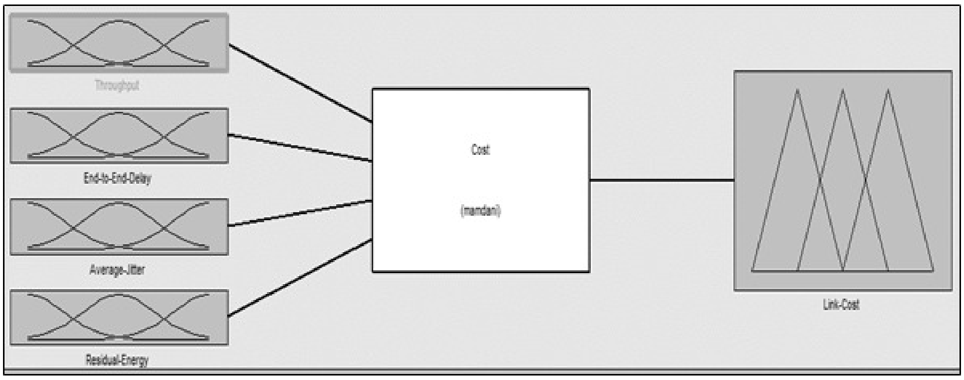

Fig. 1. Architecture of Fuzzy based Integrated Link Cost

Table 1. Architectural details of various Client WMN Scenarios

No. of Nodes	Radio Range	Area(mm)	Time Constraints
500	100	1000 × 1000	0.2,0.4,0.6,0.8,1.0,1.2,1.4,1.6,1.8,2.0
1000	100	1000 × 1000	1.0,1.2,1.4,1.6,1.8,2.0,2.2,2.4,2.6,2.8
1500	150	2000 × 2000	1.6,1.8,2.0,2.2,2.4,2.6,2.8,3.0,3.2,3.4
2000	150	2000 × 2000	1.6,2.0,2.5,3.0,3.5,4.0,4.5,5.0,5.5,6.0

nodes network scenarios. So, We conducted 200 trials for each network node archticture. In total, we conducted 800 trials to evaluate and compare the performance of all six implemented algorithms.

4.1 Comparative Performance of 500 node Client WMNs

Table 2 shows the comparative performances of all implemented algorithms on different time constraints. From Table 2 we observe that the Butterfly optimization algorithm outperforms other in terms of minimum cost path as compared to ACO,DSR, AODV, BAT and BBO within the stipulated time. ACO and DSR approach failed to produce any result for all the time constraints. AODV does not discover a route for 0.2,1.6, and 2.0 seconds while for 0.4-time constraint, it gives minimum route cost 6 times but also failed 5 time to produce the results.For 0.6 time constraint it gives minimum route cost 8 times including 12 times failure for route discovery. Similarly, for 0.8,1.0, and 1.2 seconds it generates 7,12, and 9 times optimal paths with 3,7 and 4-time failure, respectively. As shown in the table for time constraints 1.4 and 1.8 seconds, the AODV approach generates the minimal cost path 6 and 4 times without any failure. BAT algorithm for the 1.2,1.4,1.8 timing constraints successfully discovered the route but did not produce the minimum core route. The BBO based approach discovered the routes in the given time constraints

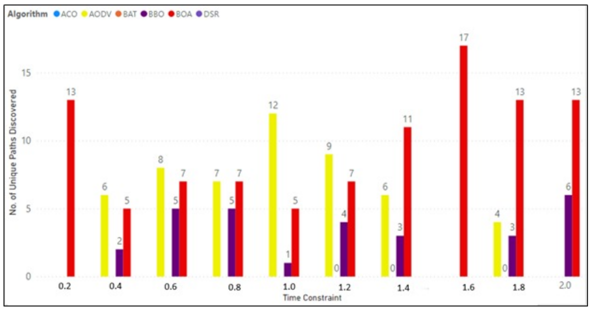

Fig. 2. Comparative performance of 500 node client WMN

but did not obtain the optimized route path in any timing constraint. It is observed from the table that Butterfly Optimization Algorithm(BOA) outperformed other approaches as it produces a minimum route path 13 times for 0.2,1.8, and 2.0 seconds. It finds the better minimal route path for other remaining timing constraints compared to ACO,AODV,BAT and BBO algorithms, including the same best performance in other given time constraints. Figure 2 shows the graphical representation of the best performance in each timing constraint.

4.2 Comparative Performance of 1000 node Client WMNs

To assess all implemented six approaches on 1000 node scenarios, We considered ten different timing constraints and conducted 20 trials in each

Table 2. Performance of 500 Node Client Network

	Time Constant									
Algorithm	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2
ACO	-	-	-	-	-	-	-	-	-	-
AODV	-	6 + 5 FAIL	8 + 12 FAIL	7 + 3 FAIL	12 + 7 FAIL	9 + 4 FAIL	6	-	4	-
BAT	G	G	A	A	B	0	0	C	0	A
BBO	G	2+G	5	5 + A	1+B	4	3	C	3	6 + A
BOA	13+G	5+G	7+A	7 + A	5+B	7	11	17+C	13	13 + A
DSR	-	-	-	-	-	-	-	-	-	-

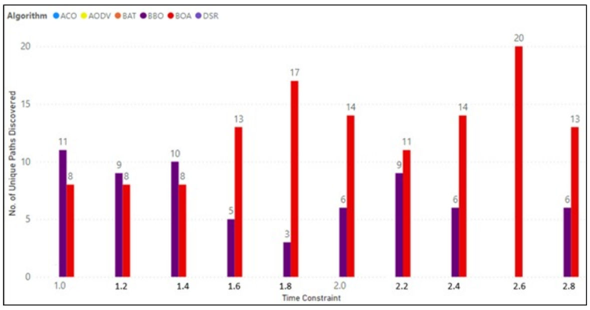

Fig. 3. Comparative performance of 1000 node client WMN

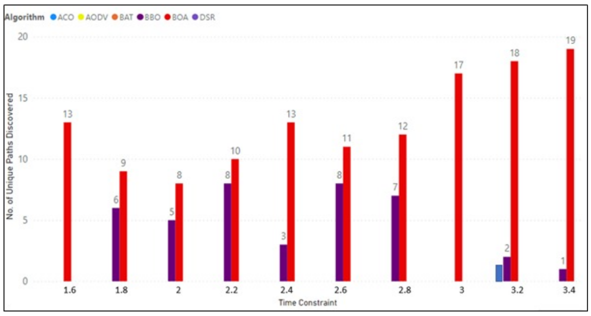

Fig. 4. Comparative performance of 1500 node client WMN's

timing constraint. The simulation results are shown in Table 3 and Figure 3. The results indicate that the Butterfly Optimization approach gives higher performance for most of the given time constraints than other defined approaches. For total number of 200 trials, BOA produced minimum cost path 113 times, BBO 65 times, and BAT in 1.0 and 2.8 seconds time constraints produced equal best results once, for 1.4 and 1.6 seconds it generated twice equal best results and in 1.2 seconds shared thrice equal best results with BBO and BOA.In the remaining seconds BAT discovered the route but did not find minimal cost path.

4.3 Comparative Performance of 1500 node Client WMNs

Table 4 and Figure 4 show the comparative performance of AODV, BAT, DSR, BBO, ACO, and BOA with higher time constraints 1.6,1.8,2.0,2.4,2.8,3.0,3.2 and 3.4 seconds for 1500 nodes architecture. We observe that in the given time constraint, BOA performed better as compared to other algorithms. In the 1500 dynamic nodes architecture, ACO, DSR, and AODV could not discover or generate any route in any timing constraints. BAT and BBO produced equal best routes for stimulated time. For 3.2 and 3.4 seconds, BAT discovered a route but failed to obtain the minimum cost path, whereas, for the same time constraints, BBO discovered optimal routes twice and once. In total, BOA in total 200 trails produced a minimum route cost path 130 times than BBO, which discovered path 40 times.

4.4 Comparative Performance of 2000 node Client WMN's

To evaluate and compare the performance of 6 algorithms in 2000 node Client Wireless Mesh Network, out of 800 trials(10 timing set * 20 trials per set), BOA discovered a minimal cost path 150 times along with an equal best performance with BAT and BBO in some time constraints. Table 5 and Fig.5 show the comparative performance of all the six approaches for the higher time. The performance of AODV, BAT, BBO, Butterfly optimizations for 2000 node points are compared. Table 5 and Fig. 5 indicate that the Butterfly Optimization algorithm shows a good agreement regarding the minimum cost path compared to DSR, ACO, AODV, BAT, and BBO within the stipulated time. It may be noted that the results of Butterfly's effec-

Table 3. Performance of 1000 Node Client Network

	Time Constant									
Algorithm	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8
ACO	-	-	-	-	-	-	-	-	-	-
AODV	-	-	-	-	-	-	-	-	-	-
BAT	A	C	B	B	0	0	0	0	0	A
BBO	11 + A	9 + C	10 + B	5 + B	3	6	9	6	0	6+A
BOA	8 + A	8 + C	8 + B	13 + B	17	14	11	14	20	13+A
DSR	-	-	-	-	-	-	-	-	-	-

- represents route not discovered 0 represent no minimal cost A=1, B=2, C=3, D=4, E=5, F=6 and G=7

Table 4. Performance of 1500 Node Client Network

	Time Constraint									
Algorithm	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4
ACO	-	-	-	-	-	-	-	-	-	-
AODV	-	-	-	-	-	-	-	-	-	-
BAT	G	E	G	B	D	A	A	C	0	0
BBO	G	6+E	5+G	8+B	3+D	8+A	7+A	C	2	1
BOA	13+G	09+E	08+G	10+B	13+D	11+A	12+A	17+C	18	19
DSR	-	-	-	-	-	-	-	-	-	-

- represents route not discovered 0 represent no minimal cost A=1, B=2, C=3, D=4, E=5, F=6 and G=7

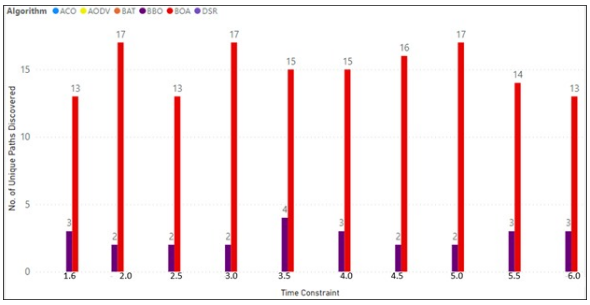

Fig. 5. Comparative performance of 2000 node client WMN's

tiveness methods are well consistent with other algorithms in the specified time limit. Here the time constraint is higher than the previous node scenarios. ACO, AODV, and DSR did not perform the given time constraints.

4.5 Overall Comparative performance of all the networks

To compare the performance of 6 algorithms, we have conducted 800 trials. There are various timing limitations for each different network dynamic node architecture. As shown in Table 6 and Figure 6, Out of 800 total trials, the Butterfly Optimization algorithm produced 504 times optimal cost path, BBO produced 160 times, and AODV produced

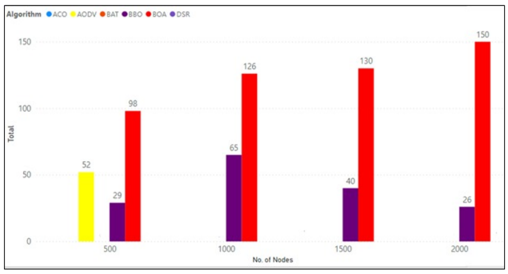

Fig. 6. Comparative performance of all approaches

52 times in total. Multiple algorithms have given the same best performance 56 times. The findings show that the suggested BOA method outperforms the other implemented five available approaches.

5. Conclusion

In this paper we propose, a new BOA routing-based technique for dynamic shortest route evaluation in WMNs. We implemented the proposed approach along with 5 other namely ACO,DSR,BBO,BAT and AODV routing approaches in MATLAB for different time constraint and node scenarios. The performance was compared based on minimal cost path evaluation parameter. BOA based Routing Approach for Wireless Mesh Network's outperformed all the other approaches in all the client node network scenario i.e 500,1000,1500

Table 5. Performance of 1500 Node Client Network

	Time Constraint									
Algorithm	1.6	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
ACO	-	-	-	-	-	-	-	-	-	-
AODV	-	-	-	-	-	-	-	-	-	-
BAT	D	A	E	A	A	B	B	A	C	D
BBO	3+D	2+A	2+E	2+A	4+A	3+B	2+B	2+A	3+C	3+D
BOA	13+D	17+A	13+E	17+A	15+A	15+B	16+B	17+A	14+C	13+D
DSR	-	-	-	-	-	-	-	-	-	-

Table 6. Performance of 1500 Node Client Network

Number of nodes	No. of trial	ACO	AODV	BAT	BBO	BOA	DSR	No. of equals
500	200	0	52	0	29	98	0	13
1000	200	0	0	0	65	126	0	6
1500	200	0	0	0	40	130	0	22
2000	200	0	0	0	26	150	0	15
Total	800	0	52	0	160	504	0	56

and 2000. As a result, we observed that the current proposal for WMN's is an outstanding optimization method and can be considered as the best dynamic near shortest path assessment approach routing in Wireless Mesh networks.

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