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A SURVEY ON ANT SYSTEM BASED MULTICAST ROUTING IN MOBILE AD HOC NETWORKS

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Abstract: Transferring multiple copies of packet to different nodes is called Multicasting. Wired and infrastructure-based wireless networks are maintained by many multicast routing protocols. But, relating this concept in Mobile Ad hoc wireless networks (MANETs) is a majorexperiment. Problems in ad hoc networks are the scarcity of bandwidth, short lifetime of the nodes due to power constraints and dynamic topology due to the mobility of nodes. These problems put in force to design a simple, scalable, robust and energy efficient routing protocol for multicast environment. In this paper we will talk overunlike multicasting routing protocols for mobile ad hoc networks and their distribution issues.

Keywords: Multicasting, Mobile Ad- Hoc Networks (MANETs), Routing Protocols, Ant Colony optimization.

I. INTRODUCTION

MANET (Mobile Ad hoc network) is a collection of wireless mobile nodes dynamically forming a transitory communication network without the use of any surviving infrastructure. Multicasting is intended for group communication that supports the propagation of information from a sender to all the receivers in a group.It consists of simultaneously sending the same message from one source to several destinations. Its features enhance video-conferencing, distance education, co-operative work, and video on demand, replicated database updating and querying, etc. The Ad hoc environssuffer from frequent path breaks due to mobility of nodes; hence efficient multicast group maintenance is necessary. Maintaining the multicast group can be done by either soft state approach or hard state approach. In the soft state approach, the multicast group membership and associated routes are refreshed periodically which necessitate flooding of control packets. But, in the hard state approach, the routes are reconfigured only when a link breaks, thus making it a reactive scheme.Most of the protocols in MANETs are application dependent. They are designed as per demand of application. Therefore there is a compulsionofdeveloping a protocol which is adaptive. Recently new class of algorithms came up based on "swarm intelligence". These algorithms are nature inspired from biological, natural self-organizing system. The Ant colony optimization (ACO) algorithm belongs to a class of Swarm Intelligence (SI). These techniques are inspired by biology e.g. ants, termites and bees foraging for food, can be artificially simulated and utilised to solving real wireless network problems. At very first it was used to solve Travelling Salesman Problem (TSP). This algorithms is based on behaviour of ants, their food searching mechanism inspired all researchers to find shortest route in communication network which was further implemented for ad-hoc networks. Ant colony routing (ACR) is a clan of scattered bionic routing protocols based on swarm intelligence.In this paper we deal a study of ant-based routing algorithms for MANETs. We classify algorithms and encapsulate their procedures.

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II. BIO-INSPIRED NETWORKING

Biological systems which evolved over billions of years ago, share several fundamental properties with the Internet, such as absence of centralized coordination, increasing complexity as the system grows in size, and the interaction of a large number of individual, self-governing components, etc. It is easy to draw analogies between Biological Systems and Internet even though they have different origins. Bio inspired networks takestheir inspiration from Biological systems.

Swarm Intelligence (SI) is an Artificial Intelligence technique based on the study of collective behaviour in decentralized, self-organized systems. It is used to model the corporative behaviour 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. 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, which means communication via the environment.

SI-based algorithms belong to a wider class of algorithms, called bio-inspired algorithms. In fact, bio-inspired algorithms form a majority of all nature-inspired algorithms. From the set theory point of view, SI-based algorithms are a subset of bio-inspired algorithms, while bio-inspired algorithms are a subset of nature-inspired algorithms. That is

SI-based $\subset$ bio-inspired $\subset$ nature-inspired.

Conversely, not all nature-inspired algorithms are bio-inspired, and some are purely physics and chemistry based algorithms. Many bio-inspired algorithms do not use directly the swarming behaviour. Therefore, it is better to call them bio-inspired, but not SI-based. For example, genetic algorithms are bio-inspired, but not SI-based. Flower algorithm[1], or flower pollination algorithm[2], developed by Xin-She Yang in 2012 is a bio-inspired algorithm, but it is not a SIbased algorithm because flower algorithm tries to imitate the pollination characteristics of flowering plants and the associated flower uniformity of some pollinating insects.

Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) and Honeybees paradigms are SI based optimization techniques. Particle swarm optimization (PSO)[3], is inspired from the conduct of flocks of moving birds. Honeybees paradigm, Artificial Bee Colony (ABC) algorithm is inspired by the intelligent foraging behaviour of honey bees. Oneof the drawbacks of ABC algorithm is the blocking of its optimum path.

III.ANT COLONY OPTIMIZATION (ACO)

Ant Colony Optimization (ACO) [4] is general purpose optimization technique which is based on foraging behaviour of ant species in real life. These real life ants walking to and from a food source, deposit a chemical substance called pheromone which establish the shortest path for other members of colony to be followed. Similarly, in ACO, artificial ants are the agents which are used to solve the various optimization problems. These agents (ants) moving around in the network from one node to the other, updating routing tables (called pheromone table) of the nodes that they visit with what they have learned in their traversal so far. Afterwards agents selecting best shortest path from updated pheromone table.

In most cases, an artificial ant will deposit a quantity of pheromone represented by $\Delta\tau_{i,j}$ only after completing their route and not in an incremental way during their advancement. This quantity of pheromone is a function of the found route quality. Pheromone is a volatile substance. An ant changes the amount of pheromone on the path (i, j) when moving from node i to node j as follows:

$$\tau_{i,j} = \sigma \cdot \tau_{i,j} + \Delta\tau_{i,j}$$

Where σ is the pheromone evaporation factor. It must be lower than 1 to avoid pheromone accumulation and premature convergence.

At one point i, an ant chooses the point j (i.e. to follow the path (i, j)) according to the following probability

$$P_{i,j} = \frac{(\tau_{i,j})^{\alpha} . (\eta_{i,j})^{\beta}}{\sum_{(i,k)\in C} (\tau_{i,k})^{\alpha} . (\eta_{i,k})^{\beta}}$$

Where,

- $\tau_{i,j}$: is the pheromone intensity on path (i, j).
- $\eta_{i,j}$: is the ant's visibility field on path (i, j)(an ant assumes that there is food at the end of this path).
- α and β : are the parameters which control the relative importance of the pheromone intensity compared to ant's visibility field.
- C: represents the set of possible paths starting from point i ((i,k) is a path of C).

A. Ant Colony Algorithm-

There exist two types of agents, forward and backward agents. All forward and backward agents have the same structure. The agents travel inside the network by hopping at every time period from a node to the next node along the existing links. The agents link with each other in an indirect way by simultaneously reading and writing the routing counters on their way.

The elementary plan of ant colony algorithm is taken from food searching behavior of ants. Whenever ant is searching for the food, it deposits the pheromone on the way in which they travel. The pheromone is nothing but it is the liquid which evaporates as time passes. Thus the pheromone content on the way in which it will travel is nothing but theindication of probability usage of the path.

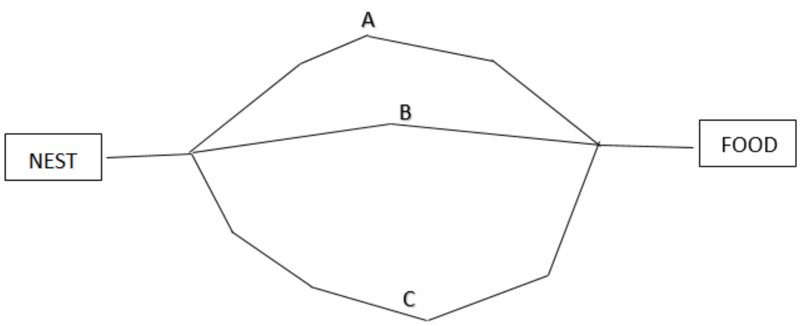

Figure 1: Ant Colony technique to find shortest path.

The above figure shows three paths from nest to food. At juncture the first ant selects path randomly. Since the shortest path to the food is B, the ants travel through the path B, Henceit will reach first to food. Now while returning to the nest ant has to select path. Here ant decides the path depending on pheromone concentration and it is obvious that the pheromone concentration on shortest path will be higher than the others. After some time pheromone concentration on shortest path will be highest and all ants will take shortest path only. This behaviour of finding the shortest path is used in communication networks. Due to its dynamic and probabilistic nature, this algorithm is used for mobile ad-hoc networks where topology changesoften. In [5] Simple ACO meta-heuristics algorithm is given which shows why these kinds of algorithms could perform well in mobile ad-hoc network.

B. Motives for using ACO in ad hoc networks-

ACO suits to ad hoc networks as it shares most of the characteristics of ad hoc networks:

i. Dynamic topology:

This property is responsible for the bad performance of several routing algorithms in mobile multi-hop ad-hoc networks. The ant colony optimization meta-heuristic is based on agent systems and works with individual ants. This allows a high adaptation to the current topology of the network.

ii. Local work:

In contrast to other routing approaches, the ant colony optimization meta-heuristic is based only on local information, i.e., no information blocks or routing tables have to be passed on to the neighbours or to all other nodes existing in the network.

iii. Link quality:

It is possible to integrate the connection link quality into the computation of the pheromone concentration, especially into the evaporation process. This will improve the decision process with respect to the link quality.

iv. Support for multi-path:

Each node has a routing table with entries for all its neighbours, which contains also the pheromone concentration. The decision rule, to select the next node, is based on the pheromone concentration on the current node, which is provided for each possible link. Thus, the approach supports multipath routing.

IV.CLASSIFICATION OF ANT COLONY ALGORITHMS FOR MANET

Various algorithms have been formulated to date by different scholars and they are modelled around the ant colony optimisation (ACO). The algorithms attempt to find the shortest path of sending data from sender to the destination in mobile wireless environment. The ant based algorithms are shown in the Figure 2below.

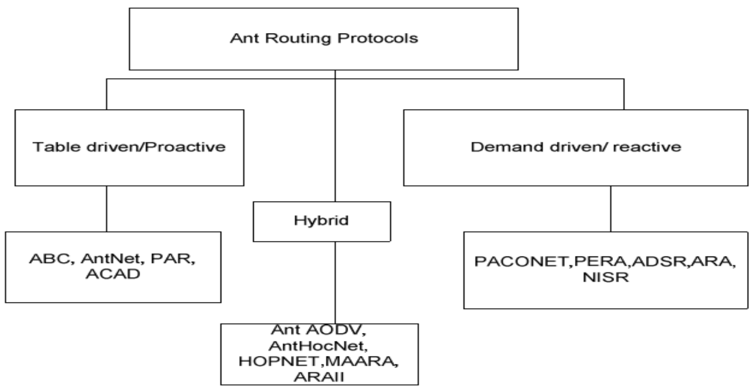

Figure 2: Swarm based routing protocols for wireless network

A. Ant Colony Based Routing Algorithm(ARA)-

ARA isa routing protocol based on AntNet and has relatedprocedures in terms of route discovery. But in ARA,routes are maintained primarily by data packets as they flowthrough the network. This is the very first routing algorithm based on ACO which aims to reduce routing overhead. The proposed routing algorithm consists of three segments (a) Route Discovery (b) Route maintenance (c) Route failure Handling. The path to the destination is protectedby increasing the pheromone value in the

routing table as data packets travel along instead of using periodic ants like AntNet. This brings higher benefit as flooding of periodic ants is being reduced. Recognized paths do not maintain their initial pheromone deliberation forever. The pheromone concentration value will be reduced from time to time. ARA implements a pheromone decay mechanism where its value in the routing table decreases over time. This is to have faster meeting of pheromones on the network edges. In case of a route failure, an attempt is made to send the packet over an alternate route; otherwise, it is returned to the previous hopexpecting that there exists an alternate route in the network.
As data packets increase the pheromone of a routing path andat the same time, pheromones of other alternate routes evaporate, making the whole data traffic network will quickly converge to a particular route. New routes are never discovered in ARA until a route error message notifies the source to initiate a new route discovery action. ARA has no updating mechanism to adapt the changes in a dynamic network such as MANET.

B. Probabilistic Emergent Routing Algorithm (PERA)-

PERA uses a protocol based in on demand routing that is table driven: each mobile automaton maintains a table with routes. Packets only contain the address of the destination machine. An intermediate machine consults its table in order to choose the next hop. Contrary to what happens in protocols based in routing tables, as the ones used on the Internet, the protocol used in PERA only updates tables on demand. There are two main tasks that the routing function must fulfil: route discovery and route maintenance, which are used, respectively, to initially fill the table when a packet must be routed to an unknown destination, and later, for keeping updated a given route updated in case it is still needed. For this reason, each entry in the route table that is stored by each robot can be erased or updated.

C. AntHocNet-

In [5] the AntHocNet algorithm has been projected which consists of both reactive as well as proactive components. The path has been set in reactive manner by using reactive Fant(Forward Ant) and after multiple paths has been set between source and destination. The communication session is monitored in proactive manner by proactive Fants. In this algorithm the reactive Fant searches path from source(s) to destination (d) and on arrival of, when it arrives at d, it become the Bant(Backward Ant) which track back the same path to update the routing table. The routing table τ_i in node i contains for each d and each possible next hop n. A value $\tau_{ind} \in R$. $\tau_{ind}$is quality of the path over n to d, which we call pheromone value. In this fashion pheromone tables in different nodes indicates that multiple paths between s to d, and the data packets can be routed from node to node. In every single node Ant selects next hop with a probability proportional to its pheromone value. After the path has been set, the source s sends the proactive Fant to destination which uses same pheromone values of data packets. They can be used to monitor the quality of path in use. In the event of link failure nodes try to locally repair paths or sends warning message to neighbours such that they can update their routing table.
Therefore AntHocNet consists of reactive path set up, stochastic data routing, proactive path maintenance and link failure handling. The Simulation results are carried out with Qualnet simulator and the performance has been compared with AODV protocol. The algorithm is tested for the different scenario by varying parameters like pause time, area dimensions. The result shows that in all scenarios the proposed algorithm gives better delivery ration than AODV. For simpler scenario the average delay of AntHocNet is higher than AODV but in difficult scenario it is lower. In AntHocNet alternative path are available in case of route failure, therefore there is less packet loss. This paper determines that proposed algorithm performs better than AODV in terms of delivery ratio and average delay in difficult (high mobility) scenario and furthermore suggests that, by improving the exploratory working of proactive ants and extending the concept of pheromone diffusion, more information about possible path improvements will be available in nodes which can guide the proactive ants and this will lead to better results with less overhead.

D.Ant-AODV-

Shivanajay, Tham and srinivasan [6] put forwardproactive-reactive hybrid protocols which poolelements from AntNet and the AODV routing protocol. The Ant-AODV routing protocol maintains a population of forward ants which explore the network with a source-routing list of visited nodes in the packet's header. Moreover, when a node requires a route to a specific node it may reactively launch RREQ packets, though it is not clear whether the launched RREQ packets use source or distance-vector routing. The protocol also uses frequent hello messages which allow nodes to be continuously aware of their neighbours, and notifies nodes of link failures. Nodes maintain distance-vector routing tables with target/next-hop pairs and connected hop count and sequence numbers for each route. The protocol is compared to the AODV protocol and results indicate that the end-to-end delay and packet delivery fraction of Ant-AODV is comparable to AODV, with Ant-AODV having a slightly higher normalized routing overhead due to the continuousproactive measure of forward ants.

V. LOAD BALANCING

The existing adhoc routing protocols has the major drawbacks such that they do not have provisions for assigning the load capacity and/or quality of a path during route setup. Hence they cannot balance the load on different routes. Mutually, proactive and reactive protocols chose a route grounded on the metric, the smallest number of hops to the destination. But it may not be the most significant route when there is congestion or bottleneck in the network. It may cause the packet drop rate, packet end-to-end delay, or routing overhead to be increased particularly in the cases when the traffic is concentrated on a special node like a gateway through which mobile nodes from ad hoc network can connect to Internet. There are various proposed algorithms for load balancing that consider traffic load as a route selector, but these algorithms do have shortcomings, Table1 show list of algorithms with their disadvantages.

Table 1: Analysis of ant colony optimization swarm based routing protocols

Routing Protocol	**AntHocNet**	**ANT AODV**	**ARA**	**PERA**
Scheme	Hybrid	Hybrid	Reactive	Reactive
Route discovery approach	Flooding	Flooding	Flooding	Flooding
Strategy for loop prevention	Sequence numbers	Sequence numbers	Unique sequence numbers	Sequence numbers
Type of ants in use	Proactive and reactive forward and backward ants	Forward and backward ants	Forward and backward ants	Forward and backward ants
Energy aware mechanism	Not available	Not available	Not available	Not available
Pheromone evaporation	Yes	Yes	Yes	Yes
Technique for detecting route failure	Local repair error message	Local repair error message	Backtracking	Missing HELLO packets
Type of route created	Multi-path	Single path	Multi-path	Multi-path
Algorithm Problem	Overhead problem	Overhead in route error and repair	No built-in mechanism to adapt to changes in network topology	High duplication of ants in the network that result in congestion

VI. CONCLUSION

This paper, presents a general view of multicast routing protocols in ad-hoc networks. Any multicast routing protocol in MANETs tries to overcome some difficult problems which can be categorized underbasic issues or considerations. All protocols have their own advantages and disadvantages. The current status of research efforts to addressthem from the perspective of bio-inspired networking iscaptured. Researchers have started to realize the significanceand potentials of bridging the gap between thesetwo distinct domains under the cross-disciplinary field ofbio-inspired networking. Through the existing research results, it has been shown that the inspiration from biologyis, indeed, a powerful source of innovative network design.

Despite the considerable amount of on-goingresearching this direction, the bio-inspired networking research community is quite young, and there still remain significantly challenging tasks for the research community toaddress fundamental challenges for the realization of many existing and most of the emerging networking architectures. In this regard, a vast space of biological systems, which still remains unexplored, needs to be thoroughly investigated in order to discover their objects to be used towards accelerating the evolution in the information and communication technologies domain.

REFERENCE

[1] X.-S. Yang, "Flower pollination algorithm for global optimization," Unconventional Computation and Natural Computation, p. 240–249, 2012.

[2] M. K. a. X. H. Xin-She Yang, "Multiobjective flower algorithm for optimization," Procedia Computer Science, p. 18:861–868, 2013.

[3] B. T. N. A. M. Z. A. L. B. &. D. A. Boukerche, "Routing protocols in ad hoc networks: A survey," Elsevier Computer Networks , vol. 55, p. 3032–3080, 2011.

[4] M. B. &. T. S. M. Dorigo, "Ant colony optimization," Computational Intelligence Magazine,IEEE, vol. 1, no. 4, p. 28 –39, 2006.

[5] Gianni Di Caro,Fredrick Ducatelle and Luca Maria Gambardella. AntHocNet: An Ant-Based Hybrid Routing Algorithm for Mobile Ad- Hoc Networks. PPSN VIII, LNCS 3242,pages 461-470, Springer-Verlag 2004.

[6] M. Shivanajay, C.K. Tham, and D.srinivasan, "Mobile Agents based Routing Protocol for Mobile Ad-Hoc Networks", presented at IEEE GLOBECOM 2002, Symposium on Ad-Hoc Wireless Networks (SAWN 2003),Taipei, Taiwan, pp. unknown, Nov 2002.