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DETECTION OF COLLISION USING OPTIMIZED DEEP MODEL BY LION CROW SEARCH OPTIMIZER LCSO

Akhil Khare[a]*, K. Selvakumar[b] and Raman Dugyala[c]
[a*]Research Scholar, Department of Information Technology, Annamalai University, Annamalainagar, India a*
[b]Professor, Department of Information Technology, Annamalai University, Annamalainagar, India b
[c]Professor, CSE, CSIT, Hyderabad c

Abstract
Wireless sensor network (WSN) nodes strategically collect environmental changes. Each node has less processing, memory, and energy. The transceiver lets nodes transmit and receive packets. WSN nodes provide data to a central processing unit. Wireless Sensor Networks need power, storage, communication, and processing. The sensor computing capabilities decline. These networks' nodes can send data to the base node for processing across multiple hops. WSNs may be setup without humans. The limits slow Wireless Sensor Network performance. Extension of node operation requires energy-saving methods. This technology is used in military, healthcare, environmental monitoring, and microsurgery. Wireless sensor node access to shared media is difficult to regulate. Energy savings, PDR, and latency in wireless sensor networks are improved by the MAC. Several Wireless Sensor Networks (WSN) technologies access the transmission medium and fix network issues. A wireless sensor network (WSN) has autonomous sensors across a large area. Massive sensors in Wireless Sensor Networks (WSNs) report and monitor. Expanding the network to many sensor nodes raises collision risk. A unique wireless sensor network collision detection and mitigation mechanism is presented in this paper. The Fractional Artificial Bee Colony (FABC) algorithm chooses a cluster leader following a WSN simulation. RSSI, priority level, delivery rate, and energy utilization determine the network-based statistic. The Deep Recurrent Neural Network (DRNN) has been modified to suit the task of collision detection. The training of the deep recurrent neural network (DRNN) is conducted via the Lion Crow Search optimizer (LCSO). Following the completion of collision detection, the subsequent step involves the implementation of a collision mitigation process utilizing a pre-scheduling technique known as Dolphin Ant Lion Optimizer (Dolphin ALO).
Keywords: Wireless sensor network, deep recurrent neural network, collision detection, Cluster head selection, Received Signal Strength Index (RSSI), priority level, delivery rate, and energy consumption.

1. Introduction

Wireless Sensor Networks (WSNs) find utility in a wide array of applications, encompassing environmental monitoring, object tracking, and surveillance. These networks function as a revolutionary technology by utilizing the dispersed sensor nodes inside the network. The surveillance of the physical components inside network settings is crucial for the purpose of mitigating diverse undesirable consequences [10] [2]. However, the sensor node has the capacity to identify the presence of an event and displays several characteristics, such as communication and potential processing capabilities. However, the sensor nodes consistently monitor the deployed region. A group of sensor nodes is organized to create a sensor network. In the present day, the need of implementing security measures has significantly escalated across several network systems. Furthermore, the widespread utilization of sensor nodes is observed in unattended areas that require a substantial degree of security [2]. The occurrence of data collision among sensor nodes in a Wireless Sensor Network (WSN) is notable as a result of the substantial quantity of network nodes that are present. If many sensor nodes within a common network area send data simultaneously utilizing a shared frequency channel, it is expected that collisions would occur between the data packets [15] [16] [7]. Collisions, as a kind of assault, can lead to disruptions in the flow of data, hence requiring the implementation of devices that provide extensive re-transmission [2]. However, the presence of packet collision has a negative effect on the overall system performance due to its contribution to the wasting of channel bandwidth, power consumption, and data loss [17] [7]. The aforementioned concerns possess the capacity to generate the interference problem, namely in the form of data corruption caused by packet loss and the inability to transmit data packets to the intended recipient. Prior research has undertaken many efforts to identify and mitigate collision avoidance. According to sources [9] and [7], it can be inferred that... The Wireless Sensor Network (WSN) demonstrates heightened sensitivity towards certain aspects, such as energy efficiency, latency, and transmission. Several studies have identified these factors as having a negative influence on the performance of Wireless Sensor Networks (WSN) [18], [20], [3].

The distributed algorithm employed in wireless sensor networks (WSNs) demonstrates a diminished level of awareness regarding the specific region or neighboring nodes in comparison to centralized algorithms. This particular attribute enhances the overall performance of the network. The optimization of data transmission among sensor nodes requires the careful examination of interference factors. Nevertheless, the longevity of nodes is significantly diminished due to retransmissions caused by collisions and interference (19) (3). To address the issue of collisions between neighboring nodes during the transmission of data, two types of interference are considered: primary interference and secondary interference. In the situation of primary interference, the node is concurrently receiving data transmission from many adjacent nodes. Secondary interference occurs when the transmission between two nodes obstructs the ability to communicate with other nodes [3]. There are now several link scheduling techniques being utilized, such as the time division multiple access (TDMA) protocol and the application of graph coloring theory [21] [22] [23]. These approaches aim to ensure that transmission among sensor nodes is conducted without any collisions. The notion of graph coloring is a widely employed method with the purpose of reducing the occurrence of collisions among nodes. The achievement of this objective is facilitated by considering the set of independent nodes and implementing an optimized link scheduling [24] [3]. The network medium is accessible through the utilization of the Energy-based collision avoidance MAC (ECA-MAC) technology, as outlined in the scholarly source cited as reference [4]. Within this particular context, a classification system is implemented with the purpose of distinguishing nodes into three unique categories: first class, second class, and third class [4].

The subsequent sections present the justification for selecting collision detection as the subject of investigation in wireless sensor networks (WSNs), along with a summary of the primary challenges faced in previous research endeavors. The main motivation behind this study stems from the documented instances of data corruption that occur during the transmission of packets. As a result, the study will focus on a restricted range of challenges, which are delineated as follows. One of the main concerns highlighted in the research articles was to the network longevity of the system, which was ascribed to the prolonged energy consumption during transmission. The duration of network operation in wireless sensor networks (WSNs) posed a considerable challenge, as highlighted in reference [4], due to the need for energy saving in the transmitting and receiving units. Another challenge that has been identified in the existing body of research is the necessity to differentiate network nodes in order to give priority to those with lower energy levels while accessing the communication channel. Additionally, Djukic and Valaee (23) have conducted research that highlights a notable concern about the retrieval of comprehensive data on network architecture. In contrast, the reduction in network performance resulting from packet collisions that develop with an increase in the number of users inside the sensor network was demonstrated by Zhao et al. (2017).

Based on the above-mentioned challenges, some of the research questions related to the collision avoidance mechanism are discussed below:

- The primary inquiry pertains to the advancement of an efficient collision detection technique and its ability to accurately identify collisions through the dissemination of nodes inside a sensor network environment.
- The second study query concerns the impact of the proposed detection model on the network's performance. This study focuses on investigating if the proposed model enhances network performance and whether the assessment demonstrates performance improvement compared to previous methodologies.
- To what extent is the collision mitigation mechanism implemented with effectiveness through the utilization of the packet pre-scheduling approach?

1. Methods

A Wireless Sensor Network (WSN) refers to a collection of sensor nodes that are strategically distributed throughout a certain region in order to monitor and record environmental variations. In this context, it is seen that each individual node possesses reduced levels of energy, processing capabilities, and memory capacity. Consequently, the transceiver is employed by these nodes to facilitate the transmission and reception of packets to and from adjacent nodes [11] [4]. Wireless Sensor Networks (WSNs) consist of a multitude of individual nodes that facilitate the transmission and communication of collected data with a centralized processing unit. The components of a Wireless Sensor Network (WSN) encompass power, storage, communication, and computing. Consequently, the computing power of these sensor components is reduced. Nevertheless, the nodes within this network are responsible for both information gathering and multi-hop data transfer, enabling the processing of data alongside the base node [5]. Wireless Sensor Networks (WSNs) has the unique characteristic of being able to operate autonomously without the need for human involvement. This is made possible by their inherent aptitude to self-configure. Nevertheless, the presence of these limiting variables adversely impacts the efficiency of Wireless Sensor Networks (WSNs). Consequently, it becomes imperative to optimize the lifespan of individual nodes through the development of methodologies and protocols aimed at reducing energy consumption. The utilization of this technology is prevalent in diverse areas, including micro-surgery [14] [4], healthcare [13] [4], environmental monitoring, and military applications [12] [4]. The issue of accessing and controlling the shared media between sensor nodes is a significant challenge in wireless network transmission. Therefore, the Medium Access Layer (MAC) is used in Wireless Sensor Networks (WSNs) to enhance network performance through the evaluation of key variables such as energy saving, Packet Delivery Ratio (PDR), and latency. Several approaches have been developed to facilitate access to the transmission medium and address network challenges in Wireless Sensor Networks (WSNs) [29] [30] [4].

Wireless Sensor Networks (WSNs) are utilized for the purpose of monitoring the environment, tracking objects, and conducting surveillance. This technology is considered illuminating due to its ability to include distributed sensors. Monitoring the physical aspects of the environment is helpful in mitigating many negative impacts [10] [2]. Nevertheless, the sensor node possesses the capability to detect the occurrence of an event and exhibits several attributes, including communication and possible processing capabilities. Nevertheless, the sensor nodes maintain a constant surveillance of the deployed region. A collection of sensor nodes is aggregated to form a sensor network. In contemporary times, the need for security measures has become increasingly imperative across many network systems. Furthermore, the deployment of sensor nodes is prevalent in unattended locations that need a high level of security [2]. The collision rate among sensor nodes in a Wireless Sensor Network (WSN) is significant due to the large number of network nodes present. When many sensor nodes within a shared network region broadcast data concurrently using the same frequency channel, it is anticipated that collisions would occur at the data packets [15] [16] [7]. However, collisions are a type of assault that can result in failures in data transmission, necessitating the implementation of mechanisms for efficient re-transmission [2]. Nevertheless, the occurrence of packet collision has a detrimental impact on the overall performance of the system as it leads to an increase in channel bandwidth waste, power consumption, and data loss [17] [7]. These aforementioned concerns have the potential to result in interference, such as the occurrence of data corruption owing to packet loss and the failure to send data packets to the intended receiver. Previous studies have made various attempts to detect and address collision avoidance [9] [7]. However, the Wireless Sensor Network (WSN) exhibits more sensitivity towards some parameters, including energy efficiency, latency, and transmission. These aspects have been identified as having a detrimental impact on the performance of WSN [18], [20] [3].

The distributed algorithm in Wireless Sensor Networks (WSN) operates based on centralized algorithms, but with limited knowledge of the specific region or surrounding nodes. This limited information allows the network to achieve improved performance. Efficient data transfer across sensor nodes necessitates the consideration of interference. However, the occurrence of re-transmission resulting from collisions and interference greatly reduces the lifespan of nodes. The user has provided two references, numbered 19 and 3. In order to mitigate the occurrence of collisions between adjacent nodes during data transmission, two types of interference are taken into account: secondary interference and main interference. In the context of main interference, the node is able to receive data communication from many surrounding nodes simultaneously. Secondary interference arises when the transmission between a pair of nodes hinders communication with surrounding nodes [3]. Several link scheduling strategies now in use include Time Division Multiple Access (TDMA) and graph coloring theory (references 21, 22, and 23) to ensure collision-free transmission among the sensors. The graph coloring theory aims to minimize collisions between nodes by taking into account a collection of independent nodes and achieving efficient link scheduling [24] [3]. The network medium is accessed using the Energy-based collision avoidance MAC (ECA-MAC) technique, as described in [4]. In this context, the author establishes three distinct degrees of importance in order to categorize the nodes and organize them into three distinct classes: first class, second class, and third class [4].

The objective is to create novel optimization-driven models that can effectively carry out collision detection and mitigation in Wireless Sensor Networks (WSN). Initially, the simulation of Wireless Sensor Networks (WSN) is conducted to establish efficient transmission. Subsequently, the process of cluster head selection is executed using the Fuzzy Adaptive Bat Algorithm (FABC). In this context, the network-based parameter is acquired, encompassing metrics such as Received Signal Strength Indicator (RSSI), priority level, delivery rate, and energy consumption. The Deep Recurrent Neural Network (DRNN) is furthermore utilized for the purpose of collision detection. In this study, the training of the Deep Recurrent Neural Network (DRNN) is conducted using a hybrid algorithm called the Lion Crow Search Optimization (LCSO). The LCSO algorithm is a combination of two metaheuristic algorithms, namely the Ant Lion Optimizer (ALO) and the Crow Search Algorithm (CSO).

2.1 Challenges

The problems confronted by classical collision detection and mitigation techniques are enlisted below:

- The issue of network lifespan elevation is a significant challenge in Wireless Sensor Networks (WSNs), since it relies on the energy conservation of sensor nodes for both transmitting and receiving units. The task of distinguishing the network nodes in order to prioritize those with restricted energy levels for accessing the communication channel is a significant problem in Wireless Sensor Networks (WSN) [3]
- The utilization of an ECA-MAC technique is employed to prioritize nodes with lower energy levels. Nevertheless, the identification of collisions is a challenging task due to the intricate nature of the random back-off time that sensor nodes employ prior to transmitting data [4].
- In order to mitigate latency, a strategy for avoiding collisions of data packets has been developed. The subterranean environment presents a significant problem for data transmission in wireless sensor networks (WSNs) due to the considerable attenuation and signal loss [7].
- The SoNCF protocol has been developed to facilitate efficient data transfer. In this context, the nodes often operate on battery power and are designed to execute routine

activities. Revitalizing or replacing batteries in sensor nodes poses significant complexity due to their reliance on battery power [8].

- The security of sensor nodes in wireless sensor networks (WSNs) is crucial, since they need to safeguard both themselves and the data they collect from external assaults. However, the hardware components of lower-end sensor nodes pose a significant obstacle to achieving adequate security measures

2. WSN model

The Wireless Sensor Network (WSN) model is depicted in Figure 1. Wireless Sensor Networks (WSN) consist of autonomous sensor devices that are deployed across vast geographical areas. Wireless Sensor Networks (WSNs) are often comprised of large nodes that are assigned to certain processes. However, the presence of several sensor nodes within a WSN might lead to collisions. Collisions may occur when multiple sensor nodes within a network simultaneously transmit on the same frequency channel. The collision of data packets in a system can result in a decrease in system performance, since there is a significant proportion of data loss and higher power consumption, mostly caused by the expansion of channel bandwidth. This issue gives rise to interferences and data corruptions. The objective is to develop an innovative methodology for the identification and prevention of collisions in Wireless Sensor Networks (WSNs). Assume K sensor nodes $l_1, l_2, \ldots, l_K$, which are installed in WSN in an arbitrary way by utilizing H targets $d_1, d_2, \ldots d_H$. Every sensor node contained initial energy ε and attains capacity to alter itself for effective data transmission. In addition, the Base Station (BS) is positioned to manage effective data transmission.

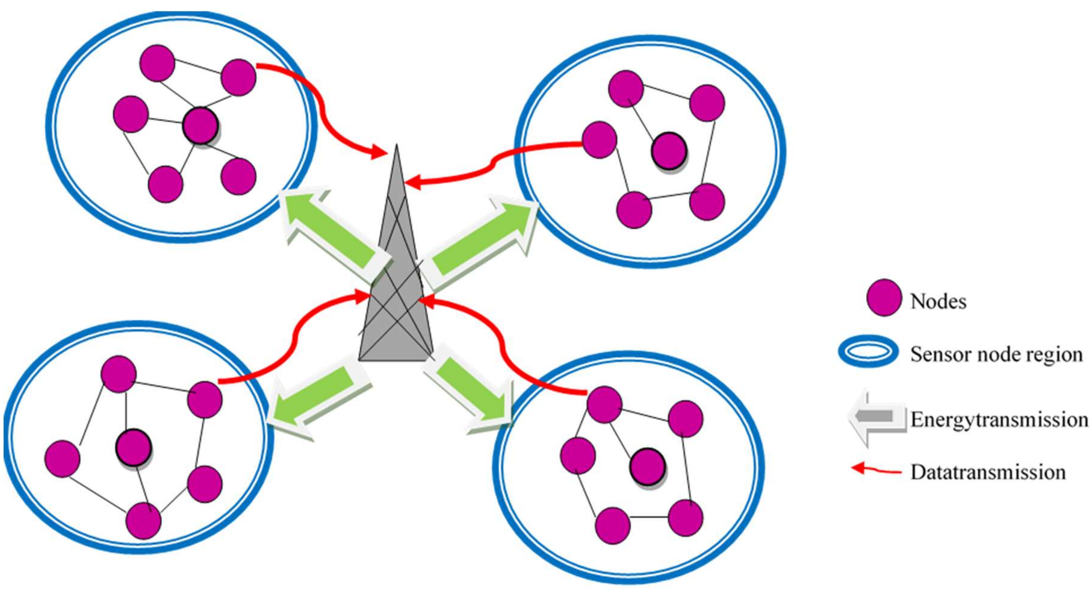


Figure 1. WSN Model

3.1 Energy Model

The energy concept is further expounded upon [31]. In order to develop an efficient routing model, it is crucial to ascertain the amount of energy spent during packet processing. At first, the threshold f_o is computed. If $f \leq f_o$, the energy consumption of node becomes proportional to communication distance square and if $f > f_o$, The energy consumption of each node is directly proportional to the fourth power of the communication distance. The two aforementioned circumstances are commonly referred to as the free space model and the multipath fading model. Let us consider that the threshold is provided by,

$$f_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \qquad (1)$$

where, ε_{fs} is energy consumption when sending data in free space model, and ε_{mp} symbolize energy consumption while sending data in multipath fading model.

The consumption of energy to send e- bits data is expressed as,

$$\varepsilon_{tr}(e) = \varepsilon_{elc}(e) + \varepsilon_{amp}(e,f) = \begin{cases} e\times\varepsilon_{elc} + e\times\varepsilon_{fs}\times f^2; If\ f \le f_o \\ e\times\varepsilon_{elc} + e\times\varepsilon_{mp}\times f^4; If\ f > f_o \end{cases} \qquad (2)$$

where, ε_{elc} depicts consumption of energy when sending and receiving one bit data, ε_{amp} refers consumption of energy when node fuse one bit data, and f is distance. The consumption of energy amongst sensor nodes receiving e-bits data is given by,

$$\varepsilon_{rx}(e) = e \times \varepsilon_{elc} \qquad (3)$$

3.2. Mobility model

The authors of the study [32] have created a mobility model that serves to depict the design of mobile nodes and assess the changes in node position based on velocity, acceleration, and location at a given moment. In this study, a mobility model is utilized to assess the routing efficiency of the proposed technique. Additionally, the model is utilised to duplicate the movement patterns of the nodes. Consider the node x and y position be expressed as (r_1, s_1) and (r_2, s_2) in a particular time. The nodes x and y changes into several velocities at particular time t. After mobility, the two nodes x and y alters to novel position. Hence, the Euclidean distance adapted for mobility of node x and y in specific path z is given by,

$$E_{(x,y,z)} = \sqrt{(r_1 - r_2)^2 + (s_1 - s_2)^2} \qquad (4)$$

where, x and y signifies two nodes contained in path z, (r_1, s_1) and (r_2, s_2) express position of node x and y at particular time t.

3. **Proposed Dolphin ALO-based Deep RNN for collision detection and mitigation in WSN**

Wireless Sensor Networks (WSNs) are composed of several sensor nodes that engage in data exchange with one another, while operating under constraints of low energy resources. Retransmission occurs as a result of collisions at the initiation of communication networks, thereby leading to an increase in network delay. A innovative approach has been devised to identify and prevent collisions between neighboring nodes during the initiation of communication. The objective is to develop a methodology for identifying and addressing collisions through the utilization of a hybrid optimization model. Initially, the modeling of

Wireless Sensor Networks (WSN) involves the deployment of sensor nodes on the sensing platform. The process of selecting a cluster head is accomplished through the utilization of the Fuzzy Adaptive Bat Algorithm for the purpose of routing, with the objective of optimizing energy consumption and prolonging the overall lifespan of the network. During the process of data transmission, the identification of collision rates is accomplished by calculating network-based parameters, which encompass energy, received signal strength indicator (RSSI), priority level, and delivery rate. The network-based parameters are extracted, followed by the execution of collision detection using the LCSO-based Deep RNN method. The training of the DRNN is conducted using the LCSO method, which is derived by combining the ALO [26] and CSA [27] algorithms. Following the identification of a collision, the mitigation of such collision is achieved by the utilization of a pre-scheduling method known as Dolphin ALO. This technique is derived from the combination of DE [28] and ALO [26]. The fitness metric has been recently developed, taking into account many criteria such as energy consumption, system integrity, delivery rate, priority level, electronic waste, and energy conservation [1]. The structure of collision detection and mitigation with the suggested Dolphin ALO is depicted in Figure 2. Proposed Lion Crow Search optimizer (LCSO) for collision detection approach. The Deep RNN classifier will be trained using integration of Ant Lion Optimizer (ALO) and Crow Search Algorithm (CSO) . It inherits the advantages of both ALO and CSA for detecting the collision.

a) Ant Lion Optimizer (ALO)

- inspired from the hunting behavior of antlions.
- It helps to address real problems with unknown search spaces and poses less parameter to adjust.
- it is flexible to address diverse issues.
- it is gradient-free technique, which is adaptable to solve real issues and can balance exploration and exploitation in an effective manner.

b) Crow Search Algorithm (CSO)

- It is devised using crow's behavior.
- It is utilized for controlling the algorithm diversity and has less parameter,
- It easy to execute and understand.
- It has the ability to solve various engineering design issues that poses various decision variables and constraints.
- The rate of convergence is good and discovers solution in less time.

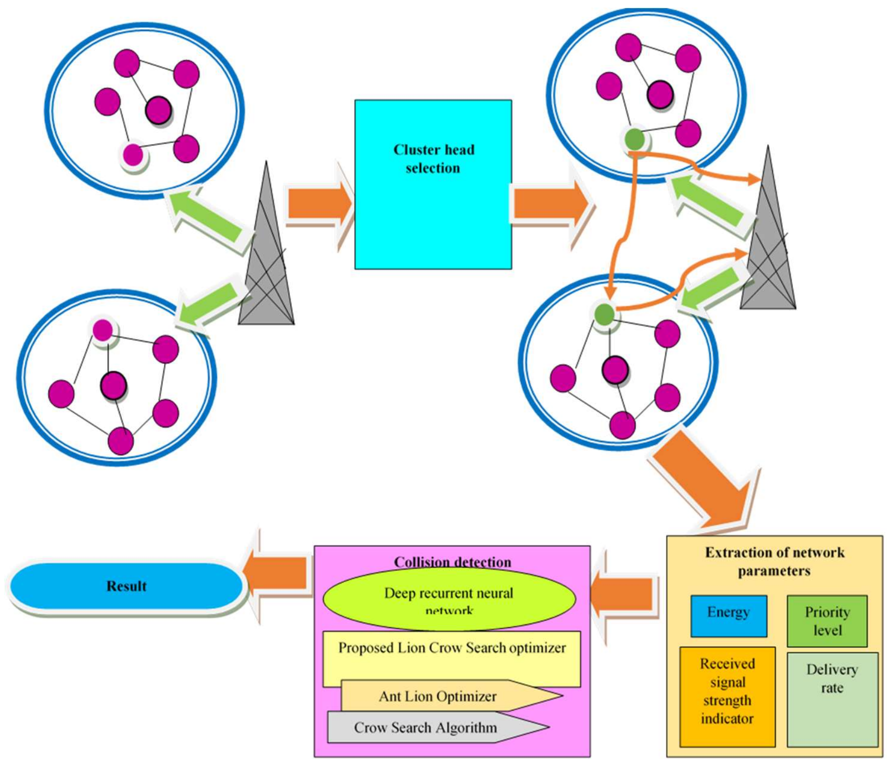


Figure 2. Structure of collision detection and mitigation framework using proposed Dolphin ALO

4. Results and Discussion

The effectiveness of proposed Lion Crow Search optimizer (LCSO) is analyzed using energy, PDR, collision detection rate and throughput by altering rounds with 150, and 200 nodes.

5.1. Experimental setup

The Lion Crow Search optimizer (LCSO) are executed on Windows 10 OS with 8GB RAM and Intel i3 processor and are implemented in python.

5.2. Simulation parameters

The simulation parameters and the values of each parameter are revealed in table 1.

Table 1. Simulation attributes

Simulation parameter	Values
Initial energy	1
Number of nodes	150 and 200
Width of simulation area	100 m
Height of simulation area	100 m

5.3. Evaluation measures

The developed method is analyzed using certain metrics that are described below.

a) Throughput: It refers count of data packets obtained by target at specific time, and is given by,

$$Throughput = \frac{Z}{r}$$

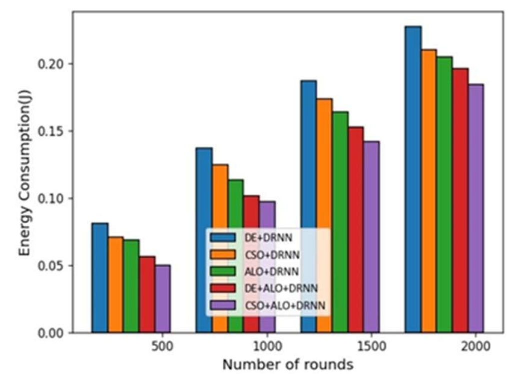
where, Z is count of nodes obtained at simulation time r .

b) PDR: The proportion of received data packets by sent data packets, and is used to evaluate efficiency of routing.

$$PDR = \frac{R_d}{S_d}$$

where, R_d is received data packets and S_d is sent data packets.

c) Energy: It indicates energy remained in nodes at highest iteration.



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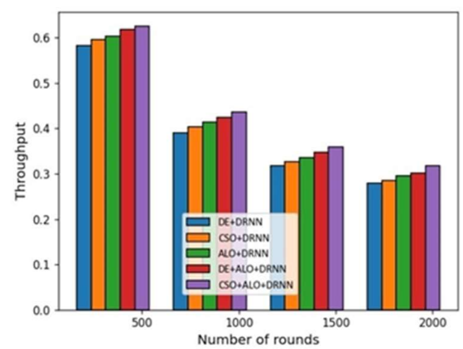

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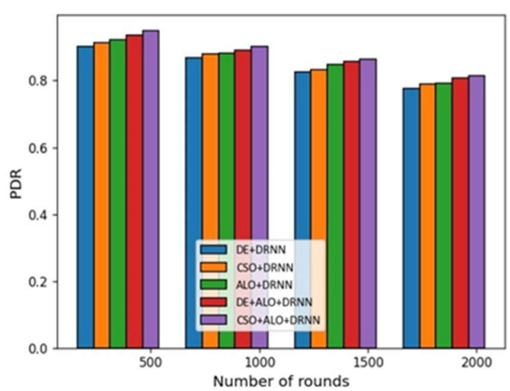

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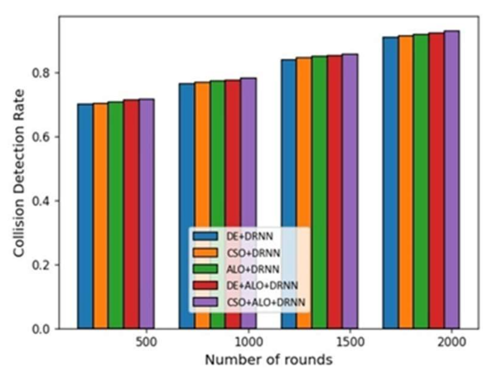


(d)

Figure 3. Algorithm analysis with 150 nodes considering a) Energy consumption b) Throughput c) PDR d) CDR

d) Collision detection rate: The rate at which the collision is detected. The collision happens whenever several nodes try to send a packet amongst network at same time.

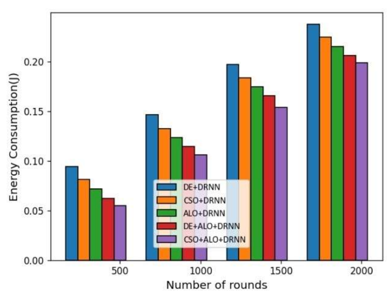
5.4. Algorithm analysis

The analysis of each algorithm is devised by altering rounds using 150 and 200 nodes considering energy consumption, PDR, throughput and CDR.

5.4.1. Assessment using 150 nodes

The analysis of the program is depicted in Figure 3, which encompasses a dataset consisting of 150 nodes.

The figure labeled as 3a) presents the assessment pertaining to energy use. The energy consumption of DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN over 500 cycles is recorded as 0.081J, 0.071J, 0.068J, 0.056J, and 0.050J, respectively. In the context of 2000 iterations, the energy consumption of the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN approaches are recorded as 0.227J, 0.210J, 0.205J, 0.196J, and 0.185J, respectively. The analysis pertaining to throughput is depicted in Figure 4b. The throughput values obtained from five different combinations of algorithms, namely DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN, over a span of 500 rounds are 0.582, 0.596, 0.604, 0.618, and 0.625, respectively. In the context of 2000 rounds, the throughput values obtained from the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN approaches are 0.279, 0.286, 0.295, 0.302, and 0.318, respectively. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF in relation to the planned Dolphin ALO + DRNN, as measured by throughput, are 12.264%, 10.062%, 7.232%, and 5.031% respectively. The study utilizing Packet Delivery Ratio (PDR) is depicted in Figure 4c. Over a span of 500 iterations, the PDR values obtained by employing several algorithms, namely DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN, are 0.901, 0.914, 0.923, 0.936, and 0.949, respectively.



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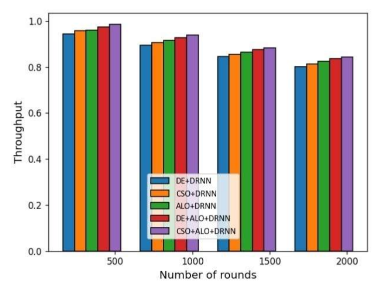

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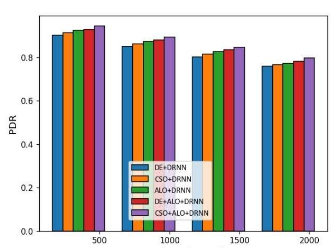

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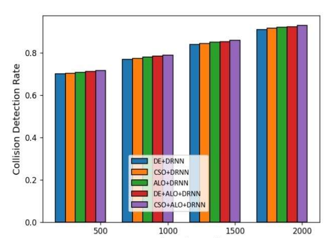

(d)

Optimization (ALO) with DRNN, DE with ALO and DRNN, and CSO with ALO and DRNN, are measured to be 0.775, 0.789, 0.792, 0.809, and 0.815, respectively. The performance enhancements seen for DDLS, ECA-MAC, seven-byte addressing string, and SoNCF in comparison to the planned Dolphin ALO + DRNN utilizing PDR are 4.907%, 3.190%, 2.839%, and 0.736%, respectively. The collision detection rate analysis is presented in Figure 4d. The collision detection rates obtained from the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN algorithms, after conducting 500 rounds, are 0.701, 0.704, 0.708, 0.714, and 0.718, respectively. In addition, the collision detection rates obtained from the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN algorithms for a total of 2000 cycles are 0.911, 0.915, 0.920, 0.924, and 0.930, respectively. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF, in relation to the planned Dolphin ALO + DRNN, as measured by collision detection rate, are 2.043%, 1.612%, 1.075%, and 0.645% respectively.

5.4.2. Assessment using 200 nodes

Figure 4 illustrates the algorithm analysis conducted on a dataset including 200 nodes. The energy usage evaluation is depicted in Figure 5a. In a series of 500 iterations, the energy consumption of the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN approaches 0.094J, 0.081J, 0.072J, and 0.062J respectively. Conversely, the energy consumption of the CSO+ALO+DRNN combination is recorded at 0.055J. In the case of 2000 iterations, the energy consumption of the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN approaches 0.237J, 0.224J, 0.215J, and 0.206J, respectively. Conversely, the energy consumption of CSO+ALO+DRNN is recorded as 0.199J. The evaluation utilizing throughput is depicted in Figure 5b. In a series of 500 iterations, the throughput values obtained from the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN approaches were recorded as 0.945, 0.958, 0.960, and 0.975, respectively. Conversely, the CSO+ALO+DRNN approach yielded a throughput value of 0.986. In the context of 2000 rounds, the throughput values obtained from the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN approaches are 0.801, 0.814, 0.825, and 0.836, respectively. Additionally, the CSO+ALO+DRNN approach yields a throughput value of 0.843. The performance enhancements of DDLS, ECA-MAC, seven bytes addressing string, and SoNCF in relation to the planned Dolphin ALO + DRNN, as measured by throughput, are 4.982%, 3.440%, 2.135%, and 0.830% respectively. The analysis conducted using the PDR method is presented in Figure 5c. In a series of 500 iterations, the performance metrics of several algorithms, namely DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN, and CSO+ALO+DRNN, were evaluated. The corresponding PDR values obtained were 0.904, 0.914, 0.925, 0.930, and 0.945, respectively. In addition, the performance metrics obtained from 2000 iterations for the algorithms DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN are 0.760, 0.767, 0.773, and 0.783, respectively. The combined algorithm CSO+ALO+DRNN achieves a performance metric of 0.798. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF in relation to the planned Dolphin ALO + DRNN utilizing PDR are 4.761%, 3.884%, 3.132%, and 1.879%, respectively. The results pertaining to collision detection rate are presented in Figure 5d. In a series of 500 iterations, the collision detection rates achieved by the DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN methods were seen to be 0.700, 0.705, 0.709, and 0.713, respectively. In contrast, the CSO+ALO+DRNN method exhibited a collision detection rate of 0.718. In the case of 2000 rounds, the collision detection rates produced by the combinations DE+DRNN, CSO+DRNN, ALO+DRNN, DE+ALO+DRNN are 0.911, 0.917, 0.921, 0.925, respectively. On the other hand, the combination CSO+ALO+DRNN yields a collision detection rate of 0.930. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF in relation to the planned Dolphin ALO + DRNN, as measured by collision detection rate, are 2.043%, 1.397%, 0.967%, and 0.537% respectively.

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