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Energy-Efficient Multihop Routing in IoT-Assisted WSN Using Multi-Objective Sandpiper Optimization

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Abstract: *A Wireless Sensor Network (WSN) is a loosely connected network of tiny computers that detects physical properties including vibration, humidity, and temperature. They consist of a few to hundreds of wireless sensor nodes. Most sensor networks have a sink or base station to connect them to the outside world. Sensor nodes have tiny resources. The research is to develop multi-objective clustering algorithm with Sandpiper Optimization (SPO) and incorporating a multihop routing technique, the initial step involves defining the specific optimization problem*

Keywords*:* WSN, Energy Optimisation, Multihop Roting

I. INTRODUCTION

Wireless Sensor Network (WSN) has evolved as a modern sensing and most redundantly used technology which is utilized by industries and people alike to deal with their daily activities right from smart wearable sensors, household appliances to smart automated industrial environments. As an enhanced version of wireless communication, WSN are interconnected networks encompassing various sensor nodes that are cost effective, consumes less power and capable of sensing, collecting and processing the information acquired from the targeted environment along with monitoring. The collected information is then transmitted to sinks through single or multi-hop communication which acts as a bridge between users and the network analyzes and processes it either locally or distributes through internet across the connected gateways.

The wireless connections are unplanned. Unlike other wireless networks, such as Wi-Fi hotspots, WSNs are not meticulously planned to connect flawlessly and have unique service quality standards. Instead, it's thought that each of them seeks to find its siblings and share the bare minimum of knowledge with them. As a result, WSNs can be deployed (installed) easily and with little awareness of the surrounding world. Current experience with actual WSNs, as well as certain theoretical roots, assist in the construction of more stable and self-sustaining networks than merely distributing them in the environment. The initial vision of launching sensor nodes from an airplane to map thousands of square kilometers remains a pipe dream. The sensor network identifies a phenomenon and must relay the information to an external person. There's still plenty to detect outside: humidity, temperature, sound, acceleration, sun radiation, rain, toxic compounds, and so on. The sensor nodes' restricted resources preclude them from processing the data thoroughly locally.

Hierarchical Wireless Sensor Network (HWSN) has been used in a variety of uses, including national security, hospitals, and environmental monitoring, to provide high-quality support to humans. Wireless sensors have the benefits of being inexpensive and lightweight. Because of their small scale, wireless sensors have little battery life. As a result, sensors are prone to failure in harsh environments.

Related Work

Many studies have been conducted in this area; (Praveen *et al.* 2020) proposed that WSNs show the efficiency of traffic distribution on multipath to satisfy the user's standard of service requirements using existing multi-charging schemes. A metric assessment has been proposed to evaluate and classify a series of relation disjoint routes from all the access paths. Using a threshold sharing algorithm, the packets are split into separate segments that can be sent to the destination in a variety of ways depending on the path vacancies. Simulations show that the modular and stable routing architecture is effective for a variety of load balances (Schweitzer *et al.* 2016). The MANET was discussed, as it seems to be vulnerable to multiple attacks.

Nilabarnisha *et al.* (2019) wireless networking advancements and electronic device miniaturization has aided the production of low-cost, low-power, multifunctional sensors in recent years. They are lightweight devices that are used for un tethered short-range communications. Sensor nodes are self-governing machines that can sense, process, and transmit information.

For wireless sensor networks, (Shen *et al.* 2020) suggested a Modified QoS improved base station managed dynamic clustering protocol that can effectively minimize energy consumption. The effect of partly correlated data on the efficiency of clustering algorithms was suggested by BenSale *et al.* (2020). Using a combination of random geometry techniques and rate-distortion theory, the overall energy consumption and network lifespan can be calculated. It also shows how compression distortion and data correlation are related. The suggested analysis was general, meaning it could be used for a wide range of random clustering algorithms.

Savad *et al.* (2019) The basic routing system satisfies many QoS metrics while still ensuring low energy consumption. Place, data-centric, and hierarchical routing protocols are the three major types of routing protocols.

Elappila*et al.* (2018) some survey articles in the literature deal with the coverage problem in WSNs. However, none of the current articles, to our knowledge, study, evaluate, and offer a concise overview of all features that encompass all aspects, as well as classify the coverage issues in their entirety. The majority of these surveys classifies only a subset of features and ignores the rest.

Arjunan et al. (2018) conducts research on the relationship between coverage and connectivity in wireless sensor networks (WSNs). The coverage protocols that are being discussed in this review may be broken down into three distinct categories: coverage distribution techniques, sleep time mechanisms, and coverage radius protocols that allow for customisable coverage distance.

AlShahwan *et al.* (2018) standardised OLSRv1 using RFC 3626. OLSRv1, built for MANET routing, constructively exchanges topological information between nodes. OLSRv2 also simplifies node communication and scales signalling. OLSRv2 compactly stores IPv4 and IPv6 addresses. OLSRv2 standardisation is being led by a diverse group. The typical MP-OLSRv2 multipath extension was proposed.

Wei (2019), an exhaustive study of an energy-efficient method and simulation for wireless sensor networks. This study uses clustered routing protocol. The method aims to improve cluster head selection and multi-hop routing to reduce energy consumption and enhance network performance. K-means and FAH (KAF) is a new algorithm presented in this research. This technique was created to boost wireless sensor network energy efficiency. This technique uses a performance-optimized clustering structure and routing mechanism.

Fakhrosadat Marjan Rafsanjani (2019), Using clustering in wireless sensor networks to save energy. This work completely analyses several clustering algorithms and cluster-based routing systems. Clustering algorithms and cluster-based multi-hop routing protocols are thoroughly examined in this work. Division of approaches into four groups based on technical approach.

Aaditya Akanksha, *et al.* (2019) use clustering to reduce energy consumption by consolidating and aggregating data at intermediary layers to extend wireless sensor network operational duration. Clustering methods without dimension limitations. User text doesn't give rewriteable information. This study investigates data clustering methods with different cluster sizes.

II. RESEARCH METHODOLOGY

This research introduces a new MOSPO-CMR approach for clustering and routing in an IoT-enabled WSN. MOSPO-CMR involves clustering and optimum route selection. In the first step, MOSPO-CMR creates a fitness function using RES, DIST, and NDEG. Next, the MOSPO-CMR approach creates an objective function with two variables, RES and DIST. Figure 1 shows the MOSPO-CMR block diagram.

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Seabirds like sandpipers live worldwide. Sandpiper colonies are common. Cognitive abilities allow the creature to find and engage prey. Sandpipers' migratory and predatory qualities are essential to their nature. Sandpipers migrate seasonally to find nutrient-rich and energy-rich food. Sandpipers often attack migrating birds when travelling by water. External assaults can cause spiral natural shape.

The language used to describe these performances indicates a connection to objective functions that optimise results. It's feasible to create a new optimal methodology. Sandpipers exhibit two natural behaviours in this research.

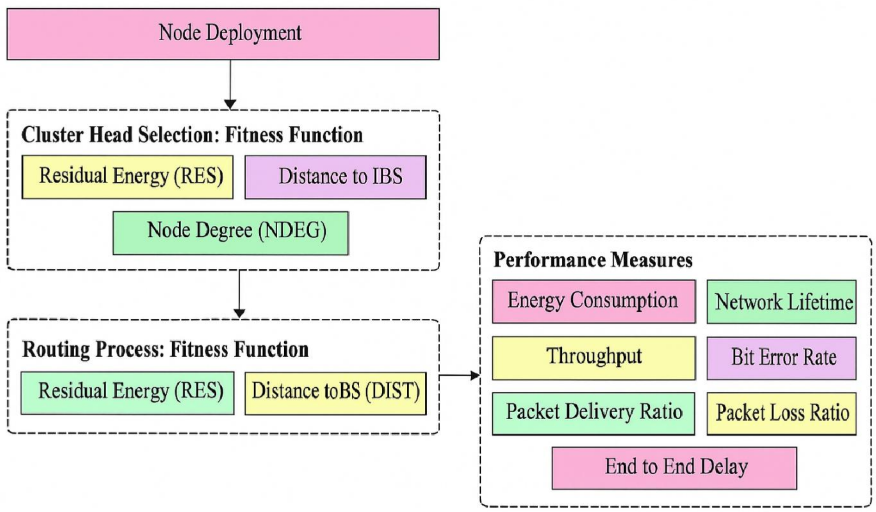

Figure 1 Research methodology

Pseudo Code for Routing Process using SPO Algorithm

Algorithm: Multi-Objective Sandpiper Optimization-Based Routing for IoT-Assisted WSN

Input: Network topology parameters (nodes, sink, communication range)

Output: Optimized routing table with minimum energy consumption and maximum network lifetime

```
Initialize network parameters and topology
Initialize sandpipers with random positions (routes)
Set iteration counter t = 0
Define maximum iterations (Max_iter)
 while (t < Max_iter) and (stopping_condition not met) do
     for each sandpiper i in population do
         Evaluate fitness fi using the objective function:
             fi = f(residual_energy_i, distance_to_sink_i)
         Update position of sandpiper i using:
             x⃗_i(t+1) = x⃗_i(t) + v⃗_i(t+1)
         Update velocity according to Sandpiper Optimization (SPO) rule:
             v⃗_i(t+1) = w * v⃗_i(t)
                      + c1 * r1 * (p⃗_i,best(t) − x⃗_i(t))
                      + c2 * r2 * (g⃗_best(t) − x⃗_i(t))
         Perform exploration and exploitation to balance search
         Enable local communication among neighboring sandpipers
```

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Update positions based on shared information
end for
Update global best solution g⃗_best(t) based on current performances
Update routing table using the global best path
Adapt dynamically to network changes (e.g., node failure, residual energy drop)
Increment iteration counter: t = t + 1
end while
Return optimized routing table with the best routes

Mathematical Representation:
Fitness Function:
$f_i = f(residual\_energy_i, distance\_to\_sink_i)$
Position Update:
$\vec{x}_i(t+1) = \vec{x}_i(t) + \vec{v}_i(t+1)$
Velocity Update (Sandpiper Optimization Rule):
$$\vec{v}_i(t+1) = w \cdot \vec{v}_i(t) + c1 \cdot r1 \cdot (\vec{p}_{i,best}(t) - \vec{x}_i(t)) + c2 \cdot r2 \cdot (\vec{g}_{best}(t) - \vec{x}_i(t))$$
where:
w → *inertia weight*
$c1, c2$ → *acceleration coefficients*
$r1, r2$ → *random numbers in [0, 1]*
$\vec{p}_{i,best}(t)$ → *personal best position of sandpiper i*
$\vec{g}_{best}(t)$ → *global best position among all sandpipers*

III. RESULT ANALYSIS

This section compares MOSPO-CMR results to modern methods, considering numerous factors. Figure 2 thoroughly compares the MOSPO-CMR approach to other ECM methods. The MOSPO-CMR approach produced less extracellular matrix (ECM) than other methods. When applied to a 100-node network, the MOSPO-CMR approach has the lowest energy consumption metric (ECM) of 10mJ.

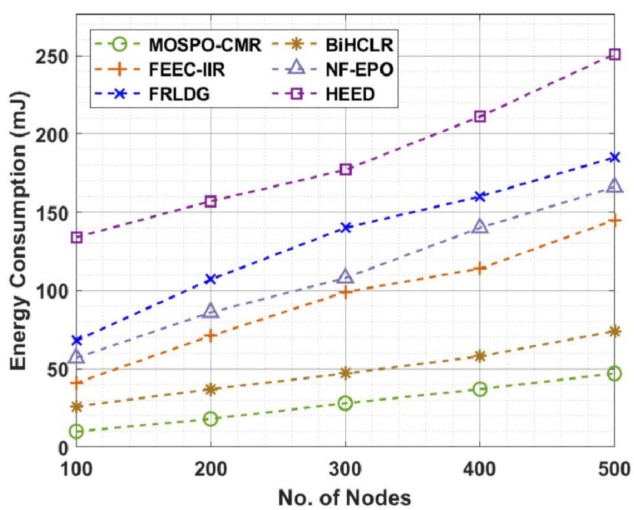

Figure 2 Comparative ECM of MOSPO-CMR with existing models

NLFT-focused comparisons of the MOSPO-CMR approach with other node methods are shown in Figure 3. The MOSPO-CMR approach has greater NLFT values than the others. MOSPO-CMR has shown an increased Non-Linear Feedback Shift Register (NLFT) of 5410 rounds in a 200-node network.

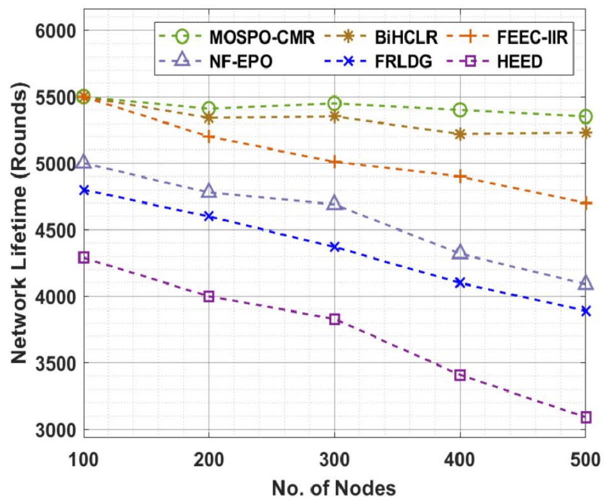

Figure 3 Comparative NLFT of MOSPO-CMR with existing models

Figure 4 compares the MOSPO-CMR THRP to modern approaches across nodes. The graphic shows that MOSPO-CMR produces better THRP values than other methods. MOSPO-CMR increased performance by 0.9943Mbps in a 100-node network. With 500 nodes, MOSPO-CMR achieved 0.9542 Mbps Throughput Rate (THRP).

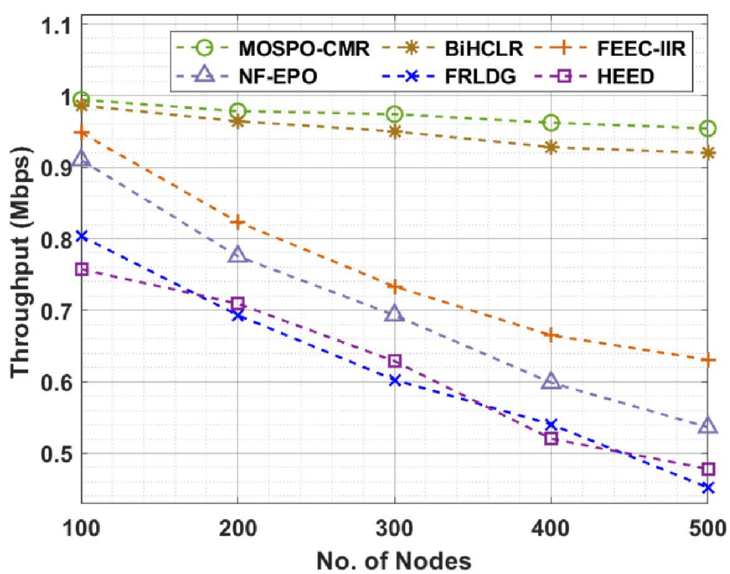

Figure 4 Comparative THRP of MOSPO-CMR with existing models

IV. CONCLUSION

This research work introduces a new MOSPO-CMR approach for clustering and routing in an IoT-supported WSN. MOSPO-CMR involves clustering and optimum route selection. The MOSPO-CMR approach creates a fitness function for CH selection using RES, DIST, and NDEG. The MOSPO-CMR method also determines an objective function with two variables, RES and DIST. Several multidimensional simulations were run to assess the MOSPO-CMR technique's improved results. The MOSPO-CMR technique outperformed other modern approaches in some assessment measures. Future hybrid metaheuristic techniques can improve IoT-supported Wireless Sensor Networks.

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