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Swarm Intelligence in MANETs: A Survey

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Abstract—

The Wireless Adhoc Networks (WANETs) are decentralized network with no infrastructure and access point to control the nodes. Since the topologies in WANETs are dynamic the routing becomes the challenging task as nodes are moving with low bandwidth and traditional routing algorithm doesn't work with WANETs. This paper gives the systematic literature review of techniques and routing algorithm that exists in WANETs, also the applicability of Swarm Intelligence (SI) in MANETs. The aim of performing the survey is to gain better knowledge of Swarm Intelligence and techniques that are applied to the WANETs.

Keywords— Swarm Intelligence, MANETs, Mobile Adhoc Networks, Routing.

I. INTRODUCTION

A Wireless Adhoc Networks (WANETs) is a network type that doesn't rely on the infrastructure. It is decentralized network with no central authority to control the network. WANETs have various applications in today's scenario. Mobile Adhoc Networks (MANETs), Smart Phone Adhoc Networks (SPANs), Internet Based MANETs (iMANETs) are some of the type of WANETs. There is no Access point, in Adhoc Networks, to manage the nodes also the topology is dynamic. Therefore, traditional routing algorithm doesn't work with MANETs. Routing in MANETs is a challenging task.

Swarm Intelligence (SI), is a branch that inspired by the natural and artificial system. It is a study of natural phenomenon and individual's behaviour in decentralized environment. It is rapidly increasing area of Artificial Intelligence (AI). The algorithm used in SI has a various application in optimization and data analysis.

In this paper, we give a systematic literature review of Swarm Intelligence techniques that are applied to the routing in MANETs. Also, the limitations that is present in traditional routing algorithms. The work justifies the applicability of SI in MANETs.

The rest of the paper has been organized as follows: Section 2 explains MANETs and the traditional routing algorithms. Section 3 presents the Swarm Intelligence and algorithms. Section 4 gives a systematic literature review and the last section concludes.

II. MOBILE ADHOC NETWORKS (MANETS)

A Mobile Adhoc Network (MANETs)[1] is a collection of two or more wireless devices having the capacity to communicate with oneanother without the help of any centralized administrator. Each node in wireless Adhoc network functions as both a router and a host. The network topology is dynamic in nature because the connectivity among nodes may vary with time because of node mobility, node departures, and new node arrivals. Hence, there is a need for effective routing protocols to allow the nodes to communicate. Ad hoc nodes or devices should be able to detect the presence of other such devices so as to allow communication and information sharing. Besides that, it should also be able to identify types of services and corresponding attributes. Due to the number of wireless nodes changing quickly, the routing information must also change to reflect changes in the link connectivity. Therefore, the topology of the network is very dynamic and the changes are often uncertain as compared to the fixed nature of existing wired networks.

The dynamic nature of the wireless medium, fast and unpredictable topological changes, limited battery power, and mobility raise many challenges for the designing a routing protocol. Due to immense challenge in designing a routing protocol for MANETs, a number of recent developments focus on providing an optimum solution for routing. But a majority of these solutions attain a specific goal (eg. Minimizing delay and overhead) while compromising other factors (eg. Scalability and route reliability). Thus, an optimum routing protocol that can cover most of the applications or user requirements as well as cope up with the stringent behavior of the wireless medium is always desirable.

Each node consists of a wireless interface and communicates with each other over the radio. Laptop computers and other devices communicate directly with each other are some examples of nodes in the ad hoc network. Nodes in ad hoc network are mostlymobile, but stationary nodes can also exist, such as access points.

An ad hoc network uses no centralized administrator[2]. This ensures that the network would not collapse just because one of the nodes moves out of the transmitter range of the other nodes. Nodes should be able to enter or leave the network as they wish. Because of the limited transmitter range of the nodes, multihops may be needed to reach other nodes. Thus every node acts both as a host and a router. A node can be viewed as an unrealnode consisting of a router and a set of recognized mobile hosts. A router is an entity that, among other things, runs a routing protocol. A mobile host is an IP-Addressable host or entity in the traditional sense.

Ad hoc networks can also handle topology changes and malfunctions in nodes [1]. They are fixed due to network reconfigurations. For example, if a node leaves the network and causes link breakages, new routescan be easily requested by affected nodes and the problem will be eliminated. This will increase the delay slightly, but the network will still be operational.

Traditional Routing Algorithms in Manets

The term routing is very important for a network. Routing is a process of finding acapable, dependable and secure path from a source node to a destination node via intermediate nodes in a given network. Routing in MANET is a challenging work due to dynamic topology in network as mobile nodes can move in any direction in the MANET [3]. Mobile ad-hoc networks are easy to deploy and configure which causes its popularity in comparison to the wired networks. Fast network setup is the main feature of MANET. MANET is useful in places with no communications infrastructure or when that infrastructure is adversely damaged. A small network can be setup by mobile nodes (laptop, PDA, Smart Devices)for sharing resources [1]. Routing algorithms in MANET should provide following primary expectations:

- Stable loop free connectivity
- Secure routing
- Reduced control overhead
- Have scalability and distributed routing
- Support QoS traffic prioritization
- Respond to changes in node mobility.

Routing algorithms in MANET are categorized in three heads: Proactive routing algorithms, reactive routing algorithms and hybrid routing algorithms [4].

Proactive Routing Algorithms for Manet

Proactive routing algorithm manage routes to destination even if they are not required. Proactive routing algorithms maintain updated routing information on each node in the network periodically. Advantage of proactive routing algorithm is fast connection time as path is already available on each node in the network. A disadvantage of proactive algorithm is continuous use resources to communicate routing information, even when there is no traffic that causes the overhead of control information [5]

i. Destination-Sequenced Distance Vector (DSDV) [6]

- Each node maintains a table with an entry for every possible destination.
- Nodes exchange their routing tables with their neighbors periodically.
- Based on the received tables, nodes update their routing tables.
- Each entry in table specifies
  - Destination identifier.
  - Next hop on the route to the destination.
  - Distance (in terms of hops) to the destination.
  - A sequence number that specifies how fresh the route is.

ADVANTAGES:

- Route from source node to destination node is always available as each node has path from other nodes from itself.

DISADVANTAGE:

- Large routing overhead, Uses only bidirectional links. Suffers from count to infinity problem.

ii. Optimized Link State Routing protocol (OLSR) [7] [8]

- The Optimized Link State Routing Protocol (OLSR)is an IP routing protocol optimized for mobile ad hoc networks, which can also be used on other wireless ad hoc networks.
- OLSR is a proactive link-state routing protocol, which uses *hello* and *topology control* (TC) messages to discover and then disseminate link state information throughout the mobile ad hoc network.
- Individual nodes use this topology information to compute next hop destinations for all nodes in the network using shortest hop forwarding paths.
- In figure I, node C and E are multipoint relay (MPR) of node A
  - Multipoint relays of A are its neighbors such that each two-hop neighbor of A is a one-hop neighbor of one multipoint relay of A
  - Nodes exchange neighbor lists to know their 2-hop neighbors and choose the multipoint relays

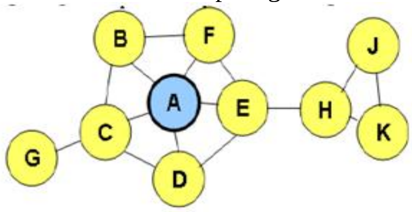

Figure I

In Figure II

- Nodes C and E forward information received from A
- Nodes E and K are multipoint relays for node H
- Node K forwards information received from H

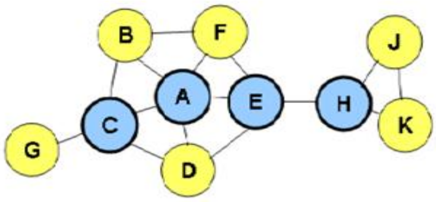

Figure II

ADVANTAGES:

- Reduces control information
- Efficiently minimizes broadcast traffic bandwidth usage.

DISADVANTAGES

- Although OLSR provides a path from source to Destination, it is not necessarily the shortest path, because every route involves forwarding through a MPR node
- OLSR also has routing delays and bandwidth overhead at the MPR nodes as they act as localized forwarding routers.

III. REACTIVE ROUTING ALGORITHMS

In Reactive routing algorithm routing tables are not always up-to-date. Instead, a node tries to find a route only when it wants to send a packet. The advantage of reactive routing algorithms is that it reduces the traffic needed for routing. A disadvantage of reactive routing algorithm is that it introduces a delay when the first packet is sent to a host as path is not readily available.

i. Ad Hoc on-demand Distance Vector [9] [10]

Three message types are used in the AODV which are route request (RREQ), route reply (RREP), and route error (RERR).

- In figure III, node 1 desires to communicate to node 8.
- Node 1 flood the network with route request (RREQ) messages.
- Each node receiving a RREQ message stores the previous hop and distance to source for the originating RREQ and forwards the RREQ to its neighbors.
- When the RREQ message reaches the designation node 8, the destination sends a unicast route reply (RREP) message back to the source using the previous hop on which it received the RREQ.
- Each node receiving the RREP message in turn forwards it to the next hop with the smallest distance to the source as shown in Figure III.

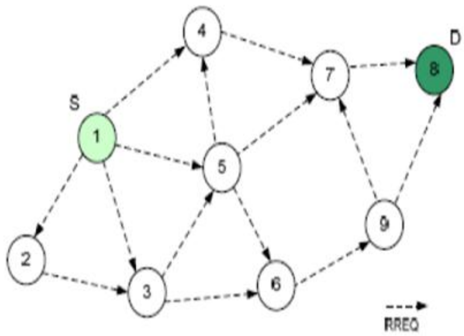

Figure III

- This process effectively builds the routing table at each node, and when any source destination pair establishes a route, the intermediate nodes learn the route as well.

ADVANTAGES

- AODV creates routes only on demand, which greatly reduces the periodic control message overhead associated with proactive routing protocols.

DISADVANTAGES

- Route setup latency exist when a new route is needed. ADOV queues data packets while discovering new routes and the queued packets are sent out only when new routes are found. It causes throughput loss in high mobility scenarios, because the packets get dropped quickly due to unstable route selection.

ii. Dynamic Source Routing Algorithm (DSR) [4]

A complete ordered route is maintained in the packet in dynamic source routing (DSR). This makes it easy to control the route from the source node and guarantees loop-free paths.

- In figure IV, node S wants to send a packet to node D, but does not know a route to D, node S initiates a route discovery
- Source node S floods Route Request (RREQ) Each node *appends own identifier* when forwarding RREQ

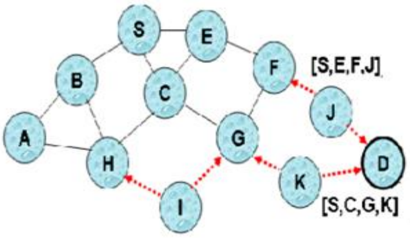

Figure IV

- In figure V,
- Destination D on receiving the first RREQ, sends a Route Reply (RREP)
- RREP is sent on a route obtained by reversing the route appended to received RREQ
- RREP includes the route from S to D on which RREQ was received by node D
- Node S on receiving RREP, caches the route included in the RREP
- In figure VI, when node S sends a data packet to D, the entire route is included in the packet header hence the name source routing
- Intermediate nodes use the source route included in a packet to determine to whom a packet should be forwarded

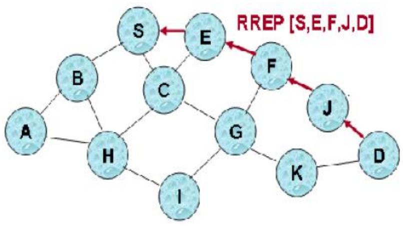

Figure V

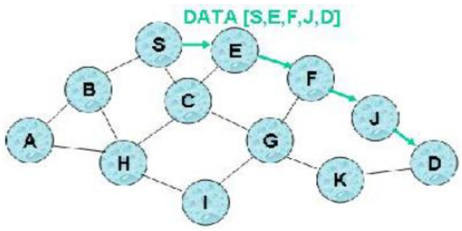

Figure VI

ADVANTAGES

- Does not flood the network with table update messages periodically.
- Intermediate nodes also utilize the route cache information efficiently to reduce the control overhead.

DISADVANTAGES

- Route maintenance mechanism does not locally repair a broken link.
- Connection setup delay is higher than in table-driven protocols.
- Performance degrades rapidly with increasing mobility.
- Routing overhead is involved due to the source-routing mechanism employed in DSR. This routing overhead is directly proportional to the path length.

IV. HYBRID ROUTING ALGORITHMS [11]

Hybrid routing algorithm combines the advantages of both reactive and proactive routing algorithms. Initially proactive approach is used to have route information then reactively demand of the route is served to the needy node.

i. Location-Aided Routing (LAR) [12]

Location-aided route discovery based on limited flooding. LAR [12] Use location information to reduce the number of nodes to whom route request is propagated. Location information may be obtained using Global Positioning System (GPS)

- LAR Exploits location information to limit scope of route request flood using GPS
- Expected Zone is determined as a region that is expected to hold the current location of the destination. Expected region determined based on potentially old location information, and knowledge of the destination's speed
- Route requests limited to a *Request Zone* that contains the Expected Zone and location of the sender node

ADVANTAGES

- Reduces the scope of route request flood
- Reduces overhead of route discovery

DISADVANTAGES

- Nodes need to know their physical locations
- Does not take into account possible existence of obstructions for radio transmissions

ii. Zone Routing Protocol (ZRP) [13]

Zone routing protocol is hybrid routing algorithm which use the advantages of both proactive and reactive routing algorithms. ZRP was proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by route discovery in reactive routing protocols.

- All nodes within hop distance at most d from a node X are said to be in the routing zone of node X.
- All nodes at hop distance exactly d are said to be peripheral nodes of node X's routing zone
- Intra-zone routing: Proactively maintain routes to all nodes within the source node's own zone.
- Inter-zone routing: Use an on-demand protocol (similar to DSR or AODV) to determine routes to outside zone.

ADVANTAGES

- Less control overhead as in a proactive protocol or an on demand protocol. **1.2)**

DISADVANTAGES

- Short latency for finding new routes.

V. SWARM INTELLIGENCE

A swarm is a large number of alike, simple agents interacting locally among themselves, and their environment, with no main control to allow a global interesting behaviour to emerge. Swarm-based algorithms have recently come up as a family of nature-inspired, population-based algorithms that are capable of producing low cost, fast, and robust solutions to several complex problems [14] [15].

Swarm Intelligence (SI) is a branch of Artificial Intelligence that is used to model the corporativebehaviour of social swarms in nature, such as ant colonies, honey bees, and bird flocks. Although these agents (swarm individuals or insects) are relatively unsophisticated with limited capabilities on their own, they are collaborating together with certain behavioural patterns to cooperatively achieve tasks necessary for their survival.

The social collaboration among swarm individuals can be either direct or indirect [16]. Examples of direct interaction are via visual or audio connection, such as the waggle dance of honey bees. Indirect interaction occurs when one individual brings about some change in the environment and the other individuals respond to the new environment, for example the pheromone trails thatthe ants deposit on their way to search for food sources. This indirect type of interaction is referred to as stigmergy, that means communication via the environment [17].

In the past decades or so, biologists and natural scientists have been intensively studying the behaviours of social insects because of the amazing capability of the natural swarm systems. While in the late-80s, computer scientists proposed the scientific judgement of these natural swarm systems into the field of Artificial Intelligence. In 1989, the expression "Swarm Intelligence" was for the first time introduced by G. Beni and J. Wang in the global optimization framework as a set of algorithms for controlling robotic swarm [18]. In 1991, Ant Colony Optimization (ACO) [19] [20] [21] was introduced by M. Dorigo and his colleagues as a different nature-inspired metaheuristic for the solution of hard combinatorial optimization (CO) problems. 1995 saw the introduction of particle swarm optimization by J. Kennedy et al. [22] [23], and was first intended for simulating the bird flocking social behavior. By the late-90s, these two most popular swarm intelligence algorithms started to go ahead of a pure scientific interest to enter the realm of real-world applications. It is perhaps worth mentioning here that after a few years, in 2005, Artificial Bee Colony Algorithm was proposed by D. Karabago as a new member of the family of swarm intelligence algorithms [24] [25].

Swarm Intelligence Models

Swarm intelligence models are referred to as computational models inspired by natural swarm systems. To date, several swarm intelligence models based on different natural swarm systems have been proposed in the literature, and successfully applied in many real-life applications.

Examples of swarm intelligence models are:

i. Ant Colony Optimization [26]
ii. Particle Swarm Optimization [22]
iii. Glowworm Swarm Optimization [27]
iv. Artificial Bee Colony [24]
v. Bacterial Foraging [28]
vi. Cat Swarm Optimization [29]
vii. Artificial Immune System [30]

In this paper, we will primarily focus on Ant Colony Optimization. Brief about all the above models is presented in the next section.

Ants, like many other social insects, communicate with each other using volatile chemical substances known as pheromones, whose direction and intensity can be recognized with their long, mobile antennae [32].

The term "pheromone" was introduced by P. Karlson and M. Lüscher in the year 1959, based on the Greek word pherein (means to transport) and hormone (means to stimulate) [33]. There are different types of pheromones used by social insects.

One example of pheromone types is the alarm pheromone that the crushed ants produce as a form of an alert to nearby ants to fight or escape from troubling predators and to protect their colony [34].

Another important type of pheromone is food trail pheromone. Not like flies, most ants live on the ground and use the soil surface to leave pheromone trails, which can be followed by other ants on their way to find food sources.

Ants that happened to pick the shortest route to food will be the fastest to return to their nest, and will reinforce this shortest route by depositing food trail pheromone on their way back to the nest. This route will slowly and gradually attract more and other ants to follow, and as more ants start following the route, it becomes more attractive to other ants as shown in the adjacent figure

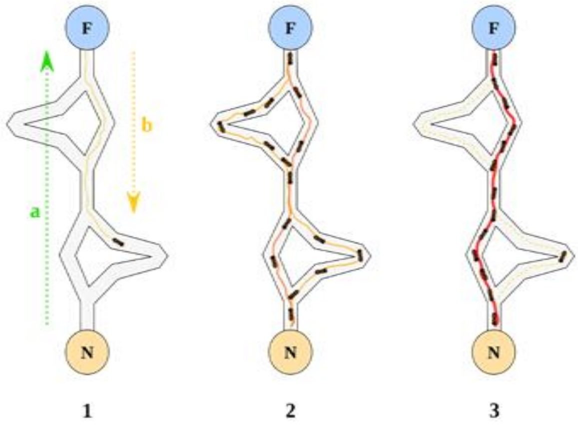

Figure VII

This autocatalytic or positive feedback process is an example of self-organizing behavior of ants in which the chance of an ant choosing a route increases as the number of ants have that already passed by that route increases.

When the food source is exhausted, no new food pheromone pathway is marked by returning ants and the volatile pheromone scent slowly evaporates.

This negative feedback behavior helps ants to deal with the changes in their environment. For example, when a well-established path to a food source is blocked by an obstacle, the ants leave that path to explore new paths. Such trail-laying, trail-following behavior is called stigmergy (communication through the environment), and can be considered as an indirect type of communication by which ants change the environment (soil surface) and the other ants detect and respond to the new environment. Stigmergy provides a mechanism that relates individual (local) and colony-level (global) behaviors: individual behavior modifies the environment (trail-laying), that in turn modifies the behavior of other individuals (trail-following) [35].

VI. LITERATURE REVIEW

In order to have clear cut, unbiased, complete and broader prospective many sources have been explored. The literature review has been carried out according to the guidelines proposed by Kitchenham. The objective of carrying literature review was to gain deeper understanding of mitigation techniques that exists in literature and to find gap in the study. The extensive literature reviews has been carried out in the following journals:

1. ACM Digital Library
2. IEEE Explorer
3. Science Direct
4. Wiley Online Library
5. Springer

The reason behind exploring these databases is their library of journals with high impact factors. The review also takes into account conference proceedings.

The Search term was "**Swarm Intelligence and ad hoc networks**". The search was filtered to include the papers and conferences of previous 10 years. This was done to limit the scope of research to the present trends instead of exploring unverified and undeveloped techniques.

The results are summarized as follows in the table:

Table I Search Result and relevant papers

S. No.	JOURNAL NAME	SEARCH RESULT	RELEVANT PAPERS
1.	ACM	35	7
2.	IEEE	16	7
3.	Science Direct	22	4
4.	Wiley	271	5
5.	Springer	5	1

Total 25 relevant papers were selected for review. The papers in journals and conferences are taken into consideration.

One of the earliest paper was published in 2005 by Diego Pinto and Benjamin Baran [36]. Their work multiobjective algorithms for Multicast Traffic Engineering using Ant Colony Optimization. The other paper of 2005 was published by Gianni, Frederick and Luca Maria. They used ACO to describe AntHocNet, an algorithm for routing in mobile ad hoc network.

In 2006 Masoud, Ali, Ashkan, Zainanabedin, Mottaghi and Fatemi [37] presented a routing model for minimizing hot spots in the network on chip using ACO. They also compared the model with the XY, Odd Even, and DvAD routing models

In 2008 Sabari and Duraiswamy [38] proposed that tree based and mesh based on demand protocols are not necessarily the best choice, since associated overhead will be more. ACO minimizes the cost of the tree under multiple constraints. It also presented a design on ant colony based multicast routing algorithm for MANET's.

In 2009, 4 different papers were published, first was published by Floriano and Mauro [39]. They proposed a novel routing algorithm over MANETs called LBE-ARAMA. This algorithm is based on ACO. Second paper was published by Wang, Osagie,Thulasiraman and Thulasiram [40]. They proposed a hybrid routing algorithm for MANETs based on ACO and zone routing framework of border casting. The algorithm, HOPNET, based on ants hopping from one zone to the next, consists of the local proactive route discovery within a node's neighborhood and reactive communication between the neighborhoods. Next paper was given by Sinha and Chaki [41], they described a new routing algorithm for MANETs using Ant Colony Optimization technique. Special attention was given to the load balancing and congestion control in network. Last paper was given by Shokrani and Jabbehdari [42]. They proposed a novel QoS routing algorithm based on ACO. Algorithm used ant like agents to discover and maintain paths, that satisfy more requirements of the incoming traffic and at the same time by control energy level of nodes, increase lifetime of network as much as possible.

In 2010, first paper was published by Daisuke, Tomoko, Fukuhito, HirotsuguToshimitsu [43]. They used ACO to bring robustness to construct paths that are not likely to be disconnected during a long period. They proposed a new ACO routing algorithm based on robustness of paths for MANETs with global positioning system(GPS). Next paper Fernando and Teresa [44], they used Simple Ant Routing Algorithm (SARA) which offers a low overhead solution, by optimizing the routing process. They used three complementary strategies: during the route discovery they used a new broadcast mechanism, called the Controlled Neighbor Broadcast (CNB). During the route maintenance phase, they further reduced the overhead, by only using data packets to refresh the paths of active sessions. Finally, in the route repair phase was also enhanced, by using a deep search procedure as a way of restricting the number of nodes used to recover a route. Thus, instead of discovering a new path from the source to the destination, they started by trying the discovery of a new path between the two end-nodes of the broken link. A broadest search is only executed when the deeper one fails to succeed.

In 2011 first paper was given byAshima, Srinivas, Debajyoti [45]. They introduced a new ant based routing protocol to optimize the route discovery and maximize the efficiency of routing in terms of packet delivery ratio (PDR) using the blocking expanding ring search (Blocking-ERS), third party route reply, local route repair and n-hop local ring techniques. Next paper was given by Sathish, Thangavel and Vaidehi [46]. The use ACO to propose a cache based ant colony routing for mobile ad hoc networks for building highly adaptive and on-demand source initiated routing algorithm. Next paper was given by Orhan, Abdullah and Alice [47]. They proposed a dynamic mobile ad hoc network (MANET) management system to improve network connectivity by using controlled network nodes, called agents. A new approach to measuring connectivity using a maximum flow formulation was proposed-this was both responsive and tractable. Next paper was published by Dorigo,Oca, Oliveira and Stutzle [48]. They researched on ACOand proposed that A key aspect of ACO algorithms is the use of a positive feedback loop implemented by iterative modifications of the artificial pheromone trails that are a function of the ants' search experience; the goal of this feedback loop is to bias the colony toward the most promising solutions.

In 2012 first paper was given by Barreiras, Munaretto, Delgado, Viana [49]. They presented a new routing protocol for Delay Tolerant Networks (DTNs), based on a distributed swarm intelligence approach. The protocol was called Cultural Greedy Ant (CGrAnt), as it uses a Cultural Algorithm (CA) and a greedy version of the Ant Colony Optimization (ACO) metaheuristic. The second paper was given by Deepalakshmiand Radhakrishnan [50]. They worked on Mobile ad hoc, another mesh-based multicast approach for mobile ad hoc networks in two scenarios, namely typical scenario and collaborative scenario. The simulation was carried out in NS-2 and comparison was conducted for the metrics packet delivery ratio, group reliability ratio, and end-to-end average delay by varying node mobility and by increasing number of senders in each group.

In 2013, 5 papers were published. First was published by Nancharajah and Mohan [51]. They used ACO and PSO to find the best solution over the particles position and velocity with the objective of cost and minimum end to end delay. The hybrid algorithm exhibited better performance when compared to ACO approach. Next paper was given by Guangyu and Boukhatem, they proposed VACO (Vehicular routing protocol based on Ant Colony Optimization), a new adaptive multi-criteria VANET routing protocol. VACO combined both reactive and proactive components to respectively establish and maintain best routing paths. Reactive forward and backward ants were sent between source and target intersection (closest intersection to the destination vehicle) to explore and set up best routes consisting of a list of intersections. Next paper was given by Istikmal, Leanna and Rahmat [52], they investigated result of AODV, DSR and DSDV that applied an Ant-algorithm which are AODV-Ant, DSR-Ant, and DSDV-Ant. DSDV represents of proactive routing type protocol based on table driven, while AODV and DSR represents of reactive routing protocol type based on demand. Performance analysis includes end to end delay, throughput, routing overhead and hop count for various scenario of node velocity, pause time and network traffic. Next paper was given by Istikmal [53]. he used optimized routing protocols in mobile ad hoc network (MANET), the optimization was done on the routing protocol DSR (Dynamic Source Routing) which was reactive routing protocol using ACO algorithm. Then the analysis and evaluation of the performance of this routing protocol in various scenario and comparsion of the result with standard DSR routing protocol was done. Final paper was published by Salim, Melloukand and Fowler [54]. They proposed a new quality of service multicast and multipath routing protocol for VANETs, based on the paradigm of bee's communication, called multicast quality of service swarm bee routing for VANETs (MQBV). The MQBV finds and maintains robust routes between the source node and all multicast group members.

In 2014 the first paper was given by Rajinder, Parvinder and Manoj [55]. They proposed and implemented the security based algorithmic approach in the mobile adhoc networks. Next paper was given by Nancharajah and Mohan [56] they proposed that a modified Ant Colony Optimization algorithm performs better compared to existing algorithms (AODV and Cooperative Opportunistic Routing in Mobile Adhoc Networks i.e. CORMAN) in terms of end- to-end delay, route acquisition time, throughput, total cache replies and packet delivery ratio. Final paper was given by Saeed, Abdolhossein and Mehrdad [57]. They proposed a novel algorithm to improve the lifetime of a wireless sensor network. The algorithm employed swarm intelligence algorithms in conjunction with compressive sensing theory to build up the routing trees and to decrease the communication rate.

VII. CONCLUSIONS

The systematic literature review has been carried out in an order to find techniques that were proposed for using swarm intelligence in MANETs. There are various techniques that exists in literature but has limitations and constraints. Therefore, Intensive research and study was done in the field to study and get in depth knowledge about the topic.

We found out that use of artificial intelligence techniques ie. Swarm intelligence techniques, are better than the traditional routing techniques used earlier.

Swarm intelligence techniques such as Ant Colony Optimization, Glowworm Swarm Optimization, Artificial Bee Colony.

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