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Improved Performance of Cloud Networks Using Chaotic Black Widow Optimization Algorithm

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Abstract – Nowadays, the speed of the internet becomes very high and users use a lot of data from a data center, so users need to access a lot of data from the nearest place to avoid any delay. The data will be stored without any interference from users. Due to the previous reasons, Cloud Computing (CC) plays an important role in finding the best route for data to reach users by general networks without a delay and with the least energy consumption. To achieve scalability, protocols are used and developed for networks for a suitable performance in the cloud computing networks. In this paper, a natural-inspired protocol is used in cloud networks to find a good routing, this protocol is called Chaotic Black Widow Optimization Algorithm (CBWOA). Some natural characteristics of the routing strategy are inspired by the black widow optimization algorithm. Taguchi's methods were used for tuning parameters of CBWOA based on orthogonal array experiments. CBWOA is applied with three constraints to measure two factors called energy consumption and throughput by finding best path direction in cloud Computing networks. CBWOA is evaluated in an experimental cloud using the current routing protocols against old routing protocols of the performance network. Finally, the best route in cloud networks is founded successfully and the performance of the developed protocol is associated with two factors, the first one is maximizing (the throughput with efficiency 93.4921% and the Packet delivery ratio with efficiency 90.3087%) and the second one is minimizing (the delay with efficiency 62.1788% and the energy consumed with efficiency 51.1406%).

Index Terms – Optimization, Black Widow Optimization Algorithm, Taguchi's Methods, CBWOA, Internet, Cloud Networks.

1. INTRODUCTION

According to increased dependence on the communication system and internet especially. Nowadays cyber-attacks targeting the system of Industrial Control Systems (ICS). This attacks on systems of ICS makes us try to protect cyber from hacker [1]. Huge data becomes very important to quick rise and comprehensive used in modern technologies like as Cloud, Social media and Smart cities, increases used data [2]. A lot of chance in some areas like as, transportation, healthcare, finance and government are achieved good benefits from this data [3, 4]. Information can share by help of big data. Big data refer to data with different complexity forms (levels and quantities). On other hand, this data impossible to handle using any shape of methods, technologies, algorithms [5, 6].

There are a lot of services are present to customer without limit to usage data it refers to Cloud. Computing (CC). CC can reduce the cost spent by the owner also the CC keep and increase availability and scalability, enabling organizations to acquire resources as necessary. scalability allows to tolerance to handle and store more data [7]. Objective functions may have many global optimizations, i.e. every objective function can have similar values at several different points in the explored state space. In addition, some local optimal points for which the objective function values lie close to the global optimum level. Real-world problems are categorized as problems with improving multimedia functionality [8].

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In general networks a routing concepts is very common and play very important role to transfer data from the source to the destination. A router is device do more tasks especially divide route in networks to send packet across this passes. To determine the path according to routing tab so it used guide to draw path for packets across route. This guide called route table which arrange the path for smoothing cross packets to destinations.

1.1. Problem Statement

In traditional computer network routing is used for selecting a certain path to send packets across networks or between networks. Data processing in cloud computing plays an important function with ad-hoc, cyber-attack, infrastructure, homogeneous and heterogeneous, so traditional network routing is not suitable for cloud networks. On other hand, a huge data packets must transfer with high performance to avoid congestion of network.

If the impact of a route failure is severe, then it results in network congestion.

1.2. Objective

This research proposes an optimization protocol called chaotic black widow optimization algorithm (CBWOA). This protocol is used in cloud networks to find a good routing in a big data access in cloud computing and users can find effective solution from the side of minimize total delay and maximize throughput. In this paper CBWOA used to find good routing path in cloud network to increase performance through maximize throughput with efficiency and Packet delivery ratio and minimize total delay.

1.3. Organization of the Paper

Section (1) shows and introduces cloud computing, big data and cyber-attacks, and it issues to make a good routing. The literature review will explain in section (2). Section (3) discusses and presents a mathematic model-based protocols. Section (4) discusses the chaotic black widow optimization algorithm. Section (5) defines Taguchi's methods of parameter design used for tuning the parameters of CBWOA. Section (6) show the network simulation protocol. Section (7) shows the computational results according to the simulation setting protocol. Section (8) concludes the paper.

2. LITERATURE REVIEW

“Vehicular ad hoc networks (VANETs)” presented by [9] the paper introduced vehicle Internet access to get low cost of the internet on road get ways. Authors allow to access internet via vehicle through routing data packet communications from get ways. Total cost will minimize according to a lot of strategies, one of this is called gateway. On the other hand, the vehicle used protocol called VeMAC uses multichannel access based on time division. “The Internet of Vehicles (IoV)" presented by [10] the paper showed sub application of the IoT. Also paper focused on new protocol called IoV so It makes a software achieve IoV considered cognitive. Environment of IoV used to show the optimal routing according to senses and learn. Also paper showed the effectiveness proposed algorithm through experimental dataset to validate the feasibility and effectiveness.

“IoT for industrial large scale internet" presented by [11], This paper proposed systems called Mac based on IEEE model for reduce energy in real time. Authors depend on divide data in router into a lot of cluster to the end point which aggregated through large-scale systems. “Low-energy adaptive clustering presented" by [12], this paper achieves the energy balance and throughput via sensor network with wireless medium, which selected in the classical clustering, this selection between the communication mechanism and cluster head improve clustering routing using LEACH protocol.

“cloud networks" presented by [2] is proposed to search about good path direction in network. Paper used a natural-inspired called cuckoo algorithm, which finding a good solution for certain problem. For good optimization performance and find the best route in cloud networks a Levy Flight algorithm was applied with different constraints to try to minimize delay and energy consumption. Paper uses a green cloud with benchmark network performance metrics against routing protocols. “ad hoc information with dynamic route information" presented by [13]. Paper focused on routing for SDVN based on intelligent fuzzy system. Paper proposed a new method to calculate stability from routing table, also paper shows improve performance after use routing.

“hybrid firefly with particle swarm optimization (PSO) algorithms for cloud network “presented cloud network with load balancing using improved PSO and firefly to minimize utilization in load of network. Paper focused on improve the performance of network through control all elements in resource matrices. Multiobjective is used for minimize load in network [14]. According to discussed literatures as above, most problem use metaheuristic to try improve behavior of network. On other hand, other method used a hybrid metaheuristic to minimize delay so we need the proposed we need this algorithm which aims to find the most effective route according to previous methods and also to avail security in the cloud.

3. MATHEMATICAL MODEL BASED PROTOCOL

Mathematical model depends on constraint based optimization in Eq. (1),

$$\begin{cases} \text{MIN } f(z), z = [z_1, z_2, z_3, z_4, \dots, z_m] \\ \text{subject to} \begin{cases} g_{i\,(z)=0} & n = 1, 2, 3, \dots \dots k \\ e_{j(z)} \geq 0, & m = 1,2,3,4, \dots l \end{cases} \end{cases} \quad (1)$$

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Where:

m: is population size.

$gi(z) = 0$: is equation constraint.

q: is inequivalent regulations number.

$e_j(z) \geq 0$: is constraint of inequality.

p: is unequal regulations number.

z_l: is the n-dimensional vector.

Also $z_l = (z_{l1}, z_{l2} \ldots, z_{ln})$. Eq. (1) can be expressed as Eq. (2),

$$\begin{cases} \text{MIN } F(Z), Z = [Z_1, Z_2, Z_3, Z_4, \ldots, z_m] \in S \\ S.T\ \ S = \begin{cases} z, g_{i(z)}\ 0,\ \ N = 1,2,3,4,\ldots,K \\ E_j(Z) \geq 0,\ \ M = 1,2,3,4,.L \end{cases} \end{cases} \quad (2)$$

In constrained optimization Y^* refer to a solution which is optimal, where $\forall\ z \in S$: $f(z^*) \leq f(z)$, active constraint if $e_j(z^*) = 0$. For z^*, the constraint equation $gi(z) = 0$ (i=1, 2…, q). penalty function is used for convert constrained optimization problem to unconstrained optimization problem.

$$Q\ (z, L) = f(z) + L_1 \sum_{i=1}^{q} [gi(z)]^2 + L_2 \sum_{j=1}^{p} [\min(0, e_j(X))]^2 + z \quad (3)$$

Where:

L_1 and L_2 are penalty factors.

Q (z, L): is penalty functions.

z(L): is minimal point.

If $z \in S$, then there is no penalty for feasible points which can be evaluated using Eq. (3), there by Q (z, L) = f(z).

4. CHAOTIC BLACK WIDOW OPTIMIZATION ALGORITHM

Black widow optimization algorithm (BWOA) as other evolutionary algorithms number of spiders use to make initial population. A new generation of black widow exist after mating; Female black widow eats the male during or after mating [15]. BOWA consist of 4 stages start with called initialization stage, procreation stage, cannibalism stage, and mutation stage.

4.1. Initialization

BWOA starts with male and female selected randomly from population to produce baby spider to get new generation. The fitness function f evaluated by BWOA. Chaotic maps are used to find the best map for the BWOA, Eq. (4) and Eq. (5). is used to generate initial population

$$p_{i+1} = C_j\ (p_i) \quad (4)$$

$$val = f\ (x_1, x_2, \ldots, x_{mvar}) \quad (5)$$

Where:

C_j: refer to chaotic mapping function.

m_{var}: dimensional optimization problem.

$n_{pop} \times m_{var}$: initial population widow matrix.

f: is fitness function.

4.2. Procreate

A lot of parents randomly are selected to create a new generation in the procreation process as Eq. (6) and Eq. (7). theta is defined as array generated to complete the further reproduction, then M_1 and M_2 are produced by using ϴ with the following equation, in which N_1 and N_2 are parents [15].

$$M_1 = \Theta \times N_1 + (1 - \Theta) \times N_2 \quad (6)$$

$$M_2 = \Theta \times N_2 + (1 - \Theta) \times N_1 \quad (7)$$

Where:

M_1, and M_2: are the young spiders from reproduction.

ϴ: is the random number ∈ [0, 1].

4.3. Cannibalism

Cannibalism divided into three kinds: in the first kind black female widow eats her husband after mating this is called sexual cannibalism. In the second kind of cannibalism the strong spiders eat other weaker ones this process is called sibling cannibalism. The last one the spiders eat their mother; we use this to measure the fitness function [16, 17].

4.4. Mutation

Figure 1 shows mutation with changes in the DNA. Mutation is very important stage because it makes the exploitation and exploration of the algorithm. In the CBWO, mutation determined according to mutation rate (M), in this stage we must limit the spiders number to mutate them [18].

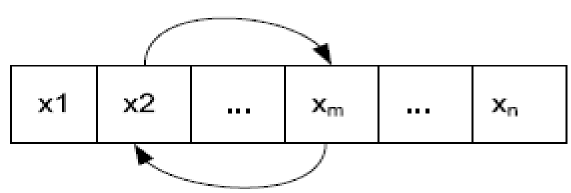

Figure 1 Mutation [15]

4.5. Optimization of Benchmark Functions Using CBWOA

Figure 3 starts with initialize the spider population, one spider of the CBWOA consists of three sections one of which is

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solution, the second one is a value of r (r is number and r ∈ [0, 4]) and the last one is mask of uniform procreate.

$$x_{n+1} = r x_n (1 - x_n), \quad n = 1,2,3 \qquad (8)$$

Here, $x_n \in [0, 1]$ represents existing population size as ratio and the sequence $\{x(n)\}_{n=0}^{N}$ presents the grow population as Eq.(8) and r is number and r ∈ [0, 4]. Each spider contains solution encodes as an objective **to** obtain a solution for optimization function. Spider encode depend on relation between binary code and gray code. In CBWOA to initialize spider population logistic maps are used, for proposed CBWOA, a randomly generated binary spider 0111010101101010 | 110011 | 1011011100010110. The first part represents of z_1 and z_2 solution (i.e., values). The second part represents the value of r and the last part represents the solution of uniform procreate. Gray code is used to mask and encoded it as figure 2.

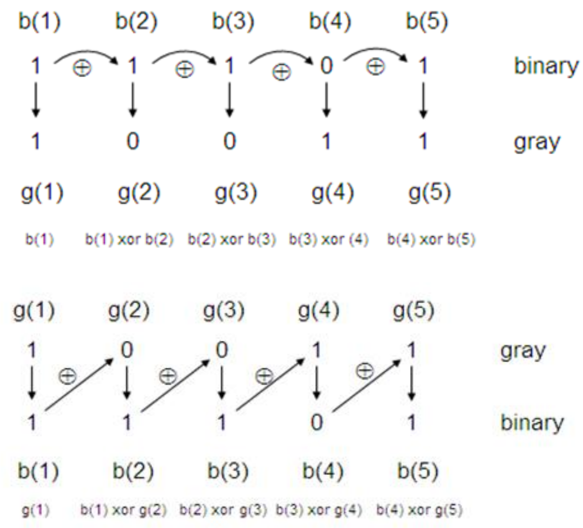

Figure 2 Gray Coding [8]

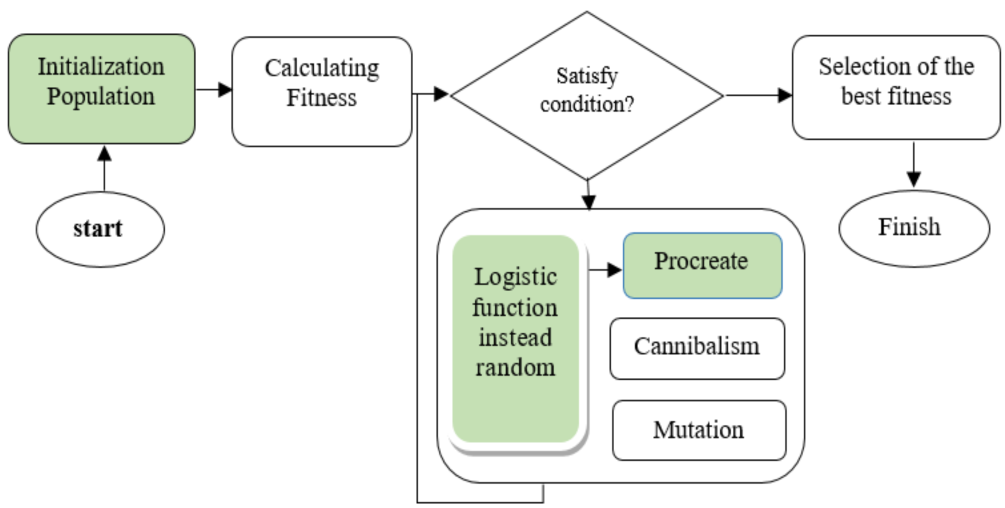

Figure 3 Flowchart of CBWOA [8]

4.6. A New Procreate Operator with Numerical Example

Suppose a randomly generated binary spider 0111010101101010 | 110011 | 1011011100010110. The first part represents of x_1 and x_2 solution (i.e., values). The second part represents the value of r and the last part represents the solution of uniform procreate. Gray code is used to mask and encoded it. The first parent randomly generated 1110100111001101 | 111001 | 1011001000110001 as the second parent.

$$m = a + \frac{b-a}{2^{k}-1} * m' \qquad (9)$$

Where:

m: is the calculated mask value,

a: lower limit.

b: upper limit.

k: bits number.

binary numbers 00111100 and 00111011 can be write as decimal number 60 and 57. Also can be represent as Gray code x_1 01110101 and for x_2 01101010 and after transform inside interval [0,1] the mask value equal 0.1686 and 0.2235. the mask value equal x_1 and x_2 0.3374 and 0.1373 according to Eq. (9) [8].

5. TAGUCHI'S METHODS FOR TUNING PARAMETERS OF CBWOA

Taguchi's methods are used to design systems with high quality from orthogonal array(OA) experiments to reduce variance for experiments through optimum control parameters [19]. From the experiments the OA created. In

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Taguchi's methods, all parameters designed by OA with completely randomized. Other factor very important in Taguchi's method is called logarithmic functions (S/N), which optimize the quality of parameters depends on it characteristics [20]. The parameters and levels are listed below in table 1:

Table 1 Parameters and Level

Parameters	Levels		
	L_1	L_2	L_3
Procreate Rate (P)	0.20	0.50	0.80
Cannibalism Rate (C)	0.20	0.50	0.80
Mutation Rate (M)	0.20	0.50	0.80
Iterations (I)	10	50	200

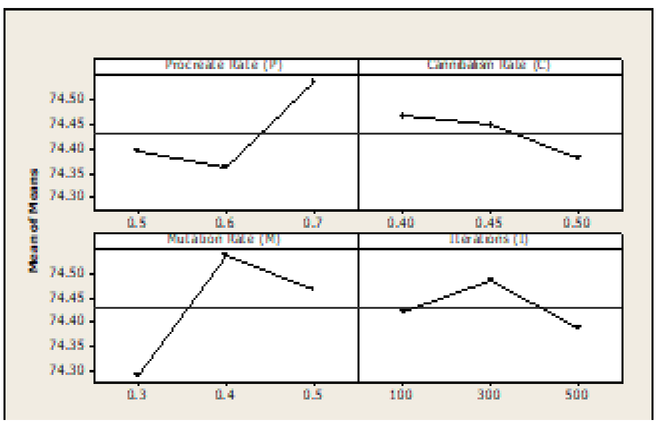

Figure 4 Means Effect of Taguchi's Methods

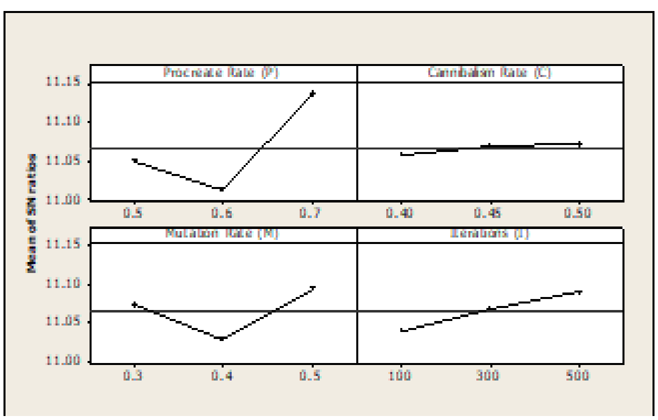

Figure 5 SN Ratio of Taguchi Methods

As shown in figure 4. and figure 5. the plots show mean and SN ratio of Taguchi's methods using Minitab softwear.

CBWOA uses parameters P, C and M was defined in the table 2. Parameters take the range (0.2, 0.8) as table 1 with ignore the effect of other parameters (constant parameters). After apply Taguchi's methods the Mutation rate (M) procreation rate (P), Cannibalism rate (C) and iterations are 0.80, 0.61, 0.44 and 100.

6. NETWORK SIMULATION PROTOCOLS

In cloud network to control the big data, the availability of memory consumption, network resources, resources allocation, virtualization and routing. Simulate routing protocols were proposed against the benchmark, it problems called CAS, HMHO, FRS and CCSOP [15]. Table 2 shows entity name, name of parameter and the number of parameters.

Table 2 Experimental Simulation Parameters

Entity name	Name of Parameter	Number of Parameters
Cloudlet	Cloudlets number	50
	Data Center number	4
Data Center	Length of Cloudlet	80
Host	Hosts number	3
	Bandwidth	8 GB
	RAM Capacity	32 GB
	Storage level	2 TB
Node	Nodes number	50,100,150,200,250, 300,350
Virtual Machine	Virtual Machines number	30
	bandwidth used	8 GB
	CPU number	3
	MIPS level	2048
	Operating System	Fedora 34
	policy type	Time-Sharing
	RAM Capacity	8 GB

7. COMPUTATIONAL RESULTS

7.1. Throughput Analysis

Figure 6 and table 3 explain CBWOA protocol for throughput comparing with oldest protocols HMHO, CAS, FRS and CCSOP. The average throughput of CBWOA is 93.4921%; while the old model performance was 91.5818%.

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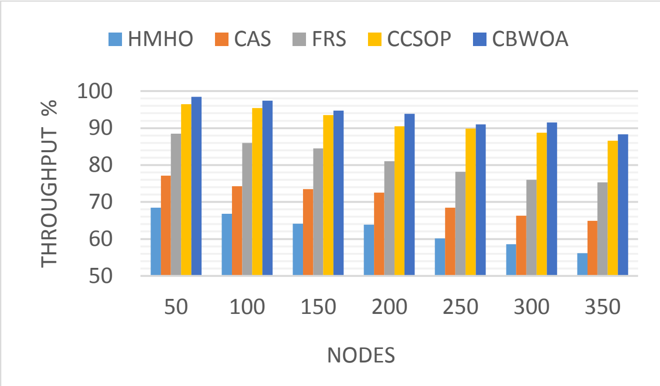

Figure 6 Throughput %

Table 3 Result of throughput %

Nodes	HMHO	CAS	FRS	CCSOP	CBWOA
50	68.4782	77.1471	88.4462	96.4781	98.4536
100	66.7714	74.2512	85.9912	95.4422	97.4522
150	64.1591	73.4443	84.4824	93.4783	94.7678
200	63.8844	72.5112	81.0417	90.4784	93.8712
250	60.1499	68.4722	78.1878	89.8793	90.0009
300	58.5668	66.2891	76.0244	88.7742	91.5498
350	56.1461	64.8723	75.3207	86.5423	88.3489
Average	62.5937	70.9982	81.3563	91.5818	93.4921

7.2. Packet Delivery Ratio Analysis

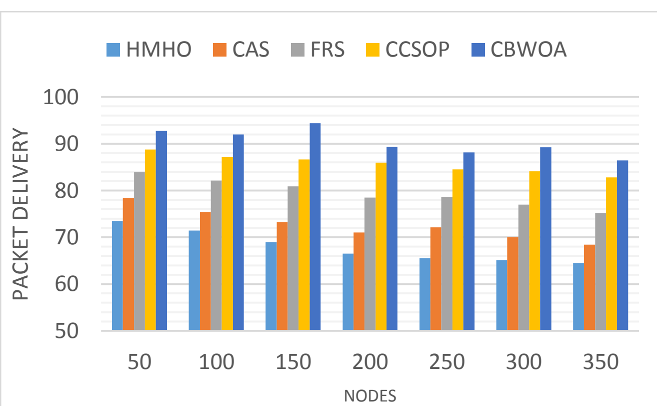

Figure 7 Packet Delivery %

Figure 7 and table 4 explain the proposed CBWOA protocol for packet delivery ratio comparing with oldest protocols HMHO, CAS, FRS and CCSOP. The percentage of Packet delivery of CBWOA is 90.3087%; while the old model performance was 85.7116 %.

Table 4 Result of packet delivery %

Nodes	HMHO	CAS	FRS	CCSOP	CBWOA
50	82.0081	65.1940	58.1480	51.0050	44.5611
100	83.0360	66.5640	59.0100	52.2060	46.9001
150	85.6672	69.8270	61.5400	54.6970	48.3451
200	87.2412	73.4220	63.0240	57.6430	53.3177
250	88.0073	74.3680	63.9830	58.5870	52.5444
300	89.6721	75.9250	65.4350	60.4190	56.4411
350	90.8121	77.9110	66.9740	61.9600	55.8746
Average	86.6349	71.8873	62.5877	56.6453	51.1406

7.3. Delay Analysis

Table 5 Result of Delay %

Nodes	HMHO	CAS	FRS	CCSOP	CBWOA
50	73.5261	78.4411	83.8851	88.7973	92.7356
100	71.4126	75.4233	82.1142	87.1453	91.9543
150	68.9991	73.2214	80.8962	86.6614	94.3544
200	66.4893	71.0222	78.5252	85.9251	89.3432
250	65.5783	72.1510	78.6543	84.5518	88.1176
300	65.1231	70.0233	76.9990	84.1022	89.2238
350	64.5432	68.4451	75.1231	82.7982	86.4319
Average	67.9531	72.6753	79.4567	85.7116	90.3087

Figure 8 and table 5 explain the proposed CBWOA protocol for delay comparing with oldest protocols HMHO, CAS, FRS and CCSOP. The average delay of CBWOA is 51.1406%; while the old model performance was 56.6453%.

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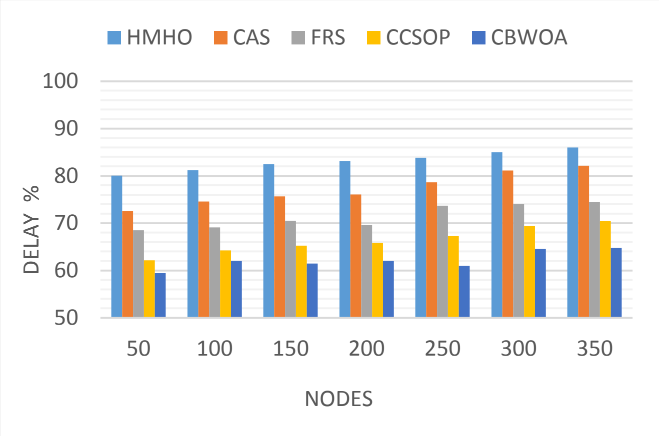

Figure 8 Delay %

7.4. Energy Consumption Analysis

Table 6 Result of Energy Consumption %

Nodes	HMHO	CAS	FRS	CCSOP	CBWOA
50	80.0410	72.5334	68.5074	62.1062	59.4543
100	81.1962	74.6011	69.1194	64.2131	61.9800
150	82.4880	75.6442	70.5059	65.2456	61.4378
200	83.1760	76.0366	69.6284	65.8376	62.0034
250	83.8443	78.5980	73.6941	67.3051	60.9981
300	84.9642	81.1287	74.0556	69.4012	64.5981
350	85.9871	82.1547	74.4797	70.4489	64.7800
Average	83.0995	77.2424	71.4272	66.3654	62.1788

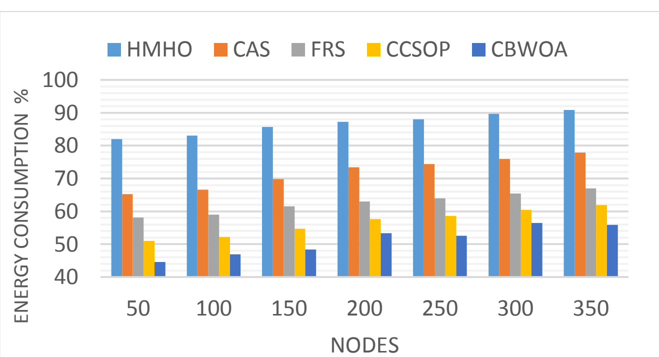

Figure 9 Energy Consumption %

Figure 9 and table 6 explain the proposed CBWOA protocol for energy consumption comparing with oldest protocols HMHO, CAS, FRS and CCSOP. The average energy consumed by CBWOA is 62.1788%; while the old model performance was 66.3654%.

8. CONCLUSION

According to the rapid development of internet services, users need to recall data at anytime and anywhere, so cloud network plays a very important role through finding the best route in a cloud network to increase delivered data across some nodes to many users. In this paper, the results showed performance improvement for cloud networks using chaotic black widow optimization algorithm (CBWOA) for any route in the cloud networks. Proposed algorithm applied three constrained optimizations to search and find the best path direction from starting point in network to the last point in the network. CBWOA analyzes the standard network performance factors and evaluates it using an experimental cloud. CBWOA shows a high performance in increasing the throughput packet with the performance 93.4921% while the old model performance was 91.5818%; and the delivery ratio performance is 90.3087% while the old model performance was 85.7116%. The decrease in energy consumption performance is 62.1788% while the old model performance was 66.3654% and the delay is 51.1406% while the old model was 56.6453%. This helped to increase performance to find the best route in cloud networks.

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