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ARTIFICIAL BEE COLONY ALGORITHM (ABC), LION OPTIMIZATION ALGORITHM (LOA), AND COMPARATIVE ANALYSIS OF THE LOADNG ROUTING PROTOCOL IN IOT (FF, LOA, AND ABC)

Ms. M.SELVI., Assistant Professor, PG and Research Department of Computer Science, Kaamadhenu Arts and Science College, Sathyamangalam.Tamil Nadu, India.
Dr.R.Rajesh., Assistant Professor and Head, PG and Research Department of Computer Science, Kaamadhenu Arts and Science College, Sathyamangalam, Tamil Nadu, India.

Abstract:
The Internet of Things (IoT) connects "everything" with "everything" and offers rapid and extensive device-to-device connectivity. IoT's overarching goal is to transmit data via the Internet without the involvement of a human. An effective routing protocol is a requirement for an IoT network to achieve its goals and safely transmit data. Everything will be connected, including smart environments like smart cities, smart homes, smart hospitals, smart clothing, and many other smart environments. The Internet of Things or Internet of Everything is used by these gadgets. IoT has become more significant as monitoring, surveillance, and data collection have developed. The effectiveness of any network is determined by its routing protocols. Lightweight on-demand Ad hoc Distance Vector Routing Protocol (LOADng) parameters can improve lifetime performance in these limited settings. As a result, we compare an IoT metaheuristic algorithm to FireFly (FF), Lion Optimization Algorithm (LOA), and Artificial Bee Colony Algorithm (ABC) in this paper to parameter optimize the LOADng routing protocol. The simulation results demonstrate how the LOA algorithm chooses the best way to achieve that result.

Keywords: IOT, LOADng protocol, firefly, LOA, ABC, metaheuristic, routing protocol

I.INTRODUCTION

In the last ten years, a lot of devices have changed or been modified, and the rise in internet use has revolutionized a lot of internet-enabled devices. The Internet of Things (IoT) is a multi-functional network of sensing, observation, and automation that uses the Internet as a medium, in contrast to the Internet, which is a global computing network made up of connected objects that employ standardized communication protocols. a networked, physically addressable, and intelligent environment. One of his cutting-edge technologies, the Internet of Things (IoT)[1], enables communication between objects as well as between objects and people. The Internet of Things (IoT) [2] is a new paradigm that employs numerous techniques to foster ubiquitous interaction among online-connected items [3]. The term "Internet" refers to the network connections that enable the sharing of data and services among numerous devices. Anything that provides a specific function to ensure effective interaction between items and humans is considered a "thing" [4]. Instead of encouraging reactive device behavior, IoT expansion has promoted proactive device activity. IoT applications and machine learning algorithms are combined to make the function smarter. The Internet of Things is made up of several heterogeneous networks with various levels of processing power, platform support, and range to unreachable locations. IoT-capable items/things are pervasive, have individual addresses, and interact with one another. Intelligent environments, healthcare, environmental and urban monitoring, transportation, different industries, and energy monitoring are a few examples of IoT uses. A part of the network architecture that transmits and receives data packets is an IoT router. internet-connected devices. It allows devices on one network to communicate with those on another by connecting a local network to the internet.

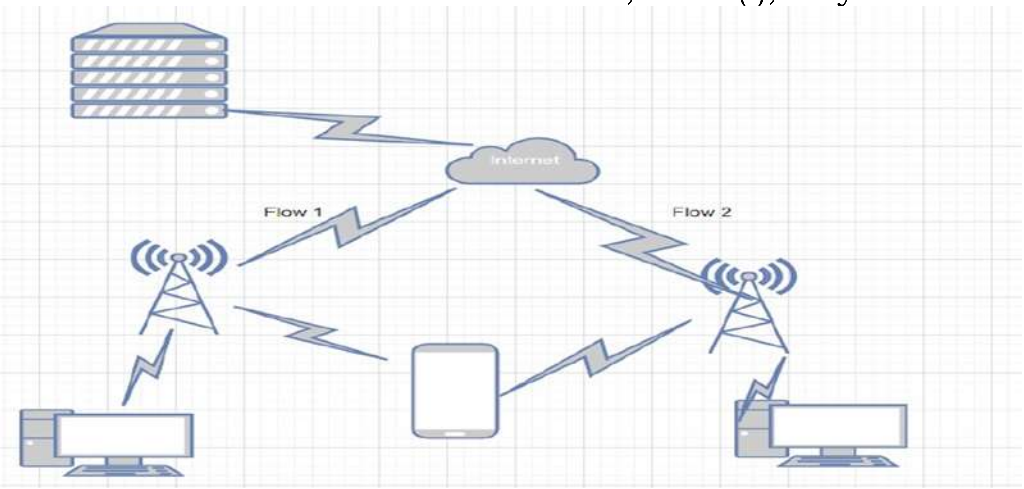


Figure 1: Routing in IOT devices

Real-time categorization and analysis of such massive data sets is essential since they clog up networks, causing data mistakes and transmission delays. Furthermore, the effectiveness and speed of the system are compromised. Finally, the equipment is unreliable in a crisis. One approach is an IoT metaheuristic strategy, which requires the least amount of storage space, the least amount of network bandwidth, and the least amount of time to gather and analyze data. This approach is one of many that have been proposed to address the data collection and analysis difficulties of IoT devices. The performance of the device ultimately improves as a result. It is crucial to categorize and analyze such large amounts of data in real time because this data causes network congestion, resulting in data errors and transmission delays. Furthermore, system speed and efficiency are jeopardized. Finally, in an emergency, the device is unreliable. Many methods have been suggested to solve the data collection and analysis issues of IoT devices, one of which is an IoT metaheuristic technique that uses the least amount of storage space, the smallest amount of network bandwidth, and the shortest amount of time to collect and analyze data. This ends up resulting in a general rise in the intertubes's effectiveness.

The development of IoT network protocols is necessary given the rise in the number of physical devices connected to the Internet. The right parties, such as smart phones, web services, cloud resources, and other devices, should have access to the data collected by these devices. IoT uses sensors and actuators to enable device-to-device communication. A monitor is used to gather, store, and process the data. To prevent the environment around a device from changing, an actuator is used. On a distant server, the analyzed data is stored. IoT items' size, energy use, and computational power result in storage and processing that is occasionally constrained to some readily available resources. Communication will be necessary for the process of gathering, sharing, and transmitting information, whether or not there is human involvement., communication between router- and host-serving nodes. In order to be compatible with the new type of network, new network algorithms must be developed or old ones must be modified due to the low processing and power of IoT devices. Routing protocols for IoT networks have gained popularity as a research topic in recent years, and the field has seen many achievements.

Flooding of route request packets increases overhead in most routing systems. It determines the best path between the source and destination nodes using metaheuristic algorithms in the routing protocol (LOADng) [7]. A lot of research has recently been done concentrating on the design and implementation of routing algorithms to improve network efficiency and longevity. In IoT networks, routing is a major problem that calls for special consideration. The firefly algorithm, lion optimization algorithm, and artificial bee colony algorithm are used to solve the issue of optimization routing in IOT. As a result, the lion optimization algorithm reduces the calculation of energy usage, delay, and best solution.

II. ROUTING PROTOCOLS FOR IOT NETWORK

To address the various challenges presented by the constrained environment, several routing algorithms have been designed to operate efficiently in IoT networks. This part goes over the standard and non-standard routing mechanisms that are specially designed for IoT scenarios. The main features, working principles, and performance of CTP, RPL, LOADng, LOADng- CTP, and CARP have been studied.

The Lightweight On-demand Ad hoc Distance-vector Routing Protocol (LOADng):

The LOADng [8] protocol is a reactive distance-vector routing system that is derived from AODV [9] (Ad hoc On- Demand Distance Vector) and extended for use in Low-power and Lossy Networks. (LLNs). It can be used as a route-over routing algorithm at the network layer or a meshunder protocol at the link layer. Because the route building process is initiated when data transmission is required and there is no path to the destination in routing tables, this IOT device simplified routing version is a good fit for constrained and low memory storage devices.

As a result, control messages perform the route creation process as well as a set of information that nodes must keep during protocol operation. LOADng classifies control signals into four types: Request for Route (RREQ): When a data packet needs to be sent to a recipient, an originator device generates an RREQ message. The RREQ packet does not include a valid route to the ultimate destination, but it does include a sequence number, a hop count, a hop limit, and routing metric information. RREP (Route Reply): When a router destination, marked as the data receiver in the routing set, receives an RREQ message, it generates an RREP message. It has the same structure as RREQ, but it adds an extra field named "ackrequired" to indicate the need for an acknowledgment message. RREP-ACK (Route Reply Acknowledgement): A LOADng router generates the RREPACK message in response to an RREP message with a true "ackrequired" field. Since routes are still maintained, the RREPACK message is sent straight to the destination. Route Error (RERR):

A router generates the RERR message when it encounters an unreachable location. The "errorcode" field is used to identify the cause of the broken route. The basic operations of LOADng as a reactive protocol include the generation of Route Requests (RREQs) messages by a LOADng Router (originator) in order to find a path to the desired node, Transmission of such RREQs through intermediate nodes accessible at the routing table entry, until they reach the destination LOADng Router, generation of RREP message by the designated destination when getting the request message. Because reversible routes are installed at intermediate nodes using the information logged in the Routing Set, responses will be unicasted hop by hop towards the originator, following the stored reverse route. If the "ackrequired" field is set to True when an RREP message reaches the request originator, the RREQ receiver must transmit an RREP-ACK response to the RREP originator. Nonetheless, if a broken route is identified, a Route Error (RERR) message is returned to the data packet's originator to notify it of the route breakage. When using LOADng routing, each node must keep a Data Base containing information about the routing processes and other network nodes such as the Routing Set, Blacklisted Neighbor Set, and Delayed Acknowledgement Set.

Working of LOADng:

The working of the LOADng protocol is described Figure 2:

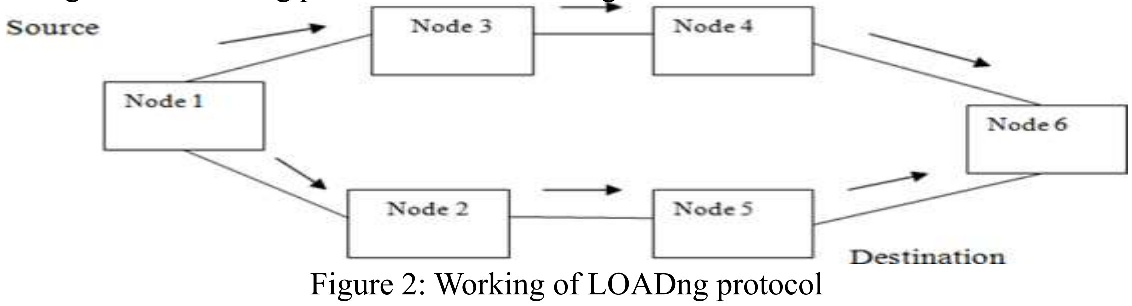


Figure 2: Working of LOADng protocol

- Discovering network routes between a source and a destination in both ways.
- Creating and maintaining a path between the origin and target.

- Control and signalling traffic is generated by the network only when data must be sent or a route to the target is unavailable.

For the various message types exchanged by nodes in both dense and sparse IoT situations, LOADng-IoT increases the packet delivery ratio and decreases end-to-end latency.

- This results in fewer control signals being needed to build routes between nodes, making the network more effective and requiring less overhead.
- LOADng-IoT reduces the amount of energy needed to construct paths and route data messages, making the system more energy optimal.
- This results in fewer control signals being needed to build routes between nodes, making the network more effective and requiring less overhead.
- LOADng-IoT reduces the amount of energy needed to construct paths and route data messages, resulting in a more energy-efficient network.

III. METAHEURISTIC ALGORITHMS

Metaheuristic algorithms try to discover the best (feasible) solution to an optimisation problem out of all possible solutions. To that end, they assess potential solutions and run a series of operations on them in order to discover new, better solutions. The algorithms described below are the artificial bee colony algorithm, the Firefly algorithm, and the Lion Optimization Algorithm.

Artificial bee colony algorithm

An artificial bee colony algorithm is a programme that mimics bees' intelligent foraging behaviour. Food source searching is one of the primary uses of bee communication in such algorithms [10]. The model includes two kinds of bee groups to search for food sources: scouts and foragers. The "scouts" initiate bee hunting behaviour.

Scout bees fly around the beehive area looking for a food supply. They perform a random search in the region with n dimensions. They can also fly up to three kilometres away from the colony to find food sources. When a food source is found, the scout bees return to the hive with their findings and use dance language to tell the other bees. This information about the quality of the food source is shared among bees in the dance region via "waggle dance." The position of a food source represents a potential solution to the problem in the bee colony algorithm, and the quality of the associated solution corresponds to the nectar amount of a food source.

Some bee "foragers" use the gathered data to associate with a specific food source and begin foraging. The quantity of food information exchanged by scouts with their nectars determines the number of foragers.The bees' behaviours will be iterated until an optimal answer is found via routing in the LOADng protocol. Figure 3 depicts the complete procedure.

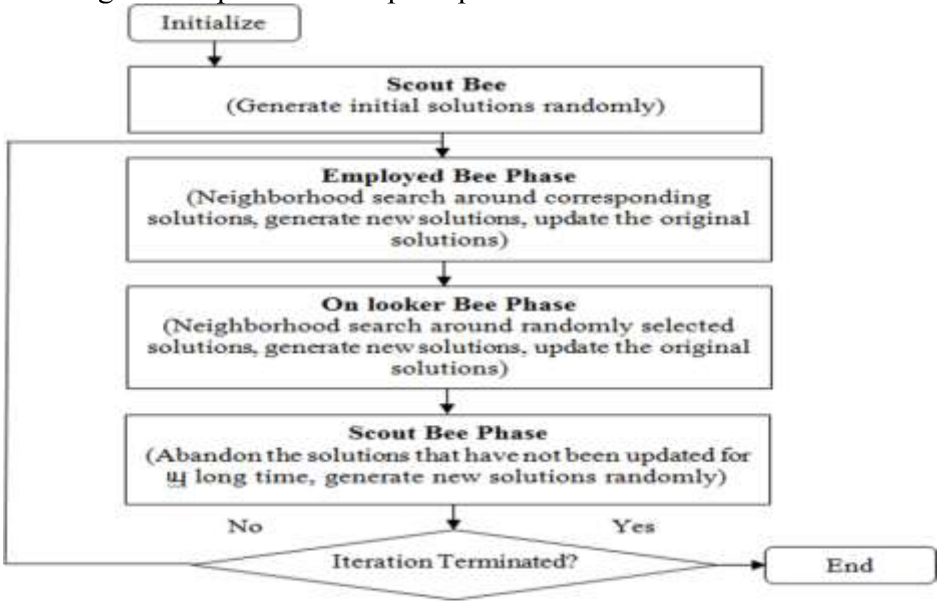

Initialize
Scout Bee
(Generate initial solutions randomly)
Employed Bee Phase
(Neighborhood search around corresponding solutions, generate new solutions, update the original solutions)
On looker Bee Phase
(Neighborhood search around randomly selected solutions, generate new solutions, update the original solutions)
Scout Bee Phase
(Abandon the solutions that have not been updated for ɥ long time, generate new solutions randomly)
No
Yes
Iteration Terminated?
End

Figure 3: Flow of ABC Algorithms

Phases of ABC

It generally consists of four phases.

1. 1. ABC's initialization. Determine the quantity of simulated bees. There are 50% working bees and 50% onlooker bees. Determine the limit number and generate the random initial potential solutions for employed.

2. 2. Phase of hired bees for all employed bees Using an equation, it generates a fresh candidate solution. [11] Determine the improved solution's fitness value. Replace the older solution if the fitness of the new candidate solution is greater than that of the current solution. Determine the chance for each person.

3. 3. The onlooker insect stage. Bees are visible to all onlookers. Using a roulette wheel, choose a hired bee. Create a fresh potential solution. Calculate the individual's health. If the new candidate solution is more fit than the current solution, it will replace the older solution. Scout bee phase: if any food source is exhausted, scout memorises the best answer and replaces it with a randomly generated solution. Until (stopping criteria is not met).

1. The first part of the foraging process is the search for food sources in the environment. The solutions will be represented by: min f f (x), x)x1, x2,,...xm s, s [xiL , xiH]

(1) , where x is the m-dimensional variable, f is the objective function, and the upper and lower limits of the ith-dimensional variable are [xiL, xiH]. If N is the overall number of employed and onlooker bees, then 2N random locations are chosen.

2. The second part will begin with the exploitation of the identified sources in order to become a paid forager. This hired bee collects the nectar. It will then return to the colony to unload the honey, and dance stigmergy will be used to share information with the remaining bees. When the food source is depleted, the hired bee transforms into a scout in search of a new food source. Employed pollinators investigate new food sources. Vij xij Rij (xij xkj)

(2) In which the Vji denotes a new location, Rji will be a random number in the range [-1, 1], k = 1, 2, 3... N and the k i.

3. The third step consists of the onlooker bee waiting in the hives, receiving a dance signal for a scout bee, and selecting a location based on the quality of food and the frequency of the dance. After each onlooker bee investigates the food supply in the neighbourhood xi. The chance Pi was computed using Equation 3:

$$P_i = \frac{f_{it_i}}{\sum_{i=1} f_{it_i}} \quad (3)$$

In an optimal path, each node has a position that indicates the best optimal solution and the quantity of nectar that is used to evaluate the fitness quality of the environment's optimal path, and is evaluated according to Equation 4:

$$f_{it_i} = \frac{1}{1+f_{x_i}} \quad (4)$$

Where f iti is the fitness value of the hired bee and fi is its objective function value. LOadng-Inspired Routing Protocol

[12] Metaheuristic technology had been developed. To enable multipath routing in an IOT network, the protocol employs the concept of swarm intelligence inspired by bees. It is emphasized in order to discover a variety of routes and properly distribute traffic.

Firefly Algorithm

The previously algorithm known as the Firefly is a nature-inspired metaheuristic optimisation method inspired by the social lives of fireflies in the wild. The appellation Lightning bugs alludes to the Firefly's synonym. There are about 2000 different firefly species in the globe. Most firefly species generate short, rhythmic ashes. Each species has a distinct flashing design. The signal of the firefly's flash attracts mating companions and possible prey. Furthermore, the flashes can be used as a method of safe warning. Yang's suggested firefly algorithm can be explained as follows.

1. Where all fireflies are unisex, one firefly will be requested to join the other fireflies without regard for their gender.
2. Firefly Its radiance indicates its attractiveness. For any two flickering fireflies, the lower light one moves towards the higher light one. The appeal is measured by the brightness. The lovely appearance of two fireflies decreases as their distance grows. If both fireflies have the same brightness, one of them will travel at random.
3. An objective function is used to determine the firefly brightness. The brightness for the maximisation issue is proportional to the value of the objective function.

The firefly optimisation algorithm is used to pick the best solution. The firefly method is depicted below: Goal function fun(y), y = (y1; :::; yd)T

```
Create fireflies initial population yj ; j = 1,.., n Intensity of light Intensityj at yj is identifed by fun(yj )
Set coefficient □ (absorptionoflight)
while stop condition true do for j □ 1 to n do
for k □ 1 to n do
if Intensityj < Intensityk then
Shift firefly j in the direction of firefly k end if
Modify attractiveness with distance dis by exp( □ *dis)
Assess new solutions and modify the Intensity of light end for
end for
Order the fireflies and locate the current global best gbest end while
```

The optimal solutions are selected using fitness function.

The firefly algorithm terminates once all iterations are completed.

Step 1: In this step, the FF population is randomly initialised and consists of a fixed solution. The population is the route in our algorithm.

Step 2: Determine the distance between any two FF i and j at xi and xj, respectively, as follows:

$$V=\|x_i - x_j\| = \sqrt{\sum_{k=1}^{D}(xi - xj, k)2} \qquad (7)$$

D is the optimisation parameter in this case, and it corresponds to the number of computational tasks in this research.

Step 3: As the distance rises, the attractiveness of the FF, which is the objective function of our algorithm, diminishes exponentially. At a distance v, Equation (8) gives the FF's attractiveness.

$$\beta(v_{i,j}) = \beta_0{}^{-\gamma 2ij} \qquad (8)$$

Where β is the FF's brightness at distance v, and 0 is the brightness at starting attractiveness when v = 0. The potential value of the light absorption rate is the variance of attractiveness, and its value influences the speed of algorithm convergence. Most of the time, the numbers 2[0.01, 100].

Step 4: At this step, the FF attraction and randomization walkthrough Levy flights. The above moving of the FF is computed depending on the distance and attractiveness as outlined below:

$xi = xi + \beta 0e-\gamma r^{2}ij(xj - xi) + \alpha\in i$ (9)

Where α is the randomization variable, and εi is a random number vector derived from a Gaussian or uniform distribution. The movement of the FF is equivalent to that of the node to the route in our algorithm [14].

Light Intensity variation and Attraction Capability

The possible routes from the transmitter user to the destination user are considered in the FOA. These potential routes are fed into the FOA, and an iterative process of position updates is used to find the best route. The attraction capacity and variation of light intensity are important factors in the firefly algorithm. The algorithm's fitness rating is calculated using light intensity. Highly non-linear and multiple multi-optimization issues are both manageable by the firefly algorithm. A low or high intensity firefly draws other low or high intensity fireflies. Think about how far a pair of fireflies, like and, are from one another. The intensity of light decreases as one moves away from the source, and media consume light. Equation (1) calculates the intensity of light using the rule of square inverse.

$$I(D) = \frac{I_s}{D_{XY}^2} \quad (1)$$

The source intensity is denoted as . The light intensity expression varies related to distance , as in equation (2).

$$L_1 = I_c e^{-\beta D_{xy}} \quad (2)$$

The constant light absorption coefficient is written as. The initial light intensity is denoted as Each firefly has a powerful attractive capacity, which has a strong firefly behaviour attraction over neighbouring firefly groups. To alter the attractive capacity, two firefly distances, X and Y, are used. The attractiveness of fireflies is proportionate to the light intensity of neighbouring fireflies. Equation gives the attractive function formula. (3).

$$\alpha = \alpha_0 e^{-\beta D^2_{xy}} \quad (3)$$

The movement towards attractiveness firefly:

The equation below describes the movement of firefly I when it is attracted to the brighter firefly j.

= + 0 −2 (−)+ (− 1/2) …(4)

The firefly's brightness, xi, the current location, and the final term in equation (4) all refer to random motion. The (rand - 1/2) represents a firefly's random moving. The coefficient is a randomisation parameter defined by the problem of interest with [0, 1], and rand is a random number generated by the uniform distribution in the space [0, 1] [9, 23]. The attractiveness of fireflies I and j varies with range dij. As one moves away from the viewer, the intensity of the light decreases, and light is also absorbed by the medium. [15]. Because the attractiveness of a firefly is proportional to the light intensity seen by neighbouring fireflies, the attractiveness function (dij) of a firefly can be a monotonically declining function represented as,

$\beta(dij)=\beta_0 e^{-\gamma d}ij$ (4)

where is the distance between firefly and firefly , is the light absorption coefficient, and 0 is the attractiveness at = 0. We take 0 = 1, = 1.

3.3. Lion Optimization Algorithm

In an IoT network, this lion optimisation technique is used to create the efficient routing protocol LOADng. This method is founded on social organisation and behaviour. It is employed to identify and swap out the worst route for the best one. This algorithm is primarily used to monitor the behaviour of the node discovered in the routing route. This moves in random numbers with uniform distribution towards the chosen region. To demonstrate the original direction for transmission, the distance between the intermediate nodes and sensor nodes positions are chosen.

Initialization:

The LOA's startup process begins with creating of a random population of lions, which is then stored in the solution space as a matrix, where lions are symbolised by solutions that are:

Lion =[x1,x2,…,xNvar] (1)

where xNvar represents the number of generic forwarder nodes chosen. %N represents the randomly generated nomad lion ratio, while the remainder are resident lions. The solution needed for selecting the best forwarder node from inputs is carried out using LOA, which can search for and find hidden relationships between individual network elements.
Hunting Process : At first, the lions are divided into sections at random. The cluster with the highest fitness value is placed in the center, and the other groups are placed on the right and left wings. If the PREY (P) manages to get away from the hunter, the PREY reports its location. Equation represents the updation function. (2).

′=+(0,1)×%×(−) (2)
Where; B represents the position of the prey, the hunter's location is represented as L, and hunter fitness improvement is represented as %I.

The left and right wings of the new hunter are calculated using equation (3).
′={(,),<(,),> (10) Where; (L, B) indicates the random value
The female lion updates their position using equation (4).
′=+2×(0,1){1}+(−1,1)×()××{2} (4)
{SB1}⋅{2}=0,‖{2}‖=1 (12)
Where;
→ Position of the female lion
→ Distance between the female lion
{SB1}→ Existing position of the female lion
{2}→ Perpendicular to {SP1}

Fitness calculation process:

The suitability calculation in this case depends on the delay and collision; consequently, the best partition that successfully sends the emergency message is selected as the forwarder. The fitness function's parameters are a minimal one-hop delay and a low packet collision rate.

$$\text{Fitness}=\min\frac{\sum_{=1}(\quad +}{2} \quad (5)$$

(5)

Pi delay represents the propagation time of each node in the partition after getting messages. The Pi collision happens in the partition nodes for delay and collision. The answer will be updated once the fitness has been calculated. Of the essential updation functions in the lion algorithm are hunting, mating, roaming, defense, and so on. Few female lions pursue prey within the pride's territory, and some may live in the same area. The best in each territory's prides will help determine the best path on every iteration. In our study, we pick the best partitions from the initial solution based on fitness. Furthermore, we must choose the best division among the updated options.

Moving toward safe place:
In each group, only a few female lions specialise in hunting. The surviving females were relocated within the territory to a safe place. Each pride's personal best place is calculated and saved. The female lion's new role is,

PF’L = 2D×rand(0,1){S1}+U(-1,1)× tan() ×D ×{S2}+PFL(6)

{S1}.{S2} =0, ||{S2} = 1 (7)

Where PFL symbolises the female lion's current position, D symbolizes the spacing between the FL and the selected point chosen by event selection between the pride territories, f S1g represents a vector whose starting point is the prior stance of the female lion

and its direction is toward the selected point, and fS2g is vertical to f S1g. In the tournament selection, first define a lion's success (SU) as improving his or her best location in the previous iteration of the lion optimization algorithm

$$SU(i,t,G)=\begin{cases} 1 & Bst_{,<} \; Bst^{-1}_{,} \\ 0 & Bst_{,=} \; Bst^{-1}_{,} \end{cases} \qquad (8)$$

In which Bstt i;G is the best position found by Lion up to iteration t. A large number of victories indicates that the lions have combined to a point far from optimal. Furthermore, a low number of accomplishments show that the lions are circling the ideal arrangement without significant improvement. As a result, the achievement esteems are used to assess the competition's measure. Tsj(S)|was estimated using the success values as:

$$T_{sj}(S)=\sum_{1}(,,) \qquad = 1,2,\ldots\ldots, \qquad (9)$$

where SU () denotes lion's success. Tsj(S) is the number of lions in the pride j that improved their fitness during the previous iteration.

The game size varies with each iteration, implying that as SU decreases, Tsj(S) increases, resulting in diversity. As a result, the following equation is used to calculate game size:

$$T^{size}_{i} = \max(2, ceil(\frac{Tsi(S)}{,})) \qquad (10)$$

Here, TSize j represents the tournament size and ceil () function returns the smallest integer value which is bigger than or equal to 2 .

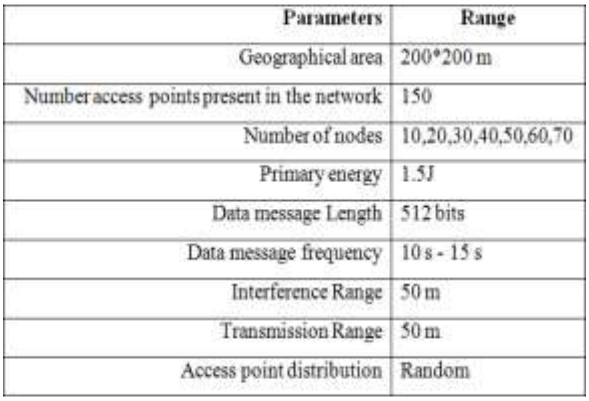
Mating: Mating is essential for lion longevity and the process of producing new generations. Cubs are born after locating suitable mother and male lions. Using crossovers and mutations, this method generated new and improved solutions from existing ones. The elimination of weak lions guarantees that the best solutions are developed.

Termination Criteria: When the limit number of iterations is reached, the iteration is over. The finest fitness is designated among the iterations. The best route is chosen based on the greatest fitness. The chosen route is used for extra handling.

IV. EXPERIMENTAL RESULTS

The purpose of the study is to evaluate the procedure in a simulation environment that can accurately represent the close conditions of IOTdata transmission. There are many available simulators, including contiki, OMNET, qualnet, MATLAB, and NS3, but this paper has used NS3 to evaluate the performance of the suggested protocol. A well-liked and well-known IoT emulator that is utilized in real-time networks is NS3 simulator, an open source simulator. Python and C++ are the programming languages used. It is used to determine whether network infrastructure is strong enough to fend off potential attacks and various threat models. In this emulator, protocols like 6LOWPAN, Zigbee, and LTE are employed. The three types of devices in this simulator are IoT nodes, blockchains, and gateways. The gateway node, IoT node, and blockchain node of the IoT simulator are tusually directed in the appropriate directions to the GatewayNode Class, IoTSensorNode Class, and Blockchain Node Class. The simulation settings and parameters used for this paper investigation are displayed in Table 1.

Table 1: Simulation Parameter



Parameters	Range
Geographical area	200*200 m
Number access points present in the network	150
Number of nodes	10,20,30,40,50,60,70
Primary energy	1.5J
Data message Length	512 bits
Data message frequency	10 s - 15 s
Interference Range	50 m
Transmission Range	50 m
Access point distribution	Random

Throughput: The amount of bytes successfully received by the destination is defined. T = / (%), where - Packets received, - Packets Departed. Figure 9 depicts the variance in average throughput for algorithms. Total packets received at the destination

node divided by the total amount of network time is used to determine throughput. It is described as network performance characterised by the efficient delivery of packets from source to destination. The network throughput is the number of data packets effectively transmitted over a communication channel to the ultimate destination node in seconds. Throughput is described in this study as:

$$\text{Throughput} = \frac{\text{Number Of Delivered Packets}*\text{Packet size}*8\text{ bit}}{\text{Total duration of simulation}}$$

Data packets per second or data packets per time period are always measured. LOA regularly outperforms the other FF, ABC algorithm in terms of throughput. Furthermore, because the contact graph is inhomogeneous, the throughput performance of various flows varies significantly (by more than two orders of magnitude), even when the set of flows was selected to maximise direct connection capacity. Despite having the same throughput, LOA delays are superior than FF, ABC.

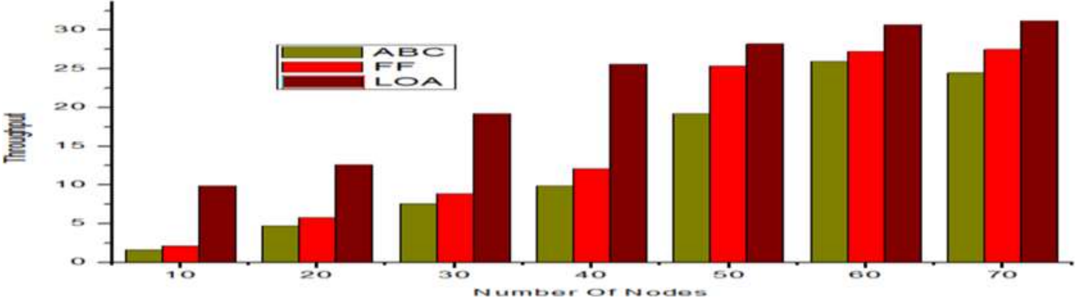


Figure 4: Throughput

Performance analysis based on Delay time : The transmission delay of a network is described as the ratio of the sum of delays in each node to the total number of available nodes. It is written as shown in the solution. (27),

$$\frac{\sum_{i}(T^{t} - T^{r})}{q} \qquad (27)$$

A comparison based on delay duration is shown in Figure 5. A good system has a short delay period. In Figure 5, the suggested LOA algorithm method has taken the shortest amount of time to transmit the data packet, according to the analysis. The LOA algorithm has a lower end-to-end delay than rival techniques because of a path selection mechanism that is effective. When the number of nodes grows, so does the delay time. The LOA algorithm produces better results when the number of nodes increases.

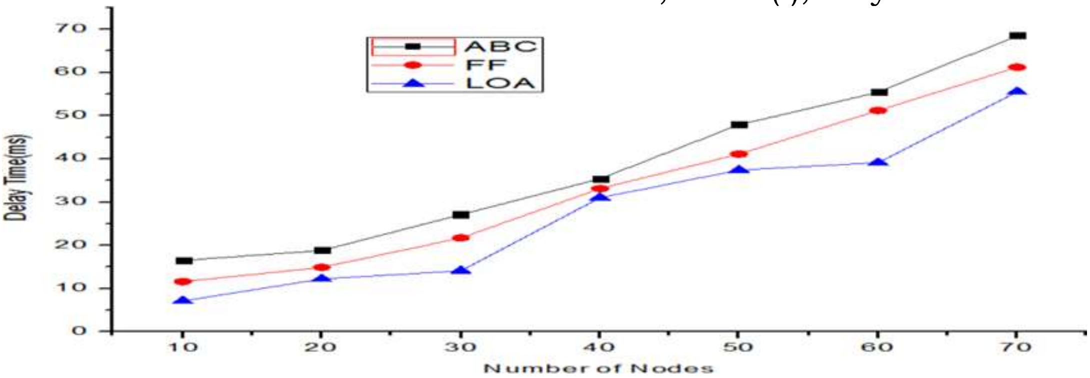


Figure 5: Delay Time

Energy Consumption: Energy usage: the enormous amount of hops corresponds to massive received energy consumption. For each packet sent and received, a node expends a certain quantity of energy. It depicts the total amount of energy used by the protocol to transport data packets from the source to the destination. Figure 6 shows that the FIREFLY algorithm used less energy to transport the data to its destination because it found the best and most suitable alternate route. The FF algorithm, according to the findings, greatly reduces network energy usage when compared to the FF and ABC algorithms. Only a subset of nodes is held responsible for achieving balanced energy usage.

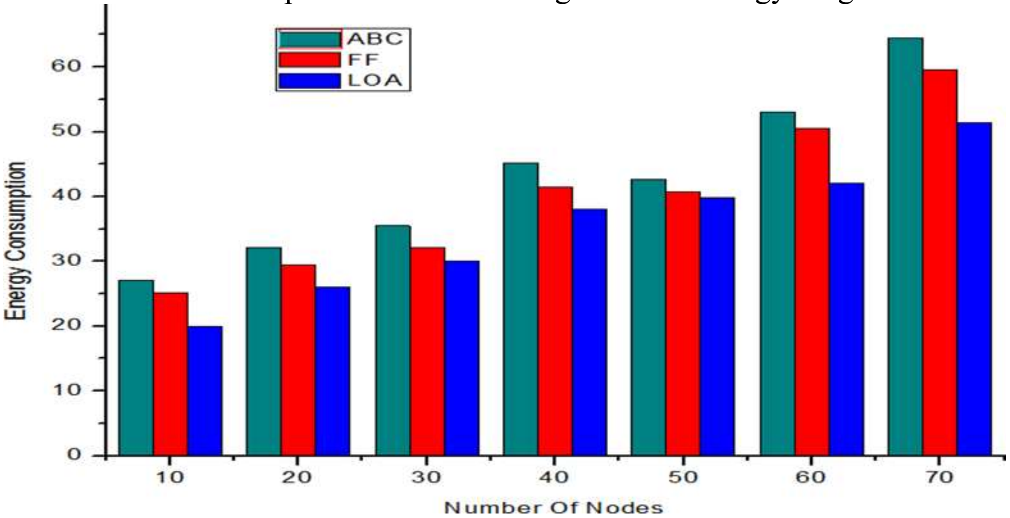


Figure 6: Energy Consumption

Packet Delivery Ratio : It can be described as the proportion of the amount of unique packets successfully received at the sinks to the total number of packets produced at the source node; although a packet may arrive at the sinks multiple times, these redundant packets are treated as a single distinct packet.Typically, sending the package in these networks is done step by step or in several steps. The formula is used to determine the packet delivery ratio in this type of network.

$$PDR = \frac{\sum \text{The number of received packets in destination}}{\sum \text{The number of sent packets}}$$

In connection 2, PDR is the packet delivery ratio, which is calculated by dividing the number of received packets by the number of sent packets. Figure 4 depicts the connection between PDR and node speed for FF,LOA,ABC algorithms based on the analysis of PDR with the variation of algorithm speed. The routing calculation detects malicious behaviour successfully. When compared to the FF,ABC algorithms, the node with indirect and direct observation mechanisms gave the LOA with a high PDR.

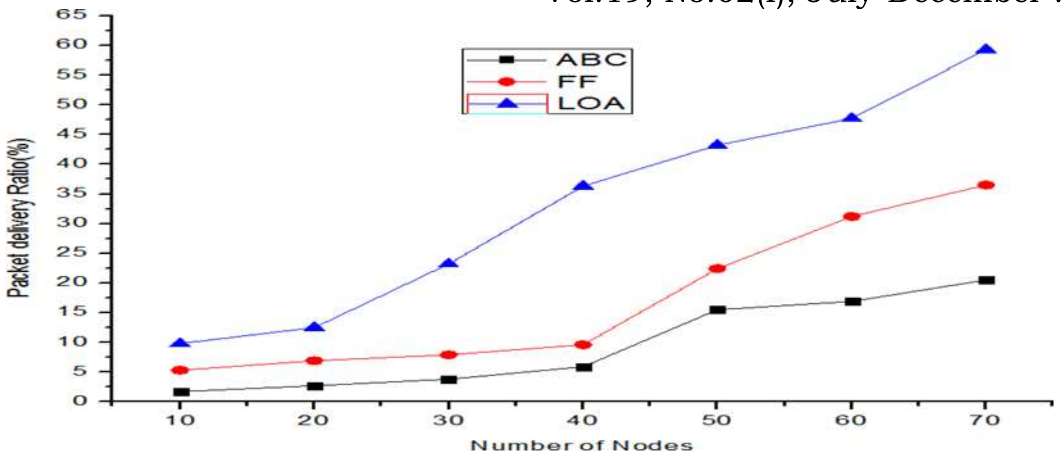


Figure 7 : Packet Delivery Ratio

Lifetime : There are various variables that affect network longevity. The period of time before the first node of the network dies is one interpretation. The First Node of the LOADng protocols is compared in Figure 9 for various values. No matter the number of nodes or the network's dimensions, this graph shows that LOA surpasses the FF and ABC algorithms in terms of network longevity. Unlike LOA, which is the most performant algorithm available.It is important to not rely exclusively on the initial node because IoT nodes in some regions gather redundant data. In addition, all of the nodes to evaluate and contrast LOA are superior, with the best outcomes as compared to other algorithms.

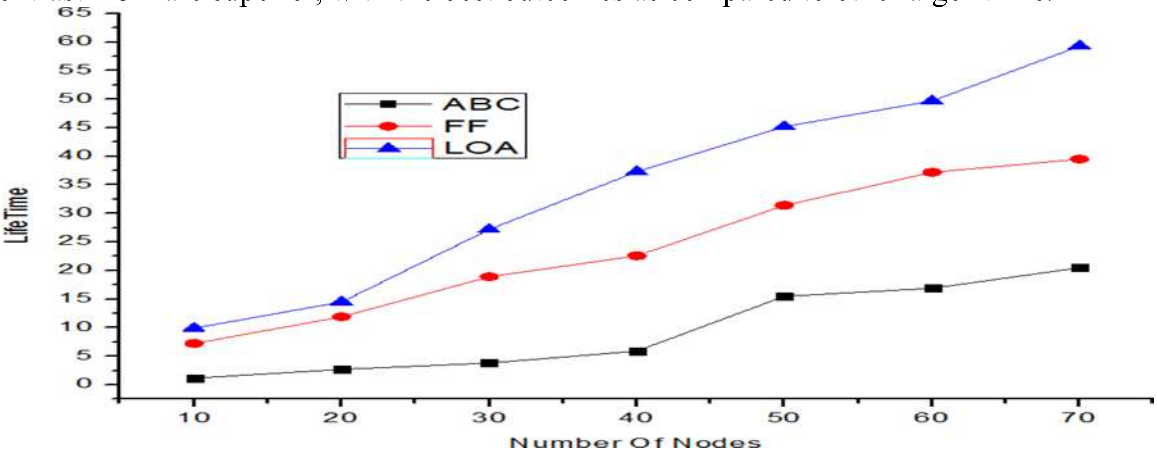


Figure 8:Lifetime

VI. CONCLUSION

This article analyzes the Firefly, LOA, ABC algorithm utilizing LOADNg, a routing protocol for IOT data transport. Throughput, Delay, Packet Delivery Ratio, Energy Consumption, and Packet Lifetime are some of the IoT metrics that the lightweight On-Demand Ad hoc Distance Vector Routing Protocol (LOADng) routing protocol is used to optimize. We can reduce the amount of time, energy used, and throughput in this simulation process by sending as many packets as we can from source to target or by increasing the ratio of packet delivery. The simulation results demonstrate the LOA algorithm's ideal route selection for this result. Firefly, LOA, and ABC perform better than the results of the optimal route process lion optimization method.

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