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A novel approach for optimization of handover mechanism using metaheuristics algorithms

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ABSTRACT

The new generation wireless system is an integrated global network, which provides many services for end users across the globe. The major requirement of end users is to allow the mobile user to roam seamlessly across the network. Heterogeneous Wireless Networks (HWNs) permit users with global devices to access the required service at any place and anywhere. The HWNs contain many Radio Access technology RATs such as GPRS (General Packet Radio Services), UMTS (Universal Mobile Telecommunication Service), Wi-Fi (Wireless Fidelity), Wi-Max (Worldwide Interoperability for Microwave Access), WLAN (Wireless Local Area Network) and transferring the ongoing call and providing seamless mobility can be achieved by Vertical Handover (VHO) mechanisms. The heterogeneous wireless networks (HWN) integrated with the network characteristics, like the bandwidth, speed support, cost, security, power consumption, delay, and range of communication are employed for obtaining better Quality of Services (QoS). For better mobility management, handover (HO) is the most significant aspect considered for solving the issues regarding mobility the designed Novel approach uses metaheuristics algorithms like grey wolf optimization (GWO) and Mayfly optimization (MFO) technique to provide a better service for end-user in terms of energy consumption, and handover delay, Call drop probability and throughput.

1. Introduction

Wireless technology is the process of communication between two or more points without cables and wires. The development of wireless technology in recent years with better quality of service (QoS) is the most challenging task for network operators. The services, like the video and audio streaming of mobiles, require seamless access all the time, and for this, the heterogeneous networks are essential with the higher bit rate capacity. Uninterrupted network coverage and QoS are required for the interoperability of the network, which is obtained through mobility management. The handover also termed the handoff (HO) is used for the management of mobility to control the mobile terminal movement during active communication. The HO process is categorized into two types, namely, vertical and horizontal HO. The horizontal handover (HHO) switches between the Access points (AP) within the same network or the base station (BS), which is widely used in homogeneous networks. The vertical handover (VHO) switches between the AP and the BS, which belong to the different networks, widely used in HWNs. The management of HO controls the AP change of the network to maintain active communication.

The handover process can be mobile or network-controlled [1,14]. During the handover process, the mobile device arrives at the new access point and the system implements the procedure to route the connection. The implemented steps are performed for various tasks such as associating, disassociating, and registering [2]. Handover redirects the mobile phone solution in the network to the new network [3,15]. Seamlessness and automation challenges can arise during the processing of network transactions from wireless to cellular (vertical handover). To overcome the challenges, you need to choose a handover management method. When moving from one location to another, keep the mobile device (MT) connection active always [4,5].

2. Literature review

The energy-aware vertical handover (VHO) for the heterogeneous wireless network (HWN) is used in several real-time applications for network selection. However, the most challenging task is the optimal network selection with the improved QoS within the available resources.

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Besides, mobility management, resource management, and handoff are the challenges associated with heterogeneous networks. Hence, an efficient vertical handover is necessary for HWNs. Many researchers have given novel solutions for handover mechanisms few of them have been discussed in this section below.

B.R. Chandavarkar, and Ram Mohana Reddy Guddeti [6] developed a MADM-based VHO in HWN. In this, Improved Multiple Attributes Alternate Ranking (MAAR) is designed to eliminate the unreliable and rank reversal issues in the network selection, in which weights of the attributes estimation and the normalization is devised for the better candidate selection of the network. As a result, the network was less complex and better compared to the conventional MADM techniques. E. Rajinikanth and S. Jayashri [7] developed the VHO in HWN for seamless connectivity management. Here, the most appropriate network for the HO was selected by considering the QoS. The decision-making for choosing the best network was employed using the fuzzy-based approach. Then, the BER, RSS, and the network's capacity were analyzed to devise the HO. Next, decision-making is employed using the artificial feed-forward neural network (FFANN). Finally, the end-to-end delay and the throughput were evaluated to show the performance enhancement. Xiaonan Tan et al. [8] developed a multi-attribute-based Neural network NN for the VHO intending to solve the complexity of the network. In this, several network environments like General Packet Radio Service (GPRS), Universal Mobile Telephone System (UMTS), Wireless Local Area Network (WLAN), fifth-generation (5G), and fourth-generation (4G) are created with a three-layered network model with the backpropagation. The parameters like the signal to interference and noise ratio (SINR), BER, speed of moving, packet loss, transmission rate, and delay were considered for the performance enhancement of the NN. The NN predicts the rate of download for the decision-making process. When the download rate is below the threshold, the HO was devised for the selection of the network. By considering the HO success rate and the download rate, the performance is evaluated for the developed method. S. H. Alsamhi and N. S. Rajput [9,15] developed the handover mechanism using the neural network based on the QoS. In this, the factors like traffic intensity, speed, RSS, and directivity are evaluated to decide to select the best network to initialize the handover. Here, the artificial neural network (ANN) is employed due to its high data handling capability. In addition, the HO is evaluated by considering the High altitude platforms (HAP). The HAP is the alternate to the BS in the obstacle criteria. Here, the steerable antennas were devised for the movement of the HAP. Also, the radial-based neural network is employed for deciding to select the network. Shidrokh Goudarzi et al. [10] developed the VHO based on the hybrid algorithm. In this, initially, the prediction is devised, and then the decision-making for the HO is employed. The RSS is predicted using the curve fitting based particle swarm optimization (CF–PSO) algorithm based on the distance between the MT and the AP, and then the selection of the network is employed using the Multi-objective Particle Swarm Optimization (MOPSO) algorithm, in which the HO decision was employed based on the low latency. The RSS indicator (RSSI) is calculated by the artificial neural network with Radial Basis Functions (RBF). Besides, the MOPSO algorithm chooses the best network through the RSSI predicted by the CF-PSO. Thus, it minimizes the ping-pong effect and the HO number. Finally, the parameter like the cost function is evaluated to depict the performance enhancement of the developed method.

Shidrokh Goudarzi et al. [11] developed VHO based on the optimization algorithm. In this, an artificial bee colony (ABC) algorithm was employed to the selection of the optimal network. The (SEarch by Fixed Intervals) SEFI was incorporated with ABC to obtain better performance enhancement while selecting the network for the HO. The parameters like security, BER, delay, cost, and bandwidth are used for the attainment of the optimal network selection. The performance of the developed technique is obtained by considering the efficiency. The near-optimal solution attainment provided the better HO with the optimal time.

Anna Maria Vegni, and Enrico Natalizio [12] developed VHO for both the soft and the hard HO in the HWN. In this, Mobile Controlled Handover (MCHO), and Network Controlled Handover (NCHO) were devised for the decision-making for the triggering of the HO. The effectiveness of the system is evaluated in terms of the waiting time.

3. Handoff optimization using metaheuristics algorithms such as grey wolf and mayfly

3.1. System model

The system model of the VHO in the HWN is explained using the assumptions and the preliminaries.

3.1.1. Assumptions

The Wireless Local Area Network (WLAN) is considered with cellular coverage area comprised of small cells. The cellular coverage area consists of the access point (AP) and is represented as B, and the expression for the AP is given as, $B = \{b_1, b_{2,}..., b_M\}$. The cellular coverage area has the base station (BS) and is represented as D, and is given as, $D = \{d_1, d_2, ..., d_N\}$. Other than the highly-dense urban deployment N is considered as$N = 1$. The AP within the cellular coverage area N is considered as$N > 1$. The D and B coverage area details of the attached candidate points are maintained using the VHO Decision Controllers (VHDC). The VHDC is employed to add the load status of the AP in B and BS in D. The available MN in the cellular coverage is represented as, $\overline{V} = \{v_1 v_2, ..., v_L\}$. The MN is serviced by AP or request for the HO to the AP or BS corresponds to D, in which the mobility is not necessary at the time. Thus, the MNs are subdivided into subsets and is expressed as,

$$V_s = \left\{ v_{m1}, v_{m2}, ..., v_{m_{n(s)}} \right\} \tag{3.1.1}$$

During the time interval s, the MNs requesting the handoff are represented as $n(s)$, and their indexes are denoted as $m_1, m_2, ..., m_{n(s)}$. The term $U_s = \overline{V} - V_s$.

3.1.2. Preliminaries

The preliminaries considered for the HWN for the VHO are detailed in this section. According to the environment of the network, the preliminaries can be changed and is flexible to change. The assumptions considered for the VHO are explained below.

3.1.2.1. Heterogeneous model. The devices that access the network have different configurations and settings. The different configurations are capable of computation, battery, management of network interface, mobility pattern, etc.

3.1.2.2. Model of communication radius. The communication model has the radius r with the center a between the coverage area and the communication device J is expressed as,

$$A(a, r) = \{P_1, P_2 \in M : |E(P_1 - P_2) \leq Q_{P1}\} \tag{3.1.2}$$

where the coverage distance is represented as A $E(P_1 - P_2)$ represents the distance between the BS and the AP of the HWN, and the deployed BS is referred to as M.

3.1.2.3. Scalable network. The HO is employed between the MNs, and the network is assumed as the closed region in the scalable networks. The HO is performed frequently between the nodes. Let us consider the closed region with 100 nodes and the area associated with the region $500m \times 500m$. The modified definition is expressed as $|E(h - AP/BS) < Q_h$, The MN is represented as h, and $h - AP/BS$ is the distance between the MN and BS.

Table 1
Simulation Parameters setup.

Parameters	Value
Channel type Channel/wireless channel	Channel type Channel/wireless channel
Radio-propagation model Propagation/ two-ray ground	Radio-propagation model Propagation/ two-ray ground
Network interface type Phy/Wireless Phy	Network interface type Phy/Wireless Phy
MAC type Mac/802_11	MAC type Mac/802_11
Number of base station 13	Number of base station 13
Number of access point 13	Number of access point 13
Traffic type CBR-UDP traffic	Traffic type CBR-UDP traffic
Mobility pattern Constant velocity vehicle movement pattern	Mobility pattern Constant velocity vehicle movement pattern
Interface queue type Queue/Drop Tail/ Pri Queue	Interface queue type Queue/Drop Tail/ Pri Queue
Link layer type LL	Link layer type LL

3.2. Handover optimization using metaheuristics algorithm

In this section, the proposed vertical Handover algorithm for managing the hand-off mechanism of the heterogeneous networks is presented. The optimization of handover is developed by integrating the characteristics of Grey wolf and the Mayfly algorithms, in which the network initialization is assisted using the hunting characteristics of GWO, while the hand-over decision is declared using the flight behavior of MFO.

Inspiration: The proposed Metaheuristics algorithm is characterized under the metaheuristics algorithm, as it mimics the cooperative hunting characteristics of the Grey wolf and the flight characteristics of the Mayfly. The Grey wolf is a social animal, which inherits the hunting strategies, such as searching for a food source, encircling food sources, and attacking prey. Further, the grey wolf inherits follows the social hierarchal method to attain food with a high convergence rate. On the other hand, the social behavior of the mayflies is integrated with the hunting behavior of the Grey wolf to obtain an optimal solution, with a high convergence rate.

The vertical Handover (VHO) process employed in the wireless network based on the QoS is devised in different stages, namely, initialization of the HO, pre-processing of the HO, and execution of the HO. By using the above-mentioned steps, the overall performance can be improved. The steps are detailed below Initialization Phase, Selection Phase, and Execution Phase.

3.2.1. Initialization Phase

The initialization of the HO is employed through the GWO algorithm, where the parameters, like the security level, battery level, QoS, and received signal strength (RSS) are evaluated for triggering the HO. The optimal selection of the network for the HO is the most challenging task in conventional techniques. The power loss and the signal of the network of the mobile device are dropped due to poor optimization. Thus, the better selection of the network from the available networks through considering the Quality of Service (QoS) is essential, which is rendered using the proposed algorithm. The weights of the QoS are adjusted to select the efficient available network to establish the HO and by assigning weights to the QoS parameters conditions of the network are estimated. The weights to the QoS parameters are assigned by considering the service parameters, and the value may be either $0 \ \ or \ \ 1$, which is evaluated using the cost function.

3.2.2. Selection Phase

The terminal side selection of the network is undergone by considering multiple criteria, like the battery, velocity, and so on. Likewise, on the service side, the parameters, like security, QoS, and so on are evaluated. Then, the network is chosen by evaluating the factors, like QoS parameters and the profile of the provider. The factors, like the user preferences and QoS, are considered in the selection of networks on the user side. Finally, the most effective selection of the network is employed using the Metaheuristics algorithm. Thus, the optimal network is selected to execute the HO process.

3.2.3. Execution Phase

The mobile IP protocol (MIP) is employed for the network execution in the HO and the decision-making parameters are evaluated for the VHO in HWN. Thus, the appropriate network is selected optimally through the best solution evaluated by the optimization technique. By using this, the best VHO is obtained by the selection of the network through the better solution by considering the lowest cost function of the network for making the decision. The GWO is employed for assigning weights $(w_1, w_2, \ldots\ldots w_i)$ and the network selection of the HWN for the VHO based on the GWO is employed using the sensitivities and importance of the access point.

The decision-making for devising the VHO based on the developed HGWO algorithm is employed in this phase for choosing the network, which uses the progressing features of the standard MFO and the GWO. Furthermore, meta-heuristic optimization based on exploration and exploitation is employed for solving the issue regarding high-dimensional optimization. Several researchers developed optimization techniques for solving high-dimensional optimization issues based on the meta-heuristic approach. Thus, this research inherits the benefits of GWO and MFO to develop the meta-heuristic approach, which is used for choosing the network from the available sources of the current time.

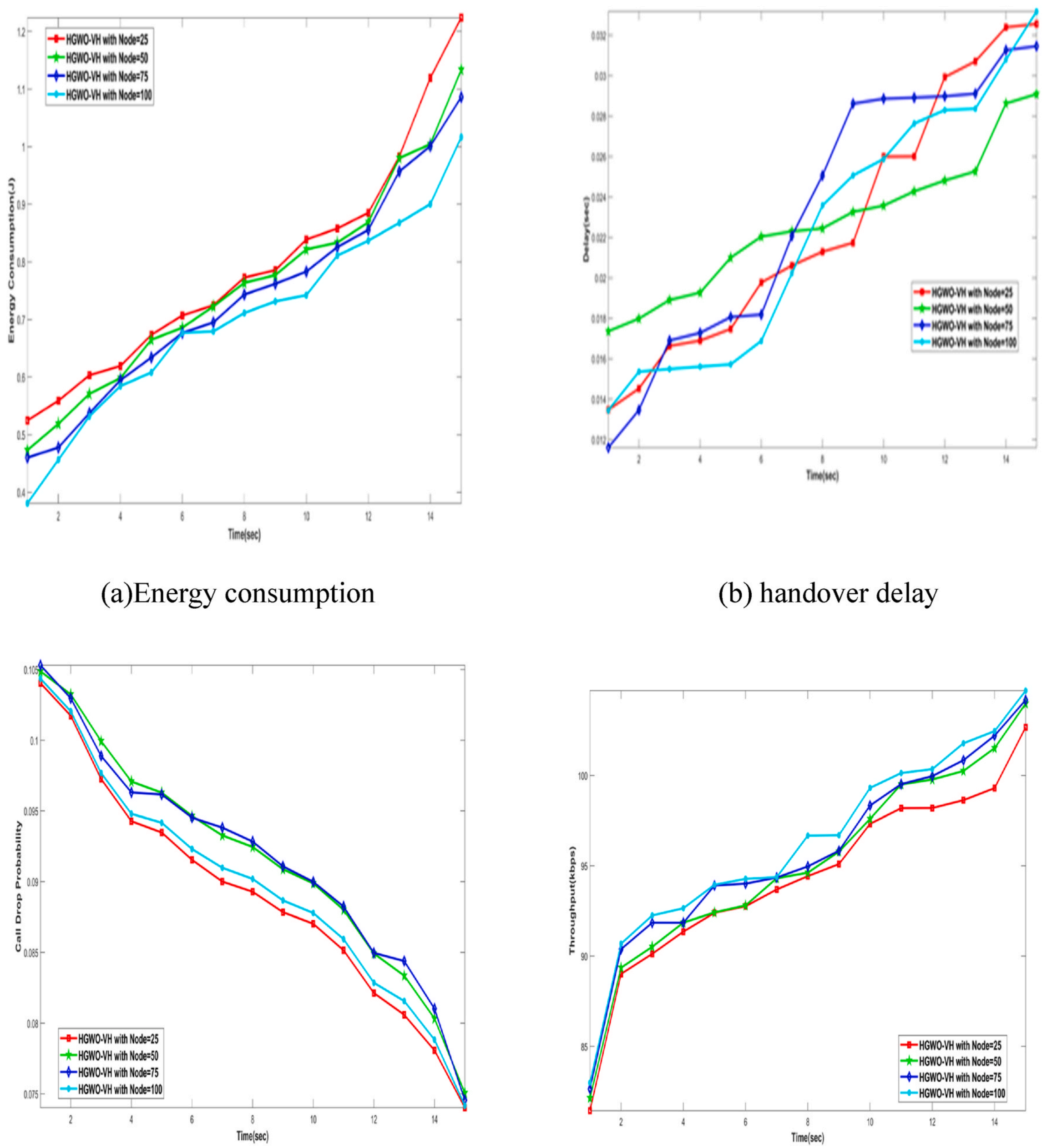
3.3. Algorithmic flow for the proposed metaheuristics hand-over optimization in heterogeneous networks

The overall execution of the proposed method for the HO is depicted in the step-by-step procedure is detailed below:

Step 1: The random population is generated initially, and the initialization optimization parameters are set to be $\overrightarrow{a}, \ \overrightarrow{A}, \ and \ \overrightarrow{C}$.
Step 2: The fitness of the grey wolf population is evaluated individually. The fitness of the wolves is estimated by taking the average throughput, delay, energy consumption, and call drop. The wolves with the highest fitness are saved, which are represented as, $\overrightarrow{X_\alpha}, \ \overrightarrow{X_\beta}, \ and \ \overrightarrow{X_\delta}$.
Step 3: Then, the position update of the wolf is performed utilizing the update equation of the mayfly optimization approach, which facilitates the generation of the next population, which is followed by the parameter updates. The parameters to be updated include the $\overrightarrow{a}, \ \overrightarrow{A}, \ and \ \overrightarrow{C}$, which are the optimization parameters initialized while the optimization process is initiated.
Step 4: After updating the position using the new update equation, the fitness of the population is re-estimated, and the best position of the wolves $\overrightarrow{X_\alpha}, \ \overrightarrow{X_\beta}, \ and \ \overrightarrow{X_\delta}$ is updated.
Step 5: The above-mentioned steps (2–4) are executed until the declaration of the optimal solution or until the maximal number of the iterations is met. The newly developed meta-heuristic algorithm for the network selection and hand-off decision-making ensures the effective performance of the network when compared with the other conventional techniques.

3.4. Mathematical formulation of the proposed metaheuristics handover mechanism

A detailed explanation of the proposed HGWO algorithm is presented in this sub-section, where the optimization follows the characteristics of the grey wolves and mayflies. The hybridization boosts the convergence of the solution to the global space rather than converging to the premature solution. Hence, the Proposed algorithm gains significance in network initialization and selection, where the initialization is managed



(a)Energy consumption (b) handover delay

(c) Call drop Probability (d) Throughput

Fig. 1. Analysis of the performance of the proposed method with varying node.

by GWO, while the MFO manages the network selection. Importantly, the exploration ability of the GWO and exploitation capability of the MFO add value to the proposed algorithm. In GWO, the parameters, like the Alpha (α), Beta (β), and Gamma (γ) are employed, which are the best solutions for the wolves. The best solution of the wolf is represented as the Alpha (α) wolf, which is considered the best position. Followed by Beta (β) is the second-best solution, and Delta (δ) is the third-best solution. The remaining wolves are represented as omega (ω) wolves in the GWO. Based on the position of the Alpha (α), Beta (β), and Delta (δ) wolf the position of the omega (ω) wolves are updated while searching the prey. Thus, the optimal search space is updated accordingly.

Solution Initialization: The random position of the grey wolf is considered in the search space, where the dimensional vector for the candidate solution is represented as d, and the candidate solutions are initialized as,

$$X = (X_1, X_2, ...X_d) \tag{3.4.1}$$

where X indicate the solutions in the search space and refer to the grey wolf positions'. Once the positions are updated, the objective functions are evaluated to find the best solutions. Let us assume that the candidate solutions of the mayfly and wolves be the same.

Calculation of fitness measure: The fitness is evaluated using the objective function, which is evaluated based on the velocities of the search agents, in other words, the distance of the grey wolf from the prey is the fitness measure. The wolves update their positions by utilizing the prey's location and the distance between them should be minimal to become the best solution for the iteration. The fitness of the candidate solutions is denoted as,

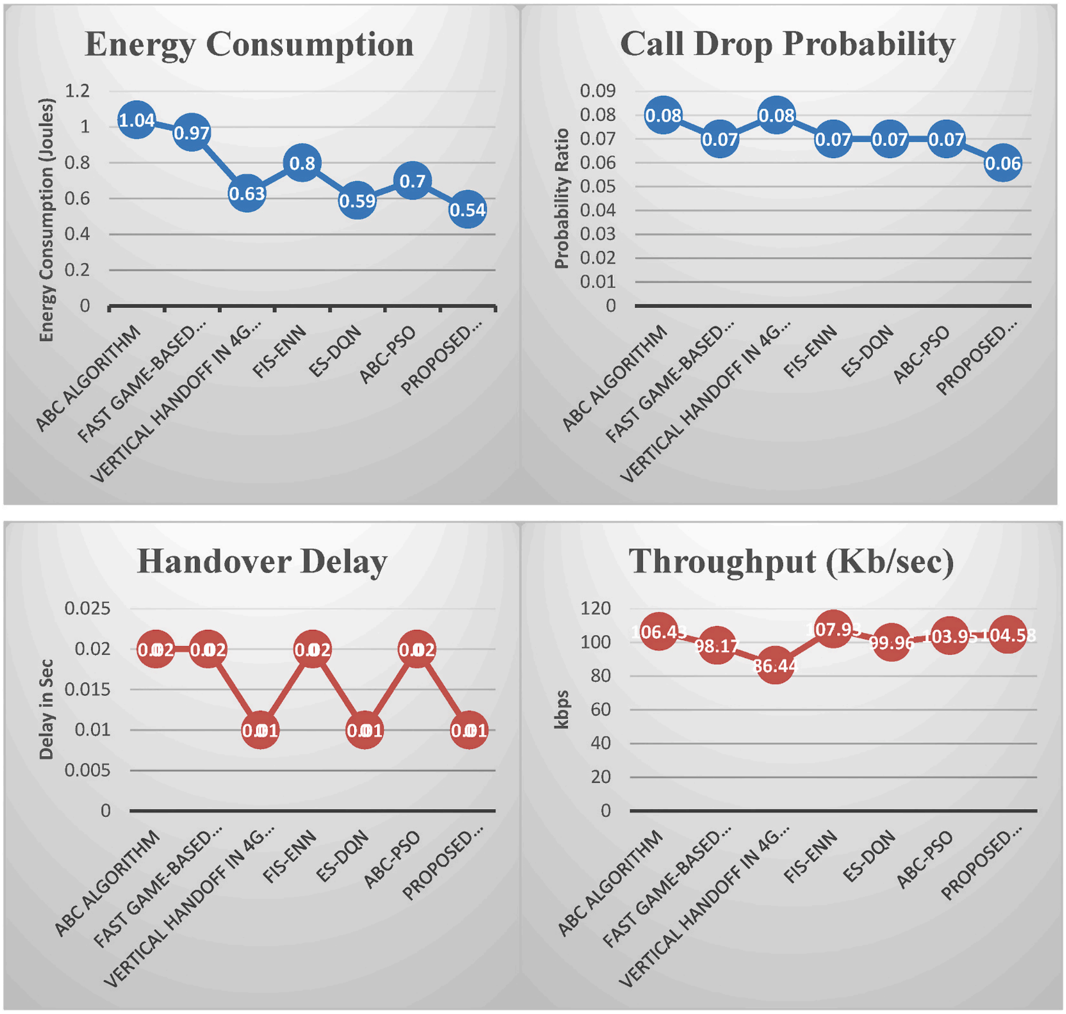


Fig. 2. Comparative analysis of proposed method.

$$V = \left(V_1, V_2, \ldots .V^d\right) \tag{3.4.2}$$

In this research, the update rule is based on the mayfly and hence, the multi-objective function is based on the velocity as mentioned in equation (3.4).

Declaring the best solutions based on the fitness measure: Based on the fitness of the candidate solutions, the best three solutions are declared in the GWO. Based on the distance vectors, the first three best solutions are represented as,

$$\overrightarrow{X_1} = \overrightarrow{X_\alpha} - \overrightarrow{A_1} \ * \ \overrightarrow{D_\alpha} \tag{3.4.3}$$

$$\overrightarrow{X_2} = \overrightarrow{X_\beta} - \overrightarrow{A_2} \ * \ \overrightarrow{D1_\beta} \tag{3.4.4}$$

$$\overrightarrow{X_3} = \overrightarrow{X_\delta} - \overrightarrow{A_3} \ * \ \overrightarrow{D1_\delta} \tag{3.4.5}$$

As mentioned before, the best solutions are acquired utilizing the distance measures, which evaluate the alpha wolf and the location of the prey's distance that is expressed as,

$$\overrightarrow{D1_\alpha} = \overrightarrow{\left|\overrightarrow{C_1} \ * \overrightarrow{X_\alpha} - \overrightarrow{X}\right|} \tag{3.4.6}$$

$$\overrightarrow{D1_\beta} = \overrightarrow{\left|\overrightarrow{C_2} \ * \overrightarrow{X_\beta} - \overrightarrow{X}\right|} \tag{3.4.7}$$

$$\overrightarrow{D1_\delta} = \overrightarrow{\left|\overrightarrow{C_3} \ * \overrightarrow{X_\delta} - \overrightarrow{X}\right|} \tag{3.4.8}$$

Normally, the update equation of the GWO while catching the prey in the exploitation phase is given below:

$$\vec{D}1 = \left|\vec{C} * \overrightarrow{X_P}(t) - (t)\right| \tag{3.4.9}$$

$$\vec{X}(t+1) = \overrightarrow{X_P}(t) - \vec{A} * \vec{D}1 \tag{3.4.10}$$

where, the prey and the grey wolf individual distance is represented as $\vec{D}1$, the grey wolf's position vector is represented as $\vec{X}$, the prey's position vector is represented as $\overrightarrow{Xp}$, the current iteration is represented as t, and $\vec{A}$ *and* $\vec{C}$ are the coefficient vectors. The coefficient vectors $\vec{A}$ *and* $\vec{C}$ can be estimated as,

$$\vec{A} = 2\vec{a} \ * \ \vec{r_1} - \vec{a} \tag{3.4.11}$$

$$\vec{C} = 2 \ * \ \vec{r_2} \tag{3.4.12}$$

where $\vec{A}$ refers to the coefficient of convergence employed for the exploitation and exploration balance maintenance and $\vec{C}$ is employed for the simulation of nature's effects. The random vectors are represented as, r_1 *and* r_2 and ranges lie between$[0, 1]$. The course of interaction is represented as $\vec{a}$, which decreases from $[2 \ to \ 0]$. The coefficient vector $\vec{A}$ decreases as $\vec{a}$ fluctuations are in the range. Thus, equations (3.4.1) and (3.4.2) are the search space formulas of the GWO algorithm. Finally, the standard GWO's update equation is given by,

$$\overrightarrow{X}(t+1)=\frac{\overrightarrow{X_1}+\overrightarrow{X_2}+\overrightarrow{X_3}}{3} \tag{3.4.13}$$

where the updated position vector of the grey wolf is represented as $\overrightarrow{X}(t+1)$ the distance between the Beta (β) wolf is represented as $\overrightarrow{D1_\beta}$, the distance between the Delta (δ) wolf is represented as $\overrightarrow{D1_\delta}$, the distance between the Alpha (α) wolf is represented as $\overrightarrow{D1_\alpha}$, the positional components of the remaining grey wolves based on the positions of Beta (β) is represented as $\overrightarrow{X_2}$, the positional components of the remaining grey wolves based on the positions of Alpha (α) is represented as $\overrightarrow{X_1}$, the positional components of the remaining grey wolves based on the positions of Delta (δ) is represented as $\overrightarrow{X_3}$. The update rule mentioned in equation (3.13) is the update rule in the standard GWO. The application of the update rule from the GWO ensures the effective balance in the exploration-exploitation trade-off thereby, maintaining the intensification and diversification phases, which avoids the local minima. Yet, the low solving accuracy and slow convergence rate limit the ability of the Grey wolf. Hence, in the research, the updated position of the grey wolf is integrated with the mayflies to overcome the major limits.

The mayfly optimization algorithm comprises female and male mayflies which are initialized randomly. The random position is considered in the search space for the mayflies and the characteristics of the mayfly employed for the algorithm are its individual and social flying characteristics for the dynamic interaction. Based on these characteristics, the position is updated. The characteristics of the mayfly in the position update are detailed below:

Female flies and position update: The female mayflies converge in the swarm with the help of the male mayflies in the optimization algorithm and the female fly move towards the male for initiating the reproduction process. The features used for the reproduction are represented as,

$$Y_I^{T+1}=Y_I^T+V_I^{T+1} \tag{3.4.14}$$

where the new position of the mayfly by utilizing the velocity is represented as V_I^{T+1} the current female mayfly's position T is represented asY_I^T. The limitation characteristic of the mayfly is represented as,

$$Y_I^0\sim U(Y_{MIN},Y_{MAX}) \tag{3.4.15}$$

Random progress is employed to make the attraction of the procedure, and hence it is considered the deterministic process. The fitness is evaluated for the appropriate attraction of the suitable male by the female mayfly. Similarly, the second female mayfly also gets attracted by the male mayfly, and the procedure continues. The velocity of the mayfly is considered as the depreciation of problems, and it can be expressed as,

$$V_{IJ}^{T+1}=\begin{cases} V_{IJ}^T+A_2e^{-\beta r^2}mf\left(X_{IJ}^T-Y_{IJ}^T\quad\right) & if \quad f(Y_I)>f(X_I) \\ V_{IJ}^T+FL^*R \quad if \quad f(Y_I)\le f(X_I) \end{cases} \tag{3.4.16}$$

Where, the random number is represented as R, and it ranges between $[-1,1]$, *FL* refers to the coefficient of random walk, in which the female mayflies are not attracted by the male flies. The Cartesian distance is used for measuring the distance between the male and the female flies and is represented *mf* because the mayfly flies in an irregular manner, which is represented in equation (3.4.16). The coefficient of the visibility is fixed and is represented as β, Y_{IJ}^T referring to the female mayfly, and its velocity is represented asV_{IJ}^T, A_2 refers to the positive constant of the positive attraction,T refers to the time instant, and I is the dimension.

Male flies and position update: The position update of the male mayfly is employed by considering the experience of their own experience and their neighbor's experience. The position update is expressed as,

$$X_4=X_I^{T+1}=X_I^T+V_I^{T+1} \tag{3.4.17}$$

where V_I^{T+1} refers to the velocity of the male fly and X_I^T refers to the current position of the male mayfly. The limitations regarding the characteristics employed for the reproduction are expressed as,

$$X_I^0\sim U(X_{MIN},X_{MAX}) \tag{3.4.18}$$

The velocity of the male mayfly is expressed as,

$$V_{IJ}^{T+1}=V_{IJ}^T+A_1e^{-\beta r^2}\left(pbest_{IJ}-X_{IJ}^T\right)+A_2e^{-\varphi r^2}\left(pbest_1-X_{IJ}^T\right) \tag{3.4.19}$$

The best position of the mayfly is represented as $pbest_1$, and the next best position is represented as $pbest_{IJ}$, A_1, A_2 denotes the constants of positive attraction used to balance the cognitive and social contribution. The expression for the next optimal solution is given as,

$$pbest_1=\begin{cases} X_I^{T+1} \quad if\ f\left(X_I^{T+1}\right)<f(best_i) \\ is\ kept\ the\ same \quad otherwise \end{cases} \tag{3.4.20}$$

The optimal global solution can be expressed as,

$$gbest\in\{pbest_1,pbest_2,......pbest_N|f(cbest))\}=\min\{f(pbest_1), \\ f(pbest_2),.....,f(pbest_N)\} \tag{3.4.21}$$

where the population of the mayfly is represented as N, for the estimation of the better solution, the distance evaluation is most significant. The Cartesian distance is employed for the distance evaluation because of the irregular velocity of the mayfly and is expressed as,

$$\left\|X_I-X_J=\sqrt{\sum_{J=1}^{N}\left(X_{IJ}-X_{IJ}^*\right)^2}\right\| \tag{3.4.22}$$

where X_{IJ} refers to the existing mayfly and X_{IJ}^* is the relation between the local and the global best solution. The varying optimal velocity of the mayfly is expressed as,

$$V_{IJ}^{T+1}=V_{IJ}^T+Du^*R \tag{3.4.23}$$

where R is the random value and *Du* refers to the coefficient of nuptial dance.

Movement of the mating process: The most significant part of the mayfly optimization technique is its mating process. The crossover operator is important for the mating process. The male occupant selects one parent, and another one is selected handpicked by considering the female occupant's connected one. Thus, both the male and the female parents are selected for the mating process. The selection process is devised by considering the random function or by the fitness function represented in [73]. Then, the female mayfly reproduces with the help of the male mayfly. Similarly, second, third, and so on female flies also reproduce. The crossover function used in the mating process is represented as,

$$offspring\quad 1=M^*Male+(1-M)^*female \tag{3.4.24}$$

$$offspring\quad 2=M^*female+(1-M)^*male \tag{3.4.25}$$

During the mating process, the initial velocity of the mayfly is fixed as zero. The random value is represented as M. The female parent is represented as *female*, and the male parent is represented as *male*.

Position Update in the proposed HGWO algorithm: In the proposed HGWO algorithm, the position of the search agents is updated by using the following equation,

$$X_{HGWO}^{t+1}=\frac{X_1+X_2+X_3+X_4}{4} \tag{3.4.26}$$

The above equation is the integration of equations (3.4.15) and (3.4.19).

Re-evaluation of the fitness measure to declare the personal best and global best solutions: The solutions in the search space are updated using the MFO update rule and the personal best and global best solutions are declared. The steps are repeated for the maximal iterations and the global best solutions are declared.

The parameters, like the Bit Error Rate (BER), Delay, Data-Rate (DR), and RSS are considered to obtain the best solution. The VHO in the HWN is employed based on the above-mentioned parameters.

4. Results and discussion

The performance of the Proposed Vertical handover Mechanism technique for the selection of network is analyzed through the variation of several nodes and compared with the existing methodologies such as Fast game-based handover, Artificial bee colony (ABC) algorithm, vertical handoff in 4 g network, Deep Q-network (ES-DQN), Fuzzy interference system Elman Neural Network (FIS-ENN), and Artificial Bee Colony - Particle Swarm Optimization ABC-PSO the analysis employed in terms of the energy consumption, delay, call drop probability, and throughput. The simulation parameters used for the evaluation of the newly devised vertical handover technique are illustrated in Table 1 given below.

4.1. Analysis by varying nodes

The analysis of the newly devised vertical handover optimization Meaustric algorithm method by varying the nodes in terms of energy consumption is illustrated in Fig. 1. The figure states that the energy consumption is minimized, handover delay is reduced, call drop probability is also minimized and throughput increased concerning the increase in the nodes due to the effective routing provided by the proposed optimization algorithm.

4.2. Comparative analysis

The comparative analysis of the newly devised Vertical Handover mechanism using the Meaustric Algorithm has shown better performance with the other techniques like the Fast game-based handover, ABC algorithm, vertical handoff in 4 g network, ES-DQN, FIS-ENN, and ABC-PSO, in terms of the average performance with metrics like Energy consumption, Delay, Call drop probability and throughput as shown in graphs below Fig. 2. The Proposed method has an average better performance with 0.54 J of energy consumption, which is better than the existing, the call drop probability ratio is less than 0.06, the handover delay is 0.01 s, and through has increased to 104.58 kbs.

5. Conclusion

The proposed Novel Approach for Optimization of Handover Mechanism Using Metaheuristics Algorithms is mainly focusing on designing and developing a vertical handover mechanism to provide a seamless service to mobile nodes during the mobility in heterogeneous wireless networks. The Novel Vertical handover Optimization using Meaustric Algorithm uses Grey Wolf optimization and the Mayfly optimization, which are integrated to design the optimization technique for the effective network service. The different QoS parameters are considered for the vertical handover. The proposed method was simulated on NS2 to analyze performance metrics in terms of the energy consumption, delay, call drop, and throughput with the values of 0.05359 J, 0.0142 s, 0.0628 s, and 104.58 kbps, respectively to be a better optimization for vertical handover mechanism for the heterogeneous wireless network.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Further reading

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