Enhancing the performance of Optimized Link State Routing Protocol using HPSO and Tabu Search Algorithm

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Abstract - This study aims at enhancing the Performance of Optimized Link State Protocol (OLSR) using Swarm Intelligence and Tabu Search Algorithm. It proposes OLSR modifications using Swarm Intelligence and Hybrid Particle Swarm Optimization (HPSO) by use of Tabu Search Algorithm (TSA). The OLSR Routing Protocol is used for the study of Mobile Ad hoc Networks (MANET) using Multimedia and Video Streamed Traffic. Simulations were done using OPNET simulator. The jitter time, data drop and end to end delay are lowered and the throughput of the network is improved. The results obtained using the TSPSO method show that when compared to the traditional OLSR, there is a decrease of 25.83 % in jitter time, 25.76% in data drop, 25.63 % in end to end delay. However there is a decrease in only 3.45 % in jitter time, 3.22 % in data drop and 2.91 % in end to end delay when PSO Algorithm is used. Also it is observed that when compared to the traditional OLSR there is an increase of 34.32 % in throughput obtained by TSPSO method and increase of 31.32 % when PSO Algorithm is used. Thus the efficiency of the proposed method is increased.

Keywords: Ad Hoc Network Optimized Link State Routing (OLSR), Hybrid Particle Swarm Optimization (HPSO), Multimedia Traffic, Tabu Search (TS) Algorithm.

I INTRODUCTION

MANETs are multi-hop wireless network formed by mobile nodes with wireless capabilities and is a collection of wireless nodes dynamically creating a wireless network without infrastructure [1]. MANET's routes are enabled in between nodes in multi-hop fashion, as wireless radio propagation range is limited. A good routing protocol minimizes computing load on host and network traffic overhead [2]. MANETs have many salient characteristics such as 1) Dynamic topologies 2) Energy-constrained operation 3) Bandwidth constrained, variable capacity links and 4) Limited physical security. Hence, routing protocols of ordinary wired networks do not suit such dynamic environment [3].

OLSR is a Proactive Link State Routing Protocol for MANETs. The key idea is to reduce Control Overhead by lowering the number of broadcasts compared to pure 'flooding' mechanisms. The concept to support this OLSR idea is use of Multipoint Relays (MPRs). MPRs are selected routers that forward broadcast messages during flooding. To reduce broadcast messages size, routers declare only a small subset of all neighbours [4]. OLSR functions include: packet forwarding, neighbour sensing, and topology discovery. Packet forwarding and neighbour sensing mechanisms provide routers information about neighbours offering an optimized way to flood messages in the OLSR network through MPRs. Neighbour sensing allows routers to diffuse local information to the entire network. Topology discovery determines entire network topology and updates Routing Tables.

OLSR uses four message types namely 'Hello' message, Topology Control (TC) message, Multiple Interface Declaration (MID) message, and Host and Network Association (HNA) message. 'Hello' messages are used in neighbour sensing. Topology declarations are TC messages [5] based.

Multimedia Traffic modelling is challenging as it has different characteristics unlike ordinary network traffic models using Poisson distribution function; this is modelled better using M/Pareto distribution [6]. The Multimedia Traffic characteristic is its busty nature showing self-similarity. Poisson distribution and similar mathematical functions were used to model conventional network traffic. Applying this technique to multimedia traffic was a failure.

To decrease end to end delay and improve network throughput, this study proposes modifying OLSR using swarm intelligence, Hybrid Particle Swarm Optimization (HPSO) with Tabu Search. Simulations were carried out for Video Streamed Network Traffic and Multimedia Traffic with improved results being obtained over current methods.

II RELATED WORK

A Bee Swarm Intelligence simulated survey algorithm was proposed by Karaboga and Akay [7]. Bee Swarm's intelligent behavior inspired researchers to develop new algorithms. The work presents survey of algorithms based on Bee Swarm's Intelligence and its applications. Kumar and Singh [8] suggested routing optimization techniques using swarm intelligence introducing preliminary MANET studies, and a Routing Optimization technique inspired by Swarm Intelligence's (SI) biological concept.

Hybrid Tabu search (TS) and PSO were proposed to generate fuzzy controller with three rules proposed by Talbi and Belerbi [9]. The algorithm dynamically adjusts membership functions and Fuzzy Rules according to environments. PSO Algorithm calculates best solution and best neighbour by TS at every iteration and this minimizes iterations and computation time while ensuring accuracy and minimum response time. The algorithm was tested on the inverted pendulum's control angle. Integration of route life prediction algorithm and PSO algorithm to select reliable MANET routes was introduced by Priyadharshini and Rubini [10].

PSO being used for network centric localization purposes generates in-network navigational decisions, obviating centralized control and reduces congestion and delay. So, this approach is effective in MANETs involving node mobility, huge deployment and limited energy. Shirkande and Vatti [11] introduced a survey on various Ant Colony based Routing Algorithms for WSN and MANETs. The algorithms comparisons were based on performance metrics, pheromone function selects next node, simulator used and energy awareness. An algorithm representing improved TS and Enhanced PSO for accuracy was proposed by Khatibzadeh, et al., [12]. This method determined more speed and less accuracy using PSO. A Hybrid Intelligence TS-PSO based Algorithm designed by Xu, et al., [13] overcame PSO Algorithm in solving Combinatorial Optimization issues and avoided TS algorithm falling into local optimum, with an increase in convergence speed.

When Particle Swarm and TS Algorithms were combined, results showed that it had convergence accuracy and feasibility. Compared to traditional Scheduling Algorithm it embodies superiority. Hybrid approaches in network Optical Routing with QoS based on GA and PSO were suggested by Edward, et al., [14] showed performance to solve NP-Complete Routing issues.

III METHODOLOGY

This study, to lower end to end delay and improve network throughput, it is propose to modify OLSR using Swarm Intelligence, Hybrid PSO (HPSO) with Tabu Search Algorithm. Simulations for multimedia traffic and Video Streamed Network Traffic were carried out using OPNET Simulator.

A. PSO

James Kennedy and Russell Eberhart in 1995 introduced Particle Swarm Optimization (PSO), a Swarm based algorithm mimicking social behaviour of birds and fishes. An individual's success in these communities is affected only by its effort and by information shared by neighbours [15]. PSO is a Population based Stochastic Optimization technique, simulating the social behaviour of a swarm of birds, flocking bees or a school of fish. Through the Algorithm's Random initializing with candidate solutions, PSO results in a global Optimum achieved by an iterative procedure based on movement and intelligence in an Evolutionary System. Each potential solution in PSO is represented as a particle. Two properties (position x and velocity v, indicated in equations 1 and 2 given below) are associated with each particle. Suppose x and v of ith particle are given as

$$x = (x_{i1}, x_{i2}, ..., x_{iN}) \quad (1)$$

$$v = (v_{i1}, v_{i2}, ..., v_{iN}) \quad (2)$$

where N stands for problem's dimensions. In every iteration, a fitness function is evaluated for all Swarm Particles. Each particle's velocity is updated tracking two best positions [16]. The first one is the best position a particle has traversed and is called "pBest". The other is best position that a particle's neighbour has traversed till then. It is a neighbourhood best called "nBest". When a particle takes a whole population as neighbourhood, neighbourhood best becomes global best and is called "gBest". So a particle's velocity and position are updated as given in equations 3 and 4 indicated below:

$$v = \omega.v + c_1 r_1 (pBest - x) + c_2 r_2 (nBest - x) \quad (3)$$

$$x = x + v\Delta t \quad (4)$$

where ω is called the "*inertia weight*" controlling impact of previous velocity of particle on current one. Parameters c_1 and c_2 are positive constants, called "*acceleration coefficients*". Parameters r_1 and r_2 are random numbers uniformly distributed in interval [0,1]. Random numbers are updated when they occur. Parameter Δt stands for given time-step.

The particles population is moved according to (3) and (4), and tends to cluster from different directions. But, a maximum velocity vmax, should not be exceeded by a particle to keep search within solution space. PSO algorithm runs through these processes iteratively till the termination criterion is satisfied [17]. PSO component guides search to promising search space regions using iterative improvement methods to exploit them in HPSO. The latter's basis is gbest PSO Algorithm. Other variants can be selected and lead to different behaviour.

The Procedure for Hybrid PSO is given below:

Step 1: Initialization of parameters (particles)

Step 2: Arbitrarily set velocity and location of each particle.

Step 3: Calculate preliminary particles robustness. pbest of each particle is set to preliminary position. Preliminary best evaluation value among particles is set to gbest.

Step 4: Revolutionize particle's velocity and position.

Step 5: Select best particles.

Step 6: If particle location violates variable limit, set it to limit value.

Step 7: Compute new particles fitness. If fitness of each character is better than earlier pbest current value is set to pbest value. If best pbest is better than gbest, value is set to gbest.

Step 8: The algorithm repeats step 4 to step 7 waiting till meeting criteria is met, usually through a good fitness or greatest quantity of iterations [18].

The Hybrid Particle Swarm Optimization Flowchart is shown in Figure 1 below.

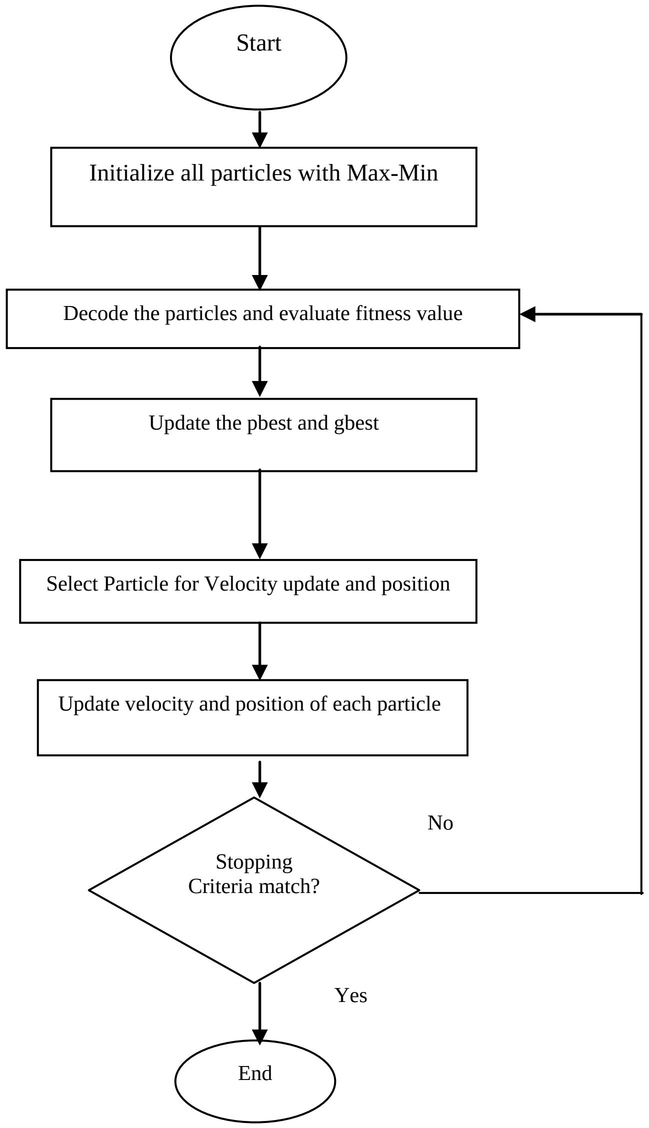

Figure 1 : Flowchart of Hybrid Particle Swarm Optimization

B. Tabu Search Algorithm (TSA)

Fred Glover proposed Tabu Search (TS) to solve combinatorial optimization issues. TS constraints search by classifying certain moves as forbidden and frees the search by a short-term memory. Tabu search uses local or neighbourhood search procedure to repetitively move from a solution x to neighbourhood of x, till stopping criterion is satisfied. In this study, ants use Tabu list concept to memorize misbehaving nodes [19]. The Tabu Search Flowchart is given in Figure 2 below.

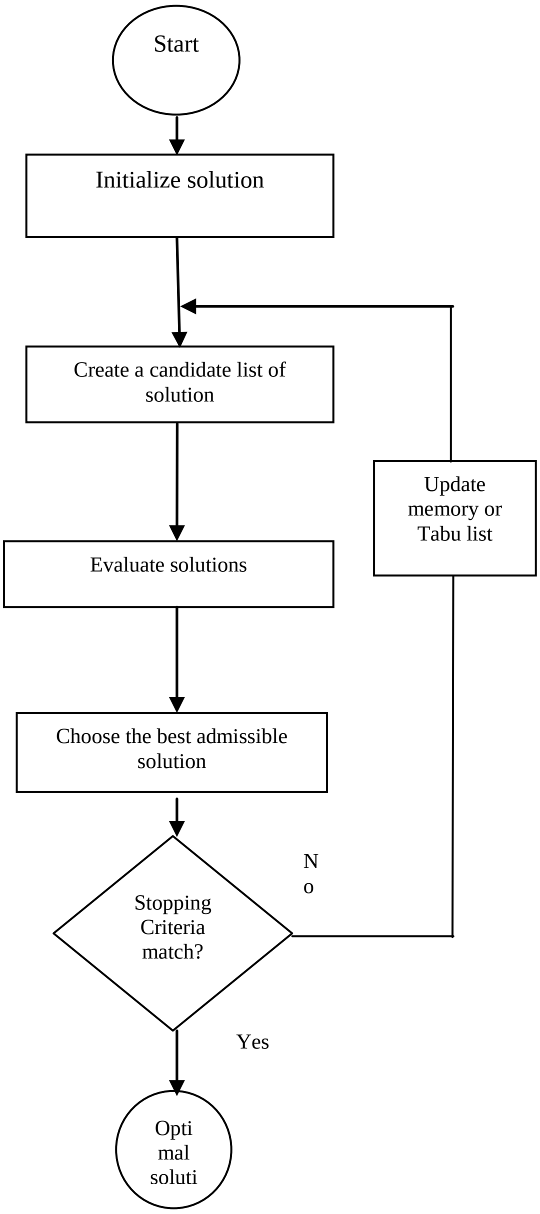

Figure 2 Flowchart of Tabu Search Algorithm

IV SIMULATION AND RESULTS

The simulation setup using OPNET Modeller consists of 20 nodes. The nodes are spread over 2000 meter by 2000 meter with the trajectory of each node being at random. Each node runs a Multimedia application over UDP. The data rate of each node is 11 Mbps with a transmit power of 0.005 Watts. The simulations are carried out for 400 sec. The results obtained by the proposed methods are as follows. Figures 3 - 6 show the Jitter time average in second, Time average of Data dropped in bits per second, Time average of end to end delay in second and Time average of throughput in bits/sec.

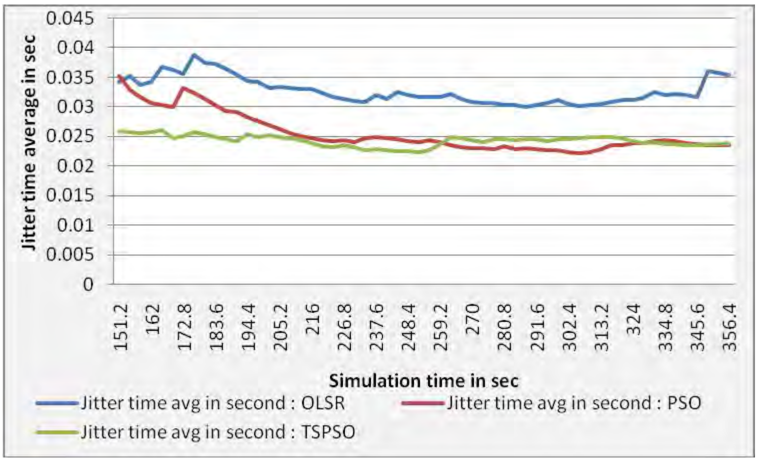

Figure 3: Jitter time average in seconds

Figure 3 given shows the jitter time average obtained by using OLSR, PSO and Tabu Search PSO (TSPSO). There is a decrease in the average jitter time in seconds for the proposed TSPSO search. When compared to the traditional OLSR there is a decrease of 25.83 % and a decrease of 3.45 % using PSO algorithm.

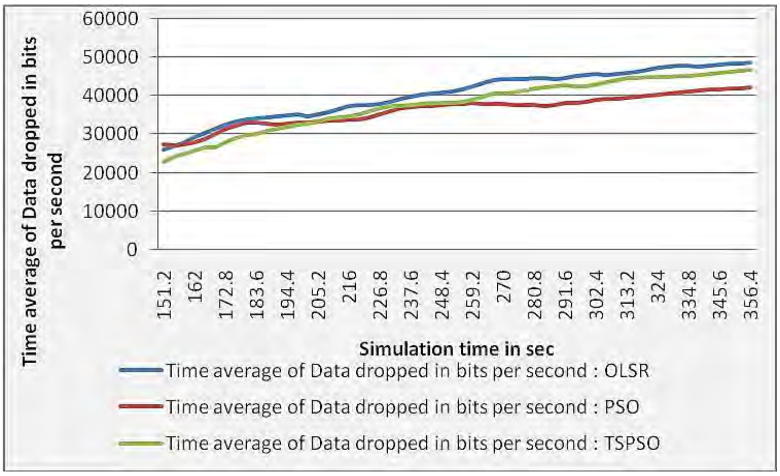

Figure 4: Time average of data dropped in bits per second

Figure 4 shows the time average of data dropped bits per second obtained using OLSR, PSO and Tabu Search PSO (TSPSO). There is a decrease in the time average of data dropped bits per second for the proposed TSPSO search. When compared to the traditional OLSR Algorithm, there is a decrease of 25.76 % and a decrease of 3.22 % using PSO Algorithm

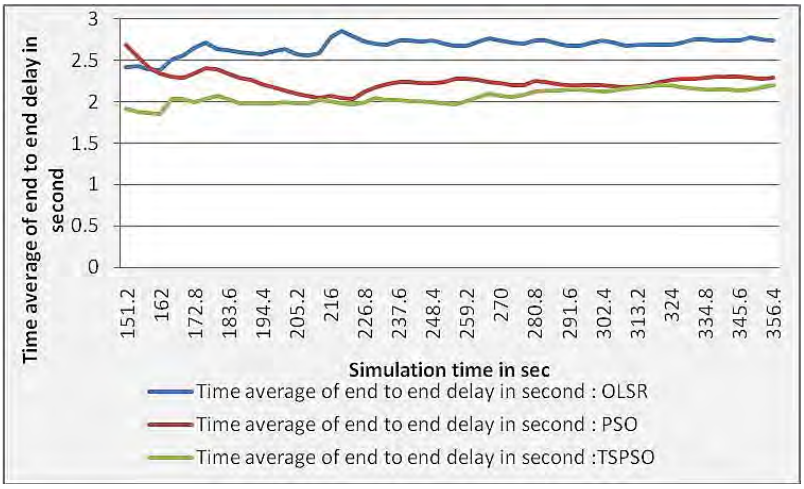

Figure 5: Time average of end to end delay in second

Figure 5 shows the time average of end to end delay in seconds obtained using OLSR, PSO and Tabu Search PSO (TSPSO). There is a decrease in the time average of end to end delay for the proposed TSPSO search. When compared to the traditional OLSR Algorithm, there is a decrease of 25.63 % and a decrease of 2.91 % using PSO Algorithm.

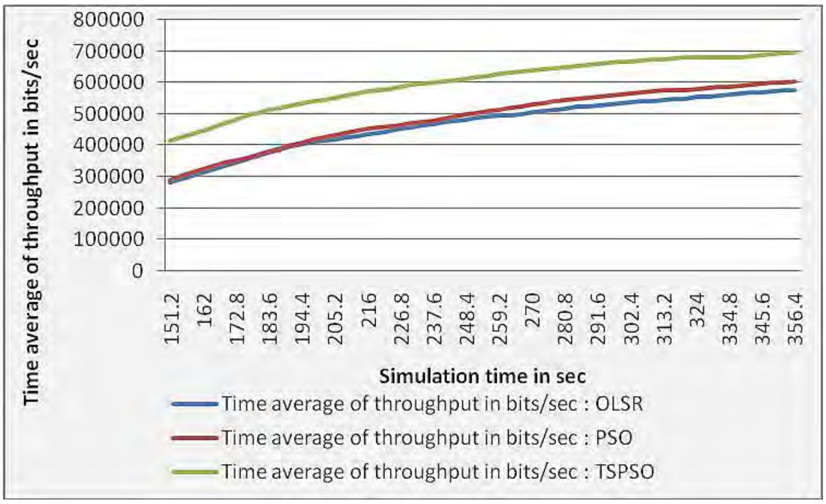

Figure 6: Time average of throughput in bits / sec.

Figure 6 shows the time average of throughput in seconds obtained using OLSR, PSO and Tabu Search PSO (TSPSO). There is an increase in throughput for the proposed TSPSO search. When compared to the traditional OLSR Algorithm, there is an increase of 34.32 % and a increase of 31.32 % using PSO Algorithm is used.

V CONCLUSION

This study evaluates the OLSR performance using Swarm Intelligence and HPSO with Tabu Search Algorithm (TSPSO). The jitter time, data drop and end to end delay are lowered and the throughput of the network is improved. Simulations were carried out for multimedia and video streamed traffic. The results obtained using the TSPSO method show that when compared to the traditional OLSR, there is a decrease of 25.83 % in jitter time, 25.76% in data drop, 25.63 % in end to end delay. However there is a decrease in only 3.45 % in jitter time, 3.22 % in data drop and 2.91 % in end to end delay when PSO Algorithm is used. Also it is observed that when compared to the traditional OLSR there is an increase of 34.32 % in throughput obtained by TSPSO method and increase of 31.32 % when PSO Algorithm is used. Thus the efficiency of the proposed method is increased.

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