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Hybrid Genetic Optimization to Mitigate Starvation in Wireless Mesh Networks

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Abstract

Background/Objectives: The objective of this work is to mitigate starvation in Wireless Mesh Networks (WMNs) being deployed in today's LAN, WAN and Internet topologies by employing a novel optimization method. **Methods/Analysis**: The QoS performance of WMNs is severely affected by a problem called starvation where nodes that are one-hop away from the gateway monopolize the channel so that far away nodes get starved of channel access. We propose a hybrid genetic algorithmic approach to mitigate starvation in WMNs by dynamic adjustment of contention window of mesh nodes optimally. In this approach, Genetic Algorithm incorporated with Gravitational Search Algorithm is used. **Findings**: Simulations are conducted using the proposed method for multimedia traffic with AODV as the routing protocol. The performance of the proposed method is compared with priority-based method, pure GA optimization, Fair Binary Exponential Back-off algorithm (FBEB) and IEEE 802.11. The local search capability of GSA incorporated in our proposed method improves the throughput by 24.64% than priority-based method and by 3.56% than pure GA optimization. In our approach, we observed a significant decrease in end-to-end delay compared to pure GA optimization. Improvement in fairness is found along one-hop, two-hop and three-hop nodes when compared with FBEB. The FBEB algorithm adjusts the CW size by indirectly estimating the traffic in communication medium leading to lesser throughput whereas our proposed method changes the CW size dynamically based on QoS parameters of network nodes leading to improvement in throughput. The proposed method increases throughput by 5.10% than IEEE 802.11 and by 1.25% than FBEB at one-hop. The proposed method increases throughput by 66.67% than IEEE 802.11 and by 22.61% than FBEB at two-hop. **Application/Improvement**: Our hybrid Genetic optimization method improves QoS performance of Wireless Mesh networks by avoiding throughput imbalances among users and reducing end-to-end delay effectively.

Keywords: Contention Window, Genetic Algorithm, Gravitational Search Algorithm, Starvation, Wireless Mesh Networks

1. Introduction

Wireless Mesh Networking is becoming an attractive communication technology because of its rapid deployment and low cost. On these networks, mesh clients and mesh routers are the two kinds of nodes. Each node operates as a host and a router to facilitate the data transmission between nodes which are not in the direct transmission range of each other[1]. The self-organizing and self-configuring capabilities of WMNs enable the network nodes to establish and maintain mesh connectivity among them. This reduces the up-front cost, improves the network robustness, makes easy the network maintenance and provides reliable service.

The flexibility of mesh networking is improved by equipping mesh routers with multiple wireless interfaces that are developed on same or different wireless technologies[2]. A similar hardware mechanism is used to develop conventional and mesh wireless routers. Mesh routers form the mesh backbone for mesh clients

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and have minimal mobility. Mesh clients having simple hardware and software requirements work also as routers to support mesh networking.

Routing is a fundamental process of WMNs. The characteristics of WMNs directly reflect the strengths and weaknesses of a routing protocol. In WMNs the reliability, the seamless mobile user connectivity, the scalability/ efficiency and the QoS are directly determined by the routing protocol[3]. The routing algorithms of a WMN work in a decentralized, self-organizing and self-configuring manner. The routing protocols applied in MANETs such as Topology Broadcast-based Reverse Path Forwarding (TBRPF), Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV) routing etc. can be used for WMNs as well[4]. For example, an AODV routing protocol is a reactive routing protocol that maintains routes between nodes which needs to communicate. The routing messages have information only about the source and destination so that its size is limited. Destination sequence numbers are used to specify about the freshness of the route with comparison of others and is used to grant loop freedom[5].

In Wireless Mesh Networks (WMNs), the data traverses in multi-hop fashion through one or more wireless links to reach the backbone wired network. However, the fair distribution of bandwidth among users is essential and it shouldn't be affected by physical location and hop distance from the gateway of the users. The performance of WMN is severely affected by a problem called starvation. Starvation occurs in a situation that nodes closer to the gateway access the channel without giving a chance to nodes situated in longer distance to the gateway. This causes unfair distribution of bandwidth among users where a couple of dominating flows obtain higher throughput and the remaining starving flows receive lower throughput[6].

If network nodes are equipped with multiple channels and transceivers, by employing scheduled access methods which coordinate transmissions over non-overlapping orthogonal channels in optimal manner, the occurrence of starvation can be avoided[7]. But commercial wireless cards are available with a single transceiver supporting a few number of orthogonal channels. The algorithm proposed in[8] reduces the extent of the starvation occurs in the network and improves the fairness by restricting the aggressive transmissions from mesh nodes that are successful in transmitting data packets. Effective mitigation of the starvation, usually results from careful network planning, enforces fair share of the network bandwidth among all the users and improves the throughput of the overall network[9]. An optimization process can be used for careful network planning and to mitigate starvation. Several Global optimization techniques such as Ant Colony Optimization (ACO), Tabu Search (TS) etc. have been proposed for wireless mesh networks to solve routing and channel assignment problems. Genetic algorithm is best suitable for the wireless mesh network environment to optimize the use of resources because of its planning ability of large networks and simplicity.

In this paper, we propose a hybrid dynamic genetic algorithm to improve QoS performance of the Wireless Mesh Networks by mitigating starvation. The proposed hybrid algorithm (Genetic algorithm incorporated with Gravitational search algorithm) dynamically optimizes the size of the contention window of the network nodes in order to avoid starvation in multi-hop mesh nodes thereby improves the fairness of the network. Our work is presented in this paper as follows: Section 2 explains the related work presented by researchers to avoid the starvation, Section 3 presents the methods used in this work, Section 4 discusses the conducted experiments and their results and Section 5 concludes our work.

2. Literature Survey

Ding et al.[10] demonstrated that the overall network throughput and the multicast throughput could be improved by employing a greedy algorithm and a novel genetic algorithm to channel assignment in multi-channel multi-radio wireless mesh networks. The genetic algorithm was performing better compared to greedy algorithm. Two multicast algorithms : the Level Channel Assignment (LCA) algorithm and Multi-Channel Multicast (MCM) algorithm were proposed by Zeng et al.[11] to maximize throughput by reducing interference and improving capacity of the network for multi-channel multi-interface mesh networks.

Verma et al.[12] proposed a Constrained Small-World Architecture for Wireless Network (C-SWAWN) model to improve performance of WMNs. The Average Path Length (APL) to the centrally placed Gateway node was reduced with the addition of Long-Ranged Links (LLs). An addition of 10% LLs brought down the APL to the Gateway by 40%, thus improving the performance.

Shakya and Pokhrel[13] proposed an algorithm to optimize field based routing that was promising in Wireless Mesh Networks. This algorithm was developed for multiple subscribers in mesh networks to get optimal results interms of time, speed and utilization of resources. In this optimization, path estimation was done using Particle Swarm Optimization.

Zhen[14] investigated a Quality of Service (QoS) multicast routing in WMNs. TDMA-based timeslot allocation was presented for calculating bandwidth of a multicast tree. A multi-path multicast routing algorithm was proposed with two strategies for constructing multiple trees. Simulation results show that multi-path multicast routing algorithm improves the performance of multicast routing in terms of success ratio and network cost when compared with MAODV.

Narayan et al.[15] proposed a novel cross-layer routing metric that elegantly balances the load among different gateways in WMNs which addresses the problem of finding an optimal path and load balancing using a new routing metric. The metric was implemented in Optimized Link State Routing (OLSR) protocol by Ns-2.34 network simulator. Results proved that the proposed scheme performed better when compared with Load Aware Expected Transmission Time (LAETT).

Sun and Lv[16] proposed a novel dynamic hybrid algorithm to improve efficiency and quality for QoS routing in Wireless Mesh Networks. Fawaz et al.[17] established a Markov Decision Process (MDP) framework to identify a suitable Bulk Release Decision Policy (BRDP) where BRDP was implemented within a Starvation Mitigation and Delay-Minimal (SMDM) bundle delivery scheme. Simulations were conducted to quantify the severity of starvation experienced by the downstream SRUs and to evaluate the merit of the proposed SMDM scheme through its ability to jointly mitigate starvation. Therefore the proposed method achieved minimal bundle delivery end-to-end delay to the destination SRU.

Xue and Ekici[18] proposed a novel v (t) - regulated CSMA algorithm using the RTS/CTS mechanism in a distributed environment. Link scheduling had been applied in this work that links with long queues to reduce average delay. The v (t) - regulated CSMA algorithm ensured a more frequent switch between schedules to reduce the effect of temporal starvation. The proposed algorithm achieved an optimal throughput and proved through numerical evaluations that the algorithm indeed mitigated the temporal starvation problem. Also better delay performance was achieved than other throughput-optimal CSMA algorithms.

Lim et al.[19] proposed a novel starvation detection technique that identifies whether the node is in Flow-In-the-Middle (FIM) state by exploiting physical energy detection mechanism which was implemented basically in 802.11 devices. A simple strategy was presented to mitigate the starvation. Simulation helps to show the effectiveness of the proposed scheme. The results demonstrated that the proposed scheme recognized the starvation and gets alleviated it effectively.

Gurewitz et al.[20] demonstrated the existence of starvation in Wireless Mesh Networks by means of real network measurements, an analytical model and test bed experiments. To mitigate the starvation, a counter starvation policy had been developed using the basic mechanisms of IEEE 802.11e. The performance of the counter starvation mechanism was analyzed through simulations and experiments. Its effectiveness in mitigating starvation was demonstrated by ensuring the fair sharing of bandwidth.

Masri et al.[21] proposed a neighborhood-based congestion control protocol, which was overhead-free, to avoid starvation. The under exploited fields in the IEEE 802.11 frame header were optimized to get multi-bit congestion feedback explicitly. This feedback was used to control the rate accurately without requiring any additional overhead.

Ronasi et al.[22] proposed a Markov chain model to compute the extent of starvation in multi-hop scenarios of Wireless Mesh Networks. Fair Binary Exponential Back-Off (FBEB) algorithm was developed to reduce the degree of starvation by modifying the MAC protocol. Usage of the channel by the starving nodes (multi-hop nodes from the Gateway) was improved by a factor of 7 with 20% loss in throughput that was acceptable in mesh networks.

Lim et al.[23] proposed a mechanism to improve fairness and alleviate starvation by employing a queue management policy in which packet transmissions were prioritized based on the distance between Gateway and source node. High priority was given to the packets that were coming from far away source nodes.

3. Methodology

A Wireless Mesh Network is a packet-switched network consisting of mobile nodes, access points and network gateways[24]. Wireless Mesh Networks can effectively extend the high-speed Internet to the users at "last mile" using wireless nodes and wireless backbone. These networks become a promising wireless technology to satisfy the needs of mobile Internet users since it has fault-tolerant, self-organizing, self-healing and self-optimizing wireless infrastructure. The possibility of rapid deployment, low investment cost and low investment overhead cost make the WMN technology potentially strong in diverse wireless environments. The successful deployment of Wireless Mesh Networks is threatened by users demand for QoS guarantees which requires an effective framework for resource management. In Wireless Mesh Networks, the resource management has three important areas: configuration of the network and its deployment, routing and mobility management and admission control. Of the above three, routing in the multi-hop environment of WMNs is very critical. The effective resource management is a part of routing and sharing of bandwidth plays a prominent role in resource management of Wireless Mesh Networks.

In Enhanced Distributed Coordination Function (EDCF) of 802.11, services are differentiated for various traffic categories by using different minimum Contention Window (CW_{min}) values, which are maintained at static over duration. Low-priority traffic, i.e., FTP performance with higher CWmin values is suppressed from two-hop or multi-hop neighbors, even during the absence of high-priority traffic from one-hop neighbors and thus generating starvation in two-hop or multi-hop network nodes. This unfair utilization of bandwidth is caused by IEEE 802.11 MAC and transmission control protocol (TCP) in the transport layer. However, the fair distribution of bandwidth among users is essential and it shouldn't be affected by physical location and hop distance from the gateway of the users. The QoS guarantees in multi-hop Wireless Mesh Networks are severely affected by the starvation. In this work, we propose a Hybrid Genetic algorithm to mitigate the starvation.

3.1 Genetic Algorithm (GA)

GA is an optimization technique based on variations and selections. Once the solution of the problem is encoded in the form of chromosomes then it compares the relative performance of the solution. In the definition domain, at randomly selected points, the target function that is to be optimized is evaluated by Genetic Algorithm[25]. The results in this evaluation are used to generate a new population of points in the definition domain. Then the definition domain is again evaluated using this new population. This process is repeated until the points in the population approach a local minima and maxima of the target function. GA achieves good results even the function has several local minima or maxima.

The general procedure of GA can be explained as follows. With a predefined number of individuals, a random initial population is created. Then the fitness of each individual is evaluated using a fitness function[26]. The best-ranked individuals are sorted out and kept in the new population. The genetic operators such as crossover and mutation are applied to get the remaining number of individuals in the new population. This procedure is repeated until we get the satisfying solutions. For a given problem, GA is able to find the best enough solution in quick time and this solution is directly applicable. This makes GAs suitable for Wireless Mesh Network design in which solutions are updated iteratively[27]. Simple operation and implicit paralization are the main attractions of the Genetic Algorithms. These algorithms involve only copying of strings and swapping of part of the strings[28]. GA optimization can be applied to different routing protocols. When GA is used with AODV the best results are obtained interms of performance.

3.2 Gravitational Search Algorithm (GSA)

GSA is a nature inspired heuristic optimization based on law of gravity and law of motion[29]. This algorithm can be used to improve the exploration and exploitation capabilities of a population based algorithm. This algorithm has a collection of search agents considered as objects. These objects interact with each other by gravity force and their performance is measured interms of masses. A global movement because of which all the objects move towards with each other with heavier masses is caused by the force of gravity. If the movement of heavier masses is slow that indicates good solutions. Masses obeying the law of gravity and law of motion are given by "1" and "2".

$$F = G\,(M_1 M_2 / R^2) \qquad (1)$$

$$a = F/M \qquad (2)$$

Where F is the magnitude of the gravitational force, M_1

and M_2 are the masses of two objects, G is a gravitational constant, R is the distance between the masses and 'a' is the acceleration.

In GSA, each mass (agent) has four specifications: position, inertial mass, active gravitational mass and passive gravitational mass[30]. The solution of a problem is represented by the position of the mass and a fitness function is used to determine the gravitational and inertial masses. That is, the algorithm is traversed by adjusting properly the gravitational and inertial masses to get solutions presented by the masses. By lapse of time, masses are attracted by heaviest mass presenting an optimum solution.

In a system of N agents representing solutions to the problem of dimension n, the position of the i^{th} agent in d^{th} dimention is represented as:

$$X_i = \left(x_i^1, .., x_i^d, .., x_i^n\right) \qquad i = 1, 2, .., N$$

A force from mass j acts on mass i at time t (masses of objects i and j being M_i (t) and M_j (t)) is described as follows:

$$F_{ij}^d(t) = G(t)\frac{M_i(t) * M_j(t)}{R_{ij}(t) + \varepsilon}\left(x_j^d(t) - x_i^d(t)\right)$$

Where G(t) is the gravitational constant, ε is a small constant and $R_{ij}(t)$ is the Euclidean distance between i and j objects which is computed as:

$$R_{ij}(t) = \| X_i(t), X_j(t) \|_2$$

The masses of the agents are compared based on fitness:

$$m_i(t) = \frac{fit_i(t) - worst(t)}{best(t) - worst(t)}$$

Where $fit_i(t)$ represents the fitness value of agent i at time t, worst(t) and best(t) representing the minimum fitness and maximum fitness values of all agents. The masses are normalized as follows:

$$M_i(t) = \frac{m_i(t)}{\sum_{j=1}^{n} m_i(t)}$$

The total force that acts on agent i in dimension d is given by:

$$F_i^d(t) = \sum_{j \in k_{best}, j \neq i}^{N} rand_j F_{ij}^d(t)$$

where k_{best} is the set of first k objects which have the best fitness value and biggest mass, and $rand_j$ is a random number in the interval [0, 1].

Acceleration of the i_{th} agent at time t in the d dimension is calculated by:

$$a_i^d(t) = \frac{F_i^d(t)}{M_i(t)}$$

The next velocity and next position of an agent are computed as follows:

$$v_i^d(t+1) = rand_i * v_i^d(t) + a_i^d(t)$$
$$x_i^d(t+1) = x_i^d(t) + v_i^d(t+1)$$

where $rand_i$ is a random number between 0 and 1.

3.3 Proposed Hybrid Algorithm

It had been proved that the starvation problem in wireless networks was solved effectively by changing the size of contention window of the individual traffic based on its priority and QoS performance. Several methods had been proposed to change the contention window size of the individual nodes dynamically in order to improve fairness in multimedia traffic environment. In this paper, we propose a hybrid genetic algorithmic approach to mitigate starvation in Wireless Mesh Networks, thereby satisfying the QoS requirements of the users and optimizing the bandwidth utilization among the users. In this hybrid algorithm, Genetic Algorithm is incorporated with a gravitational search algorithm to add local search capability and for faster convergence. This work concentrates on the functions in the network layer and MAC layer. This cross layer technique is employed to identify optimal Contention Window (CW) for individual nodes to avoid starvation where the size of CW is based on the network layer QoS parameters and the available channel. In the proposed model, QoS parameters such as number of hops to the gateway, packet loss rate and delay in the network layer are used to compute the size of contention window for individual nodes.

The proposed hybrid algorithm is incorporated with AODV routing protocol. Genetic Algorithms are known to have larger convergence time compared to other metaheuristic algorithms. However, their global search capabilities make them very attractive in solving NP problems. To improve the convergence time various hybrid techniques have been proposed in literature. Also, it was shown that solutions within the population may not improve in certain scenarios. Gravitational Search Algorithm (GSA) has a very good convergence capability, but lacks in the global search capability. In this work, the hybridization of both the algorithms is investigated. The idea of proposed hybridization is to incorporate the local search capability of the GSA in GA leading to faster convergence. The objective function of the proposed algorithm is to improve throughput and minimize end-to-end delay for the multimedia traffic. The selection of optimal Contention Window (CW) maximizes the channel utilization and improves the throughput. The optimal contention window is computed based on number of hops to the gateway, packet loss rate and delay in the network layer. The genetic parameters used are single point crossover with uniform mutation probability of 0.1. The encoding was done using IEEE754 with Roulette Wheel Encoder mechanism to select the chromosomes. The chromosomes are represented by three components, namely, number of hops to the gateway, packet loss rate and end-to-end delay for a route from source to the gateway. Number of hops is encoded by using 4 bits and the IEEE 754 format is used to represent packet loss rate and end-to-end delay.

To find the best contention window values for the individual nodes, each node from source to destination is given a random CW value and the network is evaluated by our proposed technique using a fitness function.

3.4 Pseudo Code for the Proposed Algorithm

Given: P – Size of initial population (the number of random feasible routes) =10
I – Number of iterations -250
C – Rate of cross over (0.5)
M – Rate of Mutation (0.75)

Input Data: Initial population of Random routes is initiated
where a node in the route is represented by 1.

Fitness: Fitness is based on Number of hops, Packet loss rate and End-to-end Delay.

Output: A list of routes with minimum packet loss rate.

Generate an initial population of size P
Evaluate initial population for fitness
{The CW is adapted based on the number of hops and the closeness of the node to the destination}
While (current_iteration i < I)
{
Breed C^*P new solutions:
Select two parent solutions from the current population
Form child solution via *Single point* crossover
Generate random number between 0 and 1
If (random < M)
Mutate the child solution
Check whether the child is a feasible solution
Add child to population
Remove C^*P least fit solutions from the population
}
//The population obtained in GA form the initial population for GSA//
While (current_iteration i < I)
{
Compute mass, force and acceleration for all agents
Update velocity and position
}
Check Whether termination condition is reached else GA iteration
Select the best CWmin for individual traffic based on the fitness value evaluated by the fitness function

Return [best solutions].
CW_{min}].

In the proposed algorithm, the input data are given as the parameter values such as number of hops, packet loss rate and end-to-end delay. The output of CW_{min} achieved helps to minimize packet loss rate and thereby obtaining best solutions. Figure 1 shows the flowchart of the proposed Hybrid GA-GSA.

The fitness function of the proposed hybrid algorithm is given by,

$$f(t) = \frac{E_i}{E_{max} e^{-\left(\frac{cache_i}{cache_{max}}\right)}}$$

where

$E_i = end\_end\_delay$

$E_{max} = max\_end\_end\_delay$

$cache_i = cache\_utilized$

$cache_{max} = max\_size\_of\_cache$

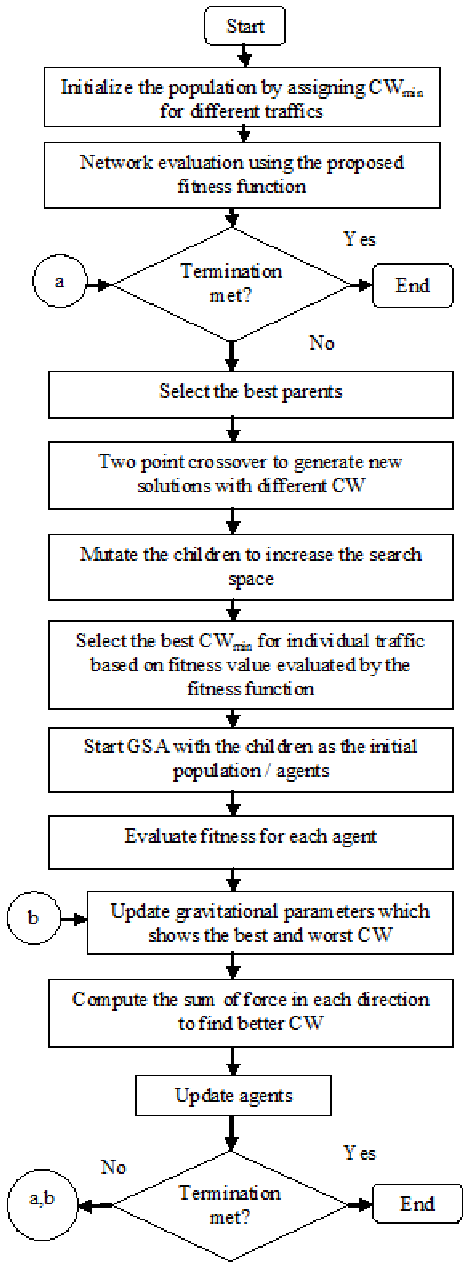

Figure 1. Flowchart of the proposed Hybrid GA-GSA.

4. Experimental Results

To evaluate the performance of the proposed hybrid genetic algorithm, an Opnet simulation scenario has been set up with 20 client nodes and one gateway. Multimedia traffic with random TCP flows is used to simulate the network behavior in multi-hop environment. The routing protocol used in this simulation is AODV with proposed Hybrid Genetic Algorithm. The objective function of the proposed optimization process is to fairly distribute the channel bandwidth among users by avoiding throughput imbalances and to reduce end-to-end delay. The network is evaluated through simulations for a duration of 180 Secs. The performance of the proposed method is compared with[6] and Genetic optimization method without hybridization of GSA. The simulation is conducted with the experimental setup parameters presented in Table 1.

Table 1. Simlation parameters

Number of Nodes	20
Number of Gateways	1
Area	4 km X 4 km
Traffic	Multimedia with Random TCP flows
Routing Protocol	AODV with proposed hybrid algorithm
Simulation Time	180 Sec

The proposed hybrid method increases the throughput by 24.64% when compared with priority-based starvation avoidance method and by 3.56% when compared with pure GA-based optimization as shown in Figure 2. The local search capability of GSA incorporated in the proposed hybrid GA helps in improving the functioning of the algorithm.

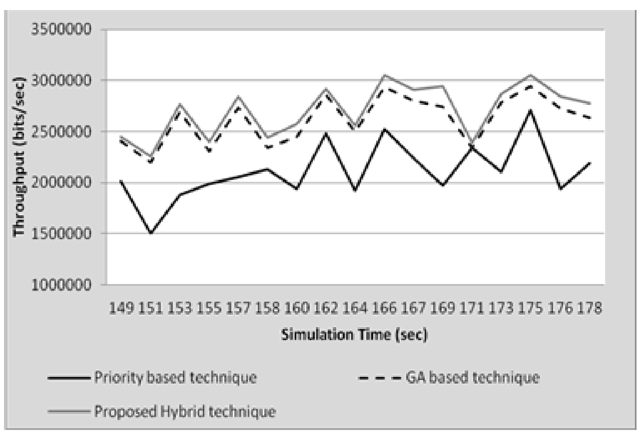

Figure 2. Throughput comparison.

The proposed method decreases the end-to-end delay by 18.32% when compared with optimized GA as shown in Figure 3. The refinement of the GA with GSA helps in decreasing the end-to-end delay. The fitness of solutions is computed based on minimizing the end-to-end delay which greatly improves the performance of the proposed method.

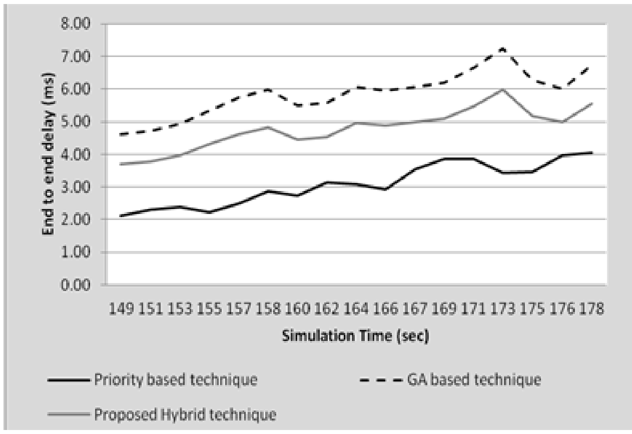

Figure 3. End-to-end delay comparison.

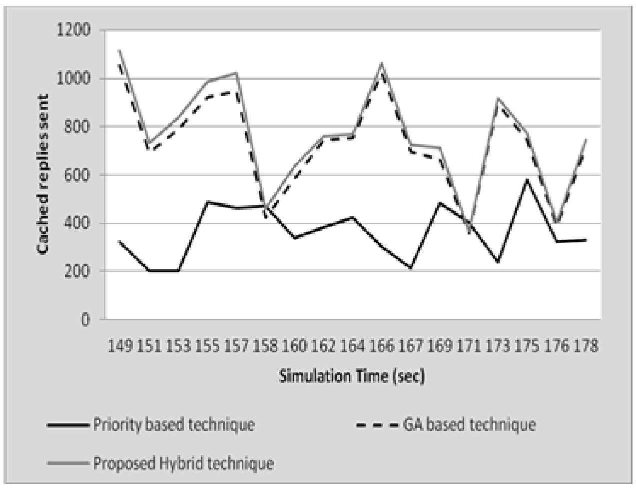

Figure 4. No. of Cache replies sent.

The proposed method increases the cached replies sent by 111.49% when compared with priority-based method (Figure 4). The pure GA-based method and our hybrid method uses almost the same number of cache replies in the route discovery process. It is observed from Figure 5 that the proposed hybrid GA achieves better fitness than GA optimization. The GSA in the hybrid algorithm not only helps to avoid local minima, but also achieves faster convergence.

Our experimental simulation results are also compared with Fair Binary Exponential Backoff Algorithm (FBEB)[22] and IEEE 802.11 in terms of average throughput and fairness index. The FBEB algorithm adjusts the CW size by indirectly estimating the traffic in the communication medium. When a node transmits a packet successfully, the CW was not reset for a wait time T. If a packet collision occurs, then the node doubles its CW and starts the process again. When the contention window is doubled it creates a problem to other nodes which suffer from starvation, leading to lesser throughput. In our proposed method the contention window is changed dynamically based on QoS parameters of network nodes.

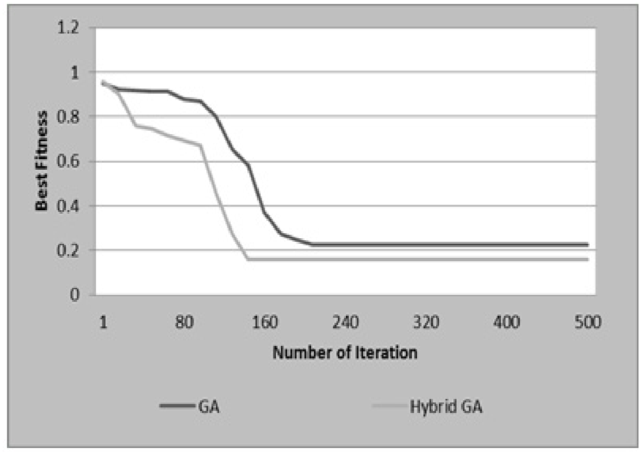

Figure 5. Fitness performance of proposed method.

Table 2. The average throughput achieved

The average throughput achieved	At single-hop	At two-hop	At three-hop
Proposed	3.22	1.28	0.84
FBEB	3.18	1.02	0.98
IEEE 802.11	3.06	0.64	0.18

The proposed method increases the average throughput across the network at single-hop, two-hop and three-hop nodes. Our optimization increases the throughput by 5.10% than IEEE 802.11 and by 1.25% than FBEB at one-hop. The proposed method increases throughput by 66.67% than IEEE 802.11 and by 22.61% than FBEB at two-hop. The proposed method increases throughput by 129.41% than IEEE 802.11 and decreases by 15.38% than FBEB at three-hop. Table 2 presents the average throughput performance of the proposed method, FBEB and IEEE 802.11.

Table 3. Fairness index

	Fairness Index
Proposed Technique	0.74
FBEB	0.7
802.11	0.45

The proposed method also increases the fairness index than FBEB and IEEE 802.11. The proposed method increases the fairness index by 5.56% than FBEB and by 48.74% than 802.11 as given in Table 3. The fairness index measures the fairness of the throughput achieved among different flows.

5. Conclusion

In this paper, the proposed method adopts a novel dynamic genetic algorithm to solve starvation in unicast routing problem for WMN in the network layer and MAC layer. To avoid the slow convergence of the GA and utilize the fast convergence of GSA, a novel hybrid algorithm to localize the solution space is proposed. Simulations are conducted for multimedia traffic. The Results obtained are compared with priority-based starvation avoidance method and GA-based optimization without hybridization of GSA. Performance is compared in terms of parameters such as throughput, end-to-end delay and number of cached replies used. Comparative results show that hybrid GA mitigates the starvation effectively and achieves higher throughput when compared with priority-based method and GA-based optimization. The fairness index improvement is statistically significant compared to FBEB technique not only in the QoS front but in cache utilization also. Improvement in fairness is found along one-hop, two-hop and three-hop nodes. Our hybrid Genetic optimization improves QoS performance of Wireless Mesh Networks by avoiding throughput imbalances among users and reducing end-to-end delay effectively.

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