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Constrained Cuckoo Search Optimization Based Protocol for Routing in Cloud Network

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Abstract – Cloud Computing (CC) is the process of providing on-demand data to the user via the internet. In CC, users don't need to manage data storage and computational power actively. Finding the best route in a cloud network is entirely different from other general networks which it is due to high scalability. Protocols developed for other general networks will never suit or give better performance in cloud networks due to its scalability. This paper proposes a bio-inspired protocol for routing in a cloud network, namely Constrained Cuckoo Search Optimization-based Protocol (CCSOP). The routing strategy of CCSOP is inspired by the natural characteristics of the cuckoo bird towards finding a nest to lay its eggs. Levy Flight concept is applied with different constraints to enhance optimization performance towards finding the best route in a cloud network that minimizes energy consumption. CCSOP is evaluated in Greencloud using benchmark network performance metrics against the current routing protocols. The efficacy of CCSOP is evaluated using benchmark performance measures. CCSOP appears to outperform current cloud network routing protocols in terms of energy consumption.

Index Terms – Cuckoo, Cloud, Energy, Flight, Levy, Optimization, Routing, Scalability.

1. INTRODUCTION

The overall benefit of large data is, of course, enormous. A comprehensive and quick rise in the usage of emerging technologies, including 5G, Cloud, smart cities and social media, results in increasingly diverse and disparate data [1]–[3]. Processing opportunities in several areas like healthcare, government, transportation, and finance are gained from this data. Still, they also come with a host of complications, such as volume, variety, velocity, variability, visualization, and value, termed "big data"[4]–[6].The complicated processes of gathering, analyzing, and displaying large and complex data are essential in big data technologies. By utilizing robust network platforms to interconnect data entities, big data technologies continually support and enhance existing platforms that seek to connect, exchange, and share information. This feature helps uncover hidden patterns and extract sensitive and essential information [7]–[10]. Big data is also a honeypot for several security threats that provide a myriad of new and complex issues. Actually, with the advancement of data as the world's information and networking capabilities develop, the size of network coverage is increasing, making the network environment more complex[5], [11], [12].Big Data can be described as a voluminous amount of data present in a multitude of forms, each of which presents different quantities and levels of complexity, along with varying velocities and degrees of ambiguity, which makes it impossible to handle using any form of traditional technology, method, algorithm, or off-the-shelf commercial software[13]–[15].

Cloud computing is a new model that can provide on-demand services to its consumers regardless of limitations. Cloud virtualization makes it possible to abstract hardware, making it easier for consumers to use vast amounts of storage, powerful computing, and high availability without frequent contact with cloud service providers[16], [17]. Additionally, it transfers the cost and responsibilities from user to cloud service provider, making it possible for small businesses, which typically face a massive undertaking in their quest to begin operating with IT. Getting an IT setup off the ground represents a significant financial and operational commitment due to the requirement to cover the entire cost spent by the

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owner. It includes IT personnel, software licenses, hardware expenses, and maintenance of infrastructure. The benefits of cloud computing include increased scalability and availability, enabling organizations to acquire resources as necessary[18], [19]. It is imperative to have availability, fault tolerance and scalability to store and handle a large amount of data. With cloud computing, users can have all of them, regardless of location, as the cloud allows big data to be accessible, fault-tolerant, and scalable. Big data and cloud computing are both ideas that can coexist[20].

1.1. Problem Statement

Routing is how a precise path is identified and used to deliver the data to the destination. Big data transmission distinguishes itself totally from traditional computer network data transfer. In cloud computing, data processing is complete since all of the necessary functions are combined with infrastructure, ad-hoc, heterogeneous and homogeneous networks. Traditional computer network routing methods will never be suitable for cloud computing, as their ability to manage large data is hampered. Link stability is most required to access big data where the quantity of data packets is high. If the impact of a route failure is severe, then it results in network congestion.

1.2. Motivation

In the future, getting good access to massive data (i.e., big data) will be much easier. Big data is increasing rapidly in its volume and will keep growing. Hospitals act as a significant source for big data where sensor networks monitor patients and continuously store sensed data in the cloud.The best practice when working with big data and cloud computing is to avoid using traditional routing methods. A new routing system based on optimization is necessary to utilize the available bandwidth and minimize the delay properly.

1.3. Objective

This research intends to propose an optimization-based reactive multicast routing system to provide big data access to cloud computing users in an efficient manner. This research applied the inherent properties of CCSOP to discover the optimal and stable path in cloud computing, which avoids network congestion while increasing network lifetime and energy efficiency.

1.4. Organization of the Paper

The current section of the article focused on big data, cloud computing, and issues that need to be addressed when routing the data. Section 2 of the paper focuses on discussing the state of art. Section 3 discusses the proposed protocol for accessing big data in cloud computing. Section 4 discusses the simulation settings used for evaluating the proposed protocols against existing protocols. Section 5 defines the performance metrics used for evaluation. Section 6 discusses the results obtained from the simulation. Section 7 concludes the paper with a future dimension.

2. LITERATURE REVIEW

“Energy-Aware Real-Time Routing”[21] is proposed to avoid delay in IEEE 802.15.4a MAC. Data are cumulated to form different number clusters while they travel to the base station. A hierarchical routing strategy is used to enhance the scalability ratio. While a node sends a data packet to the neighbor node, hops' available energy and count are calculated to ensure successful data transmission. “Clustering Routing Algorithm” [22] is proposed to solve the issues in the network while cluster heads are chosen. It aims to maximize the lifetime of the network by balancing the energy level at nodes. Randomly, cluster heads are preferred, but it is performed only after following the classical clustering strategy. Availability of (i) node density (ii) nodes location and (iii) energy at each node are fully considered during the routing. “Gateway Placement Method” [23] aims to reduce the cost spent on internet gateways. It makes ensures that nodes can communicate with the internet gateway via a multi-hop strategy. Integer programming strategy is applied to solve the issues that arise in node connectivity to gateways. Routing of big data is performed based on time-division multiple-access. “Dynamic Routing Algorithm”[24] is proposed for high dynamicity networks to minimize energy consumption. Time-varying features are analyzed for calculating the state transition probability. Weights of the dynamic routes are computed using the node location and its available energy. Low energy consumption routes are identified via optimization. “Light Weight Routing” [25] is proposed for mobile IoT to identify the new routes and forward data between nodes. It attempts and finds the availability of neighbor nodes via passing a control message. Control messages end with (i) avoidance of interference by other nodes in selected routes (ii) updation of tables used for routing. Link reliability plays a major role in selecting a route.

“Lightweight Authentication Routing Protocol” [26] is proposed for named data networking to overcome the current issues present in routing. It gathers the node's information available in the route before sending the data, including available energy. Hierarchical routing is utilized for efficient data transfer and scaling of the network. “Swarm Network Architecture”[27] is proposed to enhance the quality of service in IoT-based networks. It aims to reduce latency with the design of gathering partial information of the node's location. It ensures network connectivity before data transmission. Network coverage areas are covered in a better way to increase the delivery ratio of packets and decrease the delay. “Enhanced Channel Aware Routing Protocol”[28] is proposed to attain better forwarding of packets in a location-free environment. Formerly collected information regarding the routes is avoided to enhance the packet forwarding ratio.

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Relay nodes are chosen via a non-sequential method, the Ping-Pong method, which demands a steady network topology. “Software-Defined Cognitive Routing”[29] is proposed to select an optimum route in a dynamic network environment. Reinforcement learning is applied to attain better cognition in the network. Different routing policies are used to sense the neighbor nodes and send the data to the destination effectively, reducing delay and power consumption.“QoS Aware Protocol for Routing”[30] is proposed for vehicular networks to achieve better transmission of data. It forwards data packets only in the trusted and connected route to the destination node. A chicken optimization algorithm is modified to select the best path connected to the destination and acts discretely. The greedy factor is used to make a decision intelligently towards route selection.

“Autonomic Service Routing”[31] is proposed for managing the network services in a cloud computing environment. It aims to provide provision for interaction between general network services and broker-based network services. Inter-domain routing strategy is used to fix the issue of timing. The previous routing decision is used to reduce the delay. “Network-Based Routing (NBS)” [32] is proposed as an energy-efficient routing protocol to transmit big data in a cloud environment. Dynamic programming strategy is used in the development of routing protocol. It formalizes the network via calculus strategy for finding the efficient route to transmit the data with low energy consumption. “Cloud Acknowledgement Scheme (CAS)”[33] is proposed to optimize the routes in a cloud environment using a long short term memory approach. Recurrent neural network strategy is used to classify the routes based on available residual energy in the nodes involved in routing. Synthetic values are generated to estimate the trust values of the network. "Hybrid Meta-Heuristic Optimization (HMHO)" [34] is proposed to maintain the big environmental data in an ad-hoc network. Initially, big environmental data is clustered for effective routing, which is defined using node connectivity. The voting concept is used to estimate the node's energy level, and it leads a way to choose the cluster head. Based on the node's behavior, alternative routes are selected. "Fuzzy-based Routing Scheme (FRS) " [35] is proposed to handle the dynamic topology of the network. Reinforcement Learning is applied to ensemble the network traffic scenario and routing experience. Bandwidth utilization is minimized with the usage of the update method. A positive update indicates the best route and a Negative update indicates the worst route for communication. The stability of the route is analyzed using the greedy approach.

2.1. Limitations in Previous Methods

This research has primarily been aimed to provide a better protocol for massive data (i.e., big data) access in cloud computing. Overall disadvantages identified in the current techniques (i.e., protocols) are:

- ✓ Concentrate on discovering routes rather than their quality.
- ✓ To find the path, utilize more energy.
- ✓ A routing system designed in a broad computer network is not compatible with cloud computing for the general data access (i.e., big data).
- ✓ It takes more time to find alternative routes in the event of a failure.
- ✓ User wait duration for accessing the expected data is high.
- ✓ More bandwidth usage even for general communication.

3. CONSTRAINED CUCKOO SEARCH OPTIMIZATION BASED PROTOCOL (CCSOP)

3.1. Constrained Optimization

Arithmetical form of constraint-based optimization is portrayed in Eq.(1),

$$\begin{cases} min\ g(Y), Y = [Y_1, Y_2, \dots, Y_l, \dots, Y_m] \in S \\ s.t \begin{cases} f_i(Y) = 0, & i = 1,2, \dots, q \\ e_j(Y) \geq 0, & j = 1,2, \dots p \end{cases} \end{cases} \tag{1}$$

where, *s.t* refers to "*subject to*", *m* refers to the size of the population, $f_i(Y) = 0$ is the constraint of the equation, q refers to the total number of inequivalent regulations, $e_j(Y) \geq 0$ is the inequality constraint at the i^{th} position, *p* is the total number of unequal regulations and Y_l refers to the n-dimensional vector where $Y_l = (y_{l1}, y_{l2}, \dots, y_{ln})$. Eq. (1) can also be expressed as,

$$\begin{cases} \mathrm{min\ g(Y), Y = [Y_1, Y_2, \dots, Y_l, \dots, Y_m] \in S} \\ \mathrm{s.t.}\ \ \mathrm{S} = \{\mathrm{Yf_i(Y) = 0}, \quad \mathrm{i = 1,2, \dots, q; e_j(Y) \geq 0, j = 1,2, \dots p}\} \end{cases} \tag{2}$$

Let Y^* represent the optimal solution for the issue of constrained optimization, where$\forall Y \in S: g(Y^*) \leq g(Y)$. Also, the condition is said to be an active constraint if $e_j(Y^*) = 0$. Here, the constraint equation $f_i(Y) = 0 (i = 1,2, \dots, q)$ are said to be active at Y^*. For converting the constrained optimization to the unconstrained problem, the penalty function is used, which is built by using Eq.(3).

$$Q(Y, N) = g(Y) + N_1 \sum_{i=1}^{q} [f_i(Y)]^2 + N_2 \sum_{j=1}^{p} \left[min\left(0, e_j(Y)\right)\right]^2 + Y \tag{3}$$

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Here, N_1 and N_2 are said to be the factors of penalty which is positive constant; the penalty terms are the second and third terms and $Q(Y,N)$ is said to be the penalty functions. If $Y \in S$, then there is no penalty for feasible points which can be evaluated using Eq. (3), thereby$Q(Y,N) = g(Y)$. The value for the second and third term will be significant for non-feasible points where $Y \notin S$ and N_1 and N_2 are substantial, resulting in a penalty for infeasible points. Also, the penalty value should be more significant when Y moves far from the feasible regions. The minimal point called $Y(N)$ for the unconstrained optimization problem is closer to the end of constrained optimization when N_1 and N_2have increased value. If the value$Y(N) \in S$, then it changes to the minor point for the condition that is original. The lower value for Eq. (3) is represented as,

$$\min Q(Y,N) \tag{4}$$

Eq. (4) will be equivalent to Eq.(1) when it is minimum.

3.2. Cuckoo Search Algorithm

Cuckoo Search (CS) algorithm works based on the concept that the cuckoo bird uses to seek and lay its eggs, and it uses the following constraints for enhancing simplicity:

1) Every cuckoo can lay an egg at a time, and the arbitrary nest is chosen for dumping.
2) Better quality eggs in the nest will be taken to the subsequent iterations.
3) Using the probability, $q_b \in [0,1]$ the cuckoo eggs will be detected, and the next available nest for the host is fixed. Here, the host bird can choose either to build a new nest or to discard the eggs.

3.3. Constrained Optimization-based Levy Flight for Cuckoo Search

The principle called Levy flight is incorporated in the basic CS algorithm. Let Mbe the size of the population and D be the variable dimension. Here, $Y_i = [Y_{i1}, Y_{i2}, \ldots, Y_{iD}]$ is said to be the i^{th} individual among the total population. Also, $b_1, b_2, \ldots, b_D$and $a_1, a_2, \ldots, a_D$ are said to be the upper and lower boundaries of $Y_{i1}, Y_{i2}, \ldots, Y_{iD}$. Assume, $b = [b_1, b_2, \ldots, b_D]^u$ and$a = [a_1, a_2, \ldots, a_D]^u$be the solution finder while $Levy\ Flight$ is carried out, expressed in Eq. [5].

$$y_i(u+1) = y_i(u) + \alpha \oplus \text{Lévy}(\beta) \tag{5}$$

where $y_i(u)$ refers to the i^{th} nest position of the iteration u . α represent the step variable which takes the value 0.01.Levy Flight is used for performing a random walk, which is articulated in Eq.(6).

$$\text{Lévy}(\beta) = \frac{\mu}{|\nu|^{1/\beta}} \tag{6}$$

where ν and μ use the normal distribution, Eq.(7) shows the normal distribution in constrained optimization.

$$\mu \sim M(0, \sigma_\mu^2), \nu \sim M(0, \sigma_\nu^2), \sigma_\mu = 1$$
$$\sigma_\nu = \left(\frac{\Gamma(1+\beta)^* sin(\pi^* \beta/2)}{\Gamma(1+\beta/2)^* \beta^* 2^{(\beta-1)/2}} \right)^{1/\beta} \tag{7}$$

where Γ represents the function called gamma distribution and $\beta = 1.5$.

The nests that are found unfit are ignored using the probability q_b , the new nests are constructed at locations based upon Eq. (8).

$$y_i(u+1) = \begin{cases} y_i(u) + \nu\left(y_j(u) - y_l(u)\right), r < q_b \\ y_i(u), \quad r \geq q_b \end{cases} \tag{8}$$

Here, the iterations for the algorithm are represented by u. Random numbers at $[0, 1]$ are denoted by r and v . The redundant nest will be removed using the probabilityq_b. The position of the nest at u^{th}will be selected using $y_j(u)$and $y_l(u)$.$Levy\ flight$ technique works based on the probability of heavy-tailed distribution that uses global searchability. The enhancement of the algorithm is carried out at the early stage of CS, wherein the random walks are generated that are not contributing to local search, resulting in degradation of algorithm performance.

$Levy\ flight$ is a method of random walk that works based on the heavy-tailed probability distribution that has developed using global search. In the early phase of CS algorithm optimization, the $Levy\ flight$ technique can improve the ability of global search of the algorithm. Nevertheless, Lévy flight can generate significant random walk steps at a later stage which is not conducive to the local search of the algorithm, which results in slow convergence of the algorithm. For handling such issues, the design of PSO with inertia weight is used, represented as $'w'$ in the Lévy flight of C-S, to accelerate the algorithm's convergence. The enhancement of the Lévy flight method of CS is expressed in Eq.(9).

$$y_i(u+1) = wy_i(u) + \alpha \oplus \text{Lévy}(\beta) \oplus y_i(u) - f_{best} \tag{9}$$

In Eq.(9), w represents the weight of inertia; the location of the i^{th} nest at the iteration of $u$is defined by $y_i(u)$. α and β is said to be the variable, and the excellent nest is defined by f_{best}. Theoretically, the minor $'w'$ performs, the better local search and the more oversized $'w'$ performs global tracking effectively. From Eq.(9), it is proved that the value of $'w'$

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reduces non linearly to a smaller value from a larger one for improving the performance of the proposed algorithm. Modified method of $'w'$ is given by,

$$w = 1 - o^{-1/u} \qquad (10)$$

Here, the total iterations are represented as $'u'$. The Levy flight method for CS algorithm is very responsive for setting the evolved variables based on velocity updation. Novel CS is introduced by providing new variable setting techniques. There are two different dynamic variables introduced for the $Levy\, Flight$ approach and adjustment techniques for variables α and β.

The enhanced adjustment of variable techniques increases the speed of convergence in CS algorithm. From the literature study, it is proved that the number of iterations always depends on the adjustment parameters of the review. The effect of convergence in the algorithm is different from the number of iterations. Novel adjustment techniques for parameter α and β are provided for increasing the speed of convergence and the performance of its optimization. Thus, the parameter for adjustment is given as:

$$\alpha_i(u) = 0.5 + 1.5\left(\frac{1}{\sqrt{u}}\right)^{\left|\frac{g_{best}(u)-g_i(u)}{g_{best}(u)-g_{worst}(u)+\varepsilon}\right|} \qquad (11)$$

$$\beta_i(u) = 0.5 + 0.1\left|\frac{g_{best}(u)-g_i(u)}{g_{best}-g_{worst}+\varepsilon}\right|^{u^{0.1}} \qquad (12)$$

where u is the algorithm based iterations, $g_i(u)$ represents the value of fitness in $u-th$ iteration for $i-th$ individual in the population, $g_{best}(u)$ means to the best fitness value for $u-th$ iteration, $g_{worst}(u)$ refers to the fitness value which is worst in the $u-th$ iteration, and ε is used for removing the $zero-division-error$ and it represents constant which is least in the system.

The algorithm of CCSOP is shown in the Algorithm 1.

1. $Begin$
2. Fetch nests M at initial randomly
3. Estimate every nest's value of fitness at the initial stage
4. u=0
5. $While\ u \geq MaxGen$
6. $u = u \pm 1;$
7. $For i$=0 to M
8. Using Eqs.(5)-(7),initiate solution for $y_i(u+1)$
9. Calculate the value of fitness for $y_i(u+1)$
10. $If\ g(y_i(u+1)) \geq g(y_i(u))$
11. Modify the solution at I and admit the solution as $y_j(u+1)$
12. $End\ if$
13. $End\ for$
14. Remove the wrong nest using probability(q_b) and construct nest at the location based on Eq. (8)
15. Preserve good nests based on threshold distance from last visited nest
16. Detect the best nest
17. Rank the obtained solutions based on the quality
18. Select the solution having a better rank
19. $End\ while$
20. Find optimal value and most exemplary solution output
21. End

From Eq.(9) and Eq.(10), it is shown that the inertia weight introduction will be reduced, and the iterations will be increased. Also, the incorporation of the individuals in the population will converge the algorithm at a faster rate. The value of α will also be modified based upon the value of fitness at the optimal state. In terms of variable β, the members in the population will also adjust adaptively based upon the iterations and fitness value of the population. Based upon the modification techniques for variables $\alpha$and β, it is proved that the excellent fitness value of individuals will have better variable value, and members with deprived fitness value will have reduced variable values. The modifications of these variables will not affect the iteration count.

4. SIMULATION SETTING

To control the big data in a cloud network, the availability of network resources, memory consumption, routing, resource allocation, and virtualization are a must. The proposed routing protocol was simulated against the existing protocols HMHO, CAS and FRS with the help of Greencloud, which is added as an extension in Network Simulator 2 (i.e., NS2). Table 1 lists the simulation settings utilized for the evaluation.

ENTITIES	PARAMETERS	VALUES
Cloudlet	Number of Cloudlets	50
	Number of Data Center	4
Data Center	Length of Cloudlet	80
Host	Number of hosts	3

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	Level of bandwidth	8 GB
	Capacity of RAM	32 GB
	Level of Storage	2 TB
Node	Number of Nodes	50,100,150,200,250, 300,350
Virtual Machine	Number of Virtual Machines	30
	Level of bandwidth	8 GB
	Number of CPU	3
	Level of MIPS	2048
	Operating System	Fedora 34
	Type of policy	Time-Sharing
	Capacity of RAM	8 GB

Table 1 Simulation Setting

5. PERFORMANCE METRICS

Performance metrics used to evaluate the proposed routing protocol are:

- **Throughput:** It indicates the average ratio of packets transmitted against total packets received in a threshold time duration.
- **Packet Delivery Ratio:** It is the measure of percentage of packets that are delivered successfully.
- **Delay:** It indicates the measure of time between deliveries of subsequent packets.
- **Energy Consumption:** It is the average amount of energy used to send the packet from the source to the destination. It contains both transceiver power and processor power.

6. RESULTS AND DISCUSSION

6.1. Throughput Analysis

Figure 1 evaluates the proposed routing protocol CCSOP for throughput against the existing routing protocols HMHO, CAS and FRS. The X-axis is marked with nodes and Y-axis is marked with the percentage of throughput. From Figure 1, it is evident that CCSOP has better throughput when compared with existing protocols, namely HMHO, CAS and FRS. Optimization plays a vital role in finding the better route to a destination where existing routing protocols utilizes the route without checking the quality. The average throughput of CCSOP is 91.582%, where the average energy consumption of HMHO, CAS and FRS are 62.594%, 70.998% and 81.356%, respectively. The numerical result values of Figure 1 are provided in Table 2.

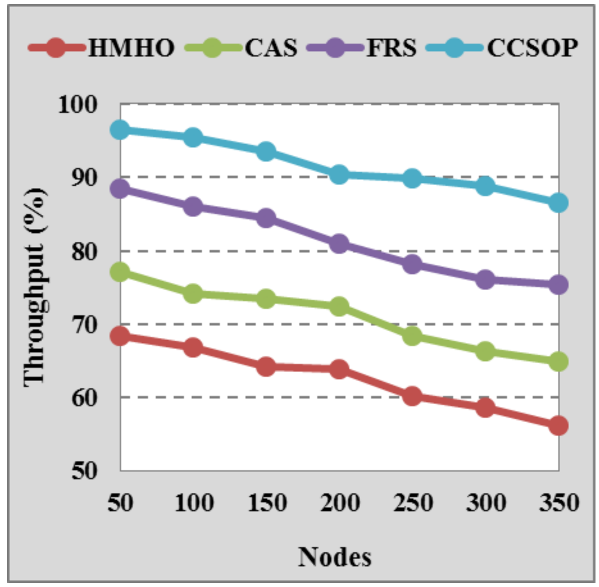

Figure 1 Protocols vs Throughput

Nodes	HMHO	CAS	FRS	CCSOP
50	68.478	77.147	88.447	96.478
100	66.778	74.251	85.991	95.442
150	64.159	73.444	84.482	93.478
200	63.884	72.511	81.041	90.478
250	60.148	68.472	78.187	89.879
300	58.567	66.289	76.025	88.774
350	56.147	64.872	75.321	86.542
Average	**62.594**	**70.998**	**81.356**	**91.582**

Table 2 Throughput Analysis Result Values

6.2. Packet Delivery Ratio Analysis

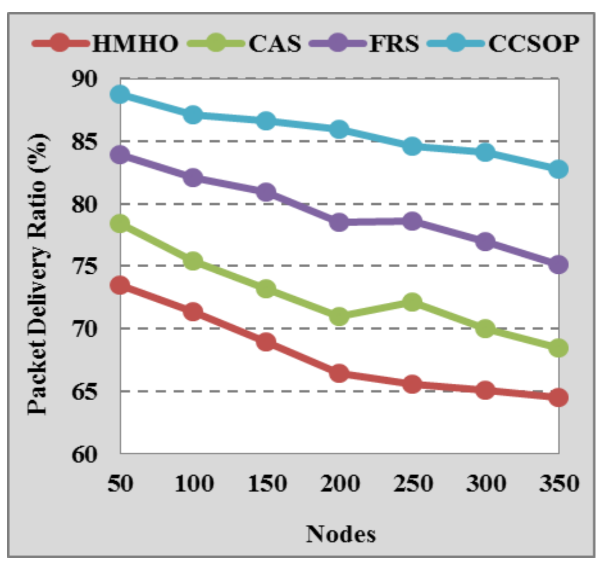

Figure 2 Protocols vs Packet Delivery Ratio

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Figure 2 evaluates the proposed routing protocol CCSOP for packet delivery ratio against the existing routing protocols HMHO, CAS and FRS. The X-axis is marked with nodes and Y-axis is marked with the percentage of packet delivery ratio. Enhanced Levy Flight approach present in CCSOP leads to finding a stable route to destination and this makes data packets reach the destination in a fast manner which reduces the packet drop a lot. Existing routing protocols find the route without checking its stability and lead to select the route having loop, which reduces the packet delivery in a remarkable level. The average Packet delivery ratio of CCSOP is 85.712%, where the average packet delivery ratio of HMHO, CAS and FRS are 72.675%, 79.457% and 85.712%, respectively. The numerical result values of Figure 2 are provided in Table 3.

Nodes	HMHO	CAS	FRS	CCSOP
50	73.526	78.441	83.885	88.797
100	71.412	75.426	82.114	87.145
150	68.999	73.221	80.896	86.662
200	66.489	71.022	78.525	85.925
250	65.578	72.15	78.654	84.558
300	65.123	70.023	76.999	84.102
350	64.543	68.445	75.123	82.798
Average	**67.953**	**72.675**	**79.457**	**85.712**

Table 3 Packet Delivery Ratio Analysis Result Values

6.3. Delay Analysis

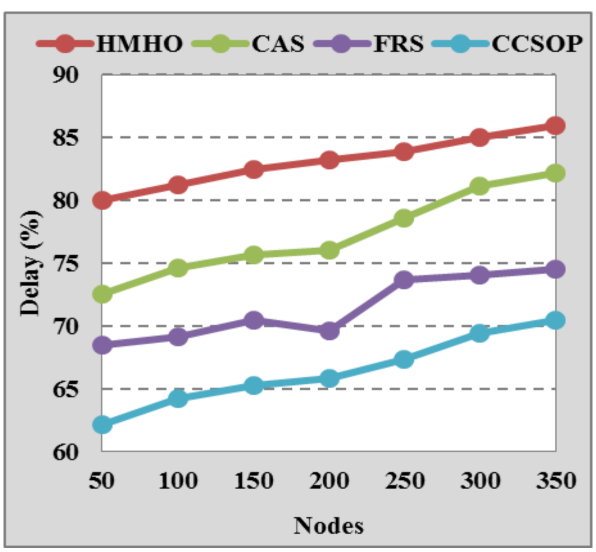

Figure 3 Protocols vs Delay

Figure 3 evaluates the proposed routing protocol CCSOP for delay against the existing routing protocols HMHO, CAS and FRS. The X-axis is marked with nodes and Y-axis is marked with the percentage of delay. Novel adjustment techniques of CCSOP increase the speed of convergence and its optimization performance in selecting the best route, which reduces delay. Selection of loop presence route by the existing routing protocols provides a way to face enhanced delay. The average delay of CCSOP is 83.099%, where the average delay of HMHO, CAS and FRS are 77.242%, 71.427% and 66.365%respectively. The numerical result values of Figure 3 are provided in Table 4.

Nodes	HMHO	CAS	FRS	CCSOP
50	80.040	72.533	68.507	62.106
100	81.196	74.601	69.119	64.213
150	82.488	75.644	70.506	65.245
200	83.176	76.037	69.628	65.837
250	83.844	78.599	73.694	67.305
300	84.964	81.128	74.055	69.401
350	85.987	82.154	74.479	70.448
Average	**83.099**	**77.242**	**71.427**	**66.365**

Table 4 Delay Analysis Result Values

6.4. Energy Consumption Analysis

Figure 4 evaluates the proposed routing protocol CCSOP for energy consumption against the existing routing protocols HMHO, CAS and FRS. The X-axis is marked with nodes and Y-axis is marked with the percentage of energy consumption. Efficient global and local search for the best route makes CCSOP consume less energy for delivering the data packets to the destination. Existing routing protocols focus only on local search and do not focus on global search, making them not select the best route globally, leading to more energy consumption. The average energy consumed by CCSOP is 56.645%, where the average delay of HMHO, CAS and FRS are 86.635%, 71.887% and 62.588%, respectively. Numerical result values of Figure 4 are provided in Table 5.

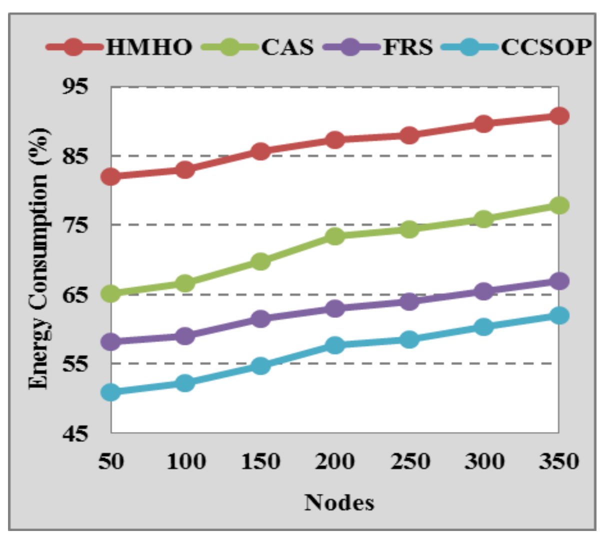

Figure 4 Protocols vs Energy Consumption

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Nodes	HMHO	CAS	FRS	CCSOP
50	82.008	65.194	58.148	51.005
100	83.036	66.564	59.010	52.206
150	85.667	69.827	61.540	54.697
200	87.241	73.422	63.024	57.643
250	88.007	74.368	63.983	58.587
300	89.672	75.925	65.435	60.419
350	90.812	77.911	66.974	61.960
Average	**86.635**	**71.887**	**62.588**	**56.645**

Table 5 Energy Consumption Analysis Result Values

7. CONCLUSION

Cloud network is a dynamic network where the user demands data at anytime and anywhere. The cloud network is not stable with the number of nodes that may get scaled high at any time. Identifying the best route in a cloud network is not easy due to its scalability and dynamicity. This paper has proposed a Constrained Cuckoo Search Optimization-based Protocol (CCSOP) for routing in the cloud network. CCSOP is inspired by the instinctive characteristics of cuckoo birds towards searching for a nest. Constrained Optimization-based Levy Flight add the benefit of enhancing the random walk towards searching for the best route to the destination. CCSOP is analyzed with standard network performance metrics and it is evaluated using Greencloud, the extension of NS2. Results make a clear indication that CCSOP has better performance of reducing the energy consumption towards identifying the best route and delivering the packets to destination. Averagely, CCSOP has consumed 56.645% of energy where the existing routing protocols HMHO, CAS and FRS have consumed 86.635%, 71.887% and 62.588% of energy, respectively. Machine learning algorithms can be ensembled with CCSOP to reduce energy consumption even more.

REFERENCES

[1] J. Ramkumar and R. Vadivel, “CSIP—cuckoo search inspired protocol for routing in cognitive radio ad hoc networks,” in Advances in Intelligent Systems and Computing, 2017, vol. 556, pp. 145–153, doi: 10.1007/978-981-10-3874-7_14.

[2] J. Ramkumar and R. Vadivel, “Meticulous elephant herding optimization based protocol for detecting intrusions in cognitive radio ad hoc networks,” Int. J. Emerg. Trends Eng. Res., vol. 8, no. 8, pp. 4549–4554, 2020, doi: 10.30534/ijeter/2020/82882020.

[3] J. Ramkumar and R. Vadivel, “Bee inspired secured protocol for routing in cognitive radio ad hoc networks,” INDIAN J. Sci. Technol., vol. 13, no. 30, pp. 3059–3069, 2020, doi: 10.17485/IJST/v13i30.1152.

[4] M. Faheem, R. A. Butt, R. Ali, B. Raza, M. A. Ngadi, and V. C. Gungor, “CBI4.0: A Cross-layer Approach for Big Data Gathering for Active Monitoring and Maintenance in the Manufacturing Industry 4.0,” J. Ind. Inf. Integr., p. 100236, 2021, doi: https://doi.org/10.1016/j.jii.2021.100236.

[5] C. Y. Huang and Y. J. Chang, “An adaptively multi-attribute index framework for big IoT data,” Comput. Geosci., p. 104841, 2021, doi: https://doi.org/10.1016/j.cageo.2021.104841.

[6] J. Qu, “Research on mobile learning in a teaching information service system based on a big data driven environment,” Educ. Inf. Technol., pp. 1–19, Jun. 2021, doi: 10.1007/s10639-021-10614-z.

[7] R. Vadivel and J. Ramkumar, “QoS-Enabled Improved Cuckoo Search-Inspired Protocol (ICSIP) for IoT-Based Healthcare Applications,” pp. 109–121, 2019, doi: 10.4018/978-1-7998-1090-2.ch006.

[8] J. Ramkumar and R. Vadivel, “Multi-Adaptive Routing Protocol for Internet of Things based Ad-hoc Networks,” Wirel. Pers. Commun., pp. 1–23, Apr. 2021, doi: 10.1007/s11277-021-08495-z.

[9] J. Ramkumar and R. Vadivel, “Improved Wolf prey inspired protocol for routing in cognitive radio Ad Hoc networks,” Int. J. Comput. Networks Appl., vol. 7, no. 5, pp. 126–136, 2020, doi: 10.22247/ijcna/2020/202977.

[10] J. Ramkumar and R. Vadivel, “Performance modeling of bio-inspired routing protocols in Cognitive Radio Ad Hoc Network to reduce end-to-end delay,” Int. J. Intell. Eng. Syst., vol. 12, no. 1, pp. 221–231, 2019, doi: 10.22266/IJIES2019.0228.22.

[11] R. R. Hoy, “Quantitative skills in undergraduate neuroscience education in the age of big data,” Neurosci. Lett., p. 136074, 2021, doi: https://doi.org/10.1016/j.neulet.2021.136074.

[12] P. L. Martínez, R. Dintén, J. M. Drake, and M. Zorrilla, “A big data-centric architecture metamodel for Industry 4.0,” Futur. Gener. Comput. Syst., 2021, doi: https://doi.org/10.1016/j.future.2021.06.020.

[13] M. Rhahla, S. Allegue, and T. Abdellatif, “Guidelines for GDPR compliance in Big Data systems,” J. Inf. Secur. Appl., vol. 61, p. 102896, 2021, doi: https://doi.org/10.1016/j.jisa.2021.102896.

[14] A. Sevtsuk, R. Basu, X. Li, and R. Kalvo, “A big data approach to understanding pedestrian route choice preferences: Evidence from San Francisco,” Travel Behav. Soc., vol. 25, pp. 41–51, 2021, doi: https://doi.org/10.1016/j.tbs.2021.05.010.

[15] V. Keskar, J. Yadav, and A. Kumar, “Perspective of anomaly detection in big data for data quality improvement,” Mater. Today Proc., 2021, doi: https://doi.org/10.1016/j.matpr.2021.05.597.

[16] T. G. Kim and S. Yu, “Big Data Analysis of the Risk of Intracranial Hemorrhage in Korean Populations Taking Low-Dose Aspirin,” J. Stroke Cerebrovasc. Dis., vol. 30, no. 8, p. 105917, 2021, doi: https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.105917.

[17] D. Balazka, D. Houtman, and B. Lepri, “How can big data shape the field of non-religion studies? And why does it matter?,” Patterns, vol. 2, no. 6, p. 100263, 2021, doi: https://doi.org/10.1016/j.patter.2021.100263.

[18] Y. Su and X. Wang, “Innovation of Agricultural Economic Management in the Process of Constructing Smart Agriculture by Big Data,” Sustain. Comput. Informatics Syst., p. 100579, 2021, doi: https://doi.org/10.1016/j.suscom.2021.100579.

[19] C. Wen, J. Yang, L. Gan, and Y. Pan, “Big data driven Internet of Things for credit evaluation and early warning in finance,” Futur. Gener. Comput. Syst., vol. 124, pp. 295–307, 2021, doi: https://doi.org/10.1016/j.future.2021.06.003.

[20] M. Nilashi et al., “Big social data and customer decision making in vegetarian restaurants: A combined machine learning method,” J. Retail. Consum. Serv., vol. 62, p. 102630, 2021, doi: https://doi.org/10.1016/j.jretconser.2021.102630.

[21] N. B. Long, H. Tran-Dang, and D. Kim, “Energy-Aware Real-Time Routing for Large-Scale Industrial Internet of Things,” IEEE Internet Things J., vol. 5, no. 3, pp. 2190–2199, 2018, doi: 10.1109/JIOT.2018.2827050.

[22] Y. Xu, Z. Yue, and L. Lv, “Clustering Routing Algorithm and Simulation of Internet of Things Perception Layer Based on Energy Balance,” IEEE Access, vol. 7, pp. 145667–145676, 2019, doi: 10.1109/ACCESS.2019.2944669.

[23] H. A. Omar, W. Zhuang, and L. Li, “Gateway Placement and Packet Routing for Multihop In-Vehicle Internet Access,” IEEE Trans. Emerg. Top. Comput., vol. 3, no. 3, pp. 335–351, 2015, doi: 10.1109/TETC.2015.2395077.

[24] Z. Ding, L. Shen, H. Chen, F. Yan, and N. Ansari, “Energy-Efficient

RESEARCH ARTICLE

Relay-Selection-Based Dynamic Routing Algorithm for IoT-Oriented Software-Defined WSNs," IEEE Internet Things J., vol. 7, no. 9, pp. 9050–9065, 2020, doi: 10.1109/JIOT.2020.3002233.

[25] J. V. V Sobral, J. J. P. C. Rodrigues, R. A. L. Rabêlo, K. Saleem, and S. A. Kozlov, "Improving the Performance of LOADng Routing Protocol in Mobile IoT Scenarios," IEEE Access, vol. 7, pp. 107032–107046, 2019, doi: 10.1109/ACCESS.2019.2932718.

[26] T. Mick, R. Tourani, and S. Misra, "LASeR: Lightweight Authentication and Secured Routing for NDN IoT in Smart Cities," IEEE Internet Things J., vol. 5, no. 2, pp. 755–764, 2018, doi: 10.1109/JIOT.2017.2725238.

[27] Q. Zhang, M. Jiang, Z. Feng, W. Li, W. Zhang, and M. Pan, "IoT Enabled UAV: Network Architecture and Routing Algorithm," IEEE Internet Things J., vol. 6, no. 2, pp. 3727–3742, 2019, doi: 10.1109/JIOT.2018.2890428.

[28] Z. Zhou, B. Yao, R. Xing, L. Shu, and S. Bu, "E-CARP: An Energy Efficient Routing Protocol for UWSNs in the Internet of Underwater Things," IEEE Sens. J., vol. 16, no. 11, pp. 4072–4082, 2016, doi: 10.1109/JSEN.2015.2437904.

[29] C. Wang, L. Zhang, Z. Li, and C. Jiang, "SDCoR: Software Defined Cognitive Routing for Internet of Vehicles," IEEE Internet Things J., vol. 5, no. 5, pp. 3513–3520, 2018, doi: 10.1109/JIOT.2018.2812210.

[30] K. Z. Ghafoor, L. Kong, D. B. Rawat, E. Hosseini, and A. S. Sadiq, "Quality of Service Aware Routing Protocol in Software-Defined Internet of Vehicles," IEEE Internet Things J., vol. 6, no. 2, pp. 2817–2828, 2019, doi: 10.1109/JIOT.2018.2875482.

[31] W. Itani, C. Ghali, R. Bassil, A. Kayssi, and A. Chehab, "ServBGP: BGP-inspired autonomic service routing for multi-provider collaborative architectures in the cloud," Futur. Gener. Comput. Syst., vol. 32, pp. 99–117, 2014, doi: https://doi.org/10.1016/j.future.2012.05.013.

[32] T. Baker, B. Al-Dawsari, H. Tawfik, D. Reid, and Y. Ngoko, "GreeDi: An energy efficient routing algorithm for big data on cloud," Ad Hoc Networks, vol. 35, pp. 83–96, Dec. 2015, doi: https://doi.org/10.1016/j.adhoc.2015.06.008.

[33] S. Kaja, E. M. Shakshuki, and A. Yasar, "Long Short-Term Memory Approach for Routing Optimization in Cloud ACKnowledgement Scheme for Node Network," Procedia Comput. Sci., vol. 184, pp. 461–468, 2021, doi: https://doi.org/10.1016/j.procs.2021.03.058.

[34] X. Peng and Y. Chang, "Energy-efficient routing technique for reliable data transmission under the background of big data for disaster region," Comput. Intell., vol. 36, no. 4, 2020, doi: 10.1111/coin.12294.

[35] L. Zhao, Z. Bi, M. Lin, A. Hawbani, J. Shi, and Y. Guan, "An intelligent fuzzy-based routing scheme for software-defined vehicular networks," Comput. Networks, vol. 187, p. 107837, Mar. 2021, doi: 10.1016/j.comnet.2021.107837.

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