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Improved Wolf Prey Inspired Protocol for Routing in Cognitive Radio Ad Hoc Networks

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Abstract – Fifth Generation (5G) technology has started providing the brand new facilities to the mobile communication world. With its enhanced performance and scalability, it has attracted many domains. Routing overhead in 5G networks is increased rapidly because of the complexity present in the route discovery process, where optimization in routing. Poor routing becomes a sophisticated and dynamic challenge in the 5G network. Hence, there exists a need for finding the best route in an optimized manner. This paper proposes an Improved Wolf Prey Inspired Protocol (IWPIP) for finding the ideal route in the dynamic environment like 5G based cognitive radio ad-hoc network. IWPIP focuses on finding the ideal route based on the reliability of route, shorter distance, and shorter hops that minimize the consumption of energy to increase the network lifetime. Before sending the data packets, routes are evaluated using a fitness function. IWPIP's efficiency has been demonstrated through comprehensive simulation, which resulted in promising outcomes in terms of throughput, packet delivery and drop ratio, delay, and energy consumption.

Index Terms – Optimization, Routing, Bio-Inspired, Energy, Delay, Cognitive Radio Ad Hoc Networks, Wolf Prey Inspired Protocol.

1. INTRODUCTION

5G cellular networks (5GCN) are emerging as significant drivers in the ICT world. 5G network users expect more enhanced data transfer rates, quality of experience, and service to meet the diversification. To provide efficient and quality enabled services in 5GCN, wireless networks need to adopt new technologies by importing a wide variety of functional networks. It includes Software Defined Network, Internet of Things, Cognitive Radio (CR), and End-to-End device technologies. The challenges in 5G get increased in parallel when technologies grow. In 5G networks, CR is identified as one of the promising technologies [1, 2] which has gained the attention of industries and academia because it can solve the network issues fully or partially. The main intention of (CR) Technology is to increase the effective utilization of spectrum that has licensed frequency. CR technology minimizes the congestion level in 2.4 gigahertz ISM band [3, 4]. Contemporary research in this domain focuses on sensing and sharing the available spectrum to the user in a network that depends on gathering spectrum information and assigning schedules for transmission between users, where the architecture followed is single-hop. CR technology-based applications have different scenarios, but in distributed network-based scenarios it is still in the rudimentary stage. Multiple challenges in CR are outlined in [5]. Traditional routing protocols available for general wireless ad hoc networks aim to optimize the latency, hop count, and energy consumption. An enormous amount of literature on traditional routing protocols uses broadcasting concepts and act greedily to make packets reach their destination [6]. Also, hop counts are used for selecting the best path. These approaches never suit for CRAHN because CRAHN doesn't have the option of selecting simultaneous spectrum bands or channels because different routes would have been utilized by different licensed users [7].

Routing indicates the process of finding a path to the destination in a network (i.e., from source to destination). Some of the issues found in the routing process involved in CRAHN are increased computation time for finding the route, discovering the lengthier route, increased complexity in finding appropriate node for transmission and controlled optimization [8]. To minimize emerging issues like this, routing protocols need to have a better ability to make decisions while interacting with different users and different environments. Auspiciously, the artificial intelligence (AI) era is stepping inside the routing process of modern networks. In the modern era of AI, routing protocols must have awareness about creating interactions with varying environments. AI adopts optimization methodologies to select the dynamic-channel and finding the best route. Optimization in routing enables smart allocation dynamic resources to CR Primary Users and CR Secondary Users, where it takes optimum actions based on operating environments for enhancing the resource utilization of spectrum.

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The processes involved in routing are [9]: (i) sharing of routing information to neighbor nodes, (ii) managing the route failure, (iii) reforming the feasible path. For performing the sufficient operations in the network, ad-hoc routing protocols should meet the below-mentioned requirements (i.e., which are considered as challenges in routing):

- **Minimal Time for Discovering the Route:** Time spent on determining the route for a specific destination should be minimum [10].
- **Minimum Control Overhead:** Packets used for discovering and maintaining the route should be minimized to save the bandwidth and avoid collisions.
- **Loop Free Route:** Selection of route having loop will end with unnecessary usage of bandwidth, undelivered data packets, and continuous movement of the data packet in the network.
- **Reconfiguration of the Route:** Protocol should have the capability of reconfiguring the routes that have a high frequency of changes and disconnect.

1.1. Problem Description

Mobility in the network provides flexibility to nodes but disadvantages like node disconnection, an enormous level of energy consumption, and increased delay also happen [6, 7]. Node disconnection leads to route failure and it happens when the node moves out of range [8]. The selection of a low-quality route leads to route failure. Conventional protocols used for routing in other ad-hoc networks are not suitable for CRAHN that uses 5G because of the scalability feature. Hence, there arises a necessity of addressing and overcoming the mobility issue when a node searches for the best alternative route in a short duration during the route failure.

1.2. Objectives

The important objectives of this research work are: (i) To propose a novel multicast reactive routing protocol inspired from swarming nature of wolves towards hunting for prey, (ii) To improve QoS demand by enhancing better route selection, (iii) To decrease fault route selection and delay, (iv) To avoid conflicts in the route selection process among nodes, (v) To conduct NS2 simulation with varying node speed.

1.3. Motivation and Contributions

This paper focuses on enhancing the routing in CRAHN by finding a better route to the destination. In general, CRAHN provides priority in allocating the maximum bandwidth to primary users than secondary users. When primary users enter the network services provided to the secondary users are minimized which affects the quality of service. The natural characteristics of CRAHN maximize the disputes in routing. In CRAHN, selecting a reliable route is difficult because of multiple factors like [11]:

- Node mobility degrades the Quality of Service.
- Switching to the next available route during congestion.
- The selection of loop or fault routes leads to congestion.
- The selection of routes having more distance leads to increased energy consumption and delay [16].

1.4. Organization of the Paper

The current section of the paper has briefed about 5G and Routing along with problem statement, objective, motivation, and contribution. Section 2 provides a review of the literature. Section 3 proposes the proposed protocol namely Improved Wolf Prey Inspired Protocol (IWPIP) for CRAHN. Section 4 discusses the simulation settings used, performance metrics, and the results obtained. Finally, Section 5 concludes the paper with future dimensions.

2. LITERATURE REVIEW

Wolf Prey Inspired Protocol (WPIP) [11] proposed to minimize the end-to-end delay which is considered as the root cause for the major problems in CRAHN. WPIP is inspired by natural characteristics of wolves while hunting for prey. The methodology used in the hunting process is used to find a better path to the destination in CRAHN. WPIP involves population initialization, selecting the target, encircling of prey, hunting for prey, and attacking for prey. The main drawback found in WPIP is the non-usage of the fitness function while sending the data to the destination its necessary to check the fitness of the route, else the packet may get dropped which will result in unnecessary retransmission and wastage of scarce resource energy. Flowchart of WPIP is provided in Figure 1. TIGHT Protocol [12] proposed for sending the data geographically. TIGHT protocol attempts to send the data in a greedy mode without thinking about the secondary users and utilizes the primary channel alone to send the data. The TIGHT protocol gives its best performance only for the primary users in terms of reduced delay and increased throughput.

Energy-Efficient Routing [13] proposed to lower the consumption of energy in 5G ad-hoc networks. It minimizes the consumption of energy by finding the available local route. Routes are saved in the backup node and other nodes will use it during the failure. For providing the service, backup nodes utilize the overlay network concept. Optimization Framework [14] proposed to find the alternate route during network congestion. It redirects the congestion to the mesh gateway to meet various demands of the user and analyzes the congestion at different periods. Backhaul routes are calculated to enhance the saving of energy. Multi-Layer Routing Strategy [15] exploited to enhance spectrum

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efficiency. It utilizes the orthogonal based frequency division for improving the efficiency of bandwidth and it transfers the network load from one network to another network. It aims to provide enhanced coverage of networks with lower latency. Segment Routing [16] exploited to solve the resource scarcity issue in 5G networks. Conventional forwarding algorithms degrade the performance of 5G due to overhead in the routing table. It learns the flow of routing to deploy the routing sharing principle in the 5G network. Smart encoding was proposed to save the overall network cost. Zone Technology Protocol [10] proposed to utilize the node power to accelerate the route searching process deeply. Initially, members of the node and leaders are selected based on the location and available energy.

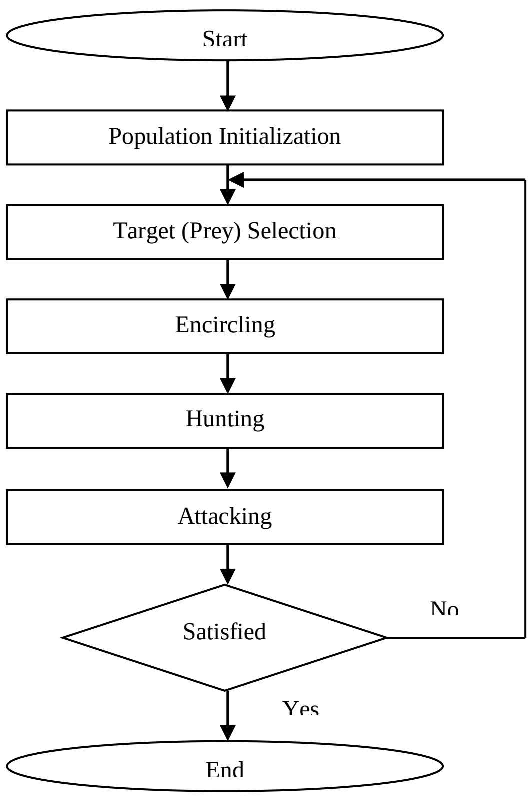

Figure 1. Flowchart of WPIP [1]

Latency aware routing [17] proposed to assure 5G networks in terms of increasing the reliability and decreasing the delay. It aimed to satisfy the enormous number of requests by using the available infrastructure and characterizing the connections between sources and destinations. Improved AODV routing [18] proposed for Zigbee based 5G networks. It considers the ubiquitous nature to adopt mobile-device-to-mobile-device communication. It utilized 5G terminals as gateways in a routing algorithm. It makes use of neighbors routing tables for finding the optimum route in an ad-hoc network. Virtual Ad-hoc Routing [19] proposed to offload the traffic to other networks to enhance network performance. It attempts to lower the traffic overhead using network management software. Optical Layer Routing Influence [20] proposed to avoid node failures. It focused on dynamic routing cum static load balancing for the survival of 5G networks. It gives preference to solve the connectivity issue to enhance network performance. The optical X-haul programming concept increases the robustness in routing and reduces latency in the overall network. Energy-Efficient Topology Controlling Algorithm [21] proposed to optimize the lifetime of IoT based 5G ad hoc networks. It focused on balancing the residual energy of nodes to maximize the lifetime of the network. Initially, network topology was evaluated using statistics and spanning trees built to enhance the robustness of the 5G network. Bandwidth based Multipath Routing [22] proposed to utilize the available bandwidth for identifying the different paths during link failure. Initially, it discovers the route by acquiring the available bandwidth of neighbor nodes by making interaction and discovers the multiple alternative routes. Cluster-based Routing Scheme [23] proposed to solve the data dissemination issue in 5G networks and utilize the minimum level bandwidth for high dense networks. Clustering was performed at two levels. In the first level, fuzzy logic is applied to analyze the contention problem. In the second level, cluster heads are utilized to minimize the overhead in gateway selection. Taylor Based Grey Wolf Optimization Algorithm [24] proposed to minimize the energy consumption when the network is scaled. It used the Taylor series to improve route optimization.

Related Works	Advantages	Disadvantages
Wolf Prey Inspired Protocol (WPIP) [11]	Optimization of Routing in finding the best alternative route	An increased failure of the route to the destination
TIGHT Protocol [12]	Reduced delay in transmitting the packet to neighbor nodes	Greedy mode in routing affect neighbor node, and Enhanced energy consumption in delivering packets to neighbor nodes

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Energy-Efficient Routing [13]	Minimized energy-consumption in searching for neighbor nodes to send the data to the destination	Reduced hop count and Increased delay in delivering data packet to the destination
Optimization Framework [14]	Sharing of routing information to neighbor nodes	Finding of the lengthier route to the destination
Multi-Layer Routing Strategy [15]	Reduced delay in delivering packets to destination	Increased Error Rate in delivering packets
Segment Routing [16]	Encoding of the route provides security	Packet rejection rate in high because of synchronization failure
Zone Technology Protocol [10]	Increased packet delivery ratio to destination	Increased Control Overhead that reduces the speed of delivering the packets
Latency aware routing [17]	Increased reliability and reduced delay in delivering packets	Probability of route failure is high
Improved AODV routing [18]	Reduced Routing overhead due to finding the best route to the destination	Increased Packet Drop while data pass through different nodes
Virtual Ad-hoc Routing [19]	Minimized energy consumption in finding the alternate route	Increased routing overhead due to finding more alternative routes
Optical Layer Routing Influence [20]	Decreased route disconnect while delivering the packets	The survival rate of the network is low because of selecting unreliable nodes
Energy-Efficient Topology Controlling Algorithm [21]	Reduced utilization of bandwidth in transmitting the packets	Reduced Network Lifetime due to exhaustive energy consumption by nodes
Bandwidth based Multipath Routing [22]	The reduced path length from the current node to the destination	Enhanced utilization of bandwidth in transmitting the packets
Cluster-based Routing Scheme [23]	Reduced Link Failure in the path to the destination	Poor selection of gateway nodes while sending the packets
Taylor Based Grey Wolf Optimization Algorithm [24]	Minimized consumption of energy in discovering the neighbors	Reduced network lifetime when the network is scaled

Table 1. Advantages and Disadvantages found in Related Works

3. PROPOSED IWPIP-BASED APPROACH

This paper has introduced an improved version of Wolf Prey Inspired Protocol, namely $IWPIP$ to minimize energy consumption and balance the gateway-node (GN) load by avoiding the energy-hole problem (EHP). The four stages involved in $IWPIP$ are:

- Wolves initialization.
- Calculation of unique fitness function.
- Fitness function evaluation.
- Wolves velocity cum location updation.

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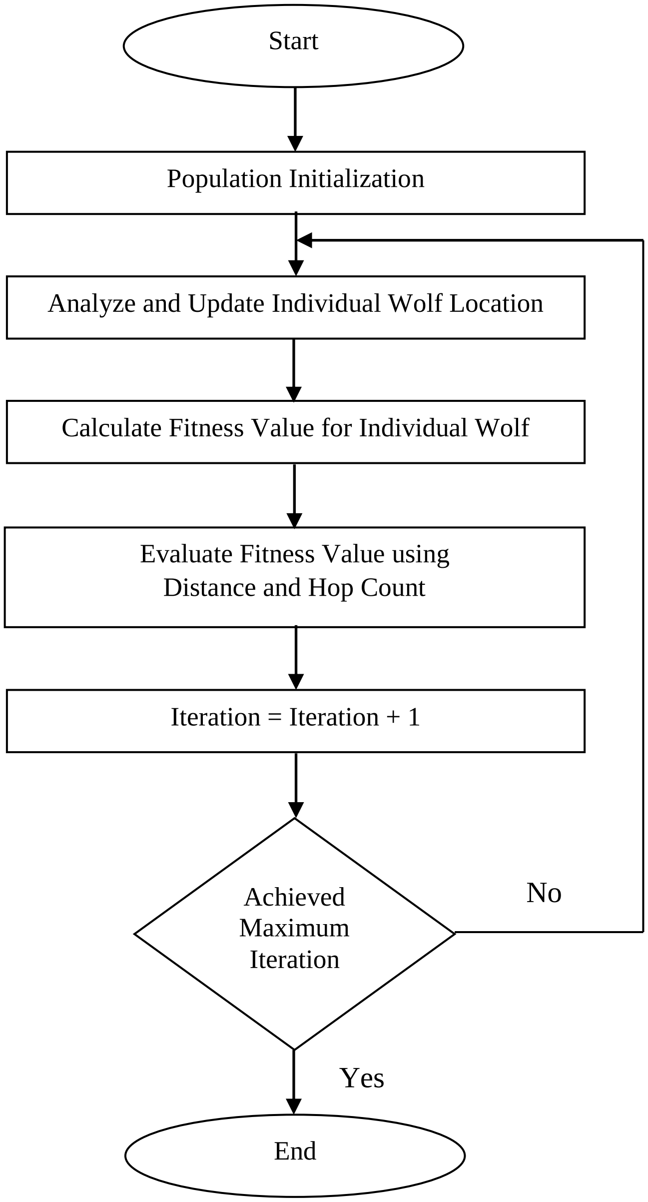

Figure 2 Flowchart of IWPIP

3.1. Wolves initialization

Every solution is taken as a way of reaching BS or alternateGN. The solution range is equivalent to the count of GN and indicated as M. The solutions provide the route between GN and BS via succeeding GN present in the network. Initialization is made to every GN with a number randomly generated, i.e., $\left(Y_{j,e}\right) = rand(00,11)$ where$1 \leq j \leq N_s$, $1 \leq e \leq N_s$, where N_s indicates the count of initial solutions. The term e indicates a component in the count ofGN. It maps the GN h_l as the subsequent GN in the route towards reaching BS via h_e, and it denotes h_e transmitting data to h_l. Equation (1) provides the formulation of mapping the route:

$$h_1 = Order(SetNextH\,(h_e), n) \quad (1)$$

Where $Order(SetNextH(h_e), n)$ indicates the function used to find the index position of nth GN in $SetNextH$, where $n = Ceiling\left(Y_{(i,e)} \times |FixNextH(h_e)|\right)$.

3.2. Calculation of Unique Fitness Function

The fitness function is used to measure the solution quality based on the parameters concerned in it. It assists the updation process involved in every iteration alpha, beta, and delta. At this point, this research applies the unique fitness function to achieve a better route from GN to BS. The global distance (D) traveling by GN formulation is defined as Equation.(2):

$$\mathbf{D} = \sum_{j=1}^{n} distance(h_j, NextH\,(h_j)) \quad (2)$$

Equation.(3) is used to calculate the overall hop count of GN in the network:

$$GH = \sum_{j=1}^{m} NextHCount(h_j) \quad (3)$$

Routing takes place by taking into account by considering the total distance traveled and the hop count. Hence, minimum distance traveled and maximum hop count provides a way of getting maximum fitness value. In short, distance traveled and hop count are conversely proportional to the fitness value in routing [12]. The fitness value having maximum value is represented as the top solution in the overall population. The formulation of the fitness function is defined in Equation.(4):

$$Fitness = \frac{L_1}{((\chi_1 \times D) + (\chi_2 \times GH))} \quad (4)$$

Where $(x_1, x_2) \in [00,11]$ such that the sum of x_1 and x_2 will be 1 and L_1 denotes a constant value. The fitness function used for routing will balance the distance traveled and hop count inside the network.

3.3. Fitness Function Evaluation

GN Performs different operations like receiving of data, consolidating the data received from different nodes, and forward the consolidated data either to BS or some other GN in the route towards the destination. To perform these different operations, GN consumes energy. Hence, GN h_j linked with the node n_i consumes energy to perform various inter cum intracluster functionalities in a single iteration and it is expressed as Equation.(5):

$$E_{cluster}(h_j) = (n_i \times E_r) + (n_i \times E_{da}) + E_t(h_j, NextG(h_j)) \quad (5)$$

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where E_r, E_{da}, and E_t indicates the different levels of energy consumed to receive, consolidate, and transmit the consolidated data to the subsequent GN in the route towards the destination. Also, any random GN h_i consumes more energy to forward the receiving data from other GN. Hence, the energy required to transmit the received data to other GN is formulated as Equation.(6):

$$ArrivedData(h_i) = \begin{cases} 01 & fNextH(h_j) \neq h_j \ forall \ h_j \in H \\ 10 & ifNextH(h_i) \neq h_i \ forall \ h_i \in H \end{cases} \quad (6)$$

GN (i.e., h_i) receives the arriving data and it forwards it to another GN in the route towards the destination. Thus, the energy needed to transmit the arriving data is computed using the Equation.(7):

$$E_f(h_j) = AD(h_j) \times E_t(h_j, NextH(h_j)) + AD(h_i) \times E_r \quad (7)$$

Indeed, overall GN consumption of energy is the total energy needed to perform different operations in the cluster, which includes forwarding data to different GN. Overall energy consumption of GN can be formulated as Equation.(8):

$$E_{gateway}(h_j) = E_{cluster}(h_j) + E_f(h_j) \quad (8)$$

GN life duration $L(h_i)$ is described as the percentage of GN residual energy and its overall consumption of energy. It is formulation is mathematically shown in Equation.(9):

$$L(h_i) = \frac{E_{residual}}{E_{overall}} \times 100 \quad (9)$$

The quality of the solution needs to be assessed to check efficiency. This research work has proposed a peculiar clustering fitness function to eradicate the energy-hole problem found in the nodes around the BS, where it applies the load-balancing concept at every GN. The proposed fitness function distributes the load of GN to other GN based on the distance that exists with BS. GN Close to the BS get to connect only with a minimum number of nodes, but the GN that are far from BS get connect to the maximum number of nodes. GN Near to the BS will receive data from GN that are far from BS and transmit it to the BS. Therefore, GN load is reduced when it is connected with other GN. This research work builds fitness function using the weighted mean load μ against all GN based on the distance with BS. C. Fitness (i.e., Clustering Fitness) is calculated using the scalability constant L_2 and it shown as Equation.(10):

$$C.Fitness(h_j) = L_2 \times \left| load(h_j) - dist(BS, h_i) \times \mu \right| \quad (10)$$

Equation.(11) provides the formulation of $IWPIP$ clustering for GN:

$$\mu = \frac{\sum_{j=1}^{m} load(h_j)}{m} \quad (11)$$

where $load(h_j)$ indicates the data arrived via GN h_j and $dist(BS, h_j)$ represents the distance that exists between h_j and BS.

Equation.(12) calculates the network's clustering fitness as the aggregate of all GN's clustering fitness:

$$C.Fitness = \frac{\sum_{i=1}^{m} C.Fitness(h_j)}{m} \quad (12)$$

3.4. Wolves Location Updation

To reach the prey (i.e., top solution), every wolf (i.e., solution) needs to make a location updation based on alpha, beta, and delta wolves. In IWPIP, alpha wolves are treated as the universal-solution in the solution set, beta wolves are the preeminent solution that is derived from the preceding iteration, and delta wolves are treated as the preeminent solution of present iteration. To make an updation of omega wolves location, this research work utilizes the aggregate of alpha, beta, and delta wolves updated location. By using this procedure, location updation leads to the optimum solution for optimization issues. Presently, the Modified location may probably have a value with a condition less than 0 or more than 1 due to algebraic calculation involves addition and subtraction. Nevertheless, $(Y_{j,e})$ is expected to fall in the range [0,1].

To prevent the receiving of negative values or a value greater than 1, this research work considers the following two locations: (i). If $(Y_{j,e} \leq 0)$, then $(Y_{j,e}) = (rand_1 \leq rand_2 ? (rand_1 \leq rand_3 ? rand_1 : rand_3) : (rand_2 \leq rand_3 ? rand_2 : rand_3))$. Where $rand_1, rand_2,$ and $rand_3$ are random values chosen for predicting alpha, beta, and delta wolves location. Here, $(Y_{j,e})$ assumed to have minimum range value in $rand_1, rand_2,$ and $rand_3$. (ii). If $(Y_{j,e} \geq 1)$, then $(Y_{j,e}) = 1$.

After assigning new positions, all solutions are re-evaluated with the aid of fitness function.

The pseudocode of IWPIP is provided in Algorithm 1 and the flowchart of IWPIP is provided in Figure 2.

1. Initialization of Wolf Population Y_i= (1, 2, …, n)
2. Identification of individual wolf location
3. Hop Count cum Distance Analysis
4. Perform fitness calculation
5. Evaluate fitness value using hop count and distance

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6. While (i< maximum iteration count)
7. For every individual wolf
8. Evaluate clustering fitness
9. End for
10. Update individual wolf location
11. Iteration = iteration + 1
12. End while
13. Return Y_n

Algorithm 1: Pseudocode of IWPIP

4. RESULTS AND DISCUSSION

4.1. Simulation Setting and Performance Metrics

The current section makes a discussion about evaluating the IWPIP using NS2 simulations. In general, there exists no trusted simulator for evaluating protocols for CRAHN. Furthermore, the details that are available regarding the protocol implementation or simulation for CRAHN are unclear to understand, especially the performance of protocols. This paper attempts to compare IWPIP against WPIP and TIGHT. This research work prefers the C++ language to use in the NS2 simulator. Table 2 shows the simulation setting used for evaluating the proposed protocol.

This research works make use of the below-mentioned metric for analyzing the performance of proposed protocol IWPIP against WPIP and TIGHT.

- ✓ **Throughput:** Measure of the overall quantity of data transmitted (or processed) from source to destination in a threshold time
- ✓ **Packet Delivery Ratio:** Measure of packets successfully received in destination against total packets sent by the source
- ✓ **Packet Drop:** Percentage of packets that not yet reached the destination due to different reasons like route failure, node failure, expiry of the packet, etc
- ✓ **Delay:** Consumed time by the protocol to deliver the packet to the destination
- ✓ **Energy Consumption:** Energy consumed to deliver the packet to the destination from the source.

Parameters	Values
Simulation Area Size	2500 × 2500 m^2
Simulator Name	Network Simulator
Version	2.35
Count of nodes	5 to 50 varying by 5
Size of Packet	0.512 kb
Mobility Model	Randomway Point
Speed of Mobility	4 m/s to 40 m/s
Type of Channel	Wireless
Type of Traffic	Constant Bit Rate
Initial Energy	15 Joules
MAC	802.16
Transmission Range	500 m

Table 2 Simulation Settings and Parameters

4.2. Performance Evaluation

4.2.1. Throughput Analysis

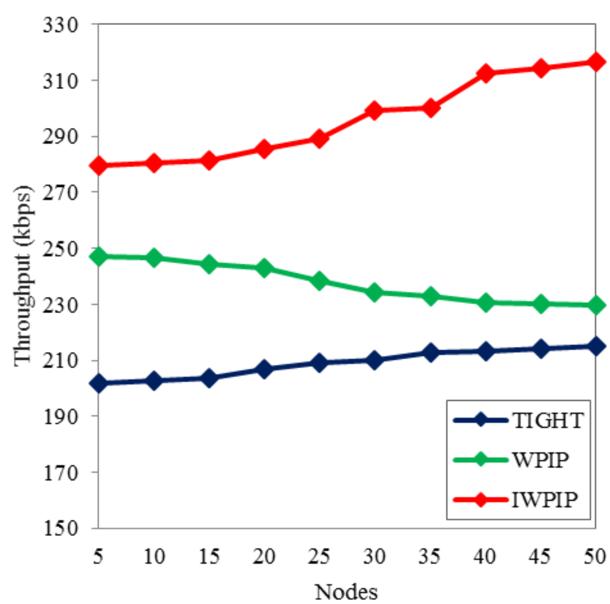

Figure 3 Throughput Vs. Node Speed

In Figure 3, nodes are plotted in x-axis varying with 5, and y-axis is plotted with results of routing protocols for the metric throughput in kbps. Plots in Figure 1 makes a clear indication that IWPIP can discover more energy-efficient routes compared to WPIP and TIGHT. Still, it can also provide more throughput. IWPIP prefers the route that has multiple short hops and very few long hops. The reason for preferring the short hop is to give more throughputs and consume low energy. Besides, data transmission faces minimum errors in short hops when comparing with long hops. WPIP and

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TIGHT do not consider the quality of the route utilized for delivering the data to the destination, where it only finds the overall energy and it forgets the distance and quality. These reasons make WPIP and TIGHT face many errors and retransmission, which ends with reduced throughput. The corresponding value of Figure 3 is provided in Table 3.

Node Speed	TIGHT	WPIP	IWPIP
5	201.97	246.91	279.41
10	202.69	246.81	280.51
15	203.80	244.40	281.37
20	206.67	242.74	285.31
25	208.95	238.33	289.08
30	210.11	234.15	299.44
35	212.90	232.78	300.14
40	213.18	230.76	312.44
45	214.08	230.32	314.15
50	214.87	229.79	316.43

Table 3 Throughput

4.2.2. Packet Delivery Ratio Analysis

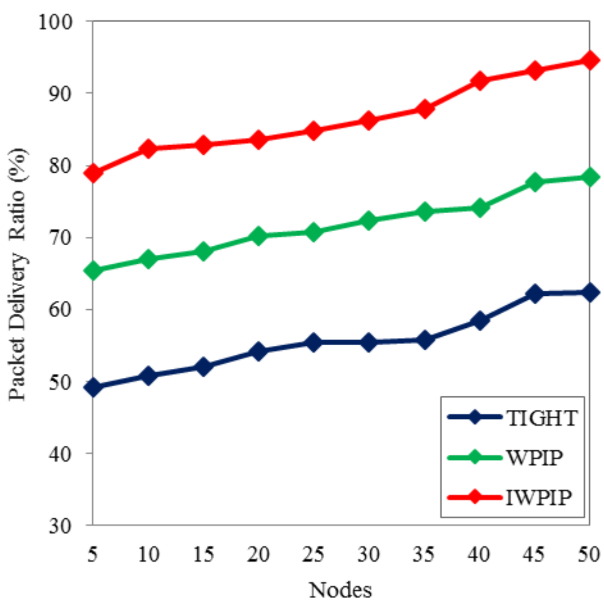

Figure 4 Packet Delivery Ratio Vs. Node Speed

In Figure 4, nodes are plotted in x-axis varying with 5, and y-axis is plotted with results of routing protocols for the metric packet delivery ratio in percentage. Plots in Figure 2 indicate the performance of routing protocols in terms of packet delivery ratio. IWPIP considers available energy at nodes and reliability of the link before sending the data, which results in increased delivery of packets. Another main reason for IWPIP's increased PDR is it avoids the utilization of nodes that are overused. This too leads as a reason for delivering more packets to the destination. WPIP and TIGHT consider only the available battery energy for sending the data packets, which results in decreased delivery of packets. WPIP and TIGHT mostly prefer the most frequently used paths (i.e., overused) for delivering the data packets. After a certain period, these overused paths fail and reduce the delivery level of packets to the destination. The corresponding value of Figure 4 is provided in Table 4.

Node Speed	TIGHT	WPIP	IWPIP
5	49.14	65.42	78.92
10	50.72	67.08	82.32
15	52.02	68.14	82.90
20	54.16	70.2	83.64
25	55.36	70.78	84.74
30	55.48	72.42	86.28
35	55.70	73.54	87.80
40	58.54	74.14	91.84
45	62.14	77.66	93.18
50	62.36	78.34	94.52

Table 4 Packet Delivery Ratio

4.2.3. Packet Drop Ratio Analysis

In Figure 5, nodes are plotted in x-axis varying with 5, and y-axis is plotted with results of routing protocols for the metric packet drop ratio in percentage. In Figure 5, nodes are plotted in x-axis varying with 5, and y-axis is plotted with packet drop ratio results in percentage. Figure 3 has plotted the packet drop ratio of IWPIP, WPIP, and TIGHT. It is clear to understand that the above considered all protocols are facing packet drop, but the proposed protocol IWPIP faces a very low level of packet drop when comparing with WPIP and TIGHT.

The reason is it avoids the overused paths and chooses the path that has short hops than long hops. Further, it considers the link quality during the route selection, which results in adapting the network even if the node speed gets increased. WPIP and TIGHT faces increased packet drop because of selecting the unstable cum unreliable overused paths that have longer hops that result in multiple errors (i.e., collision) and retransmission. The corresponding value of Figure 5 is provided in Table 5.

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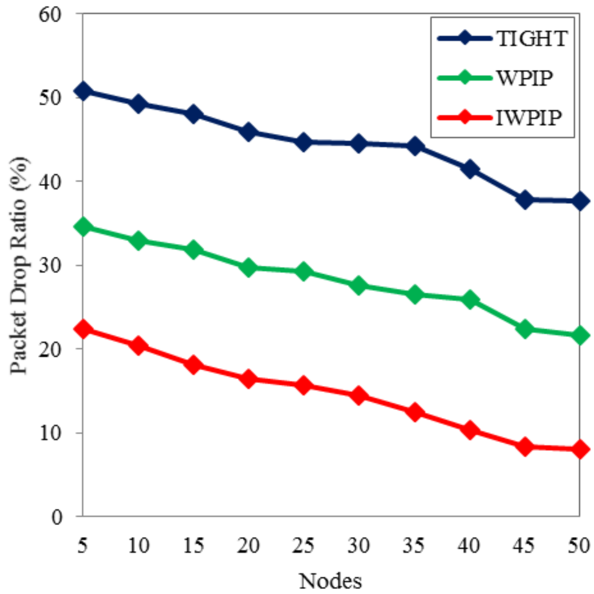

Figure 5 Packet Drop Ratio Vs. Node Speed

Node Speed	TIGHT	WPIP	IWPIP
5	50.86	34.58	22.38
10	49.28	32.92	20.38
15	47.98	31.86	18.20
20	45.84	29.8	16.46
25	44.64	29.22	15.74
30	44.52	27.58	14.42
35	44.30	26.46	12.50
40	41.46	25.86	10.28
45	37.86	22.34	8.32
50	37.64	21.66	8.10

Table 5 Packet Drop Ratio

4.2.4. Delay Analysis

In Figure 6, nodes are plotted in x-axis varying with 5, and y-axis is plotted with results of routing protocols for the metric delay in milliseconds. In Figure 6, nodes are plotted in x-axis varying with 5, and y-axis is plotted with results of delay in milliseconds. During route failure, IWPIP does not depend or stick with a single selected route, instead, it finds the alternate routes based on nodes updated location, shortest cum shorter hop paths. The reliability of the path is checked by the fitness function, where WPIP and TIGHT will not consider the reliability of the path while selecting data packets. The location of the nodes is not updated in WPIP and TIGHT, where this leads to route failure, numerous retransmission, and increased delay in delivering the data packet to the destination. Even though retransmission assures reliable link, by default delay gets increased in WPIP and TIGHT. The corresponding value of Figure 6 is provided in Table 6.

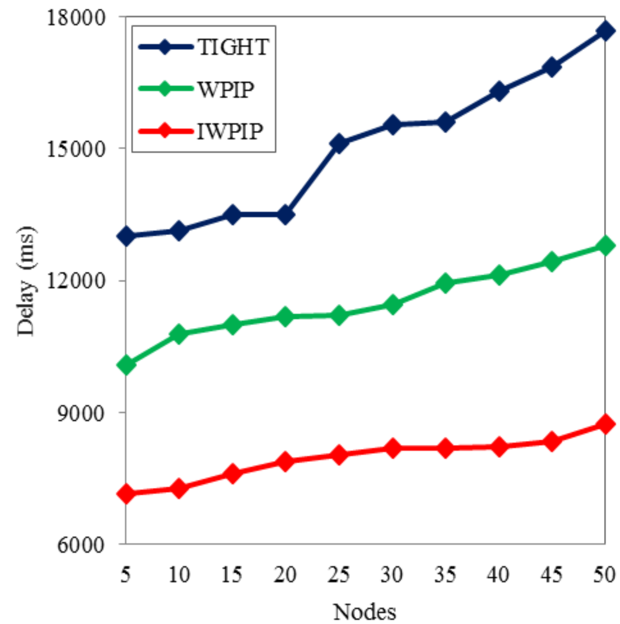

Figure 6 Delay Vs. Node Speed

Node Speed	TIGHT	WPIP	IWPIP
5	13020	10082	7154
10	13145	10787	7280
15	13506	11004	7622
20	13513	11194	7891
25	15107	11208	8052
30	15546	11461	8178
35	15605	11955	8207
40	16313	12145	8223
45	16850	12429	8330
50	17693	12801	8728

Table 6 Delay

4.2.5. Energy Consumption Analysis

In Figure 7, nodes are plotted in x-axis varying with 5, and y-axis is plotted with results of routing protocols for the metric energy consumption in percentage. In Figure 5, we perform the comparison of total energy consumed to deliver the data

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packet from source to destination; it includes the energy spent for discovering the new routes during node or link failure. IWPIP relies on the reliability of route and energy available at each node, and it finds the energy-efficient routes that consume the minimum amount of energy to send a data packet. WPIP and TIGHT depend only on the energy available at nodes, where it does not consider the reliability of route and hop distance. This makes WPIP and TIGHT consume more energy than IWPIP. The corresponding value of Figure 7 is provided in Table 7.

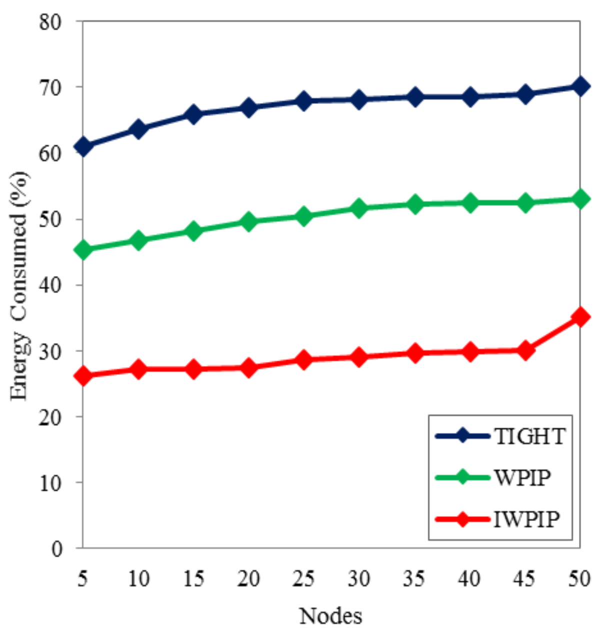

Figure 7 Energy Consumption Vs. Node Speed

Node Speed	TIGHT	WPIP	IWPIP
5	61.03	45.43	26.27
10	63.75	46.76	27.31
15	65.95	48.10	27.33
20	66.99	49.61	27.45
25	67.96	50.38	28.57
30	68.08	51.65	29.07
35	68.49	52.24	29.73
40	68.50	52.37	29.84
45	69.03	52.54	30.02
50	70.22	53.11	35.23

Table 7 Energy Consumption

5. CONCLUSION

In the domain of optimization-based research, the minimum number of metaheuristic algorithms only makes use of preceding information to control the upcoming process. In this research paper, improved wolf prey inspired protocol makes use of preceding information regarding the population forget succeeding in the process of searching. That is, this research work makes use of clustering fitness to evaluate the fitness of the route to send the data. Results of the fitness function incorporated future use. In this manner, the best routes are identified across the network. The simulation results demonstrate that the proposed IWPIP has outperformed significantly than other protocols towards improving network performance. The follow-up work focus shall on improving the performance of network routing by incorporating machine learning with optimization.

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