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Research Article

An Effective Wireless Sensor Network Routing Protocol Based on Particle Swarm Optimization Algorithm

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Improving wireless communication and artificial intelligence technologies by using Internet of Things (Itoh) paradigm has been contributed in developing a wide range of different applications. However, the exponential growth of smart phones and Internet of Things (IoT) devices in wireless sensor networks (WSNs) is becoming an emerging challenge that adds some limitations on Quality of Service (QoS) requirements. End-to-end latency, energy consumption, and packet loss during transmission are the main QoS requirements that could be affected by increasing the number of IoT applications connected through WSNs. To address these limitations, an effective routing protocol needs to be designed for boosting the performance of WSNs and QoS metrics. In this paper, an optimization approach using Particle Swarm Optimization (PSO) algorithm is proposed to develop a multipath protocol, called a Particle Swarm Optimization Routing Protocol (MPSORP). The MPSORP is used for WSN-based IoT applications with a large volume of traffic loads and unfairness in network flow. For evaluating the developed protocol, an experiment is conducted using NS-2 simulator with different configurations and parameters. Furthermore, the performance of MPSORP is compared with AODV and DSDV routing protocols. The experimental results of this comparison demonstrated that the proposed approach achieves several advantages such as saving energy, low end-to-end delay, high packet delivery ratio, high throughput, and low normalization load.

1. Introduction

Wireless sensor networks (WSNs) have recently become among the most important techniques in the world. WSN is a wireless network system that self-organizes, recognized through numerous energy- restricted micro sensors and at least one sink base station (BS) [1–3]. A WSN is made up of large, low-power sensor nodes that are intelligent with a

high-power sink that is personally responsible for building pathways between themselves while adhering to particular transmission rules. The development of wireless sensor technologies sparked Internet of Things (IoT) is required in today's world applications, ushering in a new era of pervasive and intelligent IoT applications [2]. The IoT comprises numerous inventions that provide a consistent network, everywhere, and about everything [4]. The IoT is being used in various applications, including military, monitoring systems, smart buildings, agriculture, and smart cities [5, 6]. WSNs may now build spontaneous connections betwixt devices with or without any infrastructures thanks to recent advancements in ad hoc wireless technology [7]. Furthermore, WSNs have also evolved the most important part of the smart city with IoT environments, utilizing intelligent devices that might be tailored and automatic constructed by the WSN sending, receiving, and sharing data on a very limited region. Wireless technologies of the next generation are on expecting to enable large numbers of connections and produce the highest data rates with decreased energy consumption and transmitting latency [8–16]. With the growth of IoT and WSN, IoT devices are widely used in intelligent industries [17–28]. IoT devices, on the other hand, have limited computational resources and energy [29–44]; therefore, the advancement of IoT devices has created enormous challenges for the IoT system. The sensor node sends the sensor information to the (BS) for further processing in several IoT applications [23]. This is accomplished by using efficient routing algorithms in WSNs to improve the network and make it more profitable by improving data transmission, scalability, and energy efficiency, making the network more viable [2]. On the other hand, there are numerous obstacles in building an effective communication that is resourceful routing protocol for WSNs/IoT, such as the unreliability of low-power wireless networks and restricted resources, which are typically lacking in terms of QoS needs. Due to the dynamical and self-organizing nature of WSNs, connection between devices with one another via wireless channel and the typical routing technique is inapplicable due to the topology's high dynamic characteristic. Thus, these models were only concerned with basic routing requirements. As a result, when developing routing protocols, researchers face numerous challenges [45–49]. Still, there is now an urgent need for developing routing protocols to maximize network lifetime, improve essential QoS requirements, and enable additional features that include a high-packet delivery ratios, low latency, information security, energy effectiveness, and flexible network topology [45]. Furthermore, the aforementioned requirements in the preceding line, establishing a multipath-aware routing protocol based on intelligent optimizations techniques, is still an essential prerequisite for many IoT applications [51–53].

Swarm intelligence [46] is a relatively new field well defined as the work we put effort into developing a distributed problem-solving algorithm that is based on social insect collective behavior. Currently, sensor appliances actually require networking solutions that are low in cost and complexity while simultaneously increasing reliability. Alterna-

tively, the route problem can commonly be represented including a multidimensional optimization issue in which throughput must be maximized while latency is minimized. In recent years, many bioinspired evolutionary techniques (swarm intelligence) have piqued interest, as an instance Ant Colony Optimization (ACO) and PSO, for determining optimal paths in WSN-based IoT applications [55–59]. The basic idea underlying these algorithms is to calculate the cost/fitness iteratively and calculate a function over a population initially and the cost or the fitness on a fresh population, usually acquired by performing operations to populations. Finally, we can determine the optimal solution by weighing all options against the best option. The most effective solution provides us with the population's optimal values, which may be utilized to determine the best routing path.

A unique multipath routing protocol is given in this work, which can utilize the Particle Swarm Optimization (PSO) approach to generate several pathways. The protocol is named as Multipath-based Particle Swarm Optimization Routing Protocol (MPSORP) to improve QoS in WSN for IoT applications. Figure 1 depicts the structure of a WSN for IoT applications. The diagram depicts how sensed data was delivered from the source to the end-user via a multihop path and gateway. This allows end users to access data anytime and from any location. Based on the calculation of a fitness function that may be used to locate the optimal routing path [47], the protocol enables for a source node to choose the best path to data transmission from a collection possible path identified.

The proposed protocol MPSORP is an improvement over traditional Destination- Sequenced Distance Vector (DSDV) routing protocol to consider multiple paths instead of a single path. Furthermore, MPSORP provides the optimization mechanism select optimal path to the destination nodes with achieve more load balancing and high QoS while maintaining power conservation. Generally, the structure of Mobile Ad Hoc Network (MANET) is not self-organized [48]. Still, we can make it as self-organized as possible with the assist of computational intelligence-based methods for instance swarm intelligence. A new optimized routing solution known as MPSORP was proposed to address these issues, which can improve performance QoS measurements in WSN-based IoT applications, such as average end-to-end delay, packet delivery ratio, bandwidth, and packet loss. WSN-based IoT applications have additional hurdles, for instance, high bandwidth requirement, minimal delay, real-time delivery, suitable jitter, and low packet loss ratio, in addition to the challenges posed by WSNs in term of energy limitation, deployment, coverage, and reliability. These features impose much more resource limits, including energy usage, memory, bandwidth, and computing capability [49].

In this paper, we chose this method since it is well suited to our problem. This is known as a population-based search method inspired by flocking bird social behavior or schooling fish. The performance of the suggested approach was evaluated by comparing them with the DSDV and Ad Hoc On-Demand Distance Vector (AODV) protocols using the Network Simulator NS-2 [50, 51].
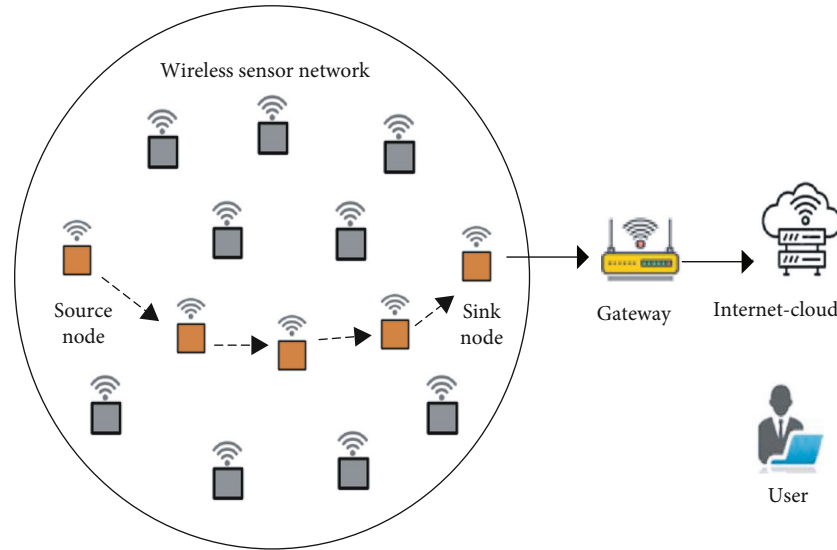
FIGURE 1: Structure of WSN-based IoT applications.

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phase one :[ Initialization Phase]
for (x =0 to number of solutions or populations). for (n =0 to number of sensor nodes).
Arbitrarily solutions are selected. Calculate new route using solution. End for .
Calculate fitness value of initialized solution. Calculate global best and Local best.
End for .
phase two :[Update Phase] while criteria does not match
for (x =1 to number of solutions)
for (n =1 to number of sensor nodes). update solution using PSO update equation. Generate new path based on update solution. End for.
Calculate fit-ness value for updated route. Calculate global best and local best.
End for.
Note the global best End while.
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PSEUDOCODE 1: Pseudocode- (PSO-) based routing algorithm.

The PSO algorithm was chosen for this investigation for a variety of reasons, including the following: to begin, its operating principle is based on swarm intelligence, which is applicable to the problem we are attempting to solve. Second, the idea of PSO is to combine the collective memory of the entire swarm with individual recollections. Moreover, PSOs can search very large spaces for candidate solutions and use these on optimization problems that are partially irregular and noisy and change over time. Also, it is a fast algorithm and requires less memory compared with other optimization algorithms and is easy to implement. Third, among the mentioned approaches, in PSO, the solution of a particular problem is being represented with the aid of a multidimensional role of a particle and a swarm of particles is working collectively to search the first-class role which corresponds to the satisfactory problem solution, so that the PSO approach is applicable to the disciplines of discrete and combinatorial optimizing. Fourth, PSO is a population-based stochastic search approach that does not use the gradient of the issue being optimized; hence, it does not require the optimization problem to be substantially differentiable, as standard opti-

mization techniques do. As a result, it can also be used in partially irregular, time-variable, and noisy optimization situations. Fifth, the simulation results for several recent researches show that PSO is a reliable method to optimize the WSN for multipath routing, because this method achieves faster convergence and gives more accurate results than nonoptimized Hopfield Neural Network (HNN), noisy HNN, shortest path (SP) algorithm, Genetic Algorithm, ACO, and new research in this field [47, 49, 52–54]. Sixth, PSO is an optimization method that is extremely simple, effective, and efficient. PSO is often used to investigate the search location. It is fairly simple to construct and can be used for both scientific study and engineering purposes. It has a higher optimization capability and can accomplish tasks quickly. PSO is a more robust and simple solution for serious environmental monitoring and data aggregating challenges [55]. The section goes over the literature review of multipath routing approaches and the methods' drawbacks as the reason for this study. This section includes an investigation of existing methodologies, which motivated the researcher to develop an effective and optimal multipath routing system.
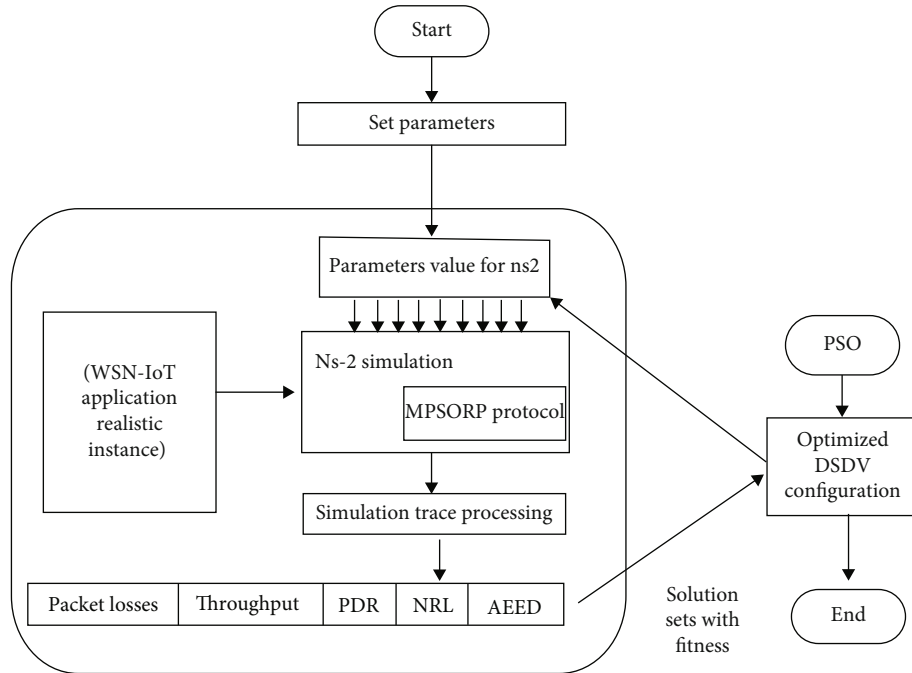
Figure 2: The optimization framework multipath using PSO.

Table 1: Simulation of parameters.

| Parameter	Value
Mobility model	Random way-point
Simulator	NS 2.34
Number of nodes	25
Area of simulation	500 k m ∗ 500 km, wide
Simulation time	3600 second
Speed	Varying from 0.006 m/s to 0.47 m/s (ocean env)
Pause time	300 second
Traffic type	Constant bit rate (CBR)
Data packet length	70 bytes
Connection rate	0.05 to 4 packets per second
Routing protocol	MPS-ORP, DSDV, AODV
Radio-propagation model	Two-ray-ground
Interface queue type	Drop-tail/Pri-queue
Maximum packet in queue	150
Network interface type	WirelessPhy/802_15_4
MAC type	802_15_4
Antenna type	OmniAntenn
Transmitting power (pt_)	0.001 Watts
Receiver threshold (RXThresh_)	$3.981e - 13$ Watts
Capture power threshold (CPThresh_)	10 dB
Carrier sensing threshold (CSThresh_)	$3.981e - 13$ Watts
Operating Freq (freq_)	$2.4e + 9$ GHz
System loss factor (L_)	1.0
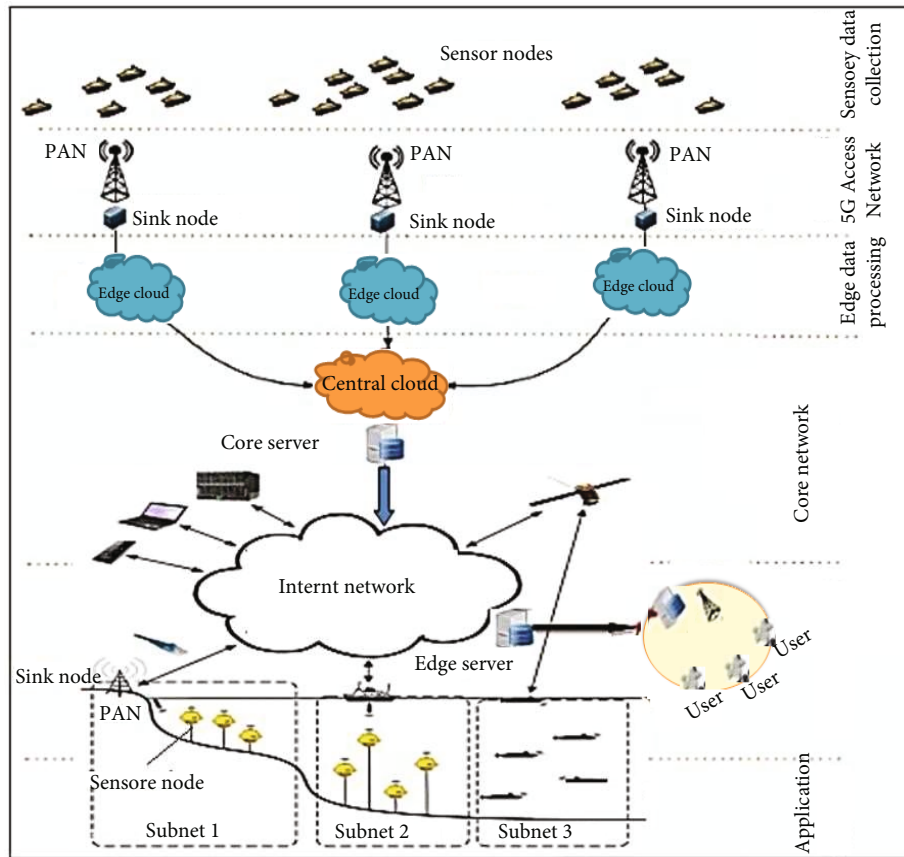
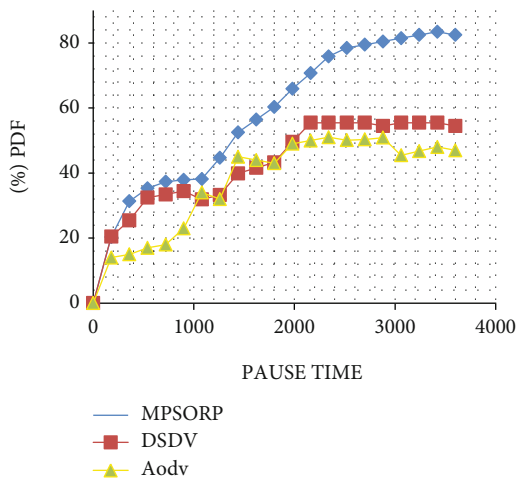FIGURE 3: Proposed system model of Internet oceanic of things.

FIGURE 4: Packet of delivery ratio versus pause time.

2. Background

The basic target of routing protocol structure is to decrease energy usage by determining the most efficient paths between source and destination. As a result, the researcher's task has been to create an energy effective routing protocol with better QoS parameters, as shown in [55–57]. As a result, several studies have been proposed by academics and academicians in order to determine the best way while taking into account QoS metrics like throughput, Packet Delivery Fraction (PDF), and delay [58].

Liu et al. proposed an accurate multipath routing protocol with two-path selection matrices assumed link stability and the value of time constraints into account, resulting in low link interruption probability and delay [59].

The authors in [60] propose an MDW (multipath DSDV-based routing protocol) for WIA-PA (Wireless Networks for Manufacturing Automation-Process Automation) network. It adopts the routing choosing criterion based on the link stability and the disjoint node strategy. Their method showed enhanced results compared to DSDV multipath (DSDVM) over QoS metrics: PDF, the average end-to-end delay, and the average remaining energy the route, but this is limited by static network and no consideration of mobility or other hard environmental condition in the evaluation of protocol.

The authors in [61] propose the Neighbor Coverage Multipath DSDV (NCMDSDV). Implementing two fields called "Second-hop" and "Link-id" in the routing table generates nonlinked pathways betwixt the source and destination nodes. According to findings, the multipath DSDV offers a higher throughput and packet delivery ratio. It is faster in comparison because it has a shorter end-to-end delay and less packet loss.
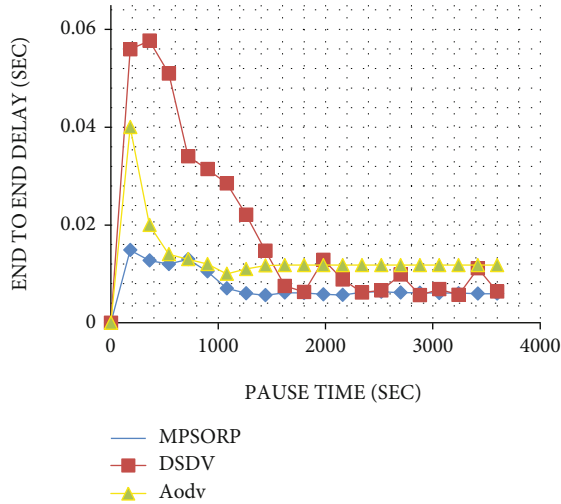
FIGURE 5: Aver-age end-to-end delay versus pause time.

Two multipath routing protocols (M-AODV and MD-SDV) were examined in [62] in order to keep improving QoS for real-time multimedia applications in MANET. The outcomes showed that MDSDV performs well in certain situations (network load and reliability for large-scale networks). Furthermore, regardless of the number of nodes in medium mobility, this protocol provides appropriate and good quality with low jitter.

Design an energy efficient routing system for an IoT application based on a WSN that has inequity in the network due to high traffic load as in [47]. To choose the best path, the three factors are considered in the proposed protocol: longevity, reliability, and traffic intensity at the next-hop node. In comparison to other protocols, the proposed protocol saves more energy, has larger packet delivery ration, has a shorter end-to-end delay, and has a longer network lifetime.

In [63], the authors present an energy-aware, distance-based model. In addition, the proposed solution has the ability to achieve the best balance energy of nodes and increases the IoT lifetime.

In [64], the authors discuss wireless sensor networks, routing strategies, and hierarchy architecture, as well as a brief discussion of wireless sensor networks' energy harvesting. Similarly, in [65], the authors proposed an enhanced QoS-based on clustering with multipath routing protocol (OQoS-CMRP) for WSNs that reduces energy consumption in the sink exposed zone by forming clusters and selecting cluster heads in the sink exposed zone using a modified PSO-based clustering algorithm to address the energy hole issue. Designing energy-effectual multipath routing protocol is critical for WSN applications. The authors of [66] present a multipath routing system that accounts for wireless interference and network energy savings. The path discovery method of the proposed protocol selects the next-hop node, potentially lowering the linking cost.

In [67], the authors suggested an energy-efficient routing system based on PSO. They used to delay and energy as two limitations to reduce PSO problem to its simplest form.

Their simulation outcomes and a comparison study with the Genetic Algorithms (GA) revealed that PSO outperforms GA in terms of finding the best path with the least amount of energy usage.

In [4], the authors suggested a bioinspired routing method for constructing, recovering, and selecting k-disjoint pathways that tolerate failure while meeting QoS requirements.

In [49], the authors conduct a survey that focuses on highlighting and explaining available swarm intelligence-based routing techniques for WSNs. Also included are instructions on constructing and building smart routes to support QoS-aware applications.

The general technique in earlier works has been to use multipath routing to reduce rates of data packet dropouts and increase network lifetime. Furthermore, previous studies did not consider optimizing the network's performance of multipath routing protocols. Nevertheless, in this study, we investigate the widespread use of mobile WSNs to meet various IoT application environments.

After reviewing numerous strategies utilized in the background in order to address the issue of optimal path finding in routing protocols, we discovered that there is still a study topic that has yet to be investigated. For example, WSN-based IoT applications minimize energy usage in discovering multipath to transport data from source to destination.

The following is the paper's primary contribution:

 (i) Designing and developing an efficient routing method for finding the optimum path

 (ii) Choosing the best path based on the most effective effect

 (iii) To increase network-related QoS metrics for instance bandwidth, packet delivery rate, and end-to-end delay

 (iv) Using the usual NS-2 simulations tool, evaluate the suggested protocol's performance

This study is aimed at proposing an effective routing recovery technique that allows the optimal transmitting path to be carefully reviewed and updated while the mobile sink moves. We develop fault-tolerant routing models to ensure network stability, improve network performance, minimize network energy consuming, lengthen network lives, and keep improving network robustness and reliability.

The main aims of this paper are to boost the effectiveness of multipath routing protocols in the network, and we differ from previous research in the following ways:

 (1) We present the method of an enhanced PSO-based multipath routing algorithm for mobile WSNs, which improves network efficiency and reliability in comparison to the most existing work

 (2) In contrast to optimal routing with a static sink, our experiment employs sink mobility to save energy, increase network throughput, reduce packet loss, and extend network lifetime
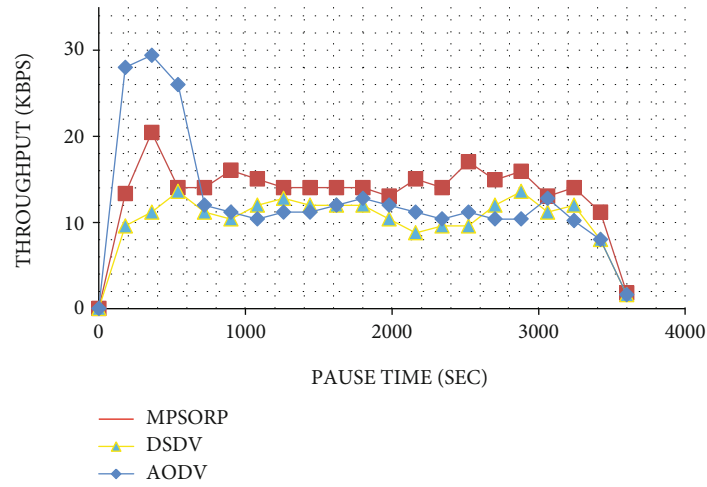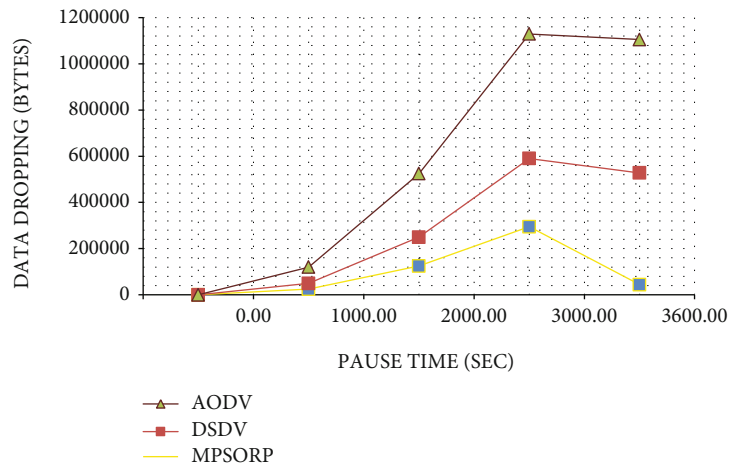
FIGURE 6: Throughput versus movement in time.

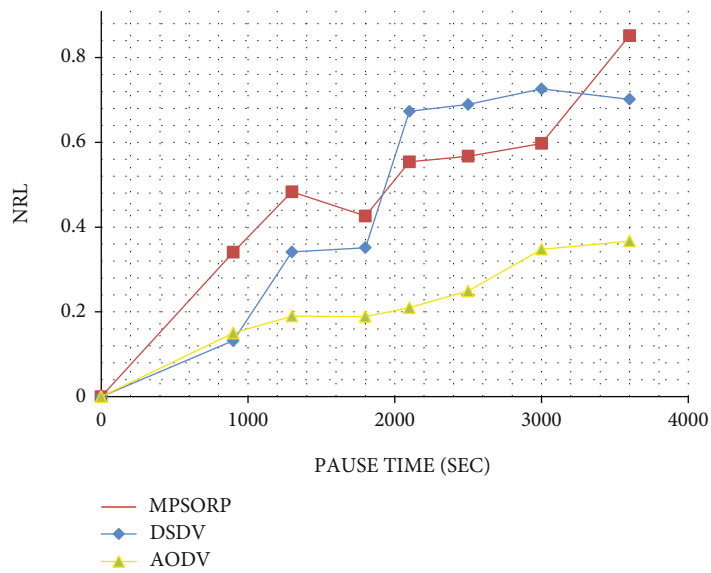FIGURE 7: Packet loss versus pause time.

FIGURE 8: Normalized routing load versus movement in time.

(3) In order to address routing concerns, we impose reliability and delay constraints on sink mobility additionally to the energy constraint imposed by the network's lifetime

3. Proposed Model

We formulate the issue of the proposed routing methods for WSN with mobile sink in this section. The routing problem might be alternatively expressed as a multidimensional optimization problem in which the throughput must be maximized, and the latency must be minimized. The proposed approach is aimed at efficiently transmitting data betwixt sources and sinks across a wireless medium with enhanced throughput, lower delay, and routing overhead, as much as energy consuming.

The mobility in mobile WSNs is used as a mobile sink node for data collecting. Meanwhile, it is built on the traditional clustering model, as well as the proactive routing environment for establishing a mobile sensor network environment. To improve the dependability of data transmission, fault tolerance technology for multipath routing is utilized to build numerous transmitting paths betwixt the source node and the destination. Although this strategy boosts the network's assist to load balancing and transmission bandwidth, it also appears to increase the power consumption as well as complexity of the route structure. Furthermore, it improves the data transmission's stability and reliability. It is a widely used technique for achieving fault tolerance at the network layer.

3.1. PSO Algorithm.
PSO techniques replicate a group of birds searching for food and sharing information using the cognitive processing as well as experience gained from food foraging and sharing of information. Individual partnerships will be used to find the first best answer, with a wide range of applications [26]. The particle mobility is influenced by two elements that use information as of iteration to iteration and particle to particle. The particle saves the best solution visited thus far, designated pbest, in its memory due to iteration-to-iteration information and experiences and attractiveness to this solution as it journeys across the solution into search space. The perfect solution visited by any particle is stored in the particle's memory due to particle-to-particle interaction, and the particle becomes attracted to this solution, denoted gbest. The cognitive and social constituents are the first and second factors. If a better or more dominant solution exists (in aspects of fitness) after iteration, the pbest and gbest for each particle are changed. This approach is repeated iteratively until the demand result is either obtained or decided that an acceptable solution is not possible within the computing constraints. The ith particle of the swarm is denoted by an n-dimensional vector in an n-dimensional search space, $Xj = (xj1, xj2\ xjn)$. One more n-dimensional vector $Vi = (_{vi1}; v_{i2} v_{in})\ T$ represent the particle's velocity.

The previously best decided place to visit of the ith particle is indicated as $P_i = (p_{i1}, p_{i2} \cdots p_{in})\ T$. The best particle in the swarm is represented by "b." Using the velocity update equation (1), the ith particle's velocity is updated.

The equation of velocity update is

$$vik = vik + c1r1(pik - xik) + c2r2(pbk - xik), \quad (1)$$

and the position is updated by

$$xik = xik + vik, \quad (2)$$

where $k = 1, 2\ n$; $I = 1; 2\ S$, where S is the swarm's size; $c1$ and $c2$ are constants, referred to as scaling parameters for social cognitive and behavior, respectively (typically, $c1 = c2$); $r1$ and $r2$ are set up random values uniformly distributed in $[0, 1]$. The basic form of the PSO algorithm is shown in equations (1) and (2). V_{max} is a constant that used arbitrarily limit particle velocities and improve the search resolution. Furthermore, to improve the governance of exploration and exploitation, the idea of an inertia weight was devised. The purpose was to do away with the necessity for V_{max}. In 1998 (Shi and Eberhart, 1998) [27], the addition of an inertia weight (w) in the PSO algorithm had been indicated in background. As a result, velocity update equation is

$$vik = w * vik + c1r1(pik\text{-}xik) + (pbk\text{-}xik). \quad (3)$$

According to Eberhart and Shi [28, 68], the best technique is to start with w at 0.9 and linearly reduce it to 0.4, enabling for initial exploration accompanied by acceleration as for a better global optimum.

3.2. Proposed Multipath-Based PSO Routing Protocol (MPSORP).
The main attentiveness of previous work of WSN was on dropping energy utilization in improved PSO protocol with cluster energy optimization algorithm. Furthermore, delay initiated and the packet dropped in communication use a lot of energy in the substitute key, which diminishes the life span of the network in an extensive sense. As a result, network life is extended at the expense of large packet losses and increased delay with low throughput. The importance of providing superior performance metrics has received some attention. It is necessary to concentrate on such constraints while expending less energy. This dissertation carries out the following activities in order to implement PSO on the DSDV protocol with cluster energy optimization.

PSO algorithm is primarily a computational technique for optimizing a problem by improving a candidate solution iteratively in relation to a given quality measure. To solve optimization problems, we must to do first formulate the issue in terms of the optimization problem. The optimum path is picked in this suggested algorithm based on fitness value, which could be determined by the lowest distance to be traveled through data up to the base node and the node's energy.

3.2.1. Fitness Function. To use PSO to select the best path, you must first determine the fitness value of each path.

$$\text{Fitnessval} = \text{dis}(i, j) + \text{dist}(j, \text{base}) + \text{remaining energy}(i) \\ + \text{remainingenergy}(j).$$

(4)

This fitness value has been utilized to choose the best local and global candidates for PSO. The best optimal solution will be the path with the lowest fitness value.

3.2.2. Calculation of Route Selection of Parameters. Source node, destination node, transmitting range, and power loss are used as an input to calculate the best selection parameter. The route choice parameter is evaluated as follows:

$$TP(tx)d - \alpha(i, j)Rsp = N\sum k = 1TP(tx)d - \alpha(i, j) + \alpha 2,$$

(5)

where TP (tx) is transmission power, $d - \alpha(i, j)$ is distance betwixt nodes i and j, σ is power level of noise, and α is path loss components.

The proposed approach has the following advantages: end-to-end delay is minimized, and energy utilization is lowered due to the small number of routes discovered. The technique uses a routing selection parameter based on the route's power and bandwidth requirements to choose the forwarding nodes or forwarding connection, resulting in a high throughput; consequently, the route chosen is bandwidth aware.

3.2.3. Proposed Algorithm. We have set PSO to find out the superior optimal path while using the least amount of energy. We end up choosing a random variety of solutions from of the set of x solutions. To create an initial solution, x is the total number of solutions. Following the random of initial solutions, we also evaluate the fitness value of each solution using equation (4). After that, we compute the best solution from among them and make it the global and local best starting point. To update the PSO, the update equation is used. For previous solutions, generate new ones, and calculate the nodes of those solutions. These solutions and their nodes are then utilized to calculate each solution's fitness value. The process will be continued until the specified iteration is complete. The superior solution to the other alternatives is replaced based on this continuing iteration as well as fitness value. Pseudocode 1 lists the pseudocode of PSO-based routing algorithm.

4. Framework of Optimization

There are two aspects to our optimization framework. As indicated in Figure 2, one is an optimization method, and the other is called evaluation of solution evaluation. PSO generates sets of solution vectors (also known as new populations) in the optimization process, which are then employed in simulation for performance evaluation. PSO is aimed at identifying the best route through the search space (solution vector). The simulation model runs each solution

after receiving a population from PSO into MDSDV one by one. Now, NS-2 takes the WSN realistic instance and the simulation settings listed in Table 1 and they are configured appropriately.

We changed NS-2 in such a way that it now accepts PSO population automatically. Then, in the simulation, NS-2 generates global data known as the trace of simulation. We evaluated the resulting network performance QoS by considering the following five measures in order to compare default and optimized MPSORP:

PDR (packet delivery ratio): the ratio of the amount of complete and accurate packets received by the actual destination to the number of data packets generated by the source.

Average end-to-end delay (AEED): the average amount of time a data packet takes to travel from source to final destination.

NRL (normalized routing load): this represents the average number of routing packets sent to deliver a single data packet.

Throughput: is defined as the ratio of the total amount of data received by a receiver from a sender to the time it takes the receiver to begin receiving the last packet. Packet loss is the number of data packets that are dropped by a protocol.

5. Simulation Model

This research uses the Network Simulator NS2.34 [29] with the Ubuntu10.10 (Linux) operating system to develop the proposed MPSORP. MPSORP, AODV, and DSDV three different routing protocols are compared in this study. The trials are carried out with 25 randomly distributed nodes in rectangular fields measuring 500 km by 500 km for simulation purposes. A rectangular area is chosen to allow for the evaluation of transmission for far-flung nodes. The de facto standard for accessing the communication medium WSNs is IEEE 802.15.4, which describes Medium Access Control (MAC) sublayers and the physical. The size for each data packet is set to 70 bytes. Table 1 shows the parameters chosen as well as their specifications.

5.1. Simulation Setup of IoT Application. In this study, the IoT-App is offered as a nautical data collecting and mapping system through Ship Ad hoc Sensor Networks (SASNET). Ships will be communicating via Very High Frequency (VHF), which is now available on most of the ships and will be outfitted by a variety of sensors such as seat depths, temperature, and wind speed as well orientation. On the ground, 5G base station nodes act as sinks for the collecting data and outfitted with Mobile Edge Computing (MEC) data collection and processing abilities. The sensory data is eventually compiled in a central cloud on the Internet to create publicly accessible, present cartography systems. We explore the suggested system's deployment constraints and advantages and its performance, utilizing our proposed routing protocol MPSORP.

The proposed Internet ocean of things system model is shown in Figure 3. The evolving IoT promises a fully connected world with numerous linked devices and services.

VHF communication is identified as the IoT enablers with the possibility that can provide an entirely new set of previously unavailable apps and services. As a result, overcome has introduced VHF to the radio spectrum for 5G, paving the way for 5G-VHF connection.

As in study, we take advantage of the new 5G era to propose a cartography application in which a SANET is utilized to collect several nautical sensual data from ships and vessels then send it back to onshore sinks that are collocated with 5G base stations that would include dedicated storage as a component of MEC services. As shown in Figure 3, we suggest a new MEC application in which a portion of the edge computing resources is used as an edge repository (cloud) of acquired sensory data that consistently reaches the shore. The edge clouds eventually merge to a central internet cloud. All of the sensory data is consolidated, filtered, and analyzed to provide real-time map of ground and underwater environmental info for beneficiary consumers. The acquired sense data and map information are frequently cached at network edges near users when the network detects significant request. The cartography system shown in Figure 3 can be collected data, for instance, sea state, dimensions, temperature, wind speed, and salinity among other things. The results of the testing and simulations show that the design effectively enables IoT interoperability. We effectively transmitted and received a message utilizing acoustic signals from the deployed underwater sensor node to the border router, which was relayed by a 4G/5G broadband Internet to a laptop and a smartphone linked to the traditional Internet.

As is well known, devices in any WSN system that uses the IEEE 802.15.4 standard can perform one of two functions: Full-Function Device (FFD) or Reduced Function Device (RFD). Coordinator, Device, and Personal Area Network (PAN) coordinator are the three modes of the former (PAN coordinator). The PAN coordinator must be configured on the destination node (sink node) to which the collected information will be sent. The rest of the nodes (those that detect the environment) are normally set up to work in RFD mode. An RFD node cannot send or receive from another RFD node; an FFD node can transmit and receive from all other modes.

6. Discussion and Results

In the proposed MPSORP's performance, compared with DSDV and AODV, five performance metrics is determined by calculating. These performance metrics are PDR, AEED, NRL, throughput, and packet loss (PL).

6.1. Packet Delivery Ratio. Figure 4 illustrates a compared of packet delivery rates for MPSORP, AODV protocol, and DSDV. DS-DV produced the much lowest packet delivery ratio. The maximum PDR reached quite 83% in the MPSORP. In the ocean environment, the speed of the sensor node slowly moving has only 0.47 m/sec based on ocean speed, and subsequently, MPSORP method provides a higher packet delivery rate as in Figure 4.

6.2. End-to-End Delay Average. The graphical outcomes shown in Figure 5 are a measurement of delay, which is a very power full tool. It demonstrates that the end-to-end delay in IEEE 802.15.4 with MPSORP is the shortest of all the routing protocols. This demonstrates that the MPSORP, which is compliant IEEE 802.15.4 standard, is remarkably well suited for delay-sensitive applications. This characteristic can be explained. MPSORP is a proactive routing protocol, and with these protocols, many pathways to destination are accessible right away. To put it another way, routing discovery does not cause any delays. Furthermore, if it is impossible to transport the packets and the MPDSDV, as a result, the routing protocol attempts to drop them and tends to outcome in less delay. It incorporates the delay as a result of route detection procedure and the queue during data packet transmission when calculating the time it takes for a packet to go from the CBR source to the destination. Only the successful data packets—fully delivered to the destinations that the DSDV and MDSDV protocols—show the biggest initial delay required for route setup, of roughly 0.055 seconds. While MPSORP has the shortest latency, at only 0.045 seconds, this might be ascribed to the facts that MPSORP is a multipath protocol based on tables which needs to maintain route tables to reduce the time required for route detection. In contrast, all of other protocols rely on on-demand routing discovery.

6.3. Throughput. In general, the network throughput grows continuously during the simulation time. In all mobility circumstances, MPSORP achieves the best throughput and displays efficient behavior.

The following are some main reasons for this high throughput: first, when the initial data packet comes, it is held until the best routing for a specific destination is discovered. Second, a choice may postpone advertising of routes that are set to change, reducing oscillations in the route tables. By postponing the advert of unsterilized routes, the number of rebroadcasts of routes with the same sequence number is reduced. As shown in Figure 6, this improves the precision of valid routes and tends to result in higher MPSORP throughput at a mobility rate of 4 packets per second.

6.4. The Packet Loss. The comparison of the three methods in terms of data discarded by each procedure is shown in Figure 7. In all circumstances, AODV is the worst in terms of data loss since it broadcasts a route request in the event of a connection failure and then waits for a route reply to receive fresh information; during this time, AODV queues the packets. AODV queue timeout refers to when packets are discarded due to expiration in the AODV queue. DSDV, on the other hand, waits for a length of time to obtain information; if no route is available and a node using DSDV wishes to transmit data, DSDV must queue the packets, which will be dropped if the queue is full.

Because MPSORP uses an alternate path in the event of a link failure, it drops slightly less data than other protocols in sparse networks (networks with 25 nodes).

Packet drop rate happens in mobile sensor networks due to transmission failures, mobility, and congestion. In this setting (marine network), the number of dropped packets is extremely high. In this context, the influence of sparseness in the network is the primary cause of dropped packets (marine network).

6.5. Normalizing Routing Load. The numeral of routing packets transferred through the emulation is known as the routing load normalized. For packets delivered over multiple hops, every transmission of a packet (every hop) counts as such transmission. In other words, it is a comparison of the total number of transferred data packets to the network's total number of control packets.

In order to save energy, it is preferable to have a few control packages as feasible. The normalized routing load vs. pause time is depicted in Figure 8. Due to the large number of route requests launched, the MPSORP has the highest routing load values, while AODV and DSDV have nearly identical figures, in contrast to the AODV protocol, which would have the lowest routing load. As a result, DSDV in concepts of routing cost has the highest routing efficiency, while MPDSDV has the best routing performance in packet delivery. This clearly shows that the optimum packet delivery metrics is frequently associated with a highest routing load.

7. Conclusion and Future Work

An energy-efficiency multipath routing protocol based on the PSO technique is proposed. This method is utilized to choose the best way among all the shortest paths found that uses the least amount of energy from the nodes and allows the wireless network to last for a long period. The suggested technique uses Particle Swarm Optimization to discover the best pathways by taking into account the distance between nodes as well as their energy. Only one optimum way is chosen from these selected paths, decreasing the network's energy consumption. The proposed MPSORP improves the performance of WSN-based IoT applications by increasing the packet delivery ratio, decreasing average delay, and reducing overall energy usage during execution. Other QoS measures, including such normalized routing load, throughput, and reduced data packet losses, have improved as a result of this effort. The proposed algorithm works by calculating the route first and then optimizing it. The simulation outcomes indicate that the proposed method is effective and gives better performance in extending the wireless sensor network lifetime. The outcomes demonstrate that the MPSORP has a higher QoS and better performance than the other routing protocols (AODV and DSDV). Finally, multipath routing algorithms are an effective way to enable real-time and dependability applications with proper QoS over IoT. In future work, PSO can be combined with an existent technique to handle with huge-scale routing challenges utilizing hybrid sensor networks.

Conflicts of Interest

The authors declare no conflict of interest.

Authors' Contributions

Mohammed Zaid Ghawy and Gehad Abdullah Amran contributed equally as first authors. All authors contributed in acquisition, analysis, or interpretation of data and results and review and rewriting of the manuscript.

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