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Helping ants for adaptive network routing

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Abstract

Appropriate routing in data transfer is a challenging problem that can lead to improved performance of networks in terms of lower delay in delivery of packets and higher throughput. Considering the highly distributed nature of networks, several multi-agent based algorithms, and in particular ant colony based algorithms, have been suggested in recent years. However, considering the need for quick optimization and adaptation to network changes, improving the relative slow convergence of these algorithms remains an elusive challenge. Our goal here is to reduce the time needed for convergence and to accelerate the routing algorithm's response to network failures and/or changes by imitating pheromone propagation in natural ant colonies. More specifically, information exchange among neighboring nodes is facilitated by proposing a new type of ant (helping ants) to the AntNet algorithm. The resulting algorithm, the ''modified AntNet,'' is then simulated via NS2 on NSF network topology. The network performance is evaluated under various node-failure and node-added conditions. Statistical analysis of results confirms that the new method can significantly reduce the average packet delivery time and rate of convergence to the optimal route when compared with standard AntNet.

Keywords: Ant colony; Network routing; AntNet algorithm; Multi-agent systems; NSFNet

1. Introduction

Routing algorithms, at the core of network control systems, play an important role in the exponentially growing communication systems worldwide. If appropriately configured,

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they can provide faster, smoother and more reliable data packet routing, and in particular greatly influence several measures of network performance such as end-to-end delay and throughput. Conventional routing algorithms depend on global exchange of information among nodes and hence become impractical as network size increases. These algorithms are based on finding shortest path such as in distance-vector algorithms (RIP[1]) [1] and link-state algorithms (OSPF[2]) [2]. However the rapid growth of networks and change of technology show that we need to reconsider our approach to routing in order to respond to the new system requirements such as rapid convergence, quick response to network changes and quality of service as well as having good performance.

Communication networks are distributed platforms with distributed information, and therefore provide good environment for multi agent systems and distributed decision making. Consequently, in the last decade, new types of routing algorithms based on multi agent systems have been introduced. Amin A. and Mayes, J.T. (1998) introduced a new agent-based distance vector routing (ADVR) algorithm based on multi agent systems [3]. Traditional DVR algorithms cause large network overhead due to the large number of messages generated through the router update process. Number of these messages is an exponential function of the number of nodes in the network. In comparison, since ADVR is an agent based solution, the number of its messages is bounded by the number of agents in the network.

Most of the other multiagent-based algorithms take their inspiration from ants' behavior. Real ants are able to find shortest path between their nest and food source by following pheromone trail of other ants. For example Schonderwoerd R. (1997) implemented ant-like agents for routing [4]. In his algorithm, each source node s sends an ant toward destination d at regular intervals, where d is selected in a random scheme. When ants reach node i, select their next hop n to their destination according to routing table of node i, then update node i's routing table. They increase the probability of choosing n as a next hop (increasing the pheromone) while selection probability of other neighbors is decreased for destination d. Di Caro and Dorigo (1997) also introduced a new algorithm based on ant behavior (AntNet) [5]. In their method two types of ants exist, forward and backward ants. Similar to the Schonderwoerd's algorithm, each node sends a forward ant to different destinations at regular intervals. But in this algorithm the forward ant does not update the routing tables of nodes that it visits, its only duty is to find a path to destination d and to collect information. When a forward ant arrives at its destination d, it generates a backward ant and dies. The backward ant then goes back in the same path as the forward ant that created it and updates the routing tables for intermediate and destination nodes.

The above AntNet has received considerable attention by various researchers. For example, B. Baran and R. Sosa improved AntNet by proposing an intelligent initialization of routing tables, an intelligent update after network resource failures, and a noisy decision making against undesirable networks "freezing" their routing probabilities in dynamic environment [6]. Later, in 2002, Kassabalidis and El-Sharkawi, M.A. showed that for large networks good routing solutions can be achieved by combined use of network clustering, autonomous systems and ant colony [7]. In other research, AntNet is used in routing for ad hoc wireless networks. For example, Marwaha, S., et al. introduced a novel method for

[1]Routing Information Protocol.
[2]Open Shortest Path First.