A survey paper on Ant Colony Optimization Routing algorithm for selecting Multiple Feasible Paths for Packet Switched Networks

Ms. Meenakshi R Patel[1], Ms. Babita Kubde[2]
[1] CSE Department,Rungta College of Engineering and Technology, Bhilai, C.G. , India

[2] CSE Department,Rungta College of Engineering and Technology, Bhilai, C.G. , India

Abstract

ACO algorithms for datagram networks was given by Di Caro & Dorigo, in year 1996. Basic mechanisms in typical ACO routing algorithms is Ant-like agents are proactively generated at the nodes to find/check paths toward assigned destinations Ants move hop-by-hop according to a exploratory routing policy based on the local routing .After reaching their destination, ants retrace their path and update nodes routing information according to the quality of the path. Routing information is statistical estimates of the time-to-go to the destination maintained in pheromone arrays. Data are probabilistically spread over the paths according to their estimated quality as stored in the pheromone variables.

AntNet algorithms may cause the network congestion and stagnation as the routing table converges. In this paper we perform a survey on modified AntNet routing algorithm using Multiple Ant-Colony Optimization. Multiple ant colonies with different pheromone updating mechanism have different searching traits. By leveraging this feature, much of work is done by designing a set of adaptive rules to facilitate the collaboration between these colonies. This approach can balance the diversity and convergence of solutions generated by different ant colonies and also overcome the problem of Stagnation.
Keywords: *ACO routing algorithm, Multiple Ant-Colony Optimization, Ant agent, Stagnation.*

1. Introduction

The AntNet[1] for adaptive routing algorithms was proposed by Gianni di Caro and Marco Dorigo. The design of this algorithms has been the inspired by ant colonies and, more generally, by the notion of stigmergy. Real ants have been shown to be able to find shortest paths using a stochastic decision policy based only on local information represented by the pheromone trail deposited by other ants. It is an alternative routing algorithm for the well-known OSPF protocol, based on Ant Colony Optimization (ACO). ACO studies the behavior of ants in a colony and mimics this behavior in software. The problem to be solved, is represented by a graph. Artificial agents, i.e. software ants, gradually construct paths in this graph.ACO has been applied to many domains, e.g. the Traveling Salesmen Problem, manufacturing control systems, etc.ACO itself is a metaheuristic. When combined with an actual problem area, it can lead to several heuristics. AntNet is a result of the application of ACO on the problem of Internet routing. Intelligent agents, ants for short, are sent over the network. They communicate indirectly by information they leave behind in the routers on their path. Over time, this information leads to optimal routing paths between the routers in the network.

Antnet Routing Algorithm is an agent based routing algorithm that is influenced from the real ant's behaviour. In Antnet ants explores the network to find the optimal paths from the randomly selected source destination pairs. Moreover, while exploring the network ants update the probabilistic routing tables and construct a statistical model of the nodes local traffic. Ants make use of these tables to communicate with each other. The algorithm uses two types of ants namely, forward ants and backward ants to collect network statistics and to update the routing table. In each node there are two types of queues, low priority and high priority. The data packets and the forward ants use low priority queues, whereas the backward ants use the high priority queues. Later forward ants do also use the high priority queues .

1. Forward Ants who gather information about the state of the network, and
2. Backward Ants who use the collected information to adapt the routing tables of routers on their path.

An AntNet router contains a special routing table where each destination is associated to all interfaces and each interface has a certain probability. This probability indicates whether or not it is interesting to follow that link in the current circumstances. The router also contains a statistical model to store the mean and variance values of the trip times to all destinations in the routing table. These are used as reference values. On a regular time base, every router sends a Forward Ant with random destination over the network. The task of the Forward Ants is collecting information about the state of the network. In each router they pass, the elapsed time since the start is stored on an internal stack together with the identifier of the router. Then the next hop is determined. Normally this is based on the probabilities in the routing table. There is however a small chance (exploration probability) that the next hop is randomly chosen. This is necessary to constantly explore the network and to be able to react fast to network changes like link failures or congestion.

The Forward Ant is transformed into a Backward Ant. This Backward Ant will follow exactly the same path as the Forward Ant but in the opposite direction. The Backward Ants use the information collected by the Forward Ants to update the different data structures in each router along their path. The time information on the stack is compared with the model in the router and based on these comparisons, the probabilities in the routing table are updated. When the Backward Ant arrives in the start router, it dies. Backward Ants have a higher priority than data packets, so that they are processed as fast as possible making the algorithm more adaptive. Forward Ants have the same priority as data packets, to suffer the same delays so that the algorithm can react to network congestion. A trip time better than the mean value will boost the probability on that interface, while a bad trip time will only slightly increase the probability. The variance value is an indication for the stability of the network. A relatively large value indicates an unstable network state; a small value indicates a stable state. In an unstable state the effects on the probabilities are weakened as it is unsure that a bad trip time indicates a long path.

Stagnation occurs when a network reaches its convergence (or equilibrium state); an optimal path is chosen by all ants and this recursively increases an ant's preference for selected path. This may lead to congestion on selected shortest path and dramatic reduction of the probability of selecting other paths.

2. Reviews

An approach to find Multiple optimal path is given in this **[5]** . According to Original Antnet Algorithm, Routing table is a local data-base that helps router to decide where to forward data packets. It contains the information which specifies the next node that should be taken by a packet to get to any possible destination in the network. The columns of the table represent the neighbour nodes and rows represent the possible destinations. The column wise values in the table are picked up and a sorting algorithm is executed on these values. The sorted values ranging from higher to lower are stored in a temporary array. The difference d, amongst the adjacent values is calculated and is compared to some threshold value say pm. If the difference d is less than pm then those values are selected and comparison amongst the adjacent values is continued until difference is greater than pm. Otherwise at the very first occurrence of difference greater than pm , the comparison is stopped and the corresponding value(s) in the array is(are) selected. The interfaces corresponding to these values are stored in a new routing table which will have the same structure as the original one, but obviously, the new table will have less number of rows.

Interacted Multiple Ant Colonies Optimization (IMACO) is a newly proposed framework[6]. In this framework several colonies of artificial ants are utilized. These colonies are working cooperatively to solve an optimization problem using some interaction technique. Exploration technique is doing an essential job in this framework. This technique is responsible for directing the activity of utilized colonies towards the different parts of the huge search space. This paper describes the newly proposed IMACO framework and proposes an effective exploration technique. Computational tests show that the new exploration technique can furthermore improve the IMACO performance.

One new direction of ACO researches that focus on enhancing the performance of ACO and reducing the effect of the search stagnation is the use of Multiple Ant Colonies Optimization (MACO) where several ant colonies work together to collectively solves an optimization problem. MACO offers good opportunity to explore a large area of the search space and find optimal or near-optimal solution. MACO seems to be appropriate approach to improve the performance of ACO algorithms. IMACO follows this approach and tries to improve the performance of ACO algorithms by utilizing several ant colonies with certain techniques to organize the work of these colonies.

A multiple-ant-colony load balancing algorithm (antBalance)[8] for the resources allocation within network sessions. Combined ant colony algorithm with dynamic load balancing in the network traffic engineering, the algorithm further extends the basic ant colony to multiple ones with dynamic pheromone release design. By influencing the ant colony pheromone with each other, each ant in one ant colony not only strengthens the pheromone of the same colony, but also weakens that of the other colonies in the paths. antBalance tries to allocate ants to different paths fairly to avoid traffic congestion in some certain paths. Besides analyzing the effective control of the pheromone, compared with basic ant algorithm, simulation experiments illustrate that antBalance achieves better resources allocation performance in terms of path bandwidth utilization, session delay and session packet loss.

Based on the knowledge Multiple Ant-Colony Optimization, the proposed algorithm antBalance introduces multiple ant colonies to simulate the competition for load balancing within network resources allocation. antBalance implements multiple-ant-colony mechanism to select paths by the transition probability table, which is inspired by [9]. Given a set of Q nodes composing a network, network sessions run within these nodes. The Load balancing problem can be stated as the problem of finding a serial of optimal paths to support these network sessions with balancing allocation of resources.

Although an ant is a simple creature, collectively a colony of ants performs useful tasks such as finding the shortest path to a food source and sharing this information with other ants by depositing pheromone. In the field of ant colony optimization (ACO), models of collective intelligence of ants are transformed into useful optimization techniques that find applications in computer networking[10]. In this survey, the problem-solving paradigm of ACO is explicated and compared to traditional routing algorithms along the issues of routing information, routing overhead and adaptivity. The contributions of this survey include 1) providing a comparison and critique of the state-of-the-art approaches for mitigating stagnation (a major problem in many ACO algorithms), 2) surveying and comparing three major research in applying ACO in routing and load-balancing, and 3) discussing new directions and identifying open problems. The approaches for mitigating stagnation discussed include: evaporation, aging, pheromone smoothing and limiting, privileged pheromone laying and pheromone-heuristic control.
The survey on ACO in routing/load-balancing includes comparison and critique of ant-based control and its ramifications, AntNet and its extensions, as well as ASGA and SynthECA. Discussions on new directions include an ongoing work of the authors in applying multiple ant colony optimization in load-balancing.

3. Conclusions

This paper is a study to overcome the problem of Stagnation and congestion by using Multiple Ant-Colony Optimization. In the improved version, of ACO, Multiple Ant-Colony Optimization can find more than one optimal outgoing interfaces are identified as compared to only one path, which are supposed to provide higher throughput and will be able to explore new and better paths even if the network topologies gets changed very frequently. This will distribute the traffic of overloaded link to other preferred links. Hence the throughput of the network will be improved and the problem of stagnation will be rectified. In the future work we intend to simulate the same using ns simulator so that exact results can be found.

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Meenakshi R Patel B.E. in CSE in 2003 from JNVU, Jodhpur, Rajasthan, India.
Babita Kubde B.E. in CT in 2002 from Nagpur Univesity,M.Tech in CSE from CSVTU Bhilai, Reader in CSE Department, RCET,Bhilai, C.G. , India.