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CSVAG: Optimizing Vertical Handoff Using Hybrid Cuckoo Search and Genetic Algorithm-Based Approaches

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Abstract: One of the primary challenges that wireless technology in the present generation is facing is always best connected (ABC) service. This is possible only when the wireless overlay networks follow a cooperative and coordinated process. Vertical handoff is one such process. Concerning this process, the main challenge is to develop algorithms that take care of optimal connection management with proper resource utilization for uninterrupted mobility. In this paper, we develop a new hybrid cuckoo search (CS) and genetic algorithm (GA) that maximizes the performance of heterogeneous wireless systems in terms of minimizing latency, handover failure probability, and enhancing the throughput. We focus on an optimized simulation framework to demonstrate the advantage of our hybrid model. It can be discerned from the simulation analysis that the proposed hybrid technique increases throughput by 17% and 8% compared to the cuckoo search and genetic algorithms applied individually. The performance of the proposed scheme is promising for applications wherein the handoff mechanisms have to be optimized to control frequent handoffs to further reduce the power consumption of user equipment.

Keywords: cuckoo search; genetic algorithm; service continuity; mobile node; heterogeneous wireless network

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1. Introduction

During the most recent couple of decades, there have been considerable improvements in wireless system technology [1,2]. As is clear and evident from Figure 1, the present patterns and requirements in the area of wireless technology involve providing ongoing mixed-media applications over different dissimilar kinds of wireless systems with ensured quality of service (QoS) [3]. Client requests to use and apply these technologies in various scenarios, at any place or time, are continuously rising. The advancement of new innovative frameworks (for example, the fourth generation (4G) remote frameworks and their mix) provides these productive applications with high information movement rates and offers a global range and consistent versatility through a different scope of heterogeneous wireless systems [4]. Mobile stations (MSs) in a conventional 4G network will be outfitted with numerous interfaces [5]. They will have the required information to make improved choices when associating with an assortment of access networks (ANs) to provide productive, interactive media applications [6]. Figure 1 shows the evolution of wireless communication [7,8].

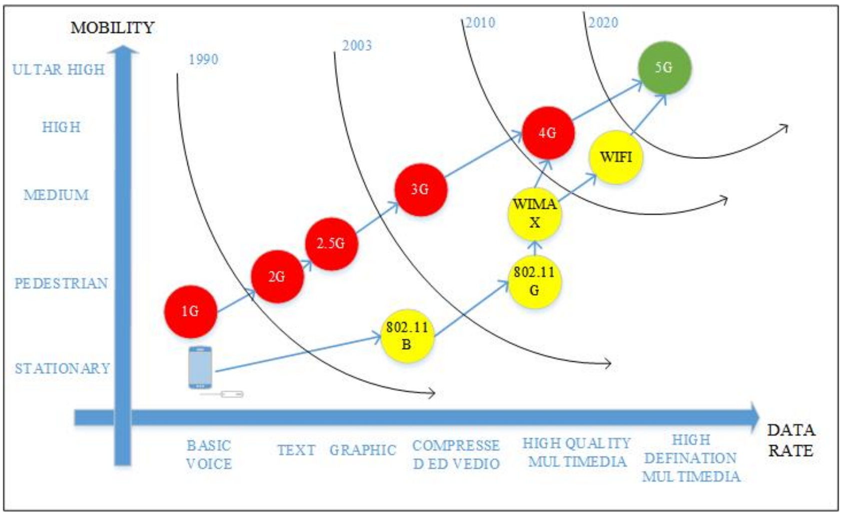

Figure 1. Evolution of wireless communication [7,8].

Cuckoo search (CS) [9] is one of the numerous nature-inspired methods utilized broadly to solve issues in various fields of engineering. It is a compelling option for global streamlining because it can maintain harmony among neighborhood and worldwide arbitrary strolls utilizing the exchanging parameter. The exchanging parameter for the first CS calculation is fixed at 25%, and insufficient examinations have been performed to evaluate the effect of the dynamic turning parameter on the exhibition of the CS calculation.

Genetic algorithm (GA) [10]—based methodology is utilized to assess the likelihood of effective handoff in heterogeneous remote systems (HWNs) to expand, limit, and or execute a system. GA has been comprehensively explored for various IoT-based applications [11–17], so it is interesting to see its performance for wireless communication.

1.1. Motivation

The conventional handoff methods are meant to deal with ping pong and corner impacts. A hybrid of the GA and CS technique can adequately advance delicate handoff choice by choosing the system of best fit for the mobile terminal (MT), with regard to the nature of administration (QoS) prerequisites, the arrangement of parameters, and the client's inclination regarding the cost of various connection focuses for the MT. The capacity to decide worldwide optima of any size utilizing hybrid and transformation tasks makes this proposed hybrid approach a promising arrangement.

1.2. Research Contributions

Our major contributions are stated as follows:

1. In this paper, we propose strategies for how heterogeneous wireless networks (HWNs) ought to be sent, and present control calculations that can be utilized to use accessible assets more productively.
2. We inspect the ideal arrangement of HWNs and propose a system, which is mindful of portability requirements, to arrange advancement to limit the pace of upward vertical hand-off occasions and to amplify the complete number of clients bolstered by the system.
3. We further explore how ideal affirmation control strategies are utilized to maintain QoS in HWNs. The proposed work is novel in the sense that the current wireless system configuration is complicated because of the dynamic condition under which clients' administrations operate make parameter improvement a mind-boggling task. However, the vibrant, and often obscure, working conditions create remote system administration models that are dependent on AI and human-derived reasoning calculations.
4. Our proposed work (i.e., hybrid use of CS and GA) provides a settled system to execute fake insight errands, for example, order, learning, and advancement. Their

adaptability makes them strikingly helpful in a full scope of use areas, including remote systems.

5. Simulations are performed in MATLAB, and performance validation of the proposed hybrid technique is performed against methods involving cuckoo search and genetic algorithm individually, and received signal strength (RSS), as well as random methods.

Novelty Analysis

The proposed work is novel in the sense that, to the best of our knowledge, it is the first attempt ever that considers hybrid optimization, particularly CS and GA, for handling the handoff mechanisms. Moreover, it is the first work that considers delay, number of handovers, throughput, and handover failure probability for handling the handoff mechanism.

1.3. Organization

The rest of the paper is organized as follows. Section 2 surveys handoff advancement methods, genetic algorithm, and wellness work. Section 3 spotlights the procedure used to accomplish low handoff idleness, considering the influence of parameters such as interface initiation interim of MT, range of inclusion region, and separation between the base station (BS) and MT for the development of the GA streamlining agent. Section 4 discusses simulation results. The list of abbreviations is included in Abbreviations.

1.4. Related Work

Wireless mobile communication technology has proliferated greatly to accommodate its users [18–23]. Optimization methods have not only benefited wireless communication in terms of user satisfaction, but also opened a great scope for the further improvements.

In RSS-based algorithms [24–26], researchers have done a considerable amount of work. In Zaharans' algorithm [24], a very high delay is observed, up to 1%, and this reduces the number of handovers up to 85%. The study does not provide any information about handover failure probability. It also states that throughput decreases as the velocity increases. Mohanty's algorithm [25] shows that HFP can always be at the required value as the velocity increases, but the study does not provide any information about the delay, number of handovers, or throughput. Regarding Yan's algorithm [26], several transfers decrease as the velocity increases, and HFP can always be kept at the required value as the velocity increases.

Bandwidth-based algorithms also show good results regarding the performance of the system. Regarding Lee's algorithm [27], relatively short handover delay is observed, and a higher throughput of up to 40% is achieved compared to its traditional counterpart. However, no information is provided regarding the number of handovers or HFP. Regarding Yang's algorithm [28], there is a very high value of transfers because of SINR; it also shows a very high value of throughput, up to about 40% compared to the conventional methods [29]. This study also fails to provide information regarding delay and HFP [30]. Regarding Chen's algorithm [31], it is suggested that there are small unnecessary handovers up to 2.5%. HFP and throughput are very high. Cost-function-based algorithms [32–34] also provide several ideas. Regarding Zhu's algorithm [32], it has been said that the high value of throughput is gained by connecting users with several networks, but the study failed to provide any information about the delay, HFP, or number of handovers. Regarding Hassan's algorithm [33], an increase in throughput of 57.9% in different background traffic is noted, but the study does not have any information about the delay, HFP, or number of handovers. Tawi's algorithm [34] shows about 50% shorter handover delays compared to the centralized vertical handoff decision (VHD). The study also states that there is low HFP due to the distribution of the decision calculation and 17% higher throughput compared to centralized VHD; it does not have any information about the number of handovers.

There are also several combination-based algorithms [35–38]. In the Nasser algorithm [35], long delay is observed because of the increased complexity and the training. However, the study fails to provide any information regarding the number of handovers, HFP, or throughput. Results similar to those for the Nasser algorithm are presented for Pahalavan's algorithm [36] regarding the delay. It also reduces the number of transfers by eliminating the ping pong effect, but the study does not include any information regarding HFP and throughput. Similar results are observed with the algorithm in [38–40], but no information is presented regarding the delay, HFP, or performance. From the literature and Table 1, it can be seen that there is a need for a procedure that can make a correlation between the different vertical handover (VHO) systems proposed and perform an assessment of these strategies. Considering this, we propose a strategy to compute the VHO procedure that would give an indication of its adequacy. Table 1 shows a comparative analysis of proposed scheme with existing schemes.

Table 1. Comparison analysis of proposed scheme with existing schemes.

VHO Strategy	Description of Algorithm	Delay	Number of Handovers	Throughput	Handover Failure Probability
[41]	An access and interface selection algorithm is proposed.	√	√	√	×
[42]	It proposes a user-centric solution where users choose the radio access network that meets the QoS requirements.	×	×	√	×
[43]	It proposes an efficient network selection mechanism using AHP and GRE.	×	×	√	×
[44]	It proposes an environment under which vertical handover should occur using Markov decision process.	×	×	√	×
[45]	It proposes two novel weighted Markov chain (WMC) approaches based on rank aggregation.	×	×	√	×
[46]	It proposes a fuzzy multi-criteria vertical handover algorithm.	×	×	√	×
[47]	It proposes a cooperative game framework for bandwidth allocation.	×	×	√	×
[48]	It proposes a Nash–Stackelberg fuzzy Q-learning decision approach.	×	×	√	×
[49]	It proposes a reputation system for vertical handover choice making.	×	×	√	×
[50]	It proposes an intelligent handoff optimization algorithm for network selection in heterogeneous networks.	×	√	√	×
[51]	It proposes an ES-DQN-based strategy for vertical handoff.	√	×	√	×
[52]	The authors present MDP-based vertical handoff.	×	×	√	√
[53]	The authors present a QoS-aware handoff based on service history information.	√	×	√	×
[54]	It proposes a multi-armed-bandit-model-based vertical handoff.	×	×	√	×
[55]	The authors present a QoS-aware intelligent vertical handoff scheme.	√	×	√	×
Proposed scheme	We present a method based on a hybrid of cuckoo search and genetic algorithm.	√	√	√	√

2. Algorithms And Methods

The current techniques have a few downsides in that some of them have not considered QoS prerequisites, arrange parameters, or the closest base station to use while the call is being moved. In addition, the QoS may dip under the specified limit, and associations are frequently dropped, if handoff solicitations are not conceded at an opportune time. The current techniques do not consider clients' preferences and the different connection alternatives for the portable client. They show low throughput, as well as questionable handoff choices, expanded intricacy, occasional pointless handoffs, and ping pong impacts, which are superfluous to the handoff process. Therefore, there is a need to build a new advanced handover strategy for improved assistance conveyance in cell systems. The ordinary techniques for handoff advancement are not dependable or savvy. They present problems in usage and are only appropriate for static circumstances. In this paper, the GA is applied for the advancement of delicate handoff choices in remote systems. The utilization of GA change, hybrid, determination, and recombination procedures can extraordinarily improve the execution of the framework. The parallel and quick assembly nature of the GA makes it appropriate and versatile for illuminating enhancement issues for a wide scope of utilizations, including remote systems. In the random method, the velocity of the mobile node is taken as it is and is implemented without applying any algorithm. In the RSS method, the handoff decisions are made by comparing the RSS (received signal strength) of the current network with the preset threshold values. These algorithms are less complex and may be combined with other parameters (such as bandwidth, cost, etc.) to obtain a better handover decision. Note that the RSS estimation of the two systems uses the RSS position for the first time at the beginning of the calculation. The calculation for handoff choice appears after checking the condition of whether the MS WLAN is organized or in LTE arrangement. On the off chance that the WLAN is organized, it is taken as a substitute for the RSS in the calculation. In addition, if MS moves to LTE, the WLAN signal settles, and the LTE signal becomes solid; if the current RSS estimate of the system is not as high as the RSS option is, it is then taken, and MS gives it to the LTE network.

2.1. Related Mathematical Model

The received signal strength (*RSS*) of both the networks is calculated using the following equation:

$$RSS(dBm) = Pt(dBm) + K(dB) - 10 \times n \times \log 10 \times [\frac{d}{d_0}] \tag{1}$$

$$K(dB) = 20 \log 10 \times [\frac{\lambda}{4} \times \pi \times d_0] \tag{2}$$

False handoff initiation probability is calculated using the following equation:

$$Pa = 1 - [\frac{1}{\pi} \times (a \tan \frac{a}{2d})] \tag{3}$$

False handoff failure probability is calculated using the following equation:

$$P_f = \frac{a \cos[\frac{d}{(v \times handoff_{delay})}]}{a \sin[\frac{a}{2 \times d}]} \tag{4}$$

where Pt = transmitted power of system; d = distance between MS and BT of system; d_0 = reference distance from BT; n = path loss exponent; v = velocity of MS; and a = coverage area radius of the system.

2.2. Cuckoo Search

The cuckoo is a family of birds with a remarkable method that contrasts sharply with other winged animal species. Some feathered species of cuckoo, such as ani and guira, lay eggs in shared nests. They can also remove the eggs of others to expand the possibilities for their own eggs. Different species use a strategy of brood parasitism to lay their eggs in different winged organisms' or host settlers' homes. Parasitic cuckoo branding is common in nests where eggs have recently been laid or will soon be laid. The cuckoo lays an egg in the host nest, which will usually hatches faster than the other eggs. When this happens, the outside cuckoo removes eggs that are not leaving the nest. This conduct is intended to reduce the possibility of authentic eggs. In addition, cuckoo birds outside may receive more nutrition by following the calls of host birds. There are times when the host bird discovers that one of the eggs has been replaced. The bird will then either dispose of the eggs or entirely surrender the nest and proceed to build another.

2.3. Levy Flights

Levy flights are irregular strolls whose bearings are arbitrary and whose stride length is derived from Levy dispersion. These Levy flights are performed by creatures and insects and can be described by sudden straight flights arranged on a 90-degree curves. Unlike ordinary irregular routes, Levy flights are very efficient in examining large-scale search areas. This is mainly due to fluctuations in Levy flights that are much faster than typical erratic running. Toll flights can reduce the amount of correction count cycles with specific arbitrary running by about four requests.

2.4. Cuckoo Search Algorithm

The CS calculation is a nature-inspired calculation that relies on the generation of cuckoo winged creatures. When working with CS calculations, it is necessary to combine possible arrangements with cuckoo eggs. Cuckoos usually lay their eggs in the nests of other cuckoos, who desire to raise them as substitutes for their own offspring. Many times, when the cuckoo finds out that they do not have their own eggs in their nest, the outside eggs are either thrown out of the nest or abandoned along with the entire nest. The CS advancement calculation is set up with three rules:

1. Each cuckoo chooses a home arbitrarily and lays one egg in it;
2. The best homes (those with a high caliber of eggs) will be maintained for the coming generations of cuckoos;
3. For a fixed number of homes, a host cuckoo can find an outside egg with a likelihood of $Pa \ \epsilon$ [0, 1]. In this situation, the host cuckoo can either discard the egg or relinquish the home and construct another one elsewhere.

The final rule can be imposed by using the fraction of the part of n that has new homes (with new irregular arrangements). The quality of the answer may correspond to an estimation of the target function. From the execution point of view, what is depicted is that each egg in the home represents one answer, and each cuckoo can lay just one egg (meaning an arrangement). We cannot allow any cooperation between an egg, a house, or a cuckoo. The point is that to suppress a bad system in the home, a new and better system of conception (cuckoo egg) is used. The above final rule can be approximated by supplanting the portion parameter pa of the n host homes with new settles (with new irregular arrangements). The quality or wellness of an answer can essentially be seen as corresponding to the estimation of the goal. From a usage perspective, each egg in a home represents an answer, and each cuckoo can lay just one egg (meaning one arrangement). We can allow no cooperation between an egg, a home, or a cuckoo. The point is to utilize the new and possibly better arrangement (cuckoo egg) to supplant a worse arrangement in the home.

Cuckoo search is exceptionally powerful as it maintains concordance between irregular walks of neighborhoods and arbitrary walks around the world. The coherence between arbitrary walks around neighborhoods and around the world is constrained by a standard parameter in the range [0, 1]. The characteristics of arbitrary walks in the neighborhood and around the world are depicted in Equations (5) and (6), respectively.

2.5. Realization and Representation of Objectives

Vertical handover systems have experienced numerous improvements, and various new advances have been presented in the most recent couple of years. There are, however, still a few gaps that require further investigation; this section summarizes them.

1. When vertical handover happens, providing the required QoS over diverse remote systems is a significant issue, and elevated levels of versatility cause further difficulties. To ensure the QoS, VHO methods should cautiously consider client portability and system conditions to pick the best applicant to organize and carry out a quick handover.
2. Guaranteeing the QoS is not sufficient to provide the most ideal experience for clients. Strength of experience (SoE) is an idea that has been gaining significance. It is identified

with clients' fulfillment. Providing great system administration does not necessarily provide complete fulfillment to the end clients. Consequently, there is also a need to consider client inclinations and varying gear when planning VHO procedures and strategies.

3. In heterogeneous conditions, systems should be oriented with the end goal that the clients are, in every case, connected as well as possible. The issues identified with a system's administration, including charging for and evaluating the utilization of the system and other such issues between administrators, must be solved in a way that ensures the quality of VHO, the strength of experience (SoE), and the strength of service (SoS). The between-system administration of these dissimilar remote systems has become a difficult and significant area of research. Diverse access systems, including 3GPP (e.g., EDGE, HSPA, UMTS, LTE) and non-3GPP (e.g., WiMAX, Wi-Fi) gauges, should be associated in an ideal way to provide clients with a decent QoS.
4. A standardized VHO assessment approach is absent. In this way, a typical approach is required so that analysts, designers, and clients can effectively look at and assess the various VHO methods employed. There is a need to establish standards or rules for good practices for VHO assessment. We have framed the objectives of our research work to overcome these pitfalls.

The objectives of the work are:

1. Optimization of vertical handover decision by minimizing the handover delay and maximizing the throughput using the proposed algorithm;
2. Optimization of vertical handover decision by minimizing the handover failure probability using the proposed algorithm based on the quality of service constraints;
3. Optimizing the vertical handover decision using the proposed handover algorithm.

2.6. Standard Parameters to Assess the Quality of the Proposed Work

The standard parameters for evaluation of the proposed work are discussed as follows.

1. Consistent (C)—Handover is considered "consistent" when it can maintain the availability of all applications running on the cell phone, providing nonstop start-to-finish information administration during switch-over within a session and offering both low inertness and negligible parcel misfortune.
2. Bundle misfortune (BM)—This is a measure of the bundles dropped during the VHO process. Numerically, it tends to be communicated as follows: bundle misfortune for vertical handover = (1—no. of bundles received)/Total no. of bundles sent. Here, bundle misfortune is calculated for the handover period only.
3. Throughput (TH)—This refers to the information rate conveyed to the portable terminals during handover. It is generally desirable to obtain higher throughput during handover to a specific system.
4. Handover latency (HL)—This alludes to the length between the commencement and finish of the handover procedure. With an increase in the unpredictability of the VHO procedure, there will be more handover deferral. In this manner, for deferral-sensitive sight or sound sessions, the decrease of the handover postponement is significant. Handover deferral is the whole of every individual whose engagement with the handover is deferred. It can be written as follows:

$$T_{handover} = TL_2 + T_{sig} + T_d + T_{IP} \quad (5)$$

where TL_2 is the time required to build up layer 2 availability between the versatile hub and passage or base station of the new passageway; T_{sig} is the time required for trading control messages; T_d is the single-direction delay for an information bundle in the new system; and T_{IP} is the IP address procurement delay in the new system.
5. The number of handovers (h)— The number of handovers included should be low, as continuous handovers would reason wastage of system assets.
6. Handover failure probability (HF)—A handover failure happens when the handover is started, but the objective system does not have adequate assets to effectively finish

it. For a given quantity of handoffs all throughout the span of call, the handover failure probability is given as $1 - (1 - Ph, j)h$, where Ph,j denotes the probability that a handoff attempt for a call of type j is blocked.

7. Handover protocol overhead (PO)—This refers to all of the overhead caused by the convention for handover flagging and the overhead of the extra bytes sent with every datum parcel. Thus,

$$P.O. = Overhead\ HO + Overhead\ A.D. \quad (6)$$

8. Vertical handover process evaluation index—This gives an indication regarding the fitting and adequacy of the handover procedure. This list can be determined as follows:

$$VHO_I = ws_{N(Sj)} + wPL_{N(1/PLj)} + A \quad (7)$$

$$A = wTH_{N(THj)} + wHD_{N(1/HDj)} + wHF_{N(1/HFj)} + wPO_{N(1/POi)} \quad (8)$$

where ws, wPL, wTH, wHD, wHF, and wPO refer to loads allocated to the previously mentioned paradigm as per their significance, while $N(I)$ is the standardization capacity of the ith paradigm. Since each system parameter has an alternate unit, no standardization procedure is required. By this strategy, one can conduct a quantitative appraisal of the different VHO algorithms. The higher the estimation of VHO for a specific VHO algorithm, the more proficient the handover choice procedure. This will be very useful to specialists in choosing whether a given VHO algorithm is appropriate for a specific handover condition. Furthermore, VHO satisfactory qualities may change for various classes of traffic types. For example, non-constant traffic (e.g., content information, email, and so forth) can endure enormous postponements, so a high estimation of handover deferral is common, which suggests that low scores for VHO_I for such traffic types are satisfactory. On the other hand, constant traffic (e.g., video and voice) is exceptionally sensitive to postponement, so high scores for handover deferral are unsuitable.

2.7. System Analysis

The corresponding steps are explained in Algorithm 1.

Step 1: As an example, let us take mobile nodes that can roam around freely and uniformly in a place that is under the control of a group of heterogeneous networks that are maintained by six individual specialist organizations. The simulation process comprises systems such as CDMA, GSM, WLAN, WiFi, and so on.

Step 2: Number of cuckoo birds: This step takes care of the number of cuckoo birds being taken in the area. Step size: In the process of CSA (cuckoo search algorithm), step size means the distance covered by a cuckoo for a fixed number of loops or iterations. A medium step size is desired to obtain an effective solution. If the step size is very large or very small, it leads to Step 3.

Step 3: This step calls the genetic algorithm and uses the population source that comes from CS (cuckoo search) to find optimum solutions, while the mobile node is busy with other work.

Step 4: At this point, the main optimization plan will choose a group of fitting systems from the accessible systems by considering non-advanced parameter estimations of the considerable number of systems in heterogeneous system conditions. These will be sent to the genetic algorithm, which streamlines the grouping of systems.

Step 5: Therefore, on the off chance that we mimic the same situation with optimized parameters with the quick cuckoo search algorithm, the client can discover the best systems in a sensible length of time, and then identify the best of these systems by using the genetic algorithm.

Step 6: We reduce the time of it takes to find the optimized network using a hybrid approach of cuckoo search with genetic algorithm. This improves latency, bandwidth, PDR, throughput, and handover failure probability.

Algorithm 1 Proposed Algorithm

Input: Network initialization
$Procedure_{Next_one}$ (location, destination);
Check velocity and position for MN (mobile nodes)
$a \longleftarrow false$
$Query_{MIIS_DBC}$ (location, destination, $MIIS_{Pkt}$)
if min_{cover_time}(loc, DIS, MIIS.Pkt)> 0 **then**
  if $DiS_{ReC_probability}(loc, DIS, MIIS.Pkt) > 0$ **then**
    $a \longleftarrow true$
    Initialize the population of host nest **return** (a) **while** $iteration < Max_{network}$
    for i=1 to N **do**
      for (updating fitness functionality by Levy flight)
      update velocity and position for mobile node
      $updateNext_{one}(loc, dest)$
      Evaluate threshold (TH)
      Update fitness function
      Step 2: Apply genetic fitness function
      Procedure $Next_{one}$ (time, prediction window, sense prediction)
      Evaluate TH
      Filter network by genetic fitness value
      Update velocity and position of mobile node
      Step 3: The hybrid cuckoo search–genetic algorithm phase:
      Procedure $check_{next}$ (time, prediction window, sense prediction)
      for i=1 to N **do**
        Calculate the probability of crossover and
        Evaluate TH
        if converge, then go to step 4
        else change next position and apply step 2 until converge
        After convergence find
        Step 4:TH value $Cuckoo_{search(GA)}$
        Evaluate parameters
        Calculate $Cost_{function}$ (TH value)
        Procedure cost function
        repeat
        update application request list ($MIIS_{weights}$)
        update list of network preference
        update QOS, $QOS_{req}(MIIS_{weights})$
        TH_TH (app_{req}, user, QoS)
        Return
      end for
    end for
  end if
end if

2.8. Computation Complexity Analysis of Proposed Work

The computational complexity of the proposed work, as shown in Algorithm 1, is $O(N \times N)$. There are two for loops, and among them, one is a nested for. Therefore, the total complexity of the proposed work is $O(N^2)$.

3. Results And Discussion

In this section, the correlations of vertical handover choice plan are examined, and we provide the assessment parameters used to dissect the presentation of hybrid model plots regarding the results of the simulation. In our simulation, we consider seven versatile hubs moving in a region secured by the heterogeneous remote systems overseen by different base stations. These base stations (BS) offer distinctive trademarks in terms of inclusion and QoS. The simulation has been done on MATLAB software, and simulation parameters are shown in Table 2.

Table 2. Simulation Parameters.

Parameters	Values
Transmit power	(6, 10, 12, 4) Mw
Bandwidth factor	(2, 2.3, 3, 4) Mbps
The bandwidth of weight factor	(3, 3.4, 4, 4.5)
A signal strength weighting factor	(0.4, 0.23, 0.5, 0.45)
The number of mobile nodes	(20, 40, 32, 60)
Communication rate	1000 kb/s

This section presents the results of the proposed conspire. The methods proposed in this paper are analyzed against the following four methods: random method, RSS method, cuckoo method, and genetic method. The results demonstrate that the novel proposed technique has the best advantage, suggesting that the objectives of the research study have been met.

3.1. Throughput

The graph shown in Figure 2 indicates the throughput under different velocities of the mobile node. This analysis uses four kinds of wireless channels with different groups of nodes. The speed of the portable hub (mobile node) increases the effects on the performance of the node and the network-based scenario. In the case of different velocities, the condition of handoff changes and reduces the packet drop and delay effect on the parameter of the throughput. The graph indicates a significant improvement in throughput (i.e., it acquires more than 10 packets/Ms for the velocity of 20 km/h). Furthermore, with an increase in velocity, it increases the throughput compared to the random, RSS-GA, and RSS-CS methods, respectively.

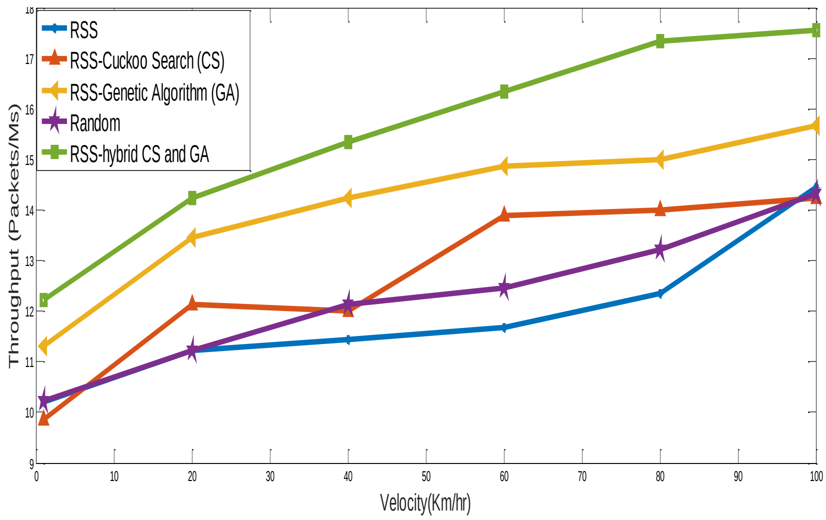

Figure 2. Throughput of the hybrid model.

This improvement is because, in the proposed approach, the use of hybrid optimization helps in improving the static base algorithms, such as RSS. The use of RSS helps in the selection of a static threshold, and this static threshold is optimized via an optimization algorithm. In most of the cases, the optimization approach does not converge and provides a random answer, which further reduces the performance time and the rate of packet drop.

In the proposed approach, the cuckoo search and genetic algorithm are also used. This methodology iteratively improves the performance of the cuckoo search.

3.2. Delay

The graph shown in Figure 3 indicates a delay under different velocities of the mobile node. Figure 3 shows the decrease in delay, as the model acquires less than 1 ms delay with an increase in the velocity. Hence, the graph indicates a significant improvement in delay using the proposed hybrid approach compared to the existing approach and other single optimization methodologies.

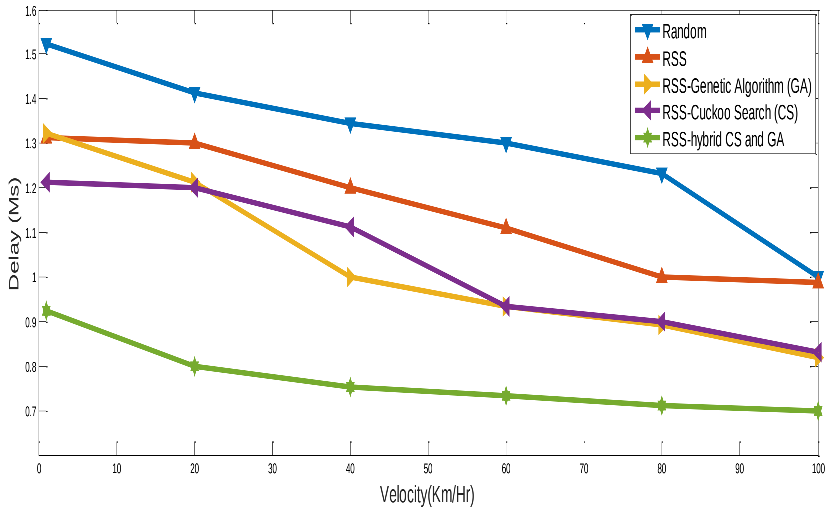

Figure 3. Delay of the hybrid model.

This improvement is because in the proposed approach, the use of hybrid optimization helps in improving the static base algorithms, such as RSS. The use of RSS helps in the selection of a static threshold, and this static threshold is optimized via an optimization algorithm. In most of the cases, the optimization approach does not converge and provides a random answer, which further reduces the performance of delay. In the proposed approach, the cuckoo search and genetic algorithm are also used. This methodology iteratively improves the performance of the cuckoo search.

3.3. Handover Failure Probability

The graph shown in Figure 4 indicates handover failure probability under different velocities of the mobile node. Handover failure probability increases the drop rate and has effects on delay; on the other hand, it reduces the throughput of the system. This analysis uses four kinds of wireless channels with different groups of nodes. The speed of the portable hub (mobile node) increases the effect on the performance of the node and the network-based scenario. In the case of different velocities, the condition of handoff changes, though it is extremely hard to decide which sort of sensor group handovers effectively reduce the delay and its effect on the parameter of handover failure. This decision results in the use of static, dynamic, and optimized base algorithms. It further consists of improving the bandwidth use by selecting an effective sensor channel or vertical handovers, and selecting an effective bandwidth that employs hybrid and single optimization approaches. In the proposed approach, the use of hybrid optimization helps in improving the static base algorithms, such as RSS. The use of RSS helps in the selection of a static threshold, and this static threshold is optimized via an optimization algorithm. In most of the cases, the optimization approach does not converge and provides a random answer, which further reduces the performance of time delay. In the proposed approach, the cuckoo search and genetic algorithm are also used. This methodology iteratively improves the performance of cuckoo search. The graph indicates a significant improvement in handover failure using the proposed hybrid approach compared to the existing approach and other single optimization methodologies.

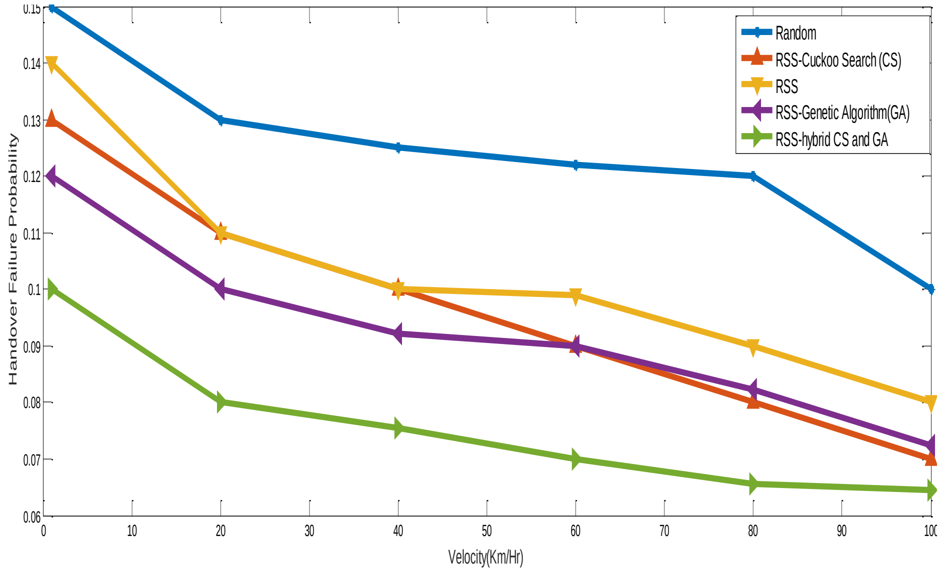

Figure 4. HFP of the hybrid model.

3.4. Number of Handovers

The graph shown in Figure 5 indicates the number of handovers under different velocities of the mobile node. Increasing the handover increases the overhead and its effects on delay; on the other hand, it increases the drop rate, reduces the throughput, and increases the delay of the system. This analysis uses four kinds of wireless channels with different groups of nodes. The speed of the portable hub (mobile node) increases the effect on the performance of the node and the network-based scenario. In the case of different velocities, the condition of handoff changes, though it is extremely hard to decide which sort of sensor group handovers reduce the delay, and the effect on the number of handover failures is reduced. These decisions result in the use of static, dynamic, and optimized base algorithms. The use of bandwidth is improved by selecting an effective sensor channel or vertical handovers and an effective bandwidth that employs hybrid and single optimization approaches. In the proposed approach, the use of hybrid optimization helps in improving the static base algorithms, such as RSS. The use of RSS helps in the selection of a static threshold, and this static threshold is optimized via an optimization algorithm. In most of the cases, the optimization approach does not converge and provides a random answer, which further reduces the performance of time delay. In the proposed approach, cuckoo search and GA are also used. This methodology iteratively improves the performance of cuckoo search.

For the velocity of 60 km/h, the handovers are lowest, with fewer than two; however, beyond this velocity, there is a slight increase in number of handovers compared to RSS-cuckoo search. The graph indicates a significant improvement in handovers using the proposed hybrid approach compared to the existing approach and other single optimization methodologies.

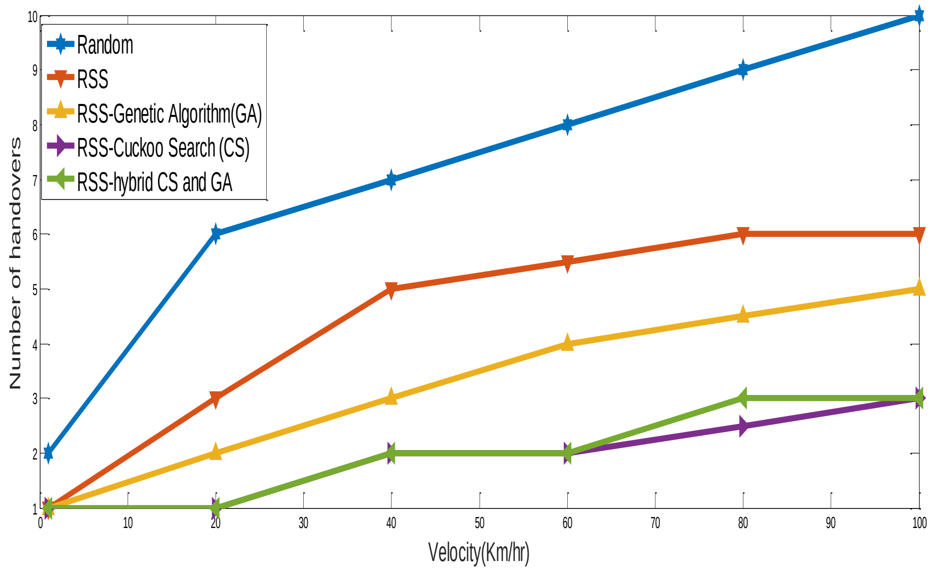

Figure 5. Number of handovers of the hybrid model.

4. Conclusions

This paper addresses the challenges in developing algorithms that perform optimal connection management with proper resource utilization for uninterrupted mobility in vertical handoff. Therefore, in this paper, a unique hybrid optimization technique has been developed that is helpful to both the user and the network. A hybrid of CS and GA is developed to maximize the performance of heterogeneous wireless systems in terms of minimizing latency and handover failure probability and enhancing throughput. The effectiveness of the proposed algorithms is measured through simulations. The simulation results show that the delay has been reduced, while maximizing the throughput and minimizing the connection failure probability. Comparative performance analysis demonstrates a high quality of service and more precise use of the technology (i.e., use of the available resources). The proposed integrated hybrid scheme will definitely stimulate the handover process by minimizing unnecessary handover and service interruption time. The real-time simulation results attest to the efficiency of the proposed approach for a constant speed of 20 km/h by an improvement of 17%, 8%, and 28% in terms of average throughput with respect to cuckoo, genetic, RSS, and random methods. This also reduces handover delay by 50%, 25%, 62%, and 87% compared to the above methods for speeds of up to 40 km/h. With increasing speeds, the probability of handover failure decreases, and it decreases to 25%, 12.5%, 25%, and 20% for the above methods for a constant speed of 40 km/h. In addition, the number of handovers for the above methods is reduced by 20%, 50%, 25%, and 75%.

In the future, we would like to examine the performance of the proposed approach with variation in the number of users and power consumption analysis of user equipment devices.

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Abbreviations

The following abbreviations are used in this manuscript :

MT	Mobile Terminal
BS	Base Station
GA	Genetic Algorithm
CS	Cuckoo Search
AI	Artificial Intelligence
ABC	Always Best Connected
HFP	Handover Failure Probability
GSQ	Gotten Signal Quality
AN	Access Network
EDGE	Enhanced Data Rate for GSM Evolution
HSPA	High Speed Packet Access
UMTS	Universal Mobile Telecommunications Service
WiMax	Worldwide Inter-operability for Microwave Access
WiMax	Worldwide Inter-operability for Microwave Access
CAC	Call Admission Control
CDMA	Code Division Multiple Access
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
UMTS	Universal Mobile Telecommunications Systems
ine LTE	Long-Term Evolution
PoA	Point of Attachment
NoA	Nature of Administration
SINR	Signal to Interference plus Noise Ratio
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network

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