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Evaluation of Performance of OLSR Protocol using Swarm Intelligence and Hybrid PSO with Gravitational Search Algorithm, Invasive Weed Search and Local Search Techniques

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***Abstract:** Mobile nodes of a wireless network move at arbitrary locations and are interconnected using routing protocols. A large number of routing protocols have been developed. There is no optimal protocol which gives the best performance in all network contexts. OLSR protocol is an optimization version of a pure link state protocol where the topological changes cause the flooding of information to all available hosts in the network. This study proposes to evaluate the performance of OLSR using swarm intelligence and hybrid PSO with gravitational search algorithm, invasive weed search and local search to lower the end to end delay and to improve the PDR and number of TC Packets. The simulations were carried out using OPNET simulator, which includes 20 nodes which 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 run for 400 seconds. The PSO - local search shows better PDR compared PSO - Invasive weed search and PSO - gravitational search. From the three hybrid techniques studied, it is observed that PSO - gravitational search is ideally suitable for networks with low delay tolerance and the performance of PSO - invasive weed optimization is better with PDR as the main Quality of Service (QoS) metric*

***Keywords:** OLSR protocol, Swarm Intelligence, Hybrid PSO, Gravitational Search Algorithm, Invasive Weed Search, Quality of Service (QoS)*

I. INTRODUCTION

OLSR is an optimization version of a pure link state protocol. The topological changes cause the flooding of information to all available hosts in the network. To reduce the possible overhead in the network, the protocol uses Multipoint Relays (MPRs). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network. OLSR uses two kinds of the control messages namely hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbours. With the hello message the MPR selector set is constructed which describes which neighbours have chosen this host to act as MPR. From this information the host can calculate its own set of MPRs. The hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbors which includes at least the MPR selector list. The TC messages are broadcasted periodically and only the MPR hosts forward the TC messages (Huhtonen 2004).

On the basis of this information, each node independently selects its own set of multipoint relays among its one hop neighbors in such a way all two hop neighbors of the node m have symmetric links with MPR. This shows that the multipoint relays cover (in terms of radio range) all two hop neighbors. The multipoint relay set is computed whenever a change in the one hop or two hop neighborhood is detected. In addition, each node m maintains its "MPR selector set". This set contains the nodes which have selected m as a multipoint relay. Node m only forwards broadcast messages received from one of its MPR selectors (Laouiti et al 2004).

Particle Swarm Optimization (Gharghory 2011) is a derivative-free and flexible optimizer replicating bird flocking for various optimization problems. It is effortless and easy to realize compared to other computation intelligence techniques. It is inspired by evolution and is a research hot spot. Though PSO has high convergence speed, literature survey reveals that it finds difficult to jump out of local optima when it falls into minima. Many approaches were introduced in literature to improve PSO performance, by merging it with other evolutionary computation techniques. Hybrid PSO, (HPSO) merged a mutation operator and natural selection to solve premature convergence. By introducing roulette wheel selection based Cauchy mutation and evolutionary selection, HPSO reduces local optimum trap probability. Gravitational Search Algorithm (GSA) is a class of optimization algorithm based on the law of gravity and mass interactions. The principle is based on Newtonian gravity which states that every particle attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. Invasive Weed Optimization (IWO) (Hajimirsadeghi et al 2009), a bio inspired numerical stochastic optimization algorithm, simulates natural weed behavior in colonizing and finding place for growth/reproduction. Some properties of IWO when compared to other evolutionary algorithms are reproduction method, spatial dispersal, and competitive exclusion. IWO process starts with initializing a population. A population of initial solutions is generated randomly in the solution space. Then population members produce seeds based on comparative fitness in the population. The seed number for each member varies linearly between Smin for worst member and Smax for best member. Seeds are randomly scattered in the search space by distributed random numbers with mean equal to zero and adaptive standard deviation. Incorporating IWO reproduction / spatial dispersal, enhances the latter's exploration and exploitation in addition to being well balanced (Zhao et al 2013). IWO achieves better OLSR performance.

II. HYBRID PSO

In HPSO, PSO component guides search to promising regions of the search space using iterative improvement methods to exploit such regions. HPSO's basis is gbest PSO algorithm. Other variants could have been selected and led to different behaviour. The inertia weight is given in Equation (1) indicated below:

$$w(t) = (1 - g(t))^{w_e} . (w_{initial} - w_{final}) + w_{final} \quad (1)$$

At iteration t, where g(t) returns many in the range [0;1] and $w_e; w_{initial}; w_{final} \in$ R are constants. The function g(t) returns 0 at search start and increases each iteration till it reaches 1 at search end. The constant $w_{initial};$ is the initial value of inertia weight and w_{final} desired value of inertia weight at the end of the search process. If a linear varying inertia weight is desired, it is set to 1. A constant inertia weight is obtained if $w_{initial}$ and w_{final} are equal. The convergence criterion is also important for the new algorithm.

Here, it is met for n-dimensional objective function f, if $d_{\max} = d_{domain<0:001,\text{ where }} d_{\max} \in R + is$ the maximal Euclidean distance to x * over current particles positions. The value $d_{domain} = \sqrt{n(b_u - b_l)^2}$ is the length of the search space diameter. NMS and PDS are used as iterative improvement methods, respectively (Gimmler et al 2006).

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

III. METHODOLOGY

PSO is a searching method based on the sociological behavior of bird flocking developed in 1995. The PSO based algorithm is trouble-free for implementation and it successfully solves various optimization problems in many application fields (Zhang 2012). PSO is a technique to maximize objectives to locate parameters by exploring a given problem's search space. Figure 1 gives the flowchart for the proposed methodology.

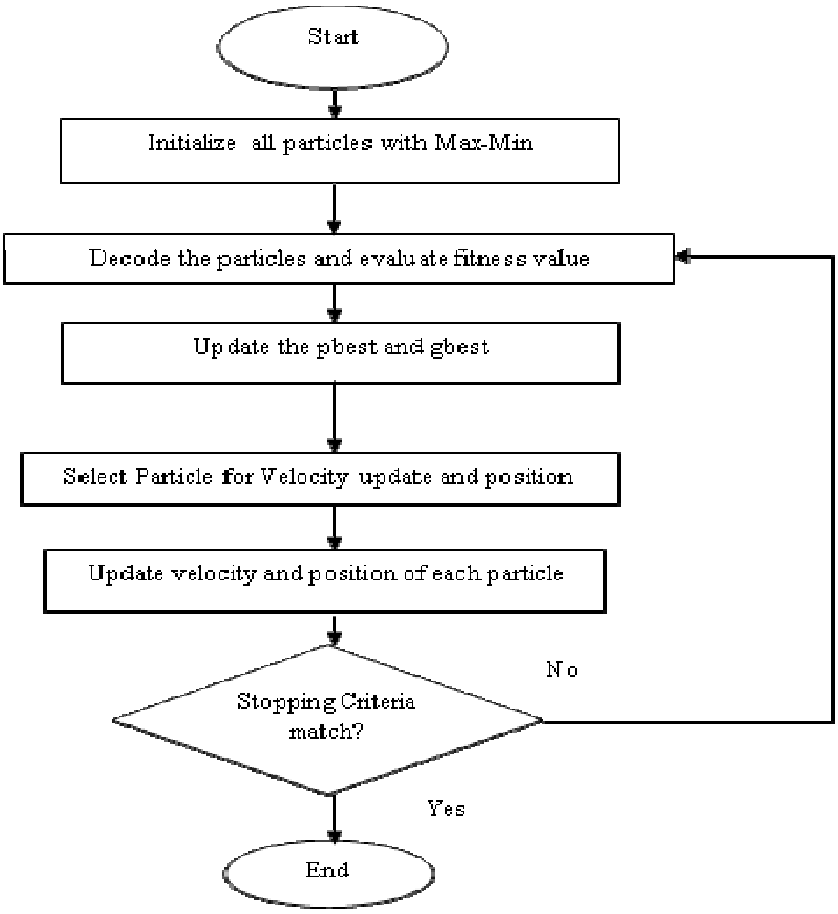

Figure 1 Flow chart for the proposed methodology

IV. Simulation Study And Results

The simulation is carried out using OPNET Simulator Ver. 14.0, which includes 20 nodes which 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 run for 400 seconds.

a) For Multimedia Traffic with FIFO

Multimedia traffic with first in first out queuing model is given below. The packet delivery ratio for multimedia traffic with FIFO is measured for hello intervals 1,2,3,4 and 5 seconds for mobility speeds 0, 5, 10, 15 and 20 m/sec. The data collected for PDR are shown in the table 1. The data in Table 1 is transformed to a graph and is shown in Figure 2.

Table 1 PDR for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	0.9163	0.9332	0.9431
5	0.9114	0.9041	0.9339
10	0.8965	0.8606	0.8681
15	0.8984	0.8672	0.8664
20	0.8272	0.8357	0.8425

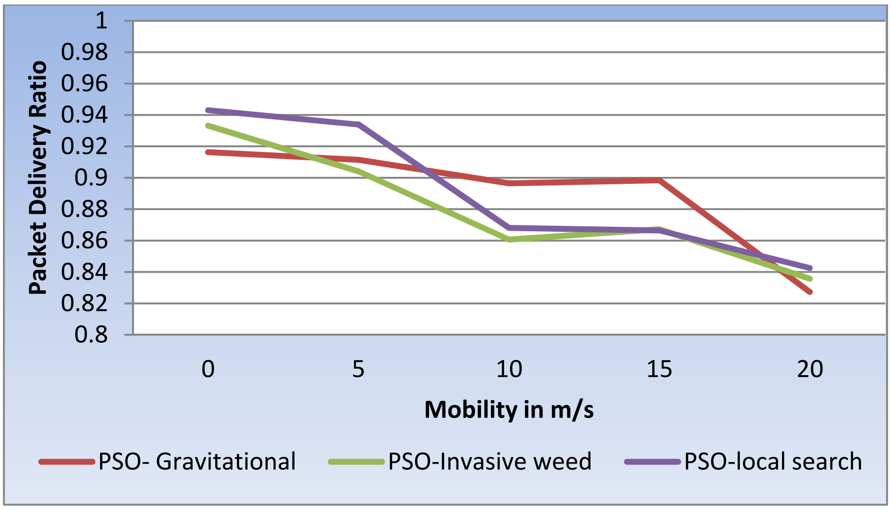

Figure 2 PDR for multimedia traffic

Figure 2 shows different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. The PSO - local search shows better PDR compared PSO - invasive weed search and PSO - gravitational search. At mobility speed of 5 m/s PSO - local search gives 2.40 % higher PDR compared to PSO - gravitational search and 3.19 % higher PDR compared to PSO - invasive weed search. At mobility speed of 20 m/s PSO - local search gives 1.81 % higher PDR compared to PSO - gravitational search and 0.80 % higher PDR compared PSO - invasive weed search.

Table 2 End to end delay for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	9.9386	10.1743	9.921
5	11.7221	12.0545	13.021
10	12.9486	13.4541	15.9152
15	13.9535	15.2781	16.191
20	16.7458	17.5318	18.5843

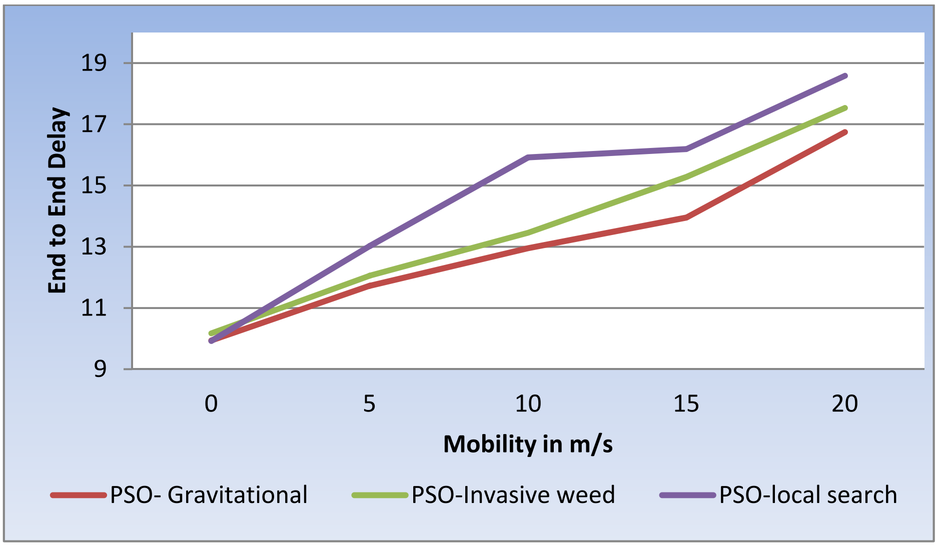

Figure 3 End to end delay for multimedia traffic

The contents of Table 2 are graphically represented and is shown in Figure 3. It shows the end to end delay for multimedia traffic using FIFO for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. The PSO gravitational search, at mobility speed of 5 m/s, shows a decrease of 2.75 % in end to end delay compared to PSO - invasive weed search. Also there is a 9.97 % decrease in end to end delay compared to PSO - local search. Using PSO - gravitational search, at mobility speed of 20 m/s, there is a decrease in end to end delay of 4.48 % compared to PSO - invasive weed search. Also there is a 9.89 % decrease in end to end delay compared to PSO - local search.

Table 3 Jitter for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	1.0597	1.0263	1.1323
5	1.2001	1.3761	1.4772
10	1.229	1.2093	1.2318
15	1.3058	1.0244	1.3329
20	1.555	1.2247	1.137

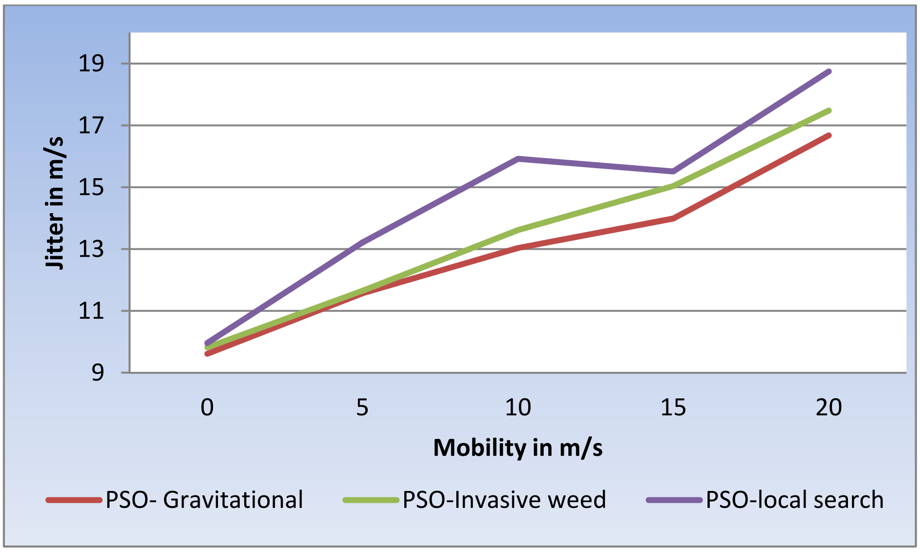

Figure 4 Jitter for multimedia traffic

The contents of Table 3 are graphically represented and is shown in Figure 6.4. It shows the jitter for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. Using PSO -

gravitational search, at mobility speed of 5 m/s there is a decrease of 12.78 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 18.75 % in jitter compared to PSO - local search. Using PSO - gravitational search, at mobility speed of 15 m/s, there is an increase of 21.55 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 2.03 % in jitter compared to PSO - local search.

Table 4 No. of TC packets for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	350	310	282
5	457	444	393
10	476	459	442
15	486	479	467
20	542	500	518

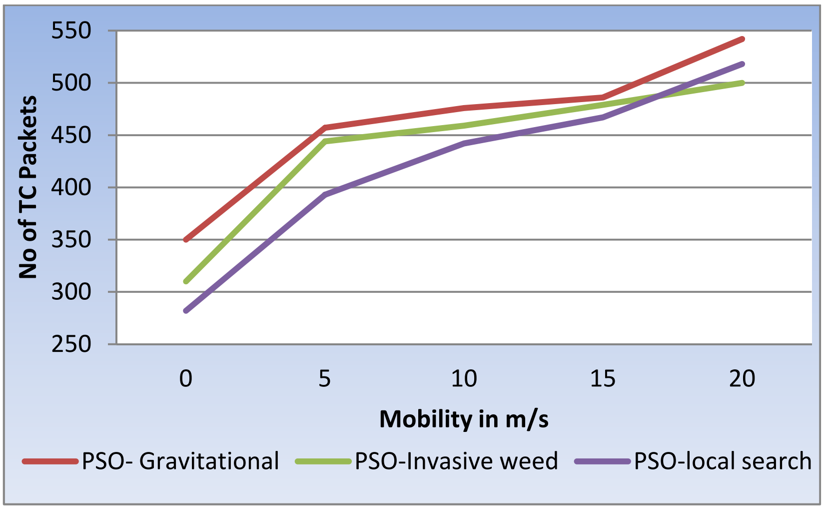

Figure 5 No. of TC packets for multimedia traffic

The contents of Table 4 are graphically represented and is shown in Figure 5. It shows the number of TC packets for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. Using PSO - local search, at mobility speed of 5 m/s there is a decrease of 14.00 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 11.48 % in number of TC packets compared to PSO - invasive weed search. Using PSO - local search, at mobility speed of 15 m/s, there is a decrease of 3.90 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 2.50 % in number of TC packets compared to PSO - invasive weed search.

b) For Multimedia Traffic with WFQ

Multimedia traffic with WFQ queuing model is given below. The packet delivery ratio for multimedia traffic with WFQ is measured for hello intervals 1,2,3,4 and 5 seconds for mobility speeds 0, 5, 10, 15 and 20 m/sec. The data collected are shown in the Table 5. It is transformed to a graph and is shown in Figure 6.

Table 5 PDR for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	0.9463	0.9445	0.9598
5	0.9304	0.9114	0.9237
10	0.9024	0.8677	0.8501
15	0.9037	0.8595	0.8297
20	0.8349	0.8215	0.8002

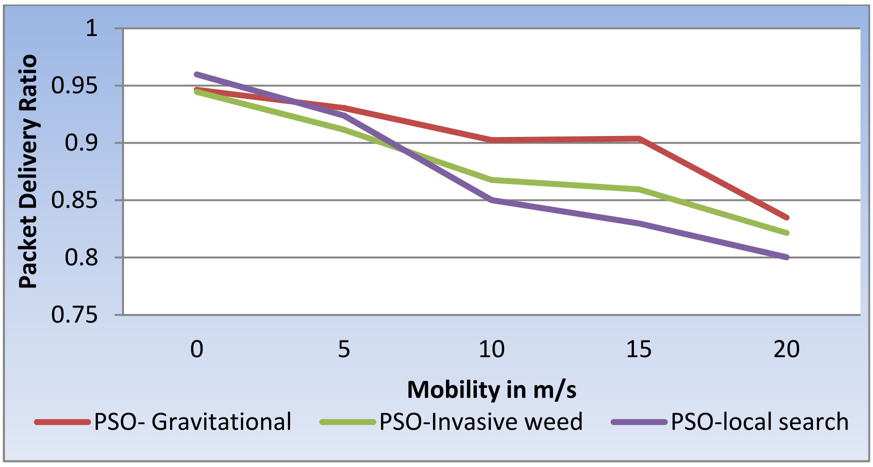

Figure 6 PDR for multimedia traffic

Figure 6 shows the PDR for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. Using PSO - gravitational search, at mobility is 5 m/s there is an increase of 2.04 % in PDR compared to PSO - invasive weed search. Also there is an increase of 0.72 % in PDR compared to PSO - local search. Using PSO - gravitational search, at mobility speed of 20 m/s there is an increase of 1.60 % in PDR compared to PSO - invasive weed search. Also there is an increase of 4.15 % in PDR compared to PSO - local search.

Table 6 End to end delay for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	9.6127	9.8218	9.9611
5	11.5727	11.653	13.2138
10	13.0343	13.6149	15.9221
15	13.9881	15.0391	15.5092
20	16.6767	17.479	18.7445

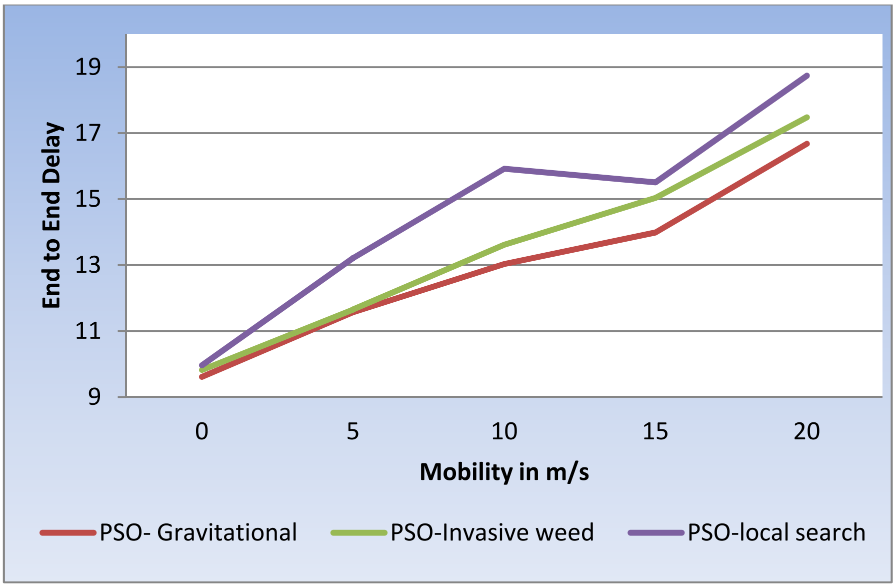

Figure 7 End to end delay for multimedia traffic

The contents of table 6 are graphically represented and is shown in Figure 7. It shows the end to end for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. Using PSO - gravitational search, at mobility speed of 5 m/s there is decrease of 0.68 % in end to end delay compared to PSO - invasive weed search. Also there is decrease of 12.41 % end to end delay compared to PSO - local search. Using PSO - gravitational search, at mobility speed of 20 m/s there is decrease of 6.98 % in end to end delay compared to PSO - invasive weed search. Also there is decrease of 9.80% in end to end delay compared to PSO - local search.

Table 7 Jitter for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	1.0371	0.9761	1.0912
5	1.1901	1.3506	1.4033
10	1.2314	1.1644	1.1735
15	1.2797	0.9916	1.3089
20	1.5099	1.1646	1.1208

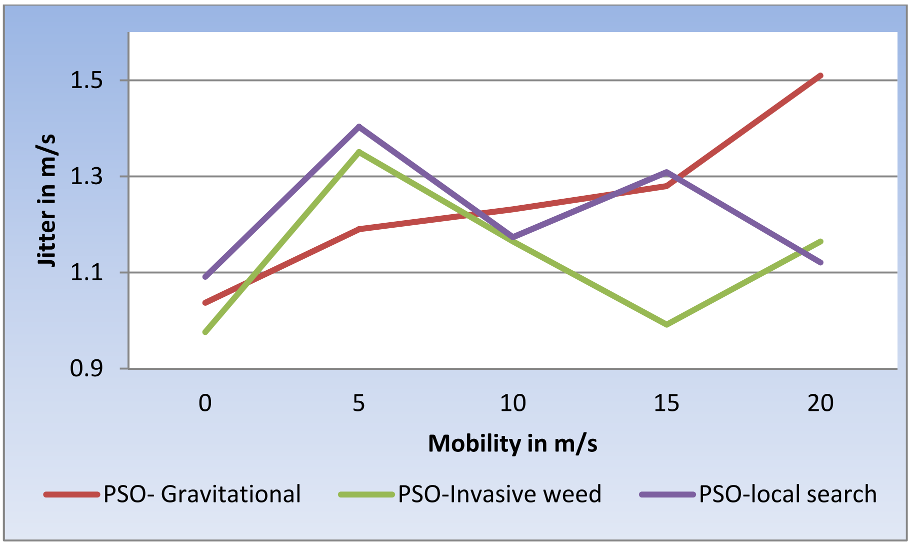

Figure 8 Jitter for multimedia traffic

The contents of Table 7 are graphically represented and is shown in Figure 6.8. It shows the jitter for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. Using PSO - gravitational search, at mobility speed of 5 m/s there is a decrease of 11.88 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 15.19 % in jitter compared to PSO - local search. Using PSO - gravitational search, at mobility of 15 m/s there is an increase of 22.51 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 2.23 % in jitter compared to PSO - local search.

Table 8 No. of TC packets for multimedia traffic

m/s	PSO- Gravitational	PSO-Invasive weed	PSO-local search
0	338	309	280
5	436	426	395
10	457	452	444
15	468	463	463
20	534	508	499

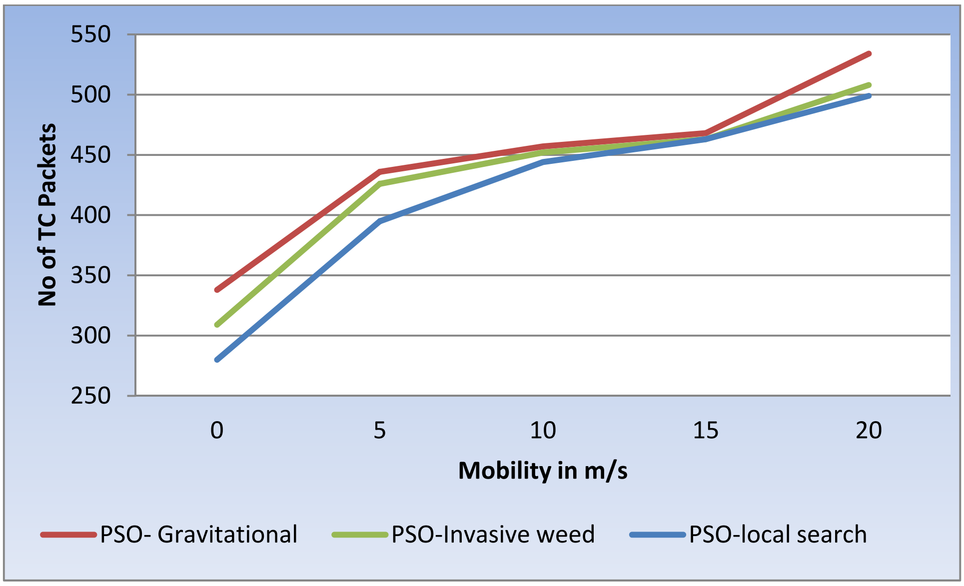

Figure 9 No. of TC packets for multimedia traffic

The contents of Table 8 are graphically represented and is shown in Figure 9. It shows the number of TC packets for different hybrid techniques using PSO namely PSO - gravitational search, PSO - invasive weed search and PSO - local search. The PSO-local search, at mobility speed of 5 m/s shows a decrease of 9.40 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 7.27 % in number of TC packets compared to PSO - invasive weed search. The PSO - local search, at mobility speed of 20 m/s shows a decrease of 6.55 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 1.77 % in number of TC packets compared to PSO - invasive weed search.

V. Conclusion

1. This study proposes to evaluate the performance of OLSR using swarm intelligence and hybrid PSO with gravitational search algorithm, invasive weed search and local search to lower the end to end delay and to improve the PDR and number of TC Packets. Simulations were carried out for multimedia traffic with FIFO and WFQ in the network.

2. Multimedia traffic using FIFO for different hybrid techniques such as PSO - gravitational search, PSO - invasive weed search and PSO - local search are studied. The PSO - local search shows better PDR compared PSO - Invasive weed search and PSO - gravitational search. At mobility speed of 5 m/s PSO - local search gives 2.40 % higher PDR compared to PSO - gravitational search and 3.19 % higher PDR compared to PSO - invasive weed search. At mobility speed of 20 m/s PSO - local search gives 1.81 % higher PDR compared to PSO - gravitational search and 0.80 % higher PDR compared PSO- invasive weed search.

3. Multimedia traffic using WFQ for PSO - gravitational search, at mobility of 5 m/s shows an increase of 2.04 % in PDR compared to PSO - invasive weed search. Also there is an increase of 0.72 % in PDR compared to PSO - local search. PSO - gravitational search, at mobility speed of 20 m/s shows an increase of 1.60 % in PDR compared to PSO - invasive weed search. Also there is an increase of 4.15 % in PDR compared to PSO - local search.

4. Multimedia traffic using FIFO for end to end delay, PSO gravitational search, at mobility speed of 5 m/s, shows a decrease of 2.75 % in end to end delay compared to PSO - invasive weed search. Also there is a 9.97 % decrease in end to end delay compared to PSO - local search. Using PSO - gravitational search, at mobility speed of 20 m/s, there is a decrease in end to end delay of 4.48 % compared to PSO - invasive weed search. Also there is a 9.89 % decrease in end to end delay compared to PSO - local search.

5. Multimedia traffic using WFQ for end to end delay, PSO - gravitational search, at mobility speed of 5 m/s shows a decrease of 0.68 % in end to end delay compared to PSO - invasive weed search. Also there is a decrease of 12.41 % in end to

end delay compared to PSO - local search. PSO - gravitational search, at mobility speed of 20 m/s shows a decrease of 6.98 % in end to end delay compared to PSO - invasive weed search. Also there is decrease of 9.80 % in end to end delay compared to PSO - local search.

6. Multimedia traffic using FIFO for jitter, PSO - gravitational search, at mobility speed of 5 m/s shows a decrease of 12.78 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 18.75 % in jitter compared to PSO - local search. PSO - gravitational search, at mobility speed of 15 m/s, shows an increase of 21.55 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 2.03 % in jitter compared to PSO - local search.

7. Multimedia traffic using WFQ for jitter, PSO - gravitational search, at mobility speed of 5 m/s shows a decrease of 11.88 % in jitter compared to PSO - invasive weed search. Also there is a decrease of 15.19 % in jitter compared to than PSO - local search. PSO - gravitational search, at mobility of 15 m/s there is an increase of 2.51% in jitter compared to PSO - invasive weed search. Also there is a decrease of 2.23 % in jitter compared to PSO - local search.

8. Multimedia traffic using FIFO for number of TC packets is studied. PSO - local search, at mobility speed of 5 m/s shows a decrease of 14.00 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 11.48 % in number of TC packets compared to PSO - invasive weed search. PSO - local search, at mobility speed of 15 m/s, shows a decrease of 3.90 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 2.50 % in number of TC packets compared to PSO - invasive weed search.

9. Multimedia traffic using WFQ for number of TC packets is studied. The PSO - local search, at mobility speed of 5 m/s shows a decrease of 9.40 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 7.27 % in number of TC packets compared to PSO - invasive weed search. The PSO - local search, at mobility speed of 20 m/s shows a decrease of 6.55 % in number of TC packets compared to PSO - gravitational search. Also there is a decrease of 1.77 % in number of TC packets compared to PSO - invasive weed search.

10. From the three hybrid techniques studied, it is observed that PSO - gravitational search is ideally suitable for networks with low delay tolerance and the performance of PSO - invasive weed optimization is better with PDR as the main QoS metric.

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