Proposal and Evaluation of Ant-based Routing with Prediction

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The rapid growth of the Internet in scale and complexity makes conventional networking techniques, which aim at the best performance by a set of optimized rules and fine-tuned parameters, unsuccessful and unfeasible in the near future. To realize highly robust, adaptive, and evolvable information networks, researchers have been paying much attention on self-organization. A self-organizing system, such as that found in nature, does not rely on any centralized or dominating component. Instead, a global behavior or pattern emerges on a macroscopic level as a consequence of autonomous behavior of components based on simple rules and local information. It leads to the higher scalability, adaptability, and robustness of a self-organizing system than a conventional system.

However, despite the properties beneficial to information networks, a self-organizing system or a self-organization based networking technology suffers from inherent disadvantages. First, in a large-scale system, it may take long time for a global pattern to emerge. Second, self-organization would fall into a local optimum while a conventional system using global information can reach an optimal solution in most cases. Furthermore, a self-organizing system is not controllable in general, whereas unnecessity of control is one of the significant aspects of self-organization. These disadvantages and complaints about them from engineers brought an idea of controlled or guided self-organization where a self-organizing system is moderately controlled through a feedback mechanism or adaptation of control parameters.

In this abstract, we take ant-based routing as an example of self-organization based networking technologies, and consider a mechanism of controlled self-organization to accelerate path convergence. Foraging behavior of ants is well-known biological self-organization. Ants finding food lay chemical substances called *pheromone* on the ground and pheromones guide ants to the food source. The feedforward-based reinforcement mechanism of pheromone trail makes ants concentrated on the shortest path without any centralized control. Because of the similarity, the foraging behavior of ants or its mathematical model called ACO (Ant Colony Optimization) has been adopted as a routing mechanism by many researchers. Previous researches show that AntNet, one of ant-based routing mechanisms, is superior to conventional mechanisms in robustness against failure, smaller control overhead, and higher communication performance [1]. However, time required for path convergence depends on the length of the path. As such, it is not scalable to the size of a network. Moreover, the considerable amount of control messages generated in path establishment deplete network bandwidth and hinder data message transmission.

To accelerate path convergence, we introduce a predictive mechanism. In [2], a predictive mechanism was proposed for faster consensus in flocking birds. With a predictive mechanism, each bird predicts the future state, i.e. location of neighbor birds, only from past behaviors of them and adapts its movement to conform to the predicted states. It implies that '*historical local information is equivalent to current global information*'. We adopt the same idea for a node to predict the future convergence from history of pheromone accumulation. In an ant-based routing mechanism, a shorter path collects more pheromones than longer paths and it attracts more ants which further deposit pheromones on the path. Therefore, the increase rate of pheromone implicitly indicates the goodness of a path. In our proposal, each node predicts a path which will obtain the largest amount of pheromone from historical information about pheromone accumulation. Then, it boosts pheromone accumulation on the predicted path to have faster convergence. Our proposal is shown to have a higher convergence property than AntNet. We plan to evaluate the robustness and adaptability of our proposal.

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