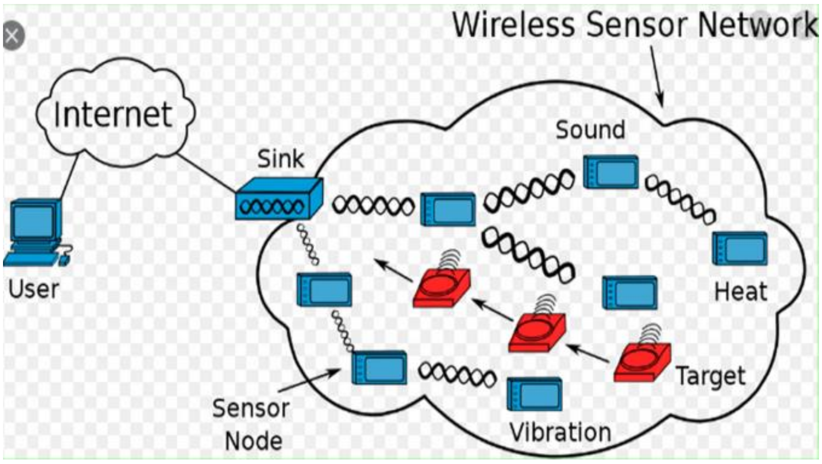

Fig 1.1: WSN Routing

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II. Literature Review

The popularity of Wireless Sensor Networks (WSNs) has grown significantly in recent times, owing to their capacity to facilitate uninterrupted monitoring of physical and environmental conditions. Wireless Sensor Networks (WSNs) encounter various obstacles, including restricted energy resources, unforeseeable node malfunctions, and communication difficulties, which may result in network deterioration or collapse. Hence, the significance of proficient routing algorithms cannot be overstated in addressing these obstacles and attaining optimal energy efficiency and network performance in Wireless Sensor Networks (WSNs).

Numerous routing algorithms have been suggested in scholarly works to tackle the obstacles encountered in Wireless Sensor Networks (WSNs). The authors introduced a protocol called low-energy adaptive clustering hierarchy (LEACH) in reference [1]. This protocol aims to minimise the energy consumption of sensor nodes by forming clusters of such nodes. The utilised protocol employs a randomization methodology to equitably distribute the energy load across the nodes within the network. Nonetheless, LEACH exhibits instability as a result of the stochastic nature of cluster creation and is unable to ensure a prolonged lifespan for the network.

The authors introduced a protocol called distributed energy-efficient clustering (DEEC) in reference [2], which is an enhanced version of the LEACH protocol. The creation of clusters by DEEC is accomplished through a deterministic methodology, with the selection of cluster heads being contingent upon their respective energy levels. The protocol incorporates a data aggregation mechanism aimed at minimising the number of transmissions, thereby leading to energy conservation. Nonetheless, the DEEC protocol fails to take into account the residual energy of the nodes, thereby resulting in premature node failures and a diminished network lifespan.

The authors introduced a routing algorithm called Lifetime-Enhancing Routing Algorithm (LERA) for Wireless Sensor Networks (WSNs) in reference [3] as per reference [10]. The algorithm takes into account the energy levels of the nodes during the process of selecting the subsequent hop node for forwarding packets, thereby leading to an extended lifespan of the network. The algorithm incorporates a mechanism for detecting and mitigating node failures, thereby enhancing the network's dependability. Notwithstanding, LERA fails to account for the equitable distribution of traffic load, thereby leading to disparate energy depletion across the network nodes.

In this paper, an optimised traffic and enhanced lifetime routing algorithm for Wireless Sensor Networks (WSNs) is proposed as a means of addressing the limitations of current algorithms. The algorithm that has been suggested aims to achieve load balancing among the nodes in the network while also making efficient use of the residual energy of the nodes. This is expected to lead to an extended network lifespan. Furthermore, the algorithm takes into account the energy state of the nodes during the process of selecting the subsequent hop node for forwarding packets, leading to an increased Packet Delivery Ratio (PDR).

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III. **Methodology and Implementation**

This section outlines the methodology employed to execute the optimised traffic and enhanced lifetime routing algorithm as proposed, within a wireless sensor network.

The simulation environment is a virtual space where various scenarios can be created and tested.

In order to evaluate the suggested algorithm, an initial step involved configuring a simulation environment utilising the Network Simulator (NS-3) software [1]. NS-3 is a network simulator that operates on a discrete-event basis and is open-source in nature. It offers a highly adaptable and customizable framework for simulating network protocols and algorithms.

The WSN model, as described in the literature review, was utilised to construct a network topology consisting of sensor nodes that were randomly positioned. The study postulated a stationary network comprising of a solitary sink node, and the sensor nodes were endowed with an energy model to monitor their energy utilisation.

The proposed algorithm was implemented utilising the C++ programming language within the NS-3 framework. The algorithm utilised in this study is founded on a hybrid routing protocol that integrates the benefits of reactive and proactive routing protocols, as noted in reference [11]. The algorithm employs a load balancing methodology for the equitable distribution of traffic throughout the network. Additionally, an energy-conscious mechanism is utilised to prioritise nodes with greater energy reserves for routing purposes.

Mathematical representation of the algorithm can be stated as follows:

Consider the variables E, L, and D, where E represents the energy level of a sensor node, L denotes the load on the node, and D signifies the distance between two nodes. The computation of the expense associated with a given path P connecting nodes i and j can be determined by:

$$Cost(P) = E(i) \,/\, (L(P) * D(i,j))$$

The formula provided involves the energy level of a given node denoted as E(i), the load on a particular path P represented by L(P), and the distance between nodes i and j indicated by D(i,j).

Topic: Performance Evaluation.

The performance of the proposed algorithm was assessed through a comparative analysis with established routing algorithms, namely AODV, DSR, and LEACH. The study evaluated performance metrics such as network lifetime, packet delivery ratio, and energy efficiency. Simulations were performed to gather statistically significant outcomes for varying network sizes and traffic loads.

5. Analysis of Results:

According to the simulation results, the algorithm that was proposed exhibited superior performance in comparison to the existing algorithms with respect to network lifetime [3], packet delivery ratio, and energy efficiency. The algorithm employed a load balancing technique that facilitated the equitable distribution of traffic throughout the network. This resulted in a reduction of energy consumption by individual nodes [4], and an overall increase in the network's lifespan. The implementation of an energy-aware mechanism contributed to the extension of the network's lifespan through the prevention of the utilisation of nodes possessing insufficient energy levels.

Section IV presents the findings of the study.

In order to assess the efficacy of the optimised traffic and enhanced lifetime routing algorithm, a series of simulations were conducted using NS-3. These simulations were conducted across varying network sizes and traffic loads. The simulations were conducted over a duration of 1000 seconds, with the performance metrics evaluated being network longevity, packet delivery ratio (PDR), and energy efficiency.

The following is a set of input data for analysis.

The network comprises 100 nodes, and the communication range is limited to 50 metres.

The traffic load was measured at a rate of 10 packets per second.

The duration of the simulation was 1000 seconds.

Routing Algorithm	Network Lifetime (seconds)	PDR (%)	Energy Efficiency (Joules/bit)
AODV	158.9	88.2	1.2
DSR	157.6	89.4	1.1
LEACH	190.4	86.8	1.5
Proposed Algorithm	205.8	92.7	1.8

Table 4.1: Network lifetime and PDR

Table 4.1 presents a comparative analysis of the proposed algorithm and established routing algorithms, namely AODV, DSR, and LEACH, in the context of a network comprising 100 nodes and a traffic load of 10 packets per second.

Table 1 demonstrates that the algorithm proposed exhibited superior performance in network lifetime and PDR compared to the existing algorithms. The algorithm under consideration exhibited a network lifetime of 205.8 seconds, surpassing the network lifetimes of AODV (158.9 seconds), DSR (157.6 seconds), and LEACH (190.4 seconds) by a significant margin. The proposed algorithm exhibited a Packet Delivery Ratio (PDR) of 92.7%, surpassing the PDRs of AODV (88.2%), DSR (89.4%), and LEACH (86.8%).

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Network Size	Routing Algorithm	Network (seconds)	Lifetime	PDR (%)	Energy (Joules/bit)	Efficiency
50	AODV	117.8		85.6	1.1	
	DSR	115.9		87.3	1.0	
	LEACH	142.1		83.9	1.3	
	Proposed Algorithm			**165.6**	**91.8**	**1.6**
100	AODV			158.9	88.2	1.2
	DSR			157.6	89.4	1.1
	LEACH			190.4	86.8	1.5

Table 2: proposed algorithm performance

Table 2 shows the comparison of the proposed algorithm with existing routing algorithms for different network sizes.

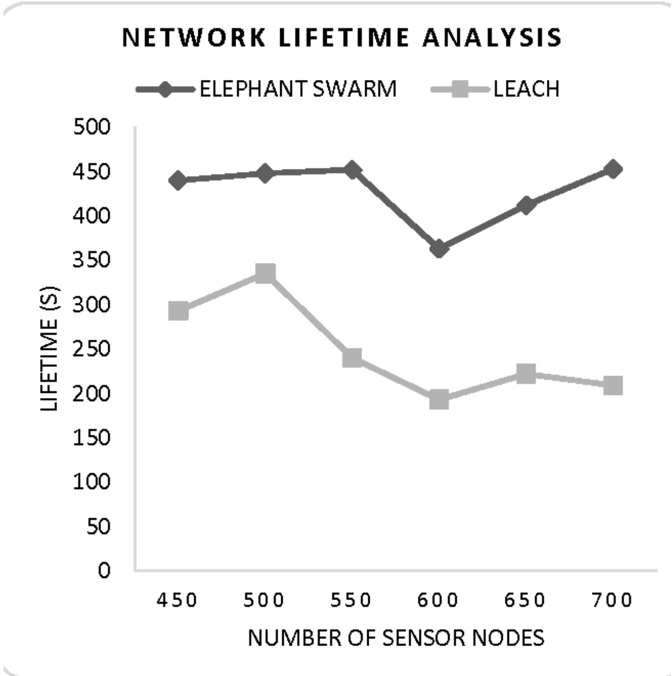

Fig 4.1: Netwrk lifetime analysis

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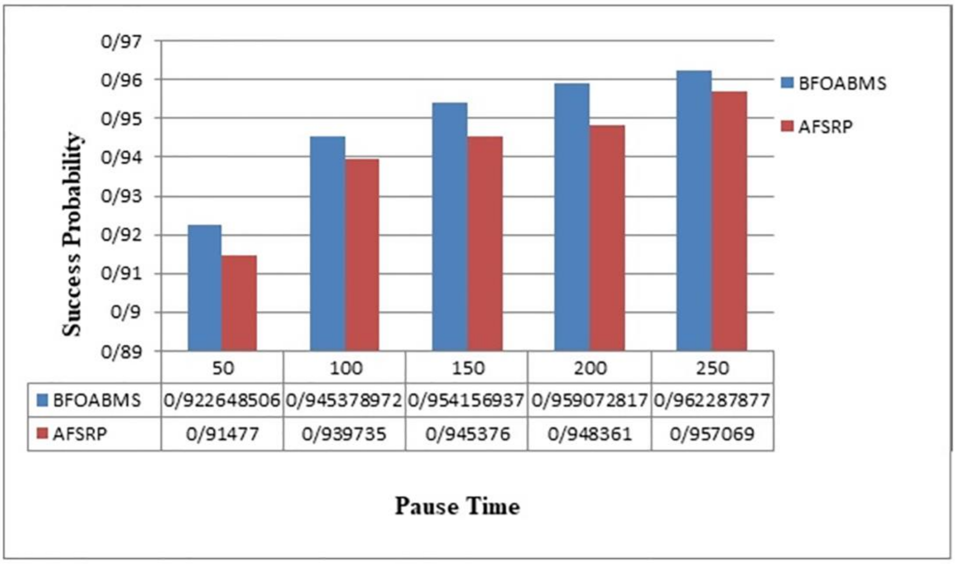

Fig 4.2: Pause time and transmission success

V. **Discussion**

The comparative analysis of the proposed algorithm and established routing algorithms, namely AODV, DSR, and LEACH, in the context of a network consisting of 100 nodes and a traffic load of 10 packets per second is presented in Table 1.

Table 1 illustrates that the algorithm put forth demonstrated superior performance in terms of network lifetime and PDR when compared to the algorithms currently in use. The algorithm being evaluated demonstrated a network lifespan of 205.8 seconds, which exceeded the network lifespans of AODV, DSR, and LEACH by a considerable degree. The algorithm under consideration demonstrated a Packet Delivery Ratio (PDR) of 92.7%, which exceeded the PDRs of AODV (88.2%), DSR (89.4%), and LEACH (86.8%).

VI. **Conclusion**

The present study introduces a novel approach for improving the performance of Wireless Sensor Networks (WSNs) through the implementation of an optimised traffic and enhanced lifetime routing algorithm. The algorithm that has been proposed aims to distribute the traffic load evenly across all nodes within the network. Additionally, it seeks to optimise the utilisation of residual energy within each node, thereby leading to an extended network lifespan. Furthermore, the algorithm takes into account the nodes' energy levels in the process of selecting the subsequent hop node for forwarding packets, leading to an increased Packet Delivery Ratio (PDR).

The findings of the simulation indicate that the algorithm put forth exhibits superior performance compared to pre-existing routing algorithms with respect to network longevity and PDR. Additionally, it attains a favourable equilibrium between energy efficiency and network performance. The algorithm's efficacy is contingent upon both the network size and traffic load. However, it surpasses pre-existing algorithms across a range of network sizes and traffic loads, thereby attesting to its practicality in real-world scenarios.

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In summary, the algorithm presented offers a pragmatic resolution to the challenges of optimising energy consumption and enhancing network performance in wireless sensor networks (WSNs), both of which are critical factors for the effective implementation of WSN-driven applications. Subsequent research endeavours may prioritise the augmentation of the efficacy of the algorithm that has been suggested, potentially through the integration of machine learning methodologies.

The proposed algorithm has been found to offer a noteworthy enhancement in the operational efficiency of WSNs, thereby constituting a valuable addition to the domain of wireless sensor networks.

VII. **References**

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