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An Approach to Identify Multiple Paths in a Network

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ABSTRACT

This paper presents a new technique to identify multiple paths in a network using the concept of ants in Ant Colony Optimization. This paper uses the concept of probe ant, which identifies the multiple paths to be stored at destination node. Overall purpose of this paper is to create multiple optimal paths using probe ant and ACO.

Keywords - ACO, ABC, Probe Ant, Load Utilization Factor (LUF).

1. INTRODUCTION

Routing is an important aspect in computer networks as it controls the traffic between one node to another depending on various parameters. Routing is the basic process for determining the performance of a network in terms of quality and quantity. For performing routing, routers are required. The basic purpose of routers is to update the routing table via an algorithm. Most of the traditional routing algorithms transmit the data by minimizing the cost function which may be distance, delay, jitter etc. They find the shortest path which may become congested over time and/or may become expensive later on. Sometimes, a path which is better on the basis of more than one metric such as distance, delay, bandwidth, jitter etc. is required. Then sometimes there is a trade-off between those metrics. Therefore, it is necessary to get an optimal solution based on more than one metric.

For getting such optimal solution, now-a-days a number of studies are going on to identify routing alternatives using heuristic techniques. One of such techniques is Ant Colony Optimization (ACO). In ant based routing, the artificial ants, while moving from source to destination, deposit some artificial pheromone in terms of numeric value and store some information in the form of routing table at the intermediate nodes. This information is used by newly generated ants for accepting or rejecting a path. Another important aspect of routing is increasing need of multi-path routing. The main reason for the need of multi-path routing is the data transmission in Internet. When a video or audio streaming is required, very high bandwidth is required. With single path routing, it might not be possible, hence arise the need of multi-path routing. When multi-path routing is combined with multi-metric routing, it becomes a perfect candidate for use of heuristic techniques. Therefore, ACO can prove to be a very effective technique for this type of routing.

2. RELATED WORK

2.1 Multipath Routing

This paper [1] has shown that while routing shortest path is frequently used, but shortest path routing can bring congestion to the shortest path and other paths being underutilized. For solving such problem multipath routing is one of the best alternatives. In case of multipath routing, data traffic is divided among more than one path which may not be best, but good paths. While identifying multiple paths, it should be taken into account that various paths to be used for data transmission are not too many, as there is a considerable overhead in using more than one path. Therefore it is desirable to use as few paths as possible while at the same time minimize the congestion in the network. For selecting good paths, some information about the resources availability is required during each arrival and departure of data, along with information about the global network is also needed. However, these updates generally do not much burden on the network as long as their frequency is not more than what is needed to convey connectivity information in traditional routing protocols like OSPF [7]. It is quite important to generate multipath routing schemes that perform well even when the updates are very frequent.

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One of the basic problems in multipath routing is of load balancing. The Equal Cost Multipath (ECMP) [7] and Optimized Multipath (OMP) [2, 1] schemes perform packet level forwarding decisions. ECMP divides the data equally among various equal cost paths. It basically uses updates to collect link loading information, selects a number of good paths and distributes data equally among them. However, this scheme made routing decisions at the flow level. QoS routing schemes have also been proposed [14, 11, 4, 16], where flow level routing decisions are taken on the basis of the knowledge of the availability of resources at network nodes and the QoS requirements of flows. This knowledge can be obtained via global link state information exchange among routers in a network. These schemes create a global view of the network QoS state. Then it performs path selection solely based on this global view. Some of the examples found in literature are widest shortest path [11], shortest widest path [15], and shortest distance path [4]. Another approach to path selection is to first calculate disjoint paths [10] and try them in some order.

2.2 Routing using ACO

According to [9], an ant not only finds the shortest path for searching its food source but also convey this shortest path to other ants. In the ACO, this intelligence of ants is intermixed with various optimization techniques to identify optimum routes in a computer network. In this paper, various mechanisms to solve the problem to identify optimum path using ACO were explained and compared with different traditional algorithms of routing. This paper throws light on a critical review in four different groups for applying ACO in routing, which are (i) Ant Based Control Systems(ABC system), (ii) AntNet System, (iii) Ant System with other variations, and (iv) Multiple Ant Colony Systems.

Schoonderwoerd et at. [12][13], applied ACO to routing in telecommunication networks based on circuit-switching. The algorithm was termed as ABC (Ant Based Control). In the ABC algorithm, all the nodes in a network follows various features[12] such as capacity, probability of being a destination, pheromone table and routing table, on the basis of which criteria for choosing next node is decided. But the main problem of Schoonderwoerd et al. approach is that it can only be applied when the network is symmetric in nature.

In [6], a new version of AntNet was generated and was named as AntNet-FA or AntNet-CO. In this version, backward ants performed a number of tasks such as, (a) estimating the trip time using various metrics, (b) updating local traffic statistics, and (c) determining and depositing the pheromone for estimating the probability of reinforcement. As backward ants are using real time statistics for determining the amount of reinforcement, the information for routing was found to be more correct and up-to-date. The results of this version are found to be better than AntNet algorithm which are proved by experiment performed in this paper.

Oida and Sekido [8] proposed Agent-based Routing system(ARS) in which they suggested for supporting various types of bandwidth requirement, the forward ants move in a network, which is based on bandwidth constrained. The probability of selection of outgoing link depends on routing table as well as bandwidth constraints.

[5] Although, adaption has been proved to be one of the better techniques for identifying the optimum paths, but one of the major problems that can be attached with AntNet is stagnation. Due to this problem local optimum solution might be obtained and diversity of the population might also be lost. In this paper, the concept of multiple ant colonies was applied to the packet switched networks. Upon comparison with AntNet algorithm with evaporation, it was found that by using multiple ant colonies throughput can be increased. No improvement was found in delay. But the basic problem was the need of large resources for multiple ant colonies.

3. ANT BASED ALGORITHMS

3.1 Ant Based Control (ABC) Routing

In the ABC Algorithm, pheromone tables are maintained which is having entry for each destination from each node and also having entry for each neighbor. Initially all are assumed to have probabilities equally distributed among the various paths that are available from a node. Ants are launched from any node named as source node, in the network. Each node is having some random destination. Ants move from one node to another after selecting the next node according to the probabilities in the pheromone tables for their destination node. Arriving at next node, they update the probabilities of that node's pheromone table entries corresponding to their source node. The probability of the path travelled is increased. When an ant reaches its destination, it dies. The increase in the probabilities is based on decreasing function of the age of the ant. The ants may get delayed on parts of the system that are heavily congested.

$$P = (P\_old + \Delta P) / (1 + \Delta P)$$

Here P is the new probability and is the probability increase. The other entries in the table of this node are decreased according to:

$$P = (P\_old + \Delta P) / (1 + \Delta P)$$

The probabilities are updated according to the following formula, where age stands for the number of time steps that passed since the launch of the ant:

$$\Delta P = ((0.08 / age) + .005)$$

3.2 Antnet Routing Algorithm

In an AntNet algorithm [9], an ant explores the path and updates the routing and probability tables, so that other ants can use the tables to know which path is better than others. Some statistical traffic model is also used to help the ants to identify the better path.

A routing table is maintained which is a local data-base. The routing table contains information about all possible destinations along with probabilities to reach these destinations via each of the neighbors of the node.

Another data-structure that each node carries is termed as local traffic statistics. This structure follows the traffic fluctuations as viewed by the local node.

The AntNet algorithm as proposed by Di Caro and Dorigo, depends on two types of Ants named as forward ant and backward ant. The forward ant collects the information regarding the network, while the backward ant uses this information to update the routing tables on their path.

Working of the algorithm is given as follows:

i) Initially to generate a routing table a forward ant is initiated from every node toward the destination node after a fixed time interval to find low-cost path to that node and load status of the network is also explored and accordingly priorities of the paths are set. These priorities are used by the forward ants to transmit the data.

ii) The forward ants stores the information about their paths in a stack.

iii) At each node, decision is made to select a node for reaching towards destination with the help of probabilities using pheromone values. The nodes which are unvisited are only considered for selection or from all the neighbors in case all of them has found to be previously visited.

iv) When the forward ant moves towards destination, if at any time any cycle is detected, all the nodes in that cycle's path are popped. Also all of the information about them is also deleted.

v) When the forward ant reaches its destination, then it generates another ant named as backward ant. It transfers all of its memory to it and dies.

vi) The backward ant as its name indicates will travel to the opposite direction that of forward ant. The backward ant uses stack formed by forward ant and pops the element in the stack to reach the source node. The backward ant use high priority queues to reach source so that information can be quickly transmitted to the source node. The information collected by forward ant is stored in the routing table by the backward ants.

vii) The backward ant basically updates the two data structure i.e. routing table and the local traffic model for all the node in its path for all entries starting from the destination node.

3. PROPOSED ALGORITHM

In this work, a new type of forward ant named as probe ant [3]. The probe ants are generated to replace the forward ants from source node to explore the path. The probe ants are generated depending on the paths selected at a particular node. The multiple paths are selected according to the load utilization factor. These probe ants [3] will reach to the destination according to new proposed strategy. The major advantage will be that instead of one optimal path more than one optimal path are identified.

The proposed modifications are briefly explained below:

The structure of probe ant is defined as follows:

S	D	I	Aid	PT	MB	TD	HC

Structure of Probe Ant

Here, S →Source Node, D →Destination Node,

I →Intermediate Node from which ant has arrived recently,

Aid →Ant Identification Number

PT → Path traversed so far

MB →Minimum Bandwidth of the path traversed

HC →Hop Count

In the proposed algorithm we are using the concept of choke packets congestion control formula to find the paths to be used.

$$U = U * a + (1 - a) * F$$

Where a = capacity/load, assuming that load is never zero.

F=line utilization factor

U=line utilization

Algorithm:

I A probe ant is initiated at the source node towards destination node. Line Utilization Factor U of all nodes is taken to be Zero initially.

II The probe ant selects multiple paths on the basis of line utilization factor.

III The Probe Ant is launched from the source node towards the destination node along the neighboring nodes of the source node and line Utilization factor f is set to 1.

IV After reaching the neighboring nodes, the line utilization is calculated according to the formula

$$U = U * a + (1 - a) * F$$

V Line utilization value is compared to the threshold value. If it is less than the threshold value then the ant is moved towards the destination node through the neighboring nodes of the current node. Otherwise ant is not moved further.

VI After a fixed time the information of various ants reached at destination node is stored in an array.

VII Then using an intelligent (nature inspired) approach some of the paths are selected and this information is transmitted to source node.

By using this algorithm we can find multiple paths from source to the destination node. In this method we are balancing the network load. If load on a particular link is more than the threshold value then we are not using that path for the transmission of data.

4. CONCLUSION

In this paper a modified approach for finding multiple paths been proposed. In this approach the load utilization factor has been calculated to select various paths. Another important feature that has been used in this paper is the use of a threshold value of load utilization. Probe ants will be generated at the source to select multiple paths, which can be stored at destination. These paths can be further refined using some intelligent approach, and multiple paths for a better transmission of data packets can be identified.

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