Chaotic ant colony algorithm to control congestion and enhance opportunistic routing in multimedia network

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Article Info

ABSTRACT

The creation of wireless multimedia networks imposed wireless devices that can retrieve multimedia material such as video and audio streams, still photos, and scalar sensor data from the environment is made possible by the availability of low-cost devices. This approach considers the issues of routing packets across a multi-hop network consisting of several traffic sources and links when ensuring bounded delay. The exits of an obstacle create several geographic routing issues, for example, congestion and delay. This article, chaotic ant colony algorithm (CACA) to control congestion and enhance opportunistic routing (CAOR) in multimedia network, is proposed to solve these issues. This mechanism uses the CACA algorithm to detect the obstacle and transmit the data packets on the obstacle edges optimal nodes. Moreover, an opportunistic routing (OR) selects the best forwarder by the forward aware factor (FAF) from the forwarder list (FL). The FAF measures node energy, node received signal strength indication (RSSI), available bandwidth (AB), and packet transmission rate for choosing the best forwarder. Experimental outcomes demonstrate that established delay, energy utilization, and throughput performances are greater than the conventional mechanism.

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1. INTRODUCTION

Multimedia applications will deeply develop how humans recognize the world and broadly function in people's daily lives [1]. Yet, the difficulty of multimedia systems and the radically rising usage of multimedia wireless nodes in intelligent processes carry congestion minimization and routing challenges [2]. For instance, while multimedia nodes gather data from different nodes, unreliable nodes could mislead users by utilizing interactivity and offering false messages in the system [3]. The obstacle makes path finding difficult and may split the network into several separate sections [4]. Finding the best meeting places is thus just as crucial as reducing energy use and increasing lifespan [5]. The trajectory grows as there are more meeting places, which increases energy consumption and data latency. Additionally, effective meeting places aid in quickly filling the network gap caused by impediments. An intelligent algorithm that may successfully avoid local sub-optimal solutions by doing a global search of the whole solution space is the ant colony algorithm [6]. However, traditional ant colony algorithms explore the solution space without fully using feedback data, resulting in unnecessary iterations and inefficiency. Chaotic ant colony algorithm (CACA) is a search algorithm based on a single ant's erratic activities and an ant colony's clever organization [7]. This

method blends chaotic dynamics and ant colony-based search with ants' chaotic and self-organizing behavior in the foraging process. Hence, it gets the optimal solution.

Opportunistic routing (OR) process is a novel, challenging concept intended for the wireless multimedia network [8]. This routing method imprisoned the attention of several researchers owing to its vital function encountered in the network. OR process is a talented communications model that cooperates with transmission between nodes [9]. OR process raises the distribution of the nature of the wireless medium to achieve hop-by-hop route formation and to obtain the advantage of route detection. OR can assist mainly decided traffic networks [10]. Every forwarder has a main alarm level that discovers the appropriateness of that best forwarder. Ant colony optimization (ACO) is a frequently used metaheuristic to tackle challenging optimization issues. It was inspired by the foraging behavior of ants [11]. It describes how ACO has been used for various optimization issues, including resource allocation, routing, scheduling, and design optimization. The CACO approach optimizes resource allocation by considering several variables, including energy usage, data transfer, and network connection [12]. The suggested method effectively distributes resources across sensors and adapts dynamically to changing network circumstances using self-organizing properties. The framework for multi-objective optimization to concurrently maximize environmental and economic goals [13]. This mechanism's purpose is to reduce the cost of overall generating. The suggested method looks for pareto optimum solutions.

The adaptive CACA mechanism dynamically modifies its parameters and behavior in response to shifting network circumstances [14]. This adaptability aids in reducing energy use and extending network lifespan. The program seeks to balance the energy usage of the sensors while determining the best paths for data transfer. They evaluate different parameters, including energy usage, network coverage, and data transmission efficiency, and compare their performance with other optimization methods. Urban transportation congestion is addressed using an enhanced ACO algorithm [15]. A modified ACO to increase traffic efficiency and reduce congestion. The system is based on the foraging behavior of ants and uses variables like road conditions, traffic volume, and journey duration to determine the best routes for automobiles. With this method, congestion-related problems in hub-and-spoke transportation networks are primarily addressed. Congestion may happen in these systems, which feature a central hub linking to several spoke sites when there is an imbalance in traffic flow [16].

Problem statement: the chaotic particle swarm optimization (CPSO) algorithm boosts exploration and exploitation by combining chaotic sequences with particle swarm optimization (PSO's) optimization capabilities. The hub and spoke system's resource allocation, including the scheduling of flights and travel routes, is optimized using the chaotic PSO algorithm. It considers variables including traffic volume, trip time, and congestion levels to determine the best traffic distribution that reduces congestion and increases system effectiveness. The chaotic sequences provide unpredictability and enhance the algorithm's capacity. However, this mechanism can't detect and provide obstacle-aware routing in the network. CACA to control congestion and improve or in multimedia networks is proposed to solve these issues. The contribution of the CACR work contribution is specified below.

Work contribution: this mechanism uses the CACA algorithm to detect the obstacle and transmit the data packets on the block edges optimal nodes. Moreover, an OR selects the best forwarder by the forward aware factor (FAF) from the forwarder list (FL). The FAF measures node energy, node RSSI, available bandwidth (AB), and packet transmission rate for choosing the best forwarder. Experimental outcomes demonstrate that established delay, energy utilization, and throughput performances are greater than the conventional mechanism. Furthermore, it reduces the congestion and uncertainty in the network. The article's remaining parts are as follows: section 2 describes the CACA to control congestion and enhance opportunistic routing (CAOR) in multimedia networks. Next, simulation results are specified in section 3, and the article's conclusions are in section 4.

An adaptive PSO method that uses twin extreme chaotic maps increases the algorithm's capacity for exploration and exploitation [17]. To reduce congestion and boost system efficiency, the suggested method tries to optimize power production and distribution schedules. It considers several variables: power demand, generating capacity, transmission limitations, and market pricing. Based on these variables, the method dynamically modifies the scheduling choices, and twin extremity chaotic maps are used to enhance the search for the best selection. The research focuses on tackling the problems associated with data transmission that run into structures, which may substantially impact signal propagation and network connection [18]. The weight-aware route guiding protocol is a means of directing data routing patterns while taking signal strength and obstacle placements into account. The weight-aware route guidance protocol gives each node weight depending on how close it is to barriers and how strong the signal is. Nodes more vulnerable to transmission problems include those closer to barriers or with poorer signal strengths. The protocol then chooses the best routing routes considering weight values and energy use.

Energy efficient obstacle-aware routing algorithm to reduce energy use and increase network lifespan [19]. The algorithm considers the existence of obstructions and how they affect signal transmission

range and propagation. It makes sophisticated routing decisions to choose pathways that reduce or completely avoid barriers, which saves energy and attenuates signals. To ensure effective routing, the algorithm constantly adjusts to changes in obstacle placements. Obstacle and mobility-aware optimal routing to select the best routing pathways, the algorithm takes into account the positions of obstacles and the nodes' mobility patterns [20]. It seeks to choose routes that reduce the effect of obstructions on signal propagation and guarantee effective data transfer. The system adjusts dynamically to node placements and obstacle configuration changes for continued optimum routing. Q-learning and its use in position-aware routing protocols that use Q-learning to increase the effectiveness of routing [21]. This paper evaluates the surveyed methods, considering issues like Q-table management, incentive systems, and trade-offs between exploration and exploitation.

The obstacle-aware connection approach considers both the sensor nodes' connectivity needs and the placements of impediments [22]. It seeks to identify the best deployment tactics that enhance network connection while averting communication-impairing barriers. To accomplish obstacle-aware connection setup, the algorithm employs a two-step process that includes obstacle identification and deployment optimization. The algorithm's functioning is thoroughly explained in the article, along with methods for deployment optimization and obstacle detection. It goes through the factors to consider while modeling obstacles, connection measures, and optimization techniques. The mobility and obstacle-aware algorithm considers the positions of barriers and connections [23]. It seeks to identify the best deployment tactics that enhance network connection while averting communication-impairing barriers. To accomplish obstacle-aware connection setup, the algorithm employs a two-step process that includes obstacle identification and deployment optimization. It goes through the factors to consider while modeling obstacles, connection measures, and optimization techniques.

OR procedure objective is to minimize packet losses in a wireless multimedia environment [24]. video-aware multicast OR uses an enhanced state-of-the-art method efficiently applicable to video streaming applications. The bandwidth-aware routing is introduced to deliver data packets opportunistically [25]. The expected transmission cost and AB are measured by the prioritization rule, locally AB, the possibility of link delivery, and for-warding candidates. This approach opportunistically transmits the data packets and offers bandwidth assurance. OR policy with a congestion diversity approach evaluates the draining time to recognize and route packets along the routes opportunistically and minimizes the network congestion [26]. This approach reduces the delay and routing overhead. An OR procedure is established on trust relationships evaluating the link trust degree between nodes. Though these approaches improve the routing efficiency, they can't detect unreliable nodes. The OR method uses ACO to improve routing efficiency [27]. The ACO algorithm uses an optimal transmission distance and remaining energy parameter that enhances the lifetime. An OR protocol uses candidate selection and coordination modes to improve network performance and energy efficiency [28]. Wireless network to progress emergency response. Power quality observing extends estimated insights into power quality variations via analyzing past data and that enhances grid stability as well as allocation of resources [29].

2. METHOD

The multimedia network contains several mobile nodes, and these nodes move randomly. The OR procedure raises the routing efficiency with reliability, and the FAF method selects the best forwarder from the FL. The FAF measures the node energy, node RSSI, AB, and packet transmission rate for choosing the best forwarder node. Figure 1 explains a CACA route formation among obstacles. Data forwarded from the sender S to the receiver in a multimedia network has several obstacles. At first, the sender desires to deliver the data to a receiver, which forwards the route request (RREQ) message to the near neighbor nodes. Suppose the sender cannot obtain the route reply (RREP) message; it finds the energy level, packet drop, and received signal strength indication (RSSI). That node presents an energy level high, and the RSS is greater than the near node but only separates the receiver. Thus the sender determines any obstacle that exists in that place. Next, discover how much region the obstacle takes in the routing path. CACA precedes logical chaotic mapping to interpose with the preliminary route pheromone to select the optimal nodes on the obstacle's existing position. This mechanism selects the procedure of the optimal node is given below.

- By using chaotic logistic mapping, the first ant colony is created. The parameter initialization comprises initialization pheromones and numerous heuristic variables while updating the number of iterations. Then separate the obstacle's present place and compute the nodes fitness function. Next, evaluate the location of every ant and modify the neighbor list.
- Verify whether there is a next-hop node to be chosen in the neighbor list; if it does not present, increase the search range and revise the neighbor list; if it presents, jump next step. Established on the transition

possibility, choose the next hop node based on residual energy and distance. Perform local pheromone update actions and node and path information recording and updating.
- Check whether the ants are moving less quickly and further than before; if so, use the selection approach and update the global pheromone; otherwise, rerelease them. Determine the method's iteration count; if the conditions are not fulfilled, continue to perform the previous three steps repeatedly; if the criteria are met and the result is produced, end the algorithm.

Figure 1. CACO route formation among obstacle

2.1. Opportunistic routing for data transmission

OR procedure is a feasible method to enhance the performance of multimedia wireless networks. When a sender sends the packets to the receiver, it first chooses an FL for data transmission. Then the sender selects the best forwarder node from FL that suits the following conditions: these nodes are straight neighbor nodes of the sender; it is closer to the receiver than to the sender; it has better-remaining energy; and it has a better packet transmission ratio with AB, and it has a better RSSI.

The FAF method selects the best forwarder procedure is given below. Every sensor node utilized energy updates established on node RSSI. In this method, the sender node selects the better RSSI node; that is, the closest neighbor node is chosen as a chance the best forwarder from the forward communication range (FCR). Figure 2 illustrates that the FCR nodes are isolated based on the closest neighbor nodes. From Figure 2, the highest RSSI nodes are established on a lesser-distance node.
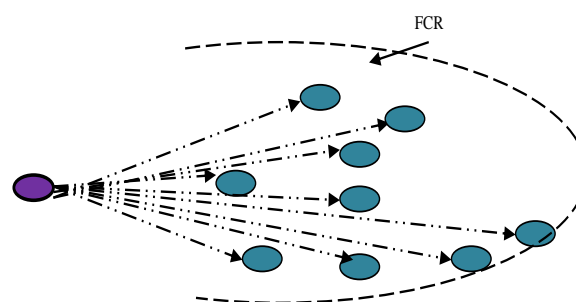

Figure 2. Isolate closest neighbor nodes in FCR nodes

Figure 3 explains an isolate better residual energy (RE) node. Here, the closer neighbor nodes are shortlisted based on the node energy. In WSN, every sensor node's energy is limited; thus, energy saving is essential. The highest RE nodes are separated from the FL. Shortlist the sensor nodes based on the node AB with packet transmission ratio from Figure 4. It is the count of transmissions for effectively transmitting a packet from the sender to the receiver through an OR. The wireless link quality decides the packet transmission ratio for every hop.
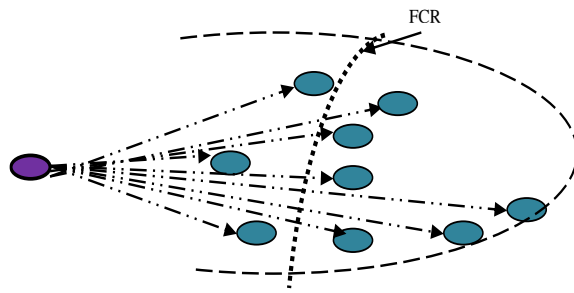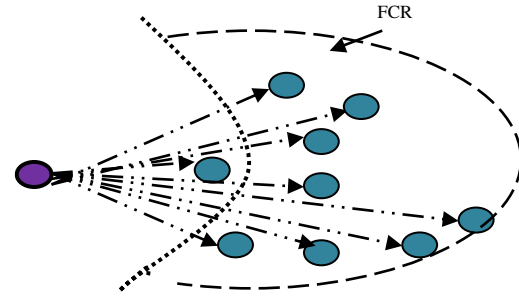
Figure 3. Isolate better RE node

Figure 4. Isolate better AB with the packet transmission rate

AB is the expected available bandwidth (E_{AB}) of OR for forwarding the packet from sender to receiver. This approach calculates E_{AB}, initially calculating the available bandwidth of the route. AB of a route as the smallest amount value of all nodes local AB on the route. Let's take a route containing m nodes and the local $AB\ of\ j^{th}$ node represented as $AB_{local,}$. Here, j=1,2,.m. Next, compute the AB of the path AB_p given (1):

$$AB_P = min\{AB_{local,1}, AB_{local,2}, \ldots.. AB_{local,m}\} \tag{1}$$

It takes the FL as the best node on the path to measure the AB under OR. Let B_{FL} indicates the AB of its set of FL candidates FL to the receiver, $AB_{local,j}$ show the node j local available bandwidth and AB_j represent the AB of n_j to the R under OR. Based on (1), AB_j it can be calculated as (2):

$$EAB_j = min\{AB_{local,j}, B_{FL,j}\} \tag{2}$$

A node's local AB denotes a node's maximum transmission capability while the channel is idle during a specified time. Thus, the local AB_{local} evaluation is based on the channel capacity C_c and R_{cidle} denotes the idle time ratio.

$$B_{local} = C_c * R_{cidle} \tag{3}$$

$$C_c = D_{DATA}/T \tag{4}$$

Assume T indicates the average time to forward a data packet plus space data (SDATA) bits efficiently. Hence, the value CC can be calculated subsequently. Usually, the time for communicating the data frame, T also comprises the time of forwarding the frame of acknowledgement (ACK), the spaces of inter-frame, arbitrary backoff delay, and retransmission time. For the jth attempt of one packet's transmission, the required time, denoted as T_j, can be measured by (5):

$$T_j = DIFS + Tbackoff(j) + T_{DATA} + FL.T_{ACK} + FL.SIFS \tag{5}$$

Here SIFS and DIFS denote the spaces of the inter-frame. T_{DATA} represents the time for communicating the data, T_{ack} indicates the time for the ACK frame, and FL denotes the FL of candidates. Hence, an efficient bandwidth to the receiver significantly decides the bandwidth guarantee. After selecting the best EAB nodes from the FL, the highest packet transmission ratio (PTR) nodes are shortlisted from the FL and choose the best forwarder. Let n_j represent the FL node to the receiver R is n_j, n_{j2}, .. n_{jR}}. The n_j equation that can calculate the PTR from node to R is given (6):

$$PTR = d_{j,FL} * C_{FL} \tag{6}$$

Here, $d_{j,FL}$ denotes the packet transmission ratio from the n_j FL, C_{FL} indicates the packet transmission ratio from the n_j receiver, The packet transmission ratio measures the node-link quality; as a result, the packet can forward to the receiver successfully at a lesser cost. Finally, the sender delivers the information to the BS through the selected best forwarder; as a result, it improves network efficiency.

3. SIMULATION RESULTS

This section uses the network simulator-2.35 tool to evaluate the network function of CPSO and CAOR approaches. The simulation environment utilizes 200 wireless nodes, and these nodes' transmission range is set to 250 meters [30]. CPSO and CAOR approach simulation time is 500 seconds. Every node communicates data packets at a pre-set rate is 2 Mbps, and it applies to the 802.11 MAC system. Figure 5 demonstrates a delay of CPSO and CAOR approaches based on various traffic loads. From this figure, the delay of CPSO and CAOR approaches increases as the traffic load increases; the raises of the CPSO approach is more rapid than the CAOR approach owing to the congestion and greater network traffic. The delay value in the existing CPSO approach also increases the traffic load since this approach concentrates only on node trust. But, the proposed CAOR approach uses OR to expand the network efficiency. In addition, the CAOR approach forms the OR by the node energy, AB, packet transmission ratio, and node RSSI. As a result, the OR minimized the network delay.

The simulation outcomes demonstrate that the function of the CAOR approach is greater than the CPSO approach during the highest traffic loads. Figure 6 shows the throughput ratio of CPSO and CAOR approaches based on traffic load. Here, the throughput of CPSO and CAOR approaches decreases as the traffic load increases; the lesser performance of the CPSO approach is slower than the CAOR approach owing to network congestion due to obstacles and the highest network traffic. But, the CAOR approach provides better network throughput since it selects the route by the RSSI, bandwidth, and energy-aware OR.
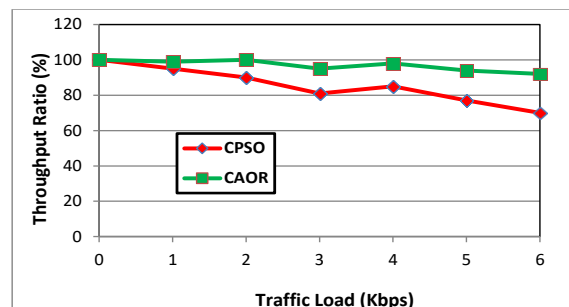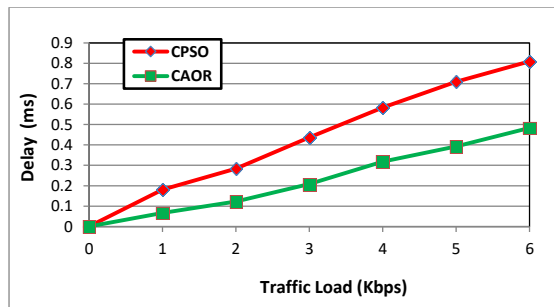

Figure 5. Average delay of CPSO and CAOR based on traffic load

Figure 6. Throughput ratio of CPSO and CAOR based on traffic load

Figure 7 explains the packet loss ratio of CPSO and CAOR. This figure raises the packet loss ratio with the traffic load increases. The following hop selection for forwarding a node-link quality could be better. But, the CAOR approach selects the forwarder node by OR; and the CAOR mechanism forms the obstacle-aware routing. As a result, it minimizes the packet loss ratio.

Figure 8 describes the residual energy of CPSO and CAOR based on traffic load. From this figure, when raises the traffic load, the CPSO and CAOR mechanism residual energy is also minimized. The CPSO mechanism increases the congestion due to cannot able to provide obstacle-aware routing. But, the proposed CAOR mechanism minimizes unwanted energy utilization and congestion.
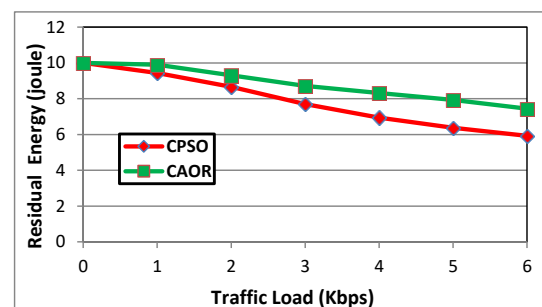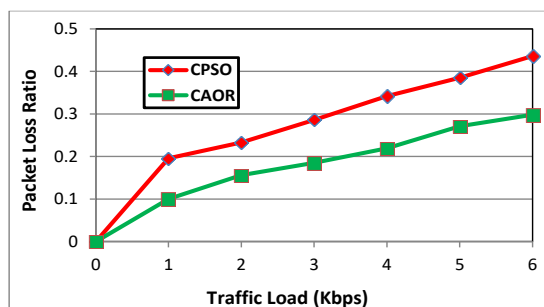

Figure 7. Packet loss ratio of CPSO and CAOR based on traffic load

Figure 8. The residual energy of CPSO and CAOR based on traffic load

4.   CONCLUSION

In this article, we introduce a CACA to CAOR in multimedia networks to enhance the throughput and minimize the delays of packets. This mechanism utilized the CACA algorithm to transmit the data packet via an obstacle-aware route. CACA algorithm to select the optimal nodes based on node distance and residual energy. Then the OR uses the FAF method for selected the best forwarder from the FL. The FAF measured the node energy, node RSSI, AB, and packet transmission rate for choosing the reliable best forwarder nodes in the network. Simulation results demonstrated that the CAOR approach reduced packet losses and network delay. Furthermore, the CAOR approach raised the throughput and increased residual energy efficiently. In the future, we will detect the malicious primary user and improve security in cognitive radio networks.

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