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Investigation on Novel Based Naturally-Inspired Swarm Intelligence Algorithms for Optimization Problems in Mobile Ad Hoc Networks

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***Abstract*—**Nature is the immense gifted source for solving complex problems. It always helps to find the optimal solution to solve the problem. Mobile Ad Hoc NETwork (MANET) is a wide research area of networks which has set of independent nodes. The characteristics involved in MANET's are Dynamic, does not depend on any fixed infrastructure or centralized networks, High mobility. The Bio-Inspired algorithms are mimics the nature for solving optimization problems opening a new era in MANET. The typical Swarm Intelligence (SI) algorithms are Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO), Modified Termite Algorithm, Bat Algorithm (BA), Wolf Search Algorithm (WSA) and so on. This work mainly concentrated on nature of MANET and behavior of nodes. Also it analyses various performance metrics such as throughput, QoS and End-to-End delay etc.

***Keywords*—**Ant Colony Algorithm, Artificial Bee Colony algorithm, Bio-Inspired algorithm, Modified Termite Algorithm.

I. Introduction

MOBILE Ad hoc Network (MANET), made up of mobile routers connected by wireless medium, is a self-configuring network without any access point. Mobile devices in networks are autonomous, move freely, and haphazardly organize themselves. Ad hoc networks don't rely on fixed infrastructure i.e. the MANET is an infrastructure less wireless network. The MANETs limited resources makes designing an efficient routing strategy very challenging [26], [7].

The basic idea of the ant colony optimization meta-heuristic is taken from the food searching behavior of actual ants. When they are on their way to search for food, they start from their hill and walk towards the food. While an ant reaches a meeting point, it has to decide which branch is to take next. While walking, ants deposit *pheromone*, which marks the route taken. The concentration of pheromone on a certain path is an indication of its usage. With time the absorption of pheromone decreases due to diffusion effects [27], [14]. This property is important because it is integrating dynamically into the path searching process.

The minimal model of swarm-intelligent forage selection in a honey bee colony that ABC algorithm consists of three kinds of bees: employed bees, onlooker bees and scout bees [6]. Half of the colony comprises employed bees and the other half includes the onlooker bees [7].

Honey bee algorithms based on moving bee colony towards searching for food. In bees colony various forager bees has been employed for searching nectar and pollen. They search in different patches around that colony looking for nectar [21].

Particle swarm optimization has ancestry in two main component methodologies. Possibly more observable are its ties on artificial life (A-life) in general, and to bird flocking, swarming theory and fish schooling in exacting. It is also related, to evolutionary computation, and has ties on both genetic algorithms and evolutionary programming [22].

Wolf Search Algorithm (WSA) that imitates the way wolves search for food and survive by avoiding their enemies [19]. Swarm-based algorithms had been applied in wireless sensor networks to solve the clustering and routing problems [23], [24]. Original BA is subject to change by different population sizes [20].

II. Related Works

A. Ant Colony Algorithm

The Ant Colony Algorithm initially proposed by Marco Dorigo in 1992. The first algorithm was aiming to search for an optimal path in a graph based on the behavior of ants. It must visit each city exactly when it is moving from one city to another. This behavior of the ants can be implemented to find the shortest path in networks. Exclusively, the dynamic component of this method allows a high adaptation to changes in mobile ad-hoc network topology, Since in these networks the presence of links are not guaranteed and link may changes occur very often [3], [27]. **A**nt colony based **R**outing **A**lgorithm (ARA) which is used to find the shortest path by using two practices 1) Route discovery 2) Route maintenance [27].

B. Honey Bee Algorithm

In the ABC model, the colony consists of three groups of bees; employed bees, onlookers and scouts. The number of employees in the colony is equal to number of food sources around the hive. In bees colony some searcher bees are employed for searching nectar and pollen. They search for

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different patches in and around the colony looking for food. Then they accumulate and assess other bees in colony from quality of the nectar that they have established, in jiggle dance. Other bees based on dance angle, dance speed with sun and dance period, get the nectar quality, flying track and distance of nectar from hoard, respectively. Another bee selects best spot or stay in hive to next waggle dance. This entity repeat until best patch for nectar is selected [25]. Colonies of social insects, such as ants, bird flocking and honeybees, have instinct ability known as Swarm Intelligence (SI). In terms of rate of convergence and capability ACO achieves global optima [26].

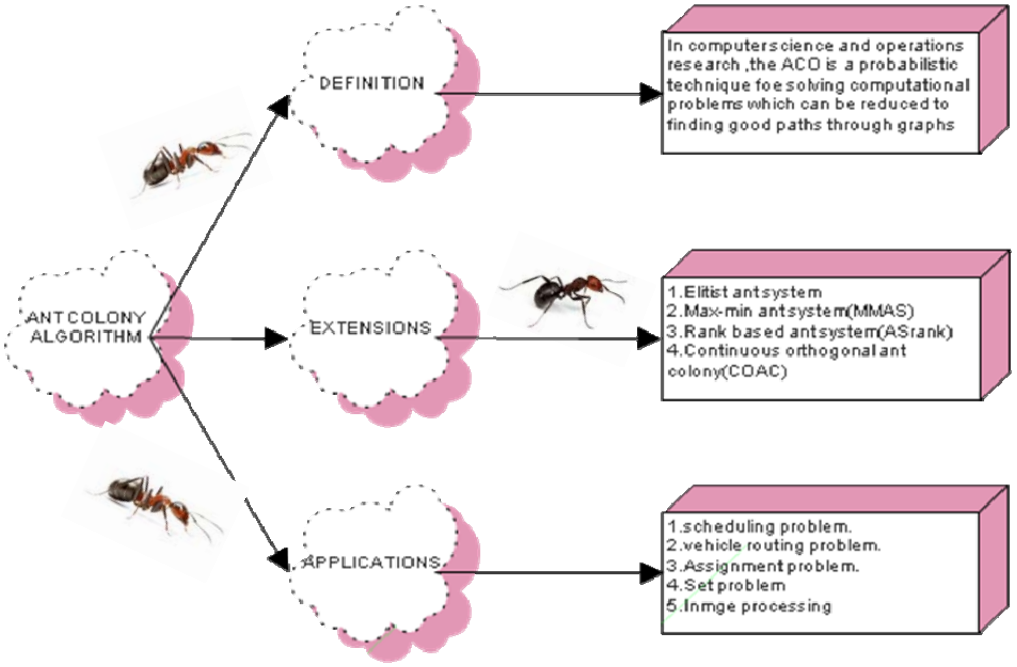

Fig. 1 Ant Colony Algorithm

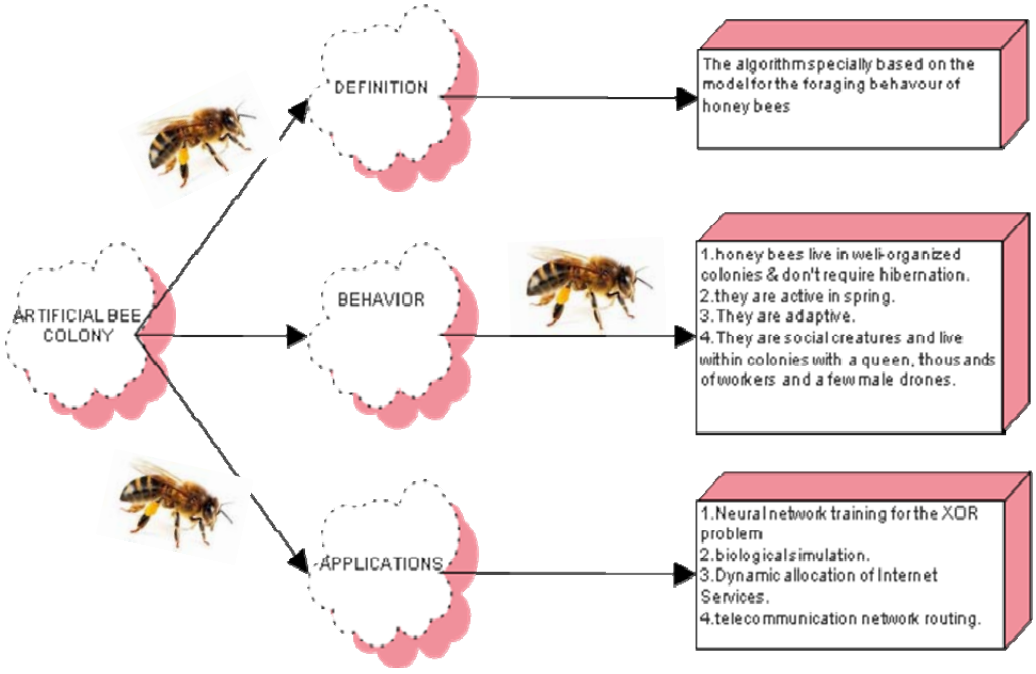

Fig. 2 Bee Colony Algorithm

C. Particle Swarm Optimization

Particle swarm optimization as established by the authors comprises a very modest concept, and paradigms can be implemented in a few strokes of computer program. It requires simply primitive mathematical operators, and is computationally low-cost in terms of both memory requirements and speed [22]. PSO has received growing interest from researchers in various fields [13].Based on the quantum-behaved PSO (QPSO) it was inspired by quantum mechanics and seemed to be a promising optimization problem solver [27].

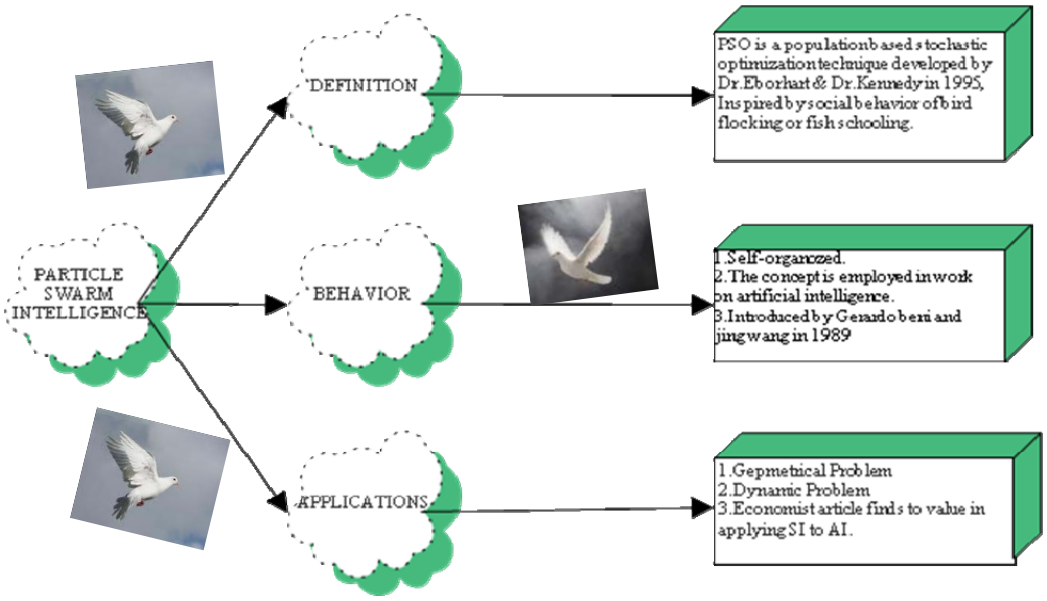

Fig. 3 Particle Swarm Optimization Algorithm

D. Termite Algorithm

Termites communicate during a variety of bahavioral signals. Colonies use decentralized, self-organized systems of activity guided by swarm intelligence. A simple example of the hill building behavior of termites provides a strong analogy to the mechanisms of Termite routing algorithm. Termite carrying pebble is the data packet and termite without pebble is the control packet. Termite is an innovative algorithm for packet routing in communication networks [15]. Opt-Termite uses concept of stigmergy for self-organization, so reducing the control packet overhead is increased. With Opt-Termite, a route with less loaded mobile nodes in terms of traffic will be chosen to reach destination [16].

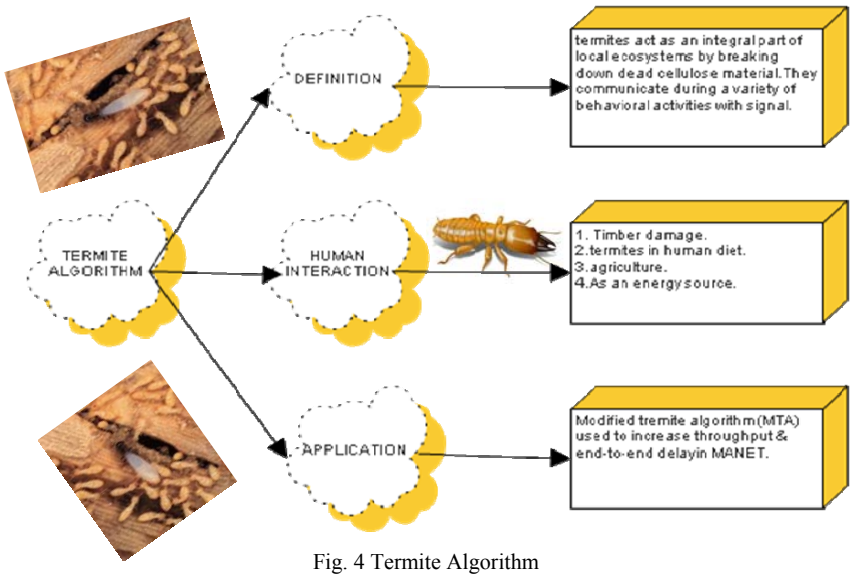

Fig. 4 Termite Algorithm

E. Wolf Search Algorithm

Wolf searching algorithm is an interesting area. The wolves travel in search of prey through their power of scent, chance encounter and tacking. Wolf Search Algorithm (WSA) that imitates the way wolves search for food and survive by avoiding their enemies. When hunting, wolves will attempt to conceal themselves as they approach their prey. Wolves have an excellent sense of smell and often locate prey by track. Similarly, each wolf in the WSA has a sensing distance that creates a sensing radius or coverage area -generally referred to as visual distance [19].

Some authors have already surveyed the basic characteristics of some of the most commonly used bio-inspired algorithms. Algorithms like ACO, PSO and BCO are surveyed in [1], [2].

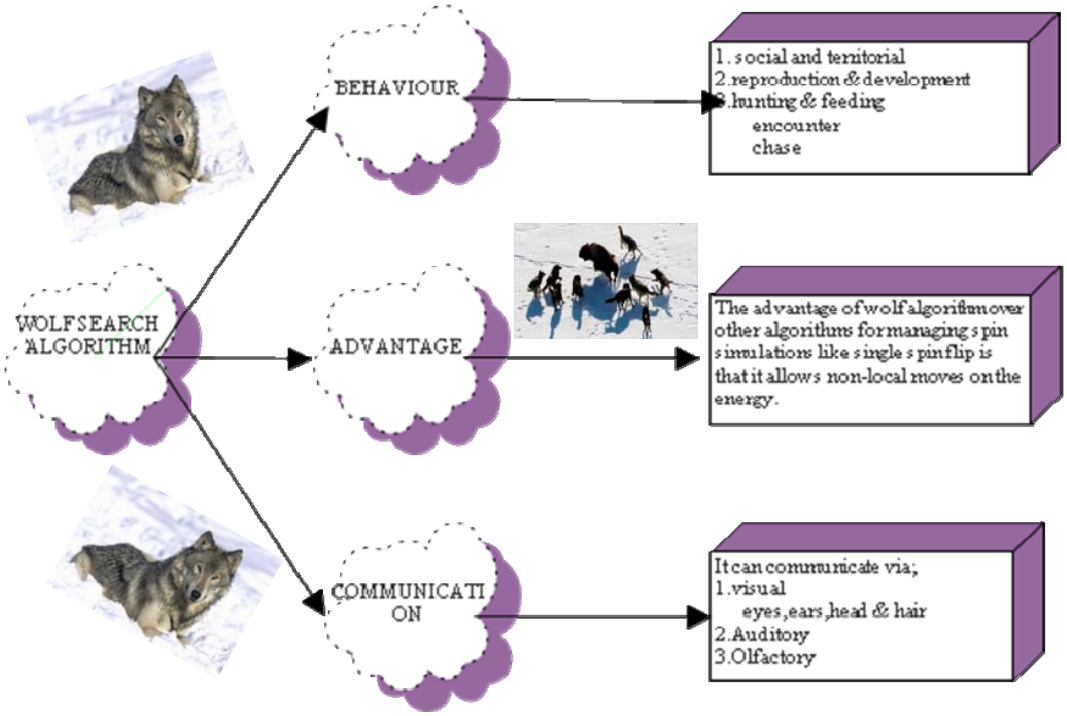

Fig. 5 Wolf Search Algorithm

TABLE I
COMPARISON TABLE

S.NO	TITLE	METHODOLOGY	PERFORMANE MERTICS	PARAMETRIC ANALYSIS	CONCLUSION
1.	Hybrid optimization using ant colony optimization and cuckoo search algorithm in MANET routing [26]	An effective strategy for reduce the use of resources while simulating.	End-to-end delay	Routes are predefined. Each node maintains table entries with destination IP address, next hop ID, hop count and life in AODV.	ACO with CS preforms better in terms of average end to end delay.
2.	ARA-The ant colony based routing algorithms for MANET [27]	Proposed a new on-demand routing approach for multi-hop ad-hoc networks.it is based on swarm intelligence and especially on ant colony optimization meta-heuristic.	overhead for routing	The ant involving in indirect communication. On demand routing reduces the number of nodes.	The ARA algorithm demonstrates high performance on route overhead.
3.	Using Dead Ants to improve the robustness and adaptability of AntNet routing algorithm [3]	AntNet uses both forward and backward ants. Create the forward ant towards destination once it reached kill that ant and create backward ant towards source.	Adaptability, Robustness	This paper illustrates the characteristics and behaviour of AntNet routing algorithm to improve adaptability and robustness under undesired network conditions like network failure or sudden burst of network traffic.	The knowledge of dead ants provides the real and accurate representation of network traffic particularly under network failure situations.
4.	The performance of a hybrid routing intelligent algorithm in a mobile ad hoc network [4]	Hybrid model that combines the ACO and PSO techniques were suggested For the optimisation technique.	End to end delay, power consumption and communication cost	This hybrid routing intelligent algorithm (PSO_ACO) has an improved performance when compared with the simple ACO algorithm in terms of delay, power consumption, and communication cost.	The path outcome using the hybrid routing intelligent algorithm (PSO_ACO) has the shortest distance, a minimum delay, low power consumption, and low cost when compared with the individual performance

S.NO	TITLE	METHODOLOGY	PERFORMANE MERTICS	PARAMETRIC ANALYSIS	CONCLUSION
					of the ACO algorithm
5.	Niched ant colony optimization with colony guides for Qos multicast routing [5]	A new algorithm was proposed NACO is a modified ACO algorithm	Minimum-cost multicast tree with the delay and bandwidth constraint (MinC/DB)	The NACO algorithm consists a constrained tree traversal(CTT) approach to search achievable trees with respect to the QoS restrictions	The NACO algorithm can reduce the MinC/DB problem to the constrained Steiner tree problem.
6.	SMBO-A Self-Organizing model of marriage in honey bee optimization [6]	Aiming to achieve better overall performance than the original version of the MBO even lowering the totalling time for finding the best solution.	Computation time	The SMBO divides problem space into several colonies, each of which has its Own queen. The size of each colony depends on the fitness of the Corresponding queen.	The main drawback of the original MBO algorithm is its very long computation time. Several assumptions and processes have been altered to increase the algorithm efficiency. The performance of the algorithm is estimated against the original MBO algorithm.
7.	A Novel-Adaptive Bio-Inspired Clustered Routing for MANET [7]	A new general framework has been proposed for achieving QoS which provides a cluster based routing and applies Artificial Bee Colony optimization Technique for effective optimal route discovery in MANET	End to end delay, scalability	It works on the principle of collective intelligence and emergence of artificial honey bees.	ABC optimization framework with cluster based environment was proposed to provide scalability and guarantees QoS by minimize the cluster maintenance overhead by using employee and Onlooker bees with nodes in the cluster.
8.	Termite-hill: Performance optimized swarm intelligence based routing algorithm for wireless sensor networks [8]	The algorithm aims to efficient relay all the traffic designed for the sink, and maintains the balance the network energy too	Packet arrival rate, energy consumption, Network lifetime	The algorithm has been investigated the impact of sink mobility and dynamic sink performance by using static, dynamic sink in WSN	The routing protocol termite hill shown good performance in terms of energy utilization efficiency, network lifetime and throughput.
9.	SWARM Intelligence based dynamic source routing for improved quality of service [9]	DSR is protocol allows the nodes to discover source node among multiple hops to a destination	Packet delivery ratio, end to end delay	To control link failure and path finding issues ACO needs to be integrated along with mobility in routing protocols which should be independent for an effective solution.	DSR and ACO optimize the node pause time and mobility. It achieved better packet delivery ratio and end to end delay.
10.	A Comparison among Wolf Pack Search and Four other Optimization Algorithms [10]	The aim is to identify the best algorithm in terms of more speed and accuracy in finding the solution, where speed is measured in terms of function evaluations.	Function evaluation	The performance of the five evolutionary algorithms is compared using two benchmark problems.	To accuracy in reaching to the specific point is of greater importance, WPS or PSO were suggested.
11.	A novel particle swarm optimization algorithm with Levy flight [11]	Levy flight is a random walk determining stepsize using levy distribution	distance	The comparison between the SPSO and LFPSO was performed on 21 benchmark functions with 30 and 50 dimensions.	The proposed method was observed to give better average results in almost all benchmark functions tested, and to be more robust in most of existing works. The LFPSO outperforms other methods and it is closely successful with the ABC algorithm.
12.	Performance Improvement of Mobile Ad Hoc Network Using Particle Swarm Optimization [12]	The misbehavior may degrade the performance of the network. it was categorized Into selfish and malicious misbehavior	Throughput, delivery ratio and delay	Handling misbehavior will guarantee the significant throughput.	PSO minimizes the number of misbehaving nodes thereby can achieve network performances which increases throughput.
13.	Using particle swam optimization for QoS in ad-hoc multicast [13]	In order to increase the QoS, should meet the stringent QoS requirements of specific multimedia traffic	Packet loss ratio	This paper tried to tackle the difficult challenges by presenting the routing protocol PSO which only not meet DSR also satisfies QoS	This research work achieves better performance than ODMRP, DCMP, and MPSP protocols in place of packet delivery ratio
14.	Ant Colony Optimization Based Modified Termite Algorithm (Mta) With Efficient Stagnation Avoidance Strategy For MANETS [14]	To address the problem, a load balancing routing algorithm namely Modified Termite Algorithm (MTA) has been developed based on ant's food foraging behavior	Node stability, Throughput, End-to-End delay	A higher ratio of node stability indicates that the neighbor node is more stable. Using this concept pheromone evaporation for the stable node is fine-tuned such that if the ratio node stability is more, the evaporation is slow and if node stability is less the evaporation is faster.	The MTA implemented on MANET shows better performance in throughput and end-to-end delay.
15.	Adaptive Routing Algorithm for MANET: TERMITE [15]	Termite is an adaptive, distributed, mobile-agents-based algorithm which was inspired by recent work on the ant colony metaphor	Packet delay, throughput	The algorithm provides multipath routing hence favors load balancing. Crashing a node can be handled by the dynamicity of the algorithm. Also the loss of termite can be handled by using a time out	The termite algorithm achieves high performance in packet delay and throughput than other SI algorithms

S.NO	TITLE	METHODOLOGY	PERFORMANE MERTICS	PARAMETRIC ANALYSIS	CONCLUSION
				mechanism	
16.	Optimized TERMITE: A Bio-inspired Routing Algorithm for MANET's [16]	Opt-Termite uses concept of stigmergy for self-organization, thereby reducing the control packet overhead. Opt-Termite mainly concentrates on load balancing for optimization.	Network traffic	It has a low control overhead as well as it offers multiple paths. It also takes care of the congestion that could be caused by the usage of the same route for a long period of time	The Opt-Termite algorithm increases the performance in case of network traffic
17.	Swarm Based Intelligent Routing for MANETs [17]	The algorithm is based on a modification of the state transition rule of ACO routing algorithm that results in maintaining higher degree of exploration along with congestion awareness in the search space.	End-to end delay and Network overhead	The comparative experimental results of the proposed algorithm with the state-of-threat AODV reactive routing algorithm of the MANET are provided keeping mobility and density of nodes as the main consideration.	The proposed algorithm showed good potential in producing better quality solution in presence of appreciable mobility in the networks. This was tested for different node mobility and node density through simulation results.
18.	A hybrid ACO/PSO based algorithm for QoS multicast routing problem [18]	The algorithm starts with generating a large amount of mobile agents in the search space. The ACO algorithm guides the agents' movement by pheromones in the shared environment locally.	delay, loss rate, bandwidth, and delay jitter	The algorithm is found to construct the multicast tree patterns more sensibly such that the tree patterns not only satisfy the QoS constraints, but also tries to minimize the tree cost	The final multicast trees generated by our algorithm are found better compared to the multicast trees generated by PSOTREE and TGBACA. Time complexity also reduced.
19.	Wolf Search Algorithm with Ephemeral Memory [19]	WSA algorithm imitates the way wolves search for food and survive by avoiding their enemies**.**	Memory requirements	For verifying the efficacy of the WSA the algorithm is tested quantitatively and compared to other heuristic algorithms under a range of popular non-convex functions used as performance test problems for optimization algorithms 2. The WSA is investigated with respective to its memory requirement	The WSA's potential contributions to finding optimal solutions in applications including Travelling salesman problems, Quadratic assignment problems, Job scheduling problems and Sequential ordering problems.
20.	An Echo-Aided Bat Algorithm to Support Measurable Movement for Optimization Efficiency [20]	An Echo-Aided Bat Algorithm (EABA) based on measurable movement is proposed to improve optimization Efficiency.	Computational cost	The conception is to employ the echo time to measure the distance from bats and objective. The bats emit an ultrasound to objective to measure the time of a round trip between their position and objective position. The echo time can guide the bats to correct velocity, direction and movement step.	The EABA has better ability of search by demonstration of experimental results. By reducing the population size it reduces computation time.

Various algorithms from Swarm Intelligence have been surveyed based on their performance and it is described in comparison table. Also some of the general behavior and applications of algorithms are showed in pictures.

III. Conclusion

The algorithms discussed in this survey paper have unique characteristics. The natural inspired resource is an excellent guidance for solving the complex problems. Each algorithm has a property of mingle with other algorithms. They have been implemented by simulation concept. The expected output has been obtained in the research works. The research works of Naturally-Inspired algorithms are also involved in Wireless Networks, Wireless Sensor Networks and image processing. Also it is possible to combine two algorithms for gaining more efficiency. The combination of PSO and GA will give better optimal solution than others. Similarly PSO with MTA would be suggested for efficient result.

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