

# Efficient Routing and Lifetime Prolongation in IoT founded Wireless Sensor Network Performance with Bee Colony-Inspired Lifetime Enhancement

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## Abstract

To extend the lifespan of Wireless Sensor Networks (WSNs), effective routing protocols are required to provide communication channels between the sources and sink. While nodes are arbitrarily distributed in a substantially unsafe situation, these steering protocols are susceptible to an extensive range of assaults. For WSNs, trust-based routing protocols are created, which employ a trusted route rather than the quickest path, to prevent these attacks. The artificial bee colony-based clustering technique is utilized because the conventional clustering algorithm reduces the energy usage of nodes. This allows it to increase the lifespan of the sensor network by evenly dividing energy use among all nodes. The artificial bee colony (ABC)-based grouping method was developed because the typical grouping technique minimizes the energy usage of nodes. By integrating diverse sensors and devices, Internet of Things (IoT) enhances the performance of WSN, by enabling efficient data collection, analysis, and communication. The creation of such traditional protocols does not guarantee the best global optimization for the lengthening of WSN life. Through simulation analysis, the suggested Artificial Bee Algorithm (ABC)-based Traffic-Aware Energy Efficient Routing (TEER) protocol's performance was evaluated and contrasted with the TEER protocols. The ABC-based TEER protocol's lifetime analysis, active node analysis is achieved and contrasted with those of other protocols. In terms of the number of rounds, the network performance for the ABC-based TEER scheme performs better than the TEER schemes. The Analysis of throughput of the ABC-TEER method, which reveals a 9.5% increase in performance in comparison to the TEER protocol.

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## 1. Introduction

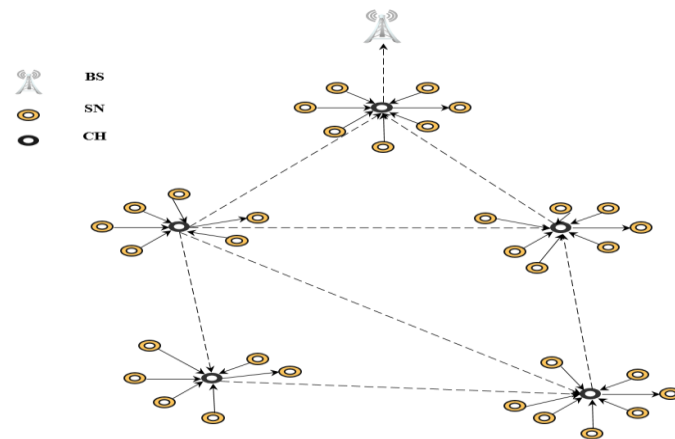
Two distinct topologies make wireless communication possible. The first is called infrastructure, and it is centralised. The second is called ad hoc, and it is decentralised. The fundamental idea is to allow speech and data

to be sent over the same cellular network infrastructure [1]. The main challenge is how to seamlessly switch from one base station (BS) to another BS without experiencing a lag or information loss. In Wireless Ad-hoc Networks (WANET), where multiple mobile nodes share a wireless channel for communication, the distributed topology is used [2]. Since there is no base station in WANET, nodes can directly communicate if they are within each other's communication range. Through multi-hop routing, the nodes can send the data packets to distant destination nodes [3].

IoT enhances WSN by integrating diverse sensors and devices, enabling seamless data collection, analysis, and communication. This symbiosis enhances observation, industrialization, and prompt decision making in the application areas such as smart cities, healthcare and industrial applications. IoT supplies a solid connection and compatibility, expanding WSN functions, rising conjugate efficacy, intelligently convenient, economically wise, and flexible executive management systems.

The technological enhancement nowadays has allowed control to be increasingly embedded in our day-to-day life. The concept of living in a so-called "Ambient Intelligence" future, which anticipated numerous devices that are collecting and analysing information from the surroundings, as well as engaging their owners, materialized. Consequently, a novel type of network was unveiled in the past few years and tagged WSN [4]. Each node in the described networks is capable of perceiving the environment and changing one or two physical parameters. Since one node cannot achieve the task, then the sensor nodes rely on wireless communication to fulfil the task. It is worthy to note that different real-world application such as military, health, and surveillance, and security can be assisted by WSNs [5]. Because of the extensive applicability of these networks in military as well as the civilian sectors for applications such as weather surveillance, animal surveillance, and disaster management, WSNs have captured a lot of focus in recent years. In this application, a large number of sensor nodes are randomly deployed in a hostile environment with no control over children or a supervisor, due to this it is very much exposed to a variety of potential attacks. Among the main challenges that sensor networks encountering nowadays, security is one of the significant factors that affect the execution of the network [6].

The studies that have been made in trust-based routing protocols and artificial bee colony based clustering techniques have advantage in optimizing WSNs in the areas of security and energy, a study was found lacking in global optimization of WSN lifespan extension. The current approaches lack the capability of incorporating multiple sensors and IoT devices for better data gathering, processing, and exchanging. Moreover, there is a need to concentrate on the simultaneous optimization methods in further research.



**Figure 1.** Elementary sensor network prototypical.

Hence, an efficient energy consuming based routing protocol is proposed which is developed through an artificial bee colony algorithm to suggest an efficient path from source to the base station. Inter-cluster data transfer is done with the help of this protocol, which transfers data to the base station as well [7]. Fixed clusters are used, and a randomized weighted approach is used to choose the cluster heads, thereby reducing energy use. The swarm intelligence method is used to choose cluster leaders with high levels of trust and enough remaining energy [8]. This reliable, energy-efficient protocol transmits data to the sink node without any data loss during the hopping process while using the ABC idea during multi-hop. Through simulation analysis, the suggested system's performance is evaluated and contrasted with the standard protocol schemes. It is clear from the simulation results that ABC-based reliable energy efficient protocol operates well and results in a greater decrease in energy usage than traditional energy efficient protocol [9]. The recommended protocol can significantly extend the lifetime of the sensor network by reducing its energy usage, both in terms of the number of still-alive nodes and their remaining the network's energy [10].

The reliable energy-efficient routing (TEER) protocol is created to increase the network's lifespan. It operates in phases, with each round consisting of the data transfer phase and the group head election stage. Every node's trust levels are assessed and recorded by the sink node. Every node also retains a copy of its faith value. Because of this, the sink node via the acknowledgment [11] dynamically updates each nodes nearby deposited faith worth. Each cluster's sensor nodes elect a cluster head at stage I. In stage II, the CHs assign each node in the cluster a time slot for TDMA data transmission. The cluster's sensor nodes report to the CH, who then communicates with the sink node directly. To provide a balanced traffic load and distributed energy consumption, the process of choosing cluster heads is repeated frequently for each round [12]. A population-based meta-heuristic technique called the artificial bee colony is reliable, simple to use, and quick enough to effectively address optimization problems. When compared to other approaches like PSO, fuzzy, and genetic algorithms, ABC performs better at tackling certain optimization problems. The artificial bees are divided into worker, observer, and scout categories [13]. The colony's size is equivalent to both working bees and spectator bees. Scout bees randomly look for food and come across sources that are close to ideal. Bees that are employed visit food sources and gather data about their location and quality [14].

The information that follows lays down the structure for the following portions of the work. The second portion provides a concise overview of the pertinent literature, and the third section clarifies the methodological and theoretical foundations of the approaches used. The findings of the simulation are presented and analysed in Section 4 of this report. In the final section of this work, under "Key findings," we will briefly summarize the most important results.

## 2. Existing Work Done

Swarm intelligence, which is related to computational techniques and biological activity in swarms (such as ants, bees, birds, and fish), deals with the collective behaviour of every member of a social society [15]. The clustering and routing issues in WSNs are optimized using numerous swarm intelligence-based algorithms. Multiple researchers have implemented ant colony optimisation, often known as ACO, as a method for multipath cluster-based routing in WSN. Another team of researchers optimized the clustering using the particle swarm optimization (PSO) algorithm [16]. Another team has employed Artificial Bee Colony (ABC) for WSN routing and clustering.

A couple additional researchers have looked at WSN routing operations utilizing ABC. The use of ABC on WSN routings has increased the lifetime of the network by preserving energy [17].

Numerous academics have suggested a modified ABC method and its use in the protocol design of WSNs. The authors put forward a technique for finding the optimal configuration of the network regarding the distribution of the sensor nodes. Pursuing the goal to enhance the useful lifetime of WSNs, another group of researchers has then developed a new meta-heuristic population-based soft computing technique [18]. Subsequently, the number of nodes within the cluster in conjunction with generations is optimised with the help of the bat swarm optimisation technique. In four different WSN deployments, the proposed technique has been used for comparing the routing protocol and clustering method of LEACH. The suggested methodology is useful in the overall management of energy utilization with the aim of enhancing node's longevity [19].

This paper reveals a research group's suggestion to employ an intelligent technique in the context of direction finding in WSNs with the usage of the ABC algorithm. The strategy used in the proposed method has proved to solve delay-energy trade-off tasks effectively and with higher performance compared to other algorithms as it enhances energy intake, network lifetime, and energy utilization and increases delivery ratio [20]. Another group of researcher has provided an advanced ant colony algorithm originally from the Dijkstra algorithm for minimizing the energy consumption of WSNs. As indicated, it was possible to make the comparison of the suggested algorithm with standard ant colony algorithm, the minimization of energy consumption and in turn, the prolongation of the lifespan of wireless sensor networks [21-23].

Many employees have presented a new routing protocol based on the characteristic of a cluster ABC. The election of the cluster head happens with the help of multiple objective fitness function. The routing problem of cost-dependent function has been identified as another function whereby the amount of hops and energy consumption in the network constrained the selection. The clustering procedure for utilizing energy levels and knowledge of the nearby location of unaware sensors uses a centralized control mechanism at the base station. Results from the suggested routing protocol and the Swarm intelligence protocol have been compared after this method has been applied to numerous topologies. This method's outcomes show how successful it is in terms of the network's lifetime, coverage, and packet delivery count [24-26].

A committee of researchers proposed a MOFCA for WSNs. It has been shown that cluster heads closest to the sink tended to expire earlier due to the extensive inter-cluster relay. The hotspots issue is what is referred to here. Uneven clustering approaches have been suggested to solve this problem. Small-size clusters have been positioned

closer to the sink thanks to inequitable clustering procedures, which have reduced intra-cluster transmission. Changes in the node deployment sites could also cause the energy-hole problem. It was discovered that the MOFCA could handle issues with energy gaps and hotspots in networks. For an efficient algorithm evaluation, node position changes must also be considered in addition to energy usage [27].

Several researchers contributed to the development of an ENC method for use in energy-harvesting WSNs. Local computations are done in order to determine the size of the group that makes up each cluster. This is done with the intention of assuring that, at any given time instance, there will be an active cluster head with sufficient energy to process the information that is supplied from the cluster members [28-29]. Due to the high volume of traffic, a novel grouping technique has been devised to make it possible for more than one cluster head to reside in a single cluster in order to share the load. Along the path, the information that has been gathered by the members of the cluster can be reliably relayed to the base station. Convexity can be used to describe the optimisation process. You should use a type of clustering referred to as Equal size clustering, which means that all the clusters that are fashioned must contain equal members. The approach minimises the number of re-clustering that happens on the network as indicated by [30].

### 3. Purpose of the work

- 1) About design, deploying an IoT based WSN aimed at improving on the real-time data acquisition, processing and transmission. It is meant to enhance system effectiveness, capacity and integration, as well as providing profound supervisory and automatic capability for smart city, smart health and smart industry applications.
- 2) To show the proposed ABC-TEER protocol based on Artificial Bee Group algorithm for WSNs and to assess lifetime, throughput and pack damage rate of WSNs.

### 4. The Proposed Work

Clustering is a very important technique in WSN that offers the ability of power save on sensor nodes and network scalability. The clustering method, as illustrated in Figure 2, divides sensors into various clusters according to their positions and nodes' energy level. Every cluster employs this method to forward collected data from its sensors to a common point called the cluster head (CH) selected from nodes belonging to the cluster with reference to defined standards. As a result, the CH will be mostly a node, which has enhanced security and at the same time consumes limited energy. Broadcasting information within the cluster and sending it on to the sink all at once is what CH is used for. Each iteration of modern clustering algorithms involves a new cluster leader, who may be chosen at random or according to some criterion such as residual energy, threshold value, coverage, etc.

To prolong the network's lifespan, a reliable energy-efficient routing (TEER) protocol is created. It runs in cycles, with each cycle including the group head vote phase and the data transmission phase. The sink node acts as a repository for the aggregated trust assessments of all the other nodes. A replica of the node's trust value is stored at each node as well. The faith worth of each node is kept nearby, and the sink node will dynamically update it using the acknowledgment as it receives it. The first step is for the sensor nodes to choose a leader for the cluster. In phase two, the CHs schedule a TDMA transmission window for each node in the cluster. The cluster's sensors feed information into the CH, which then notifies the sink node directly. In order to maintain a consistent traffic load and evenly disperse energy consumption, the method for selecting cluster heads is cycled through several times during each round.

Steps applied in the proposed algorithm is as follows:

Step 1: Set up IoT devices for data collection from source

$$D_i = \text{init}(S_i) \quad (1)$$

Step 2: Collect data

$$D_{\text{collect}} = \text{gather}(D_i) \quad (2)$$

Step 3: Send collected data to a centralized server using secure transmission protocols.

$$\text{Transmit}(D_{\text{collect}}, S) \quad (3)$$

Step 4: Encrypt the collected data

$$D_{\text{transmit}} = \text{encrypt}(D_{\text{collect}}) \quad (4)$$

Step 5: Verify the information

$$\text{Authenticate}(D_{\text{transmit}}) \quad (5)$$

Step 6: Combine the information after verification

$$D_{agg} = \text{syndicate}(D_1, D_2, \dots, D_n) \quad (6)$$

Step 7: Denoise the data from unwanted data

$$\text{Uncontaminated}(D_{egg}) \quad (7)$$

Step 8: Save the final information

$$\text{Stock}(D_{agg}, S) \quad (8)$$

Step 9: Detection of the data

$$A = \text{detect anomalies}(D_{agg}) \quad (9)$$

Step 10: Update the data

$$\text{Alert}(H, A) \quad (10)$$

$$\log(A, \text{time}) \quad (11)$$

Step 11: Plot the results

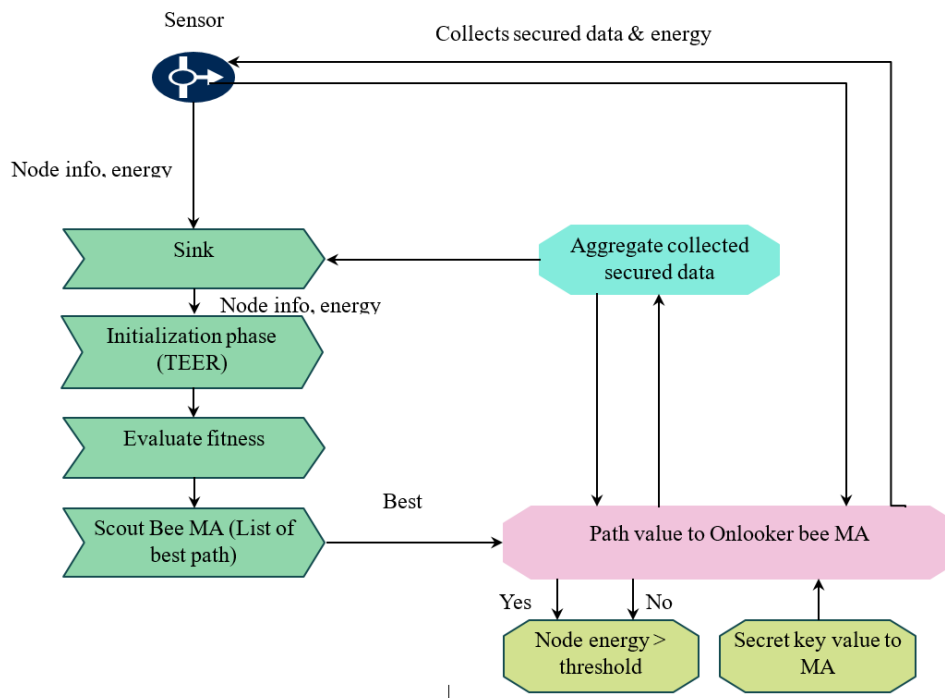
$$V = \text{visualize}(D_{agg}) \quad (12)$$

$$\text{update dashboard}(V) \quad (13)$$

$$\text{access control}(U, V) \quad (14)$$

An effective optimisation problem-solving tool is the population-based meta-heuristic algorithm known as artificial bee group. When compared to other methods, such as PSO, fuzzy, and genetic algorithm, ABC gives superior performance in resolving certain optimisation problems.

There are three types of synthetic bees: worker bees, observers, and scouts. The amount of employee bees and the number of observer bees both contribute to the overall size of the colony. In their pursuit for sustenance, scout bees often stumble onto less-than-ideal food sources. To gather data on the quality and location of food sources, workers use bees. Observer bees improve their food sources thanks to the work of worker bees.



**Figure 2.** ABC based trustworthy energy efficient routing system.

Trustworthy energy efficient routing protocols use swarm intelligence (an artificial bee colony) to determine the most effective cluster head, the most reliable track from the origin to the cluster head, and the shortest path between the two.

## 5. Result and Analysis

An experimental setup involves deploying a WSN with nodes using trust-based routing protocols and artificial bee colony-based clustering techniques. Nodes are randomly distributed, and IoT devices are integrated for data collection. Performance metrics like network lifespan, energy consumption, and throughput are measured. The ABC-based TEER protocol is evaluated through simulation, comparing its performance with existing TEER protocols, focusing on metrics such as active nodes and number of rounds. The following metrics are used to evaluate the efficiency of WSNs.

### 5.1. Packet delivery ratio (PDR)

PDR stands for packet delivery ratio, which measures how many packets are transmitted and received. The main element influencing wireless networks' success is packet transport. In terms of the PDR, this delivery ratio is successful (product delivery ratio).

$$PDR = \frac{\text{Received Packet Count}}{\text{Delivered Packet Count}} \quad (15)$$

### 5.2. Throughput

The throughput of the network is the speed at which data packets are successfully sent from the transmitting node to the obtaining node.

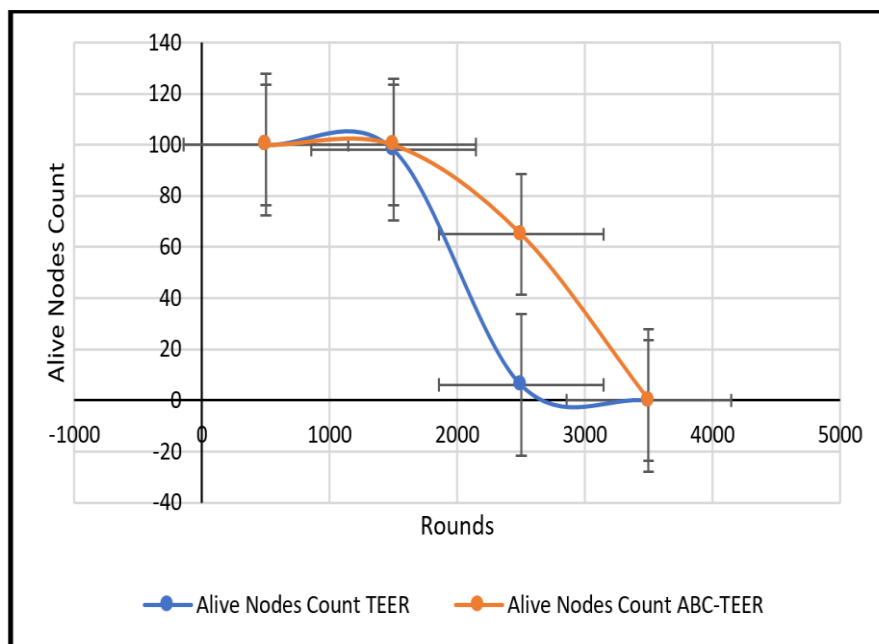
$$\text{Throughput} = \frac{\text{Foreaded data}}{\text{Transmission time}} \quad (16)$$

### 5.3. Network Lifetime

The sensing (data gathering), transmission, and reception energy needs of the nodes define the WSN's lifetime. The network's lifetime is computed founded on the number of currently active nodes, the nodes' residual energies, and the network's overall energy efficiency.

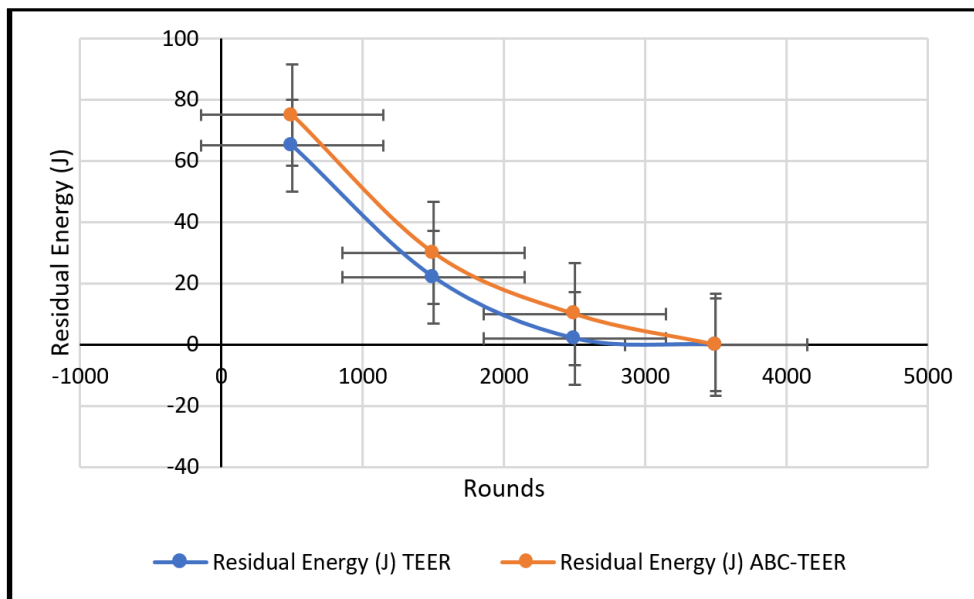
**Table 1:** Comparison of various evaluation parameters for various TEER schemes.

Rounds	Alive Nodes Count		Residual Energy (J)	
	TEER	ABC-TEER	TEER	ABC-TEER
500	100	100	65	75
1500	98	100	22	30
2500	6	65	2	10
3500	0	0	0	0



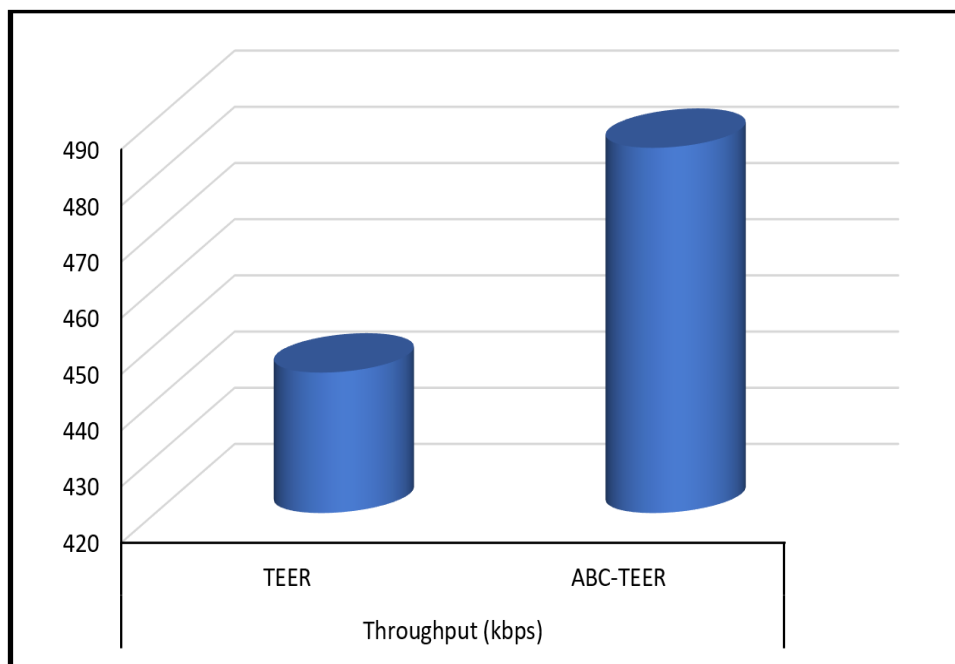
**Figure 3.** Alive Node Count Comparison of the Proposed Method.

Figure 3 illustrates how the network performance of the active nodes changes as a purpose of the number of rounds for both the TEER and ABC-TEER schemes. As depicted in this figure, the ABC-TEER scheme outperforms TEER schemes about alive nodes through the method of optimisation from ABC to select the CH and the energy taking in of the nodes is reduced. This is illustrated by the fact that the technique is applied in selecting the CH.



**Figure 4.** Residual Energy Comparison of the Proposed Method.

In this case, Figure 4 shows the comparison of the TEER schemes against the corresponding ABC-TEER schemes in terms of the amount of leftover energy at the nodes of the network during a feasible number of iterations. The figure also shows that the ABC-TEER scheme, which uses the ABC optimization technique to select CH and minimize node energy consumption deplete lesser amount of energy in the network after certain quantity of rounds than the TEER scheme. The results of the energy analysis comparison with reference to Table 1 are also presented in terms of the number of iterations using the three methods only.



**Figure 5.** Throughput Comparison of the Proposed Method.

The network throughput of the ABC-TEER scheme is investigated and compared to that of other TEER methods. Figure 5 depicts the throughput analysis of the ABC-TEER method, which reveals a 9.5% increase in performance in comparison to the TEER protocol.

## 6. Conclusion

For WSNs to last longer, it is important to establish channels of communication between the sources and sink using effective routing protocols. When nodes are positioned arbitrarily in a non-secure surrounding, several different types of attacks can be launched against these routing protocols. Trust-based routing techniques are designed for WSN that prefer to choose a known and secure path rather than the shortest one available in order to thwart such attacks. Using MATLAB, we investigate and build the TEER protocol, which is based on the ABC algorithm for reliable, low-energy routing. ABC-based TEER protocols are compared to traditional TEER protocols in terms of the percentage of still-living nodes and the amount of energy left over after each round. ABC-based TEER, TEER protocols, and throughput and packet loss rate analyses are obtained. Throughput and packet loss rate analysis, as well as longevity, are all shown to be better for the ABC-based TEER protocol in simulations. Throughput analysis of the ABC-TEER method, which reveals a 9.5% increase in performance in comparison to the TEER protocol.

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