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Improve Network Lifetime in WSN Through Cooperative Cross-Layer Isolation Method

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Abstract

Wireless Sensor Networks (WSN) is a data exchange network that has achieved tremendous growth in modern communications. The popularity of WSNs is due to the large number of sensor nodes transmitting data in densely populated areas. High traffic, delay, and bandwidth use cause energy loss and shorten WSN transmission lifetimes in multi-hop networks. Fewer energy consumption and improper routing lead to data loss while monitoring received signals. To tackle this problem, this paper introduces the Cooperative Sink Isolation (CIS) and Multi-hop Topology Driven Clustering Approach (MTDCA) techniques for enhanced Energy Aware Life Time Maximization (EALTM) in WSNs. The method retains records of exchanges carried out by sensor nodes in various duty cycles. It considers the past communications in the Routing Table (RT) and the energy levels of other nodes. The Traffic Aware Neighbour Discovery (TAND) technique is used to identify each node's traffic. Then, the Data Transmission Support Measure (DTSM) method analyses the network data communication support estimation. Next, the MTDCA technique is used to find the Cluster Head (CH) for data transmission in the network. Finally, the CIS algorithm improves the Network Lifetime (NL) based on elected CH. It boosts energy levels, extends data transmission lifetime in WSN, and delivers optimal performance at efficient energy levels. Therefore, the proposed method achieved a high throughput performance packet delivery ratio with less energy consumption than other methods.

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Introduction

A WSN has sensor nodes that collect data and send it to a Base Station (BS) or through multi-hops. Energy is critical for WSNs as sensor nodes use it for detecting, sending, and receiving data. Energy is the most important as the sensor node's battery cannot be replaced often. In most sensor areas, the node has a non-rechargeable battery, or the battery cannot be replaced. Moreover, WSNs face issues with network scalability and reliability. Raising the number of sensor nodes in the network causes communication overhead and interference among nodes, resulting in network congestion and slow data transmission. Additionally, Sensor nodes are prone to malfunctions and failures caused by environmental factors, hardware defects, or battery depletion. The primary vision of the cluster-based data aggregation mechanism of the cluster head is to minimize data transmission and, in turn, decrease communication energy usage. The cluster reallocates member nodes dynamically within the group. Figure 1 depicts the transmission of data based on groups to reduce energy consumption. Each member of the cluster gathers data and sends it to the CH, which then transmits the collected data to the BS.

However, energy conservation management and extending wireless sensing devices' overall network lifetime are

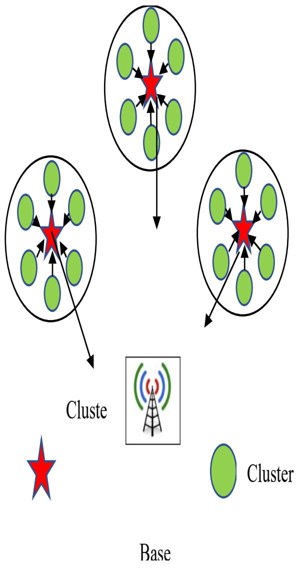

Fig. 1: Cluster-based Data transmission

vital challenges. The sensor node is heavily loaded with traffic, and the energy is reduced significantly. Minimizing sensor node energy consumption is a major challenge for WSN design. This paper suggests an MTDCA-based CIS to improve EALTM by considering topological constraints in delay-aware routing. Our proposed algorithm aims to enhance energy efficiency and NL in WSN, benefiting military, healthcare, and environmental monitoring applications. For example, monitoring environmental conditions such as temperature, humidity, wind, and pollution levels. Another instance is the military, which can track troop movements and equipment, monitor enemy activity, and facilitate communication among soldiers. The proposed system aims to design an efficient, energy-saving, delay-aware scheme by considering factors such as energy, traffic, number of hops, and neighboring nodes. In delay-aware routing schemes, routing to an awake node involves evaluating the node's previous cycle state. The simulated results effectively manage energy consumption and enhance network lifetime (NL), packet delivery rate (PDR), and overall performance.The paper is structured as: section 2 covers the literature, section 3 outlines the proposed implementation, section 4 presents experimental results, and section 5 concludes the paper.

Related Work

Halil Yetgin et al. (2017) conducted a review that focused on the recent developments of WSN for enhancing NL. The survey analyzed WSN applications and discussed methods for maximizing NL, as well as their limitations.C. Chang et al. (2016), the author, concentrated on the crucial problem of maximizing NL in WSN. So the novel introduced the Sensing Radius Adaptation (SRA) technique to extend the NL. Yet, achieving the two goals of full coverage and energy balance is a significant challenge. H. -H. Choi et al. (2021) expressed the Cooperative WPT (CoWPT) technique for prolonging the NL. The suggested approach solves the Linear Program (LP) and extends the NL in WSN. Similarly, stretch the NL using the Neighborhood-Based Estimation of Distribution Algorithm (NEDA) method designed by Z. -G. Chen et al. (2021). However, these methods have problems with extending the NL.

Yongrui Chen et al. (2010) explained the Cooperative Routing (CR) method for prolonging the NL in WSN. It reduces the packet drop and improves throughput. K. J. Sudharman et al. (2010) study concentrates on sequential estimation NL based on Fusion Center (FC) for game theoretics. However, this method does not focus on traffic so it will occur high packet loss and energy consumption.

J. Zhang et al. (2017), a novel focused on the energy efficiency problem in WSN. So the study designed VMIMOCR to enhance energy efficiency and reduce power consumption. Yet, this technique didn't give an efficient performance in WSN.

A. Akbas et al. (2016), the author designed a Joint Optimization based on mixed integer programming (JO-MIP). The JO-MIP technique enhances the energy efficiency and NL in WSN. Likewise, C. Xu et al. (2016), the author developed the Region Source Routing Protocol (RSRP) to improve NL and the efficiency of WSN. Yet, these methods still have a complicated process to improve NL and the efficiency of WSN.

S. Lata et al. (2020), the author presented a Fuzzy Clustering Algorithm (FCA) for prolonging the NL and reliability in WSN. The FCA is used to make cluster appearance and choose Cluster Head (CH) to improve NL in WSN. But still, the NL enhancement is an inferior performance in the network.

Z. Wang et al. (2020), the author explored efficient routing protocol using the ABC technique in WSN. The study enhanced the throughput and delivery ratio performance. But, this study produced a poor NL for the network.

J. Lee et al. (2016) the novel introduced Three-Layer Hierarchy (TLH) based on Semi-Distributed Clustering (SDC) to expand the NL and scalability in the network. SDC technique was used to centralized CH selection for packet transmission and balance the communication. Similarly, U. M. Durairaj et al. (2021) study expressed that Two-Level Clustering (TLC) based routing technique was used to increase the NL.

Y. Zhou et al. (2017) aimed to enhance NL by utilizing the Improved PSO method. This method assesses the energy efficiency of packet transmission and node distance, ultimately reducing the network's energy consumption. However, the study did not focus on node traffic in the WSN.

H. Ali et al. (2021) novel concentrated on reducing energy consumption and prolonging the NL in the network. So, the study introduces the ARSH-FATI method based Ranked-based Clustering (RC) method for minimizing energy consumption. Similarly, S. Sasirekha et al. (2017), the author expressed Cluster-chain mobile agent routing algorithm (CCMARA) was used to group the node for data gathering in the network. However, the main issues in designing WSNs are to preserve energy, reduce data communication delays, and extend NL.

A. Abu-Baker et al. (2021), Presented Adaptive Modulation (AM) technique to enhance the energy efficiency during packet transmission. Similarly, A. S. H. Abdul-Qawy et al. (2021) have presented improved energy efficiency using the TEMSEP protocol. TEMSEP protocol expands the NL in WSSN and reduces energy consumption. However, these techniques didn't provide efficient routing for packet transmission and maximized the energy consumption. Table 1 describes the recent literature for enhance the network lifetime.

Table 1. *Various techniques for enhance the Network Lifetime*

Ref	Author	Technique	Limitations
[21]	L. Sahoo et al. (2024)	Density-Based Spatial Clustering of Applications with Noise (DBSCAN), k-Means clustering algorithm and Fuzzy logic	This method produced less throughput and packet delivery ratio results.
[22]	S. M. M. H. Daneshvar et al. (2023)	Salp Swarm Algorithm (SSA)	This method produced high energy consumption.
[23]	K. H. V. Prasad et al. (2023)	Tasmanian Devil Optimization (TDO) and Improved Twin Delayed Deep Deterministic Policy Gradient (ITD3)	This method has issues like lower energy efficiency, security, and shorter network lifespan during data transmission.
[24]	S. K. Chaurasiya et al. (2023)	Energy-Efficient Hybrid Clustering Technique (EEHCT)	This method didn't control the packet loss during transmission.
[25]	R. Kumar et al. (2021)	Energy Optimized Multi-Constrained Sustainable Routing (EOMCSR)	Energy optimization is a challenging task.

Problem Statement

- Current methods overlook support for extending path lifetime, leading to a reduction in network longevity.
- Routing based on traffic only directs nodes when traffic occurs, resulting in energy loss across multiple nodes and impacting network longevity.
- Most WSN data transmission routing is topology-driven and independent of sensor nodes, relying on node energy. This leads to energy wastage from frequent traffic routing to a small set of nodes over short distances.
- Nodes are routed based on their energy levels. Redundant sensors in wake mode do not transmit data and lose power while listening for incoming packets, leading to increased energy losses and affecting the network's service life.

Materials And Methods

This section outlines the proposed CIS, which is based on the development of EALTM for WSNs using MTDCA to enhance NL. Initially, the method preserves records of exchanges carried out by various sensor nodes in diverse duty cycles. This process considers the energy of other nodes and the past communication history from RT.

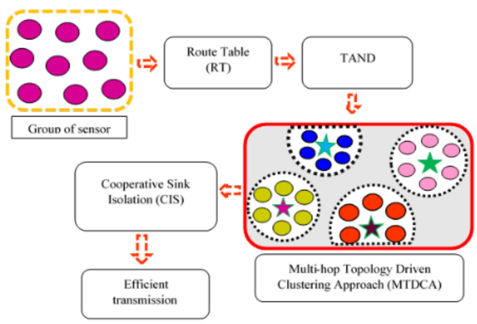

Fig. 2: Proposed Methodology

Based on the RT information, we utilize TAND for path search and estimation of DTSM for each sensor node.

These nodes are grouped using a topological clustering method to optimize routing. Priorities are determined based on the Max-Min DTSM. CIS is implemented across layers and is supported by DTSM to minimize transmissions and energy loss of WSNs as depicted in Figure 2.

Traffic Away Neighbour Discovery

In this section, the proposed Traffic Aware Neighbour Discovery (TAND) technique identifies every node's traffic based on the routing table. The method calculates the weight, angle, maximum data required, and number of data transmission rounds for each node. From this, the average traffic is calculated so that we can select a non-congested node. The below equation can be used to identify each node's weight is defined by equation 1,

$$N_{ei}(w) = N_n(\alpha * \delta * \beta + \Delta_i) \tag{1}$$

Where refers to each node weight (w), are non-negative node weight coefficient, denotes the degree difference of each node, and denotes the number of nodes within the network. To discovery the degree difference of every node,

$$\Delta_i = |g_d - N_n| \tag{2}$$

Here refers to the degree of node based on neighbour nodes. First, we analysis every node traffic rate is calculated by equation 3

$$T_c = 1 + \omega \tag{3}$$

Let us assume refers to the traffic heterogeneity factor on each sensor nodes. Then we analyze the every node packet size S (P) is calculated by equation 4

$$\mathrm{S(P)} = \sum_{i=1}^{N_n} \frac{Max(p)}{T_c} \tag{4}$$

Max(p) refers to the maximum allowable size in the network, and P refers to the packet.

$$T_r(P) = \sum_{i=1}^{r} \mathrm{S(P)}_i * N_n \tag{5}$$

Let's assume presents packet transmission round r, i refers to node iteration. The above equation 5 can be used to identify the packet transmission round.

$$Avg_{TR} = \sum_{i=0}^{N_n} \frac{T_r(P)}{r} \tag{6}$$

The above equation 6 can analyze the average traffic rate in the network. Thus, a node with a larger packet size will have a higher average traffic rate than the prior round.

Data Transmission Support Measure

Mobile nodes' energy is beneficial for communication in MANETs. When a source node utilizes a forwarding node to locate a path to a destination, it can assess the node's energy value based on its trust value along the path. The energy value of a mobile node is determined by its data transmission reliability, mobility, and energy consumption. The below equation can be used to analyze the node energy equation 7,

$$I_n(E) = A_m * V_g * T_e \tag{7}$$

Let's assume P refers to the packet, refers to current in ampere, denotes voltage, and denotes the time taken to packet (P) transmission in seconds.

$$I_n(P, i) = G_e(P, i) + G_e(P, A) \tag{8}$$

From equation 8 is employed to identify the packet transmission of spent energy from one node to neighbour node A. Where refers to energy spent to packet transmit from i to receive packet node A.

$$N_{dis} = \sqrt{((y1_i - y2_i)^2 + (z1_A - z2_A)^2)} \tag{9}$$

The above equation is used to analyze the distance normal node. Let assume, , , are current neighbour node positions (, A)

$$E_{cons} = \sum_i^{N_n} Ini_{el}(i) - Curr_{el}(i) \tag{10}$$

From equation 10 is employed to find the energy consumption. Here, refers to the initial energy level of node i and denotes the current energy level of the node.

$$U_E = \sum_i^{N_n}(I_n(E) + I_n(P, i)) - E_{cons} \tag{11}$$

The above equation analyses the node utilization energy data forward to the nearest node as much as possible.

$$T = \frac{N_{dis}}{Speed} \tag{12}$$

The above equation analyses the time (T) based on Node distance and speed.

The below algorithm provides efficient node selection for using the proposed Data Transmission Support Measure (DTSM). In the first step analysis, the packet sending rate factor an at time T and packet size of the time T. A node is a sleeping node if its value is less than the lower limit threshold =50. If the node's value exceeds the node's upper threshold limit=90, it can act as a malicious node. Value is 0 to 1. So, if the value of is close to the packet size, then the node is called the high trusted value because theis close to 1. Then the second step identifies the packet drop rate factor based on successfully received packets at time T and the number of packets sent at time T. Finally, step 3 analysis the trusted node . The range is 0 to 1 if the node value is 0, which refers to an untrusted node, while 1 refers

Algorithm 3: Cooperative Sink Isolation (CIS)

Input: Cluster Head (TD_{CH}) selection, $v_l(s)$, CH_l, $\boldsymbol{T_{node}}$, CH_{TE}
Output: Efficient data transmission from CH to BS

Start function
For each node i=1 to n, Then
Compute the distance between CH to BS (D_{BS})
$D_{BS} = \sum_{i=1}^{N_n} C_{disi} - BS_A$
Compute maximum energy (Max_{energy}) of CH and Trust node ($\boldsymbol{T_{node}}$)
$Max_{energy} = Max \sum_{i=1}^{N_n} U_{E(i)} * Max \sum_{i=1}^{N_n} T_{CH(A)}$
Compute minimum delay (Min (D))
Min (D) $= \frac{d_{delay}}{N_n}$
Calculate node density factor F_D
$F_D = \frac{1}{0.5\pi} \left[\sum_{i=1}^{B_E,CH_{TE}} T_{CH}\right]$
Compute node fitness function F_f
$F_f = \sum_{i=1}^{k} C_{dis} + D_{BS}$
If check lifetime (LT)
Compute node alive lifetime (LT)
LT=$Max(v_l(s), CH_l)$
Select maximum lifetime node
Else
Ignore node
End if
End for
Return efficient data transmission from CH to BS
End Function

to a trusted node for data forward. Refers to constant coefficient.

Multi-hop Topology Driven Clustering Approach

After selecting a trusted node at random, the MTDCA algorithm proposed in this section assists in identifying the best cluster head for transmitting data to the base station. The selection of the CH is based on the scaling function and the optimal number of clusters once the wake-up nodes are evenly distributed across the network area. The optimal number of groups is ensured because the total energy dissipation is low, and the residual energy per transmission is well distributed among all the network nodes. After the cluster is formed, each node collects and sends the data to the optimal CH.

$$CH_{TE} = I_n(N_{dis}, \mathrm{S(P)}) + U_E(\mathrm{S(P)}) + (\mathrm{S(P)}) \quad (13)$$

The above can be used to analyze the CH total energy dissipation, refers to node distance, denotes data aggregation, packet transmitted energy and utilization energy.

$$B_E = Ini_{el}(i) - [P(Ti) * T_r(P)] \quad (14)$$

The above equation is used to identify the residual energy, denotes initial node energy, denotes packet transmission range, and refers to the number of transmission rounds.

$$C_p = \sum_{i=1}^{N_n} \frac{\boldsymbol{T_{nodei}}}{N_n} \quad (15)$$

The above equation is used to identify the CH center point. Then calculate the average distance between normal nodes and is defined by the equation,

Algorithm 2: Multi-hop Topology Driven Clustering Approach

Input: Trust nodes ($\boldsymbol{T_{node}}$), C_{dis}, N_{dis}, B_E
Output: Cluster Head (TD_{CH}) selection

Start function
Import the Trust nodes ($\boldsymbol{T_{node}}$)
For each node i=1 in n, do
Calculate the minimum distance between normal nodes and C_{dis} (Min_{dis})
$Min_{dis} = \frac{C_{dis}}{N_{dis}}$
Identify the residual energy using the equation
Calculate latency for data transmission (d_{delay})
$d_{delay} = (P_{trans} + P_{pro} + P_{delay})$
Calculate the total energy of the network (T_{CH})
$T_{CH}(T) = \sum_{i=1}^{N_n} B_E(T)$
Calculate the CH threshold value (TD_{CH})

$$TD_{CH} = \begin{cases} \frac{p(s)_{op}}{1 - p(s) * \left(r \bmod \frac{1}{p(s)}\right)} * \frac{B_E(T)}{T_{CH}(T)} \\ 0 \quad otherwise \end{cases}$$

End for
Return optimum Cluster Head (TD_{CH}) selection
End Function

$$C_{dis} = \sum_{i=1}^{N_n} ||N_{dis} - C_p|| \quad (16)$$

The above algorithm selects an energy efficiency clustering with high residual energy and low energy dissipation value as the CH. In the first step, calculate the minimum distance between the trusted node and the average distance based on a central point. The second step identifies the residual energy using the equation. The fourth step is to compute end-to-end latency using packet transmission , refers to propagation, refers to processing delay. Then step four calculate the total energy of the network with high power will become CH. Finally, step five compute the CH threshold value () based on is refers to the probability of optimal CH selection refers to the number of optimum CH selection, and refers to the current round. The selected CH should be less than a threshold value between 0 and 1. The proposed method identifies the routing structure to forward the packet transmission from CH to the base station (BS).

Cooperative Sink Isolation

After the CH is selected, the CHs receive information from their respective cluster members, and the CHs forward the information to the BS using the proposed CIS algorithm. The information obtained by the proposed method is prioritized based on the minimum and maximum DTSM and processed to the cross-layer to guide the transmission with DTSM support. The equation below calculates the lifetime of the source, and the lifetime of is defined by equations 17 and 18,

$$v_l(s) = \frac{B_E(s)}{T_{CH}(s \to CH)} \quad (17)$$

$$CH_l = \frac{B_E(CH)}{T_{CH}} \quad (18)$$

Let's assume denotes energy residual of source (s), refers to the total energy.

The below algorithm efficiently transmits information from CH to BS based on the minimum and maximum DTSM. In the first step, compute the distance between CH and BS. The second step calculates the maximum energy utilization of both CH and trust nodes. The third step is that the minimum delay for packet transmission from CH to BS should be ringing 0 to 1. The fourth step is node density factor using energy residual () and total energy dissipation with constant values. The fifth step is to compute node fitness function its range (0, 1) based on the average distance between the trusted node and centre point. Finally, compute node alive lifetime (LT) based on the maximum lifetime of the source and a lifetime of . The proposed CIS method efficiently data transmit from CH to BS.

Algorithm 3: Cooperative Sink Isolation (CIS)

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  $Max_{energy} = Max \sum_{i=1}^{N_n} U_{E(i)} * Max \sum_{i=1}^{N_n} T_{CH(A)}$
  Compute minimum delay (Min (D))
    Min (D) $= \frac{d_{delay}}{N_n}$
    Calculate node density factor F_D
  $F_D = \frac{1}{0.5\pi} [\sum_{i=1}^{B_E, CH_{TE}} T_{CH}]$
    Compute node fitness function F_f
  $F_f = \sum_{i=1}^{k} C_{dis} + D_{BS}$
    If check lifetime (LT)
    Compute node alive lifetime (LT)
    LT=$Max(v_l(s), CH_l)$
  Select maximum lifetime node
      Else
        Ignore node
    End if
  End for
  Return efficient data transmission from CH to BS
End Function

Simulation Result and Analysis

This section shows the simulation results using Network Simulator version 2 (NS2) on Windows 10 with 8GB RAM. It compares the performance of the proposed Cooperative Sink Isolation-Multi-Hop Topology Driven Clustering Approach (CIS-MTDCA) to previous techniques, including the Fuzzy Clustering Algorithm (FCA), Threshold-oriented, and Energy-harvesting enabled Multi-level Stable Election Protocol (TEMSEP).

Table 2. Simulation parameters used

Simulation Parameters	Description about parameters
Simulation Tool	NS2
Number of nodes	100
Deployment	Randomly
Channel type	Wireless
Packet size	512 bytes
Area length and width	1000*1000 m
Propagation	Two Ray Ground

Simulation parameters and their description of parameter values to maximize the network lifetime present in Table 2.

Parameter evaluation

$$\text{Packet Delivery Ratio (PDR)} = \sum \frac{pd}{pS} * 100 \quad (19)$$

Here, denotes the number of packets delivered and refers number of packet sent from host and peer end.

$$\text{End to end delay} = \sum \frac{R_t(P) - S_t(P)}{N_n} \quad (20)$$

Here, refers to packet received time, denotes packet sent time and refers to number of nodes.

$$\text{Throughput} = \sum \frac{S^T}{T} * 100 \quad (21)$$

Here, denotes the successfully transmitted packets from host at time.

Throughput ensures message delivery and improved network connectivity enhances performance. As depicted in Table 3, performance naturally rises with an extended network lifetime. The efficiency of the proposed CIS-MTDCA structure is 90%, while the existing TEMSEP method is 81% and the FCA algorithm is 78%.

Table 3: Evaluation of throughput performance

Performance in %			
Number of sensor nodes	FCA (S. Lata et al. [10])	TEMSEP (Abdul-Qawy et al. [20])	CIS-MTDCA
20	47	54	70
40	57	63	74
60	63	75	79
80	73	79	84
100	78	81	90

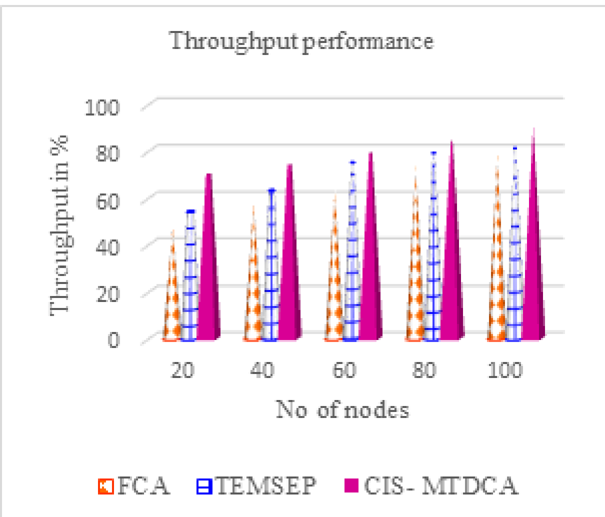

Fig. 3: Comparison of throughput performance

Comparison results indicate that the proposed CIS-MTDCA algorithm outperforms other methods concerning throughput performance, as presented in Figure 3. This integrates trust node identification, energy-efficient CH selection, average traffic identification, and CH selection for optimized routing. The CIS-MTDCA algorithm establishes all sensor nodes to eliminate untrusted nodes and improve performance. Efficient clustering and routing assure high transmission reliability and efficiency.

Table 4: Result for PDR performance

Performance in %			
Number of sensor nodes	FCA (S. Lata et al. [10])	TEMSEP (Ab-dul-Qawy et al. [20])	CIS-MTDCA
20	46	51	70
40	57	65	74
60	64	71	78
80	71	76	85
100	76	80	89

PDR is the ratio of received packets at the destination to the total sent by the source. Table 4 compares the PDR performance of the new algorithm with existing ones.

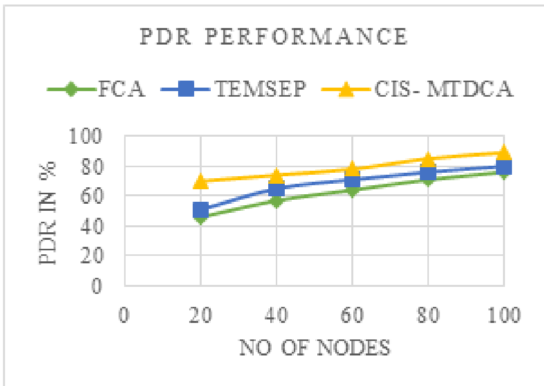

Fig. 4: Result for PDR performance

Figure 4 illustrates the packet delivery rates of the proposed CIS-MTDCA approach compared to existing models. The CIS-MTDCA approach has demonstrated excellent packet delivery rates. Optimal CH elected enhances communication efficiency and packet delivery rates. Thus, data will be transmitted before expiration, elevating the packet delivery rate. The proposed PDR result is 89%. Similarly, the existing FCA algorithm has a 76% efficiency result, and the TEMSEP algorithm has an 80% PDR efficiency.

Table 5. Evaluation of energy consumption performance

Performance in %			
Number of sensor nodes	FCA (S. Lata et al. [10])	TEMSEP (Abdul-Qawy et al. [20])	CIS-MTDCA
20	43	35	30
40	54	43	34
60	61	51	39
80	67	60	43
100	72	65	46

The energy consumption efficiency analysis results are displayed in Table 5. The new algorithm demonstrates lower energy consumption compared to traditional approaches.

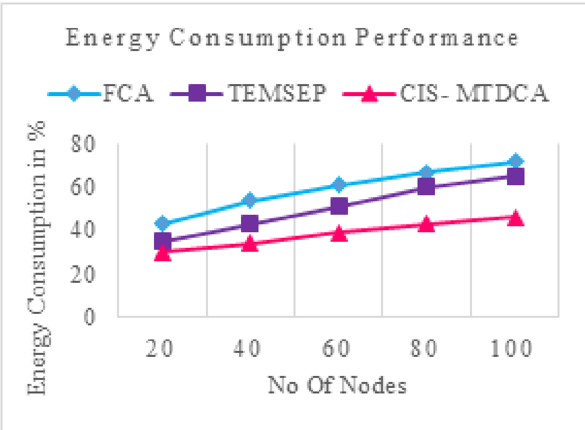

Fig. 5: Impact of energy consumption

The energy consumption performance analysis is depicted in Figure 5. The CIS-MTDCA technique aims to reduce energy consumption by minimizing data conflicts. Our research introduces CIS-MTDCA for efficient energy usage in routing, enabling immediate single-routing operations. The proposed CIS- MTDCA algorithm stands at 46%, the existing TEMSEP algorithm at 65%, and the FCA algorithm at 72%.

The network lifetime is the duration until the first or last node is depleted. Table 6 displays network lifetimes in milliseconds.

The proposed algorithm outperforms existing ones, as depicted in Figure 6. Based on the comparative results, the proposed CIS-MTDCA technique demonstrates superior performance compared to previous techniques regarding network lifespan. This research suggests that deploying sensor nodes using the DTSM approach can enhance the network, decrease energy usage, and prolong its lifespan. It achieves a network lifetime performance of 145ms, surpassing the FCA algorithm's 75ms and the TEMSEP algorithm's 123ms.

Table 6: Exploration of network lifetime performance

Performance in %			
Number of sensor nodes	FCA (S. Lata et al. [10])	TEMSEP (Abdul-Qawy et al. [20])	CIS-MTDCA
20	36	45	76
40	45	69	88
60	57	81	106
80	62	97	128
100	75	123	145

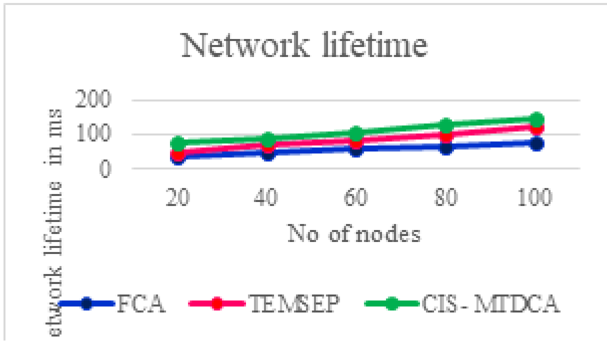

Fig. 6: Result for network lifetime

Table 7 shows the delay performance analysis of the comparison results between the proposed method and existing methods. The proposed algorithm has a lower latency performance than the previous algorithms.

The latency performance comparison graph's analysis results are depicted in Figure 7. The proposed CIS-MTDCA algorithm requires 16.3ms. The CIS-MTDCA algorithm proposed aims to improve routing efficiency to minimize latency. To enhance the selection of the shortest and most secure data transmission path and decrease latency. In comparison, the current algorithm TEMSEP exhibits a latency of 21.3ms and an FCA latency of 26.9ms.

Conclusion

This paper concludes by presenting a CIS that optimizes the EALTM of WSNs using MTDCA to address the issue of increasing NL of WSNs. The method deliberates the energy of various nodes and the past transmission history from the RT. Using the RT information, a route

Table 7: Exploration of End-to-end delay performance

Performance in %			
Number of sensor nodes	FCA (S. Lata et al. [10])	TEMSEP (Abdul-Qawy et al. [20])	CIS-MTDCA
20	8.3	7.8	4.2
40	10.2	9.3	7.4
60	41.8	11.6	10.1
80	19.4	15.3	13.7
100	26.9	21.3	16.3

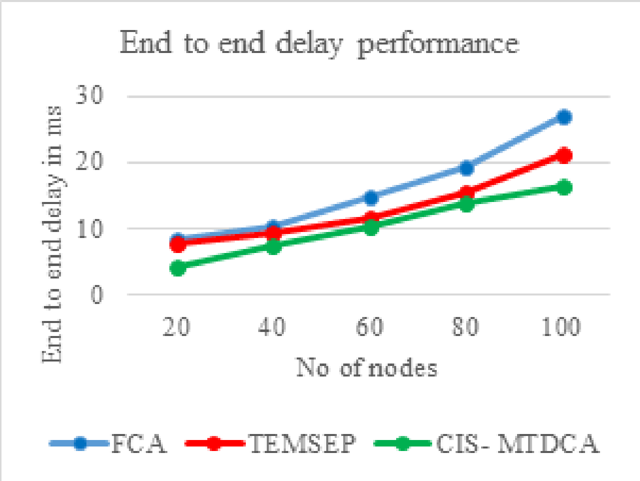

Fig. 7: Performance of End-to-end delay analysis

search is conducted using TAND, and the DTSM estimate of each sensor node is calculated. The MTDCA algorithm selects the CH based on energy, traffic, and speed, and then forwards the data sent by the cluster members to the base station. The presented simulation results are throughput has 90%, PDR has 89%, energy consumption has 46%, Network Lifetime (NL) has 145ms, and latency has 16.3ms. The proposed experiment results provide better performance compared with previous techniques. In this future work, a multipath optimization protocol will be used to enhance the lifespan of WSNs. Efficient energy management and data aggregation will prolong the WSNs' lifespan while ensuring dependable data transmission.

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