Fusion of cuckoo search and hill climbing techniques based optimal forwarder selection and detect the intrusion

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ABSTRACT

The cuckoo search (CS) technique is applying to discover the optimal route from source to destination. The main objective of this work is to offer suitable solutions for getting better the optimal routing and communicating the data via reliable sensor nodes. This CS optimization method not capable for managing the diversity of the solutions. To solve this issue, we use the CS technique to hybridize it with the hill climbing (HC) technique to minimize the probability of early convergence. This approach introduces a fusion of CS and HC techniques (CSHC) based optimal forwarder selection and detect the Intrusion in wireless sensor network (WSN). Here, a Bayesian thresholding method is predict the received signal strength and link reliability parameter for identifying intrusion in the network. The hill-climbing technique is able to attain the best solutions in a smaller period than other local search techniques. In CSHC, the optimal forwarderis selection by fitness function. This fitness function is computed based on sensor node lifetime, sensor link reliability, and buffer availability. In this approach, the experimental results suggest that the CSHC for improving 35% throughput and minimizes the 23.52% packet losses compared to the baseline approaches.

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1. INTRODUCTION

Wireless sensor network (WSN) attracts a widespread concentration due to their characteristics of least cost, exploitation simplicity, as well as adaptability. Reliability is a significant part of wireless connections, although conveying it in considerable or numerical terms is not simple [1]. In WSN, reliability is frequently connected with fault-tolerance as well as the failure of sensor nodes [2]. However, when studying WSNs comprise resource-restricted sensor nodes, other inbuilt features cooperate evenly significant functions in disturbing reliability [3]. In WSN, transmission among neighbour nodes may not be good for several reasons. The link may be unreliable, the recipient may sleeping to preserve energy, and the channel may be busy. Hence, sensor node reliability and link reliability measurement is an important factor [4].

WSNs can recognize, gather and proceed with the observed data with cooperation then transmit it to the BS [5]. Yet, sensor nodes are restrained in energy having restricted energy and are frequently difficult to be re-energized. The sensor node lifespan relies to a huge level on the battery's life, and the excessive energy utilization will reason the WSN to expire prematurely, resulting in diminishing the lifespan. Hence, in WSN, the plan of an energy-efficient routing technique is the significant point [6]. Generally, the localization techniques are separated into two parts such as evaluation of distance applying angle of arrival, residual signal strength indication, and time of arrival, [7]. Position computation by triangulation as well as trilateration [8]. The overhead of communication issues also happens when the nodes and re-flood their positional details to modify the WSN [9].Though, they necessitate widespread calculation power that raises with the enhance in computational complexity [10].

Problem statement: generally, a WSN links are unreliable since numerous interruptions like channel uncertainty, fading, and low signal strength due to storm, rainfall, and building. Thus determining a stable route is a significant element in the WSN. The components are created to repeated failures of the link that increases the packet drop rate [11]. Furthermore, another issue of WSN is the incapability of controlling the number of control packets and the raised amount of packets over the network. It created additional overhead and raised the utilization of bandwidth.

The multi-objective ant-colony-optimization (ACO) based QoS-aware cross-layer routing (MACO) approach is used to enhance the cost of energy consumption and the cost of delaying a routing path. A routing path is introduced via both the multi-pheromone as well as the multi heuristic information containing two intention functions. The MACO utilizes a fuzzy membership operation to allocate fitness values to the non-dominated solutions. However, the fuzzy technique provides inaccurate results [12]. In addition, it converges prematurely and be attentive to a local minimum, particularly with difficult issues. To solve these issues, cuckoo search, and hill-climbing optimal search technique fitness function is used to determining reliable route with a lesser link failure feasibility and enhanced the data packet delivery. In addition, a Bayesian thresholding method is predict the received signal for identifying intrusion.

Work contribution: several WSN routing approaches demand widespread power of computation that raises computational complexity. To minimize these issues, cuckoo search (CS) with the hill climbing (HC) technique is introduced in this paper. It uses less computational time with memory.

- In the preliminary stage, Bayesian thresholding method is used for the intrusion detection in the WSN.
- Then, the sender sends the route request (RuReq) message is distributed to the whole network. This RuRe message contains sensor lifespan, sensor node reliability, sensor link reliability, as well as buffer availability. The recipient receives this message, then route reply (RuRep) message forward back to the sender.
- Next, select the forwarder node through the CS and HC techniques. This optimal search algorithm fitness function is to choose the forwarder node.
- This is minimized the routing overhead, and it can assist the sender in choosing the optimal route in minimum time. It eliminates the link failure, provides a higher packet received rate, and increases network lifetime.
- Lastly, CS and HC techniques (CSHC) is measuring in the NS2 simulation tool under several conditions and equated with similar works. The received outcomes specify that CSHC offers major enhancement in the WSN.

The exits of the article are structured as follows. CS, HC and Bayesian threshold methods descriptionin section 2. Section 3 explains the CSHC working function. Simulation analysis results are explained in section 4. finally, it presents the conclusions and future work in section 5.

The end-to-end data delivery reliability approach is used for measuring and optimizing reliability. This approach detains the mapping operation among the background noise, packet reception ratio, as well as RSS. However, this approach lacking energy efficiency and a lifetime of the network [13]. Fusion of ACO and CS techniques for introducing an energy-efficient routing by low energy adaptive clustering hierarchy (LEACH). This approach reduces energy utilization. Here, ACO is applied for discovering leader nodes then the CS technique is used for data forwarder node selection during data transmission. However, this approach lacking energy efficiency during multi-hop and multilayer and increases reliability [14]. A water wave optimization and a hill-climbing routing procedures are select the optimal route. However, this approach raises the hot-spot issues [15].

This approach uses an exhaustive search technique and a near-optimal single objective genetic technique to minimize the complexity [16]. Cascading model is used for detecting node and link capacity. This approach resists cascading failures and removes network congestion. During data transmission, it checks the node Bandwidth resources. As a result, it minimizes network failure. However, this approach can't detect the congestion efficiently [17]. Particle swarm optimization, as well as intelligent searching method, is used to reduces between nodes and decrease the nodes dead in excess of time. The WSN reliability is habitually to retain an end-to-end association in the existence of node failure. However, this approach can't improve energy efficiency [18]. Link quality prediction (LQP) is significant to decide that the link is unfailing enough to accept the task of communication. However, this approach can't use an optimal search algorithm for improving route efficiency. In addition, it does not perform well during multi-hop wireless links [19].

Transmission power control for link-level handshaking approach is used to optimal transmission power allotment for data and ACK packets on network lifetime [20].

Wavelet-neural-network-based link quality evaluation technique, is utilized for measuring the link quality by signal-to-noise ratio. However, this approach lacking multi-hop link reliability. In addition, it increases the computational complexity [21]. Link quality evaluation is used to express the link quality. Though this approach is unstable, it cannot measure the reliability of the link [22]. Received signal strength indicator (RSSI)-based link quality measurement is used to enhance the quality. However, this approach makes additional computational complexity that builds inappropriate for low-cost [23]. A multi-objective route optimization technique is introduced for improving the lifetime [24]. RSS based stable link with packet received rate measurement is used for measuring a link quality. It increases the quality of the link. But, the RSS is not aware of updates in link quality in experiments [25]. Link quality estimation metric, as well as the required number of packets, is used for evaluating link quality through calculating the ratio of the transmitted as well as retransmitted packets to the amount of effectively obtained packets in a window of communication occurrence [26]. Elliptical curve cryptography (ECC) is an successful for securelytransferdata and improving the receiver end in asymmetric cryptosystems [27]. This approach generates a public as well as private key pair which is utilized to encrypt and decrypt the data. ECC-dependent encryption approachapplying an improvement strategy based on the gravitational search algorithm method. The private key generation step of the ECC system applies a optimization procedure to enhance the efficiency [28].

2. CS, HC AND BAYESIAN THRESHOLD ALGORITHM DESCRIPTION

In this section, we give the detailed algorithm description of CSHC approach. Here, presents HC, CS and Bayesian Threshold Methods working functions in the WSN. Here, we using the Bayesian threshold for detecting the intrusion. HC, CS methods are provide an optimal results in the network.

2.1. HC algorithm

It is a simple local search method, to quickly identify near-optimal router locations in a WSN so as to improve its QoS in terms of maximizing the network connectivity and client coverage. HC is an optimization method that goes to the local search. It explores the best resolution in the neighborhood throughout measuring the present state. Otherwise, continue updating the current state, if possible. Then, loop until a solution is found or until there are no new operators left to be applied in the current state. Also, inside the loop, there are two steps. Initially, picking an operator that has not yet been functional to the present state also concerns creating the new state. Then, measure the new state. The fundamental concept of HC is forever a condition that is best than the present one. Hence, it enhances the quality.

2.2. CS algorithm

The CS technique is an optimal search method that has been applied in several optimization fields with great efficiency [29]. The CS technique uses levy flights for searching. Levy flight random walk procedure that establishes random searching prototype. A cuckoo bird lies eggs in the crowd's nests; if the birds discover the unidentified eggs next, they will reject the egg; otherwise, discard the nest. For making it, cuckoo eggs replicate the eggs of a crowd [30]. Three idealized policies applied through the CS methods are decided:

- Every cuckoo lies one egg that is reserved in an arbitrary crowd nest.
- The best eggs, otherwise greatest solutions, will be present for the next iteration.
- The count of crowd nests is preset, and there is a possibility $P \in (0, 1)$ which an unidentified egg can be researched. Under this condition, the crowded birds can either reject the egg otherwise depart the nest.

2.3. Bayesian threshold algorithm

Nowadays, Bayesian theory is a familier and it is applied for detecting intrusion nodes. It introduced a heuristic threshold methid to identify and categorize the stateof a multivariate quality control system. Bayesian rules and equated with decision thresholds to decide the minimum acceptable confidence value.

3. FUSION OF CUCKOO SEARCH AND HILL CLIMBING TECHNIQUES BASED OPTIMAL FORWARDER SELECTION WITHDETECT THE INTRUSION IN WSN

In this approach, the sensor nodes which have a better position, as well as more stable links among them and the sender node measured in the subsequent iterations of the connection among nodes and its neighbors, are preferred, and the control packets of the RuReq are sent in a restricted method on these connections. Forwarding a restricted count of control packets in this technique minimizes the routing overhead. In WSN, a usual sensor node is compromised by an intrusion, accordinglysuchintrusionnode control the compromised node. It caninsertadapted data readings into the network. Consequently the adapted original data can criticallydisturb thefunction. Figure 1 illustrates aworking function of CSHC approach. To identifies intrusion we using the Bayesian thresholding method. The RSSI is gathered at the recipientcan be formulated in (1).

$$RSSI = -10m\,log_{10}(\,dis) + P \quad [dB] \tag{1}$$

Here *m* exponents the path-loss exponent of dissemination, *dis* denotes the distance among senderas well as recipient, in addition, P is the obtained power. In this approach, we calculate the average value of the link reliability (LR) with RSSI of every sensor is transmitted tothereceiver to build a decision regarding the normalorintrusion. The LR value computation equation is demonstrated in (4). The average value of RSSI and LR value is greater than the threshold that node is normal. If the value is threshold that value is a intrusion node. Here, intrusion detection (ID) based on Bayesian thresholding method is given in (2).

$$ID = \sum_{i=1}^{n} \frac{RSSI+LR}{2} \geq \kappa \tag{2}$$

Here, κ denotes the threshold. The Bayesian thresholding methodis detect the intrusion and send the notification message to all sensor nodes. Then isolates the intrusion nodes in the WSN. The sender desires to transmit the data to destination initiate the invention process.

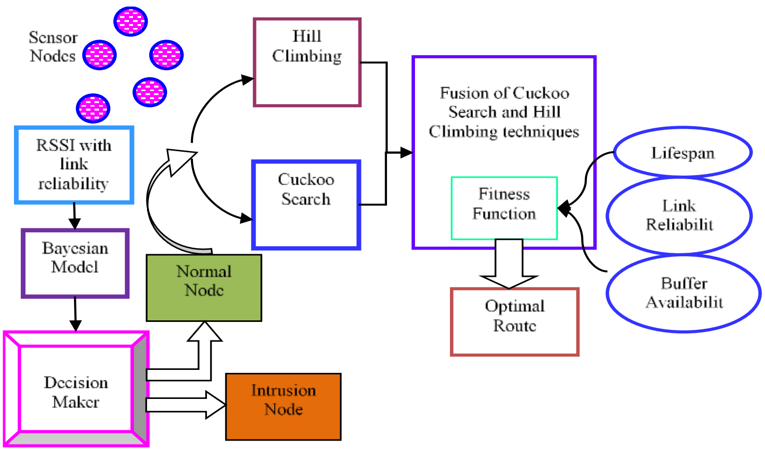

Figure 1. Working function of CSHC approach

During route invention, neighboring nodes obtain the RuReq packet, iterates this procedure, and transmits the RuReq packet over a group of neighboring connections. This procedure is continued till the recipient sensor obtains the packets. The recipient sensor obtains an entire RuReq, the recipient sensor forwarding RuRep packets to the sender by obtaining the RuReq packets route. Elements, for example, sensor lifespan, sensor node reliability, sensor link reliability, as well as buffer availability, are computed for every route. These elements are tied to the RuRep packet to other typical information. The lifespan of the link (LL) represents the time for two sensor nodes to initiate contact over a route. This element computation is used to determine the most steady route. This steady route leads to the minimize the packet drop rate during data transmission. It is defined as the difference between the distances (Δdistance) over a time period (Δt).

$$LL_s = 1(\frac{\Delta d}{\Delta t}) \tag{3}$$

The reliability of links between two sensors is the capability of transmission of data packets with the lesser probability of the link failure that is a significant element for evaluating the system strength as well as efficiency. The reliability of a link is inversely proportional to the rates at that RuReqs are transmitted by the sensor nodes, and RuReps are created as an acknowledgment for the related RuReqs. It is The sensor reliability computation is shown in (4).

$$LR_s = \frac{1}{(Transmitted_{\mathrm{RuReq}_{Rate}} \times Re\,ceived_{\mathrm{RuRep}_{Rate}})} \tag{4}$$

We are utilizing this element fitness function to choose a more steady route, thus improving the packet received rate. Buffer availability measurement is used to avoid data packet losses in the network. This measurement also minimized both the congestion and the network delay. Let qs denotes the size of the queue, and bc denotes the buffer capability. The buffer availability computation is shown in (5).

$$BA_s = \left(1 - \frac{qs}{bc}\right) \quad (5)$$

These three elements are applied for calculating the CSHC fitness function and highest fitness function node is elected as a optimal forwarder node in the WSN.

4. RESULTS AND DISCUSSION

In this section, we applying a network simulator tool to equate the CSHC routing algorithm with the CS and MACO approaches. Here, sensor nodes are distributed randomly and these sensor nodes observe the surrounding information then forward the data to BS. The BS is positioned at the margin of the sensing field.

4.1. Throughput ratio

Throughput denotes the number of data packets transmitted to the receiver node per unit time. It is measured as obtained throughput in bps unit, and it is computed by (6).

$$Throughput = \frac{\sum_0^m PacketReceived(m)*512}{1000} \quad (6)$$

Figure 2 displays the throughput of CS, MACO, and CSHC approaches versus the node density. From this figure, the CSHC approach provides better throughput than the CS, MACO approaches. Choosing an efficient route, the MACO approach takes additional time, and it employs the slow to converge. But, the CSHC approach has quicker convergence, and less parametric configuration necessitates than the meta-heuristic algorithms. CSHC approach is improved the network throughput than the CS algorithm.

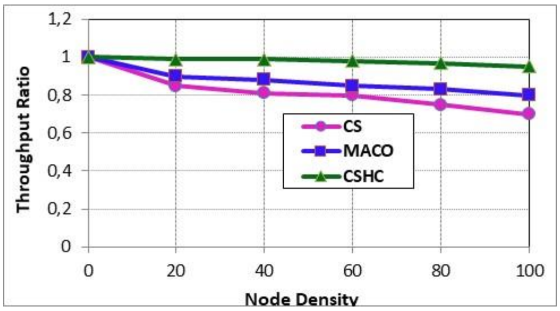

Figure 2. Throughput ratio of CS, MACO, and CSHC approaches versus node density

4.2. Control overhead

The number of created control packets is referred to with control overheads. Lesser overhead definitely concerns the evaluation of protocol effectiveness. It is defined as the ratio of the amount of control packets and the whole amount of packets.

Figure 3 explains the routing overhead of CS, MACO, and CSHC approaches versus node density. In CSHC, dissemination of RREQ control packets is prohibited, and route detection is performed in a controlled method. But, the MACO approach increases the routing overhead since this approach enforces raised the routing overhead accordingly applying the ACO meta-heuristic algorithm and storing the complete information. Thus, this approach increases the routing overhead.

4.3. Average delay

The delay is defined as the time between the receiver node received the packets and the sender node forward the packet. It is measured by the (7).

$$Delay = \sum_0^m Time\ \ of\ Packet\ \ Received - Time\ of\ \ Packet\ Sent \quad (7)$$

Figure 4 displays the average delay of CS, MACO, and CSHC approaches versus the node density. From this figure, while the node density raises, the node delay also increases in the network. We are employing the cuckoo search with hill-climbing algorithms to assist in the assortment of the optimal route in a lesser time than the cuckoo search and MACO technique. Alternatively, MACO is very slow to converge but, the CSHC approach has a quick convergence rate. Also, it recognizes the optimal route in a lesser time. In addition, the CSHC fitness function provides an optimal relay compared to the CS technique. In addition, the CSHC approach minimized the network delay than the other two protocols.

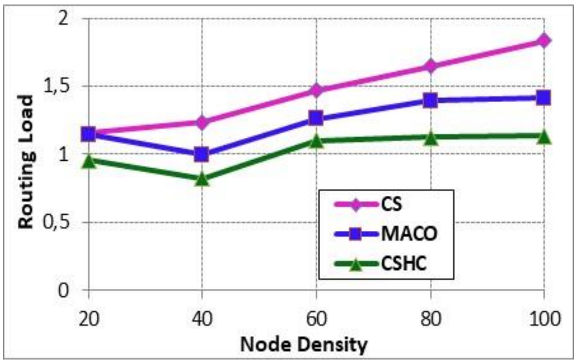

Figure 3. Routing load of CS, MACO, and CSHC approaches versus node density

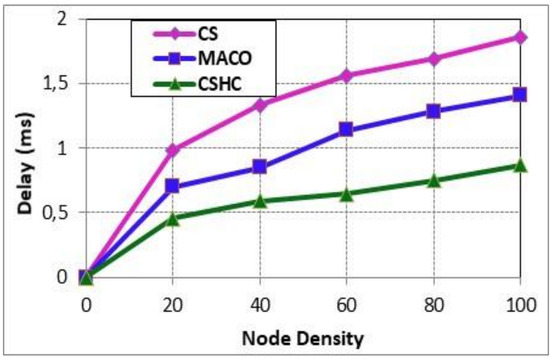

Figure 4. Delay of CS, MACO, and CSHC approaches versus node density

4.4. Remaining energy

Figure 5 demonstrates the remaining energy of CS, MACO, and CSHC approaches versus node density. From this figure, our CSHC approach has the highest remaining energy than the CS and MACO approaches. In CSHC, select the relay node by sensor lifespan, sensor link reliability, as well as buffer availability through CS and hill-climbing techniques.

Thus, the CSHC approach is reduced the extra energy utilization in the network. But, the MACO approach increases energy consumption. Also, the CS technique is the early convergence to suboptimal solutions. Thus, the CS algorithm increases the energy consumption compared to the CSHC approach.

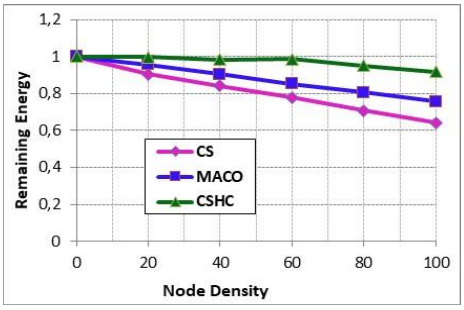

Figure 5. Remaining energy of CS, MACO, and CSHC approaches for node density

4.5. Detection ratio

Detection Ratio is declared as the correlation between the count of properly-recognized intrusion sensor and the count of intrusion sensor. It is computed by the (8).

$$DR = \frac{Count\ of\ properly\ recogonized\ \ int rusion\ Sensor}{Whole\ count\ of\ \ int rusion\ sensor} \tag{8}$$

Figure 6 explains the DR of the CS, MACO and CSHC approaches. From this figure, the DR of the CSHC is greater than other approaches based on node density. Since, CSHC approach using Bayesian threshold method to detects the intrusion sensor efficiently. But, the CS and MACO approaches can't detect the intrusion efficiently in the WSN.

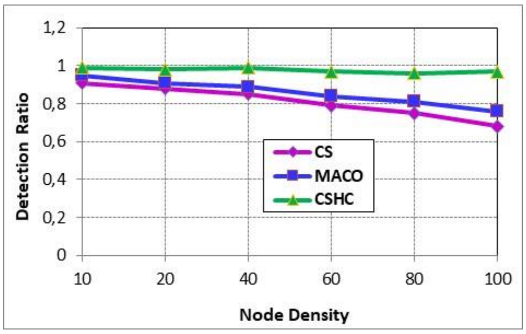

Figure 6. Detetion ratio of CS, MACO, and CSHC approaches versus node density

5. CONCLUSION

This approach presents a fusion of cuckoo search and hill climbing techniques based on optimal forwarder selection and detect the intrusion in WSN. This approach is used to improve the routing and energy efficiency in the WSN. Initially, the Bayesian threshold method detected and isolated the intrusion sensor nodes in the network. Here, wedetectsthe intrusion sensor node by received signal strength and link reliability parameter. Cuckoo search and hill climbing techniques are choosen the forwarder by the node fitness function. The CSHC algorithm fitness function is measured by the sensor node lifetime, sensor link reliability, and buffer availability. This fitness function is used to select the optimal forwarder and transmit the data through these forwarder in the network. In this approach, the experimental results suggest that the CSHC enhanced the remaining energy, detection ratio and throughput. In addition, it minimized the delay, and routing load in the network.

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