Chapter 9
Artificial Insect Algorithms for Routing in Wireless Sensor Systems

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ABSTRACT

Social insect communities are formed from simple, autonomous, and cooperative organisms that are interdependent for their survival. These communities are able to effectively coordinate themselves to achieve global objectives despite a lack of centralized planning. This chapter presents a study of artificial insect algorithms for routing in wireless sensor networks, with a specific focus on simulating termites and their behaviours in their colony. The simulating behaviour demonstrates how the termites make use of an autocatalytic behaviour in order to collectively find a solution for a posed problem in reasonable time. The derived algorithm termed Termite-Hill demonstrates the principle of the termite behavior for solving the routing problem in wireless sensor networks. The performance of the algorithm was tested on static and dynamic sink scenarios. The results were compared with other routing algorithms with varying network density and showed that the proposed algorithm is scalable and improved on network energy consumption with a control over best-effort service.

DOI: 10.4018/978-1-4666-6328-2.ch009

INTRODUCTION

Social insect communities are formed from simple, autonomous and cooperative organisms that are able to effectively coordinate themselves to achieve global objectives despite a lack of centralized planning. This chapter focuses on simulating termite behaviours in their colony for the problem of routing in wireless sensor networks (WSNs). A WSN is a distributed infrastructure composed of a large collection of nodes with the ability to instrument and react to events and phenomena in a specific environment (Saleem et al., 2010; Zungeru et al., 2012b; Akyildiz et al., 2002). WSNs are collections of compact-size, relatively inexpensive computational nodes that measure local environmental conditions or other parameters and relay the information to a central point for appropriate processing using wireless communications. Each sensor node is equipped with embedded processors, sensor devices, storage devices and radio transceivers. The critical factor in the design of WSNs is to maximize the lifetime of the sensor nodes which are battery-powered and have a limited energy supply. A key element that determines the lifetime in a WSN is the way that information is transmitted or routed to a destination node (called sink). A node with information to send to the sink does not transmit the information directly to the sink (single-hop network) (a situation when the sink is not a neighbor of the source node) because this will require a very high transmission power. Rather, the node sends the information to a neighbouring node which is closer to the sink which in turn sends to its neighbour and so on until the information arrives at the sink (multi-hop network). This process is known as routing. An important problem in WSN is how to design a routing protocol which is not only energy efficient, scalable, robust and adaptable, but also provides the same or better performance than that of existing state-of-the-art routing protocols.

Termites are relatively simple insects. Their small size and small number of neurons makes them incapable of dealing with complex tasks individually. On the other hand, the termite colony can be seen as an intelligent entity for its high level of self-organization and the complexity of tasks it can perform to achieve global objectives despite a lack of centralized planning and direct communications. One way termites communicate is by secreting chemical agents that will be recognized by receptors on the bodies of other termites. A termite is capable of determining if another termite is a member of its own colony by the smell of its body. One of the most important of such chemical agents is the pheromone. Pheromones are molecules released from glands on the termite body. Once deposited on the ground they start to evaporate, releasing the chemical agent into the air. Individual termites leave a trail of such scents, which stimulates other termites to follow that trail, dropping pheromones while doing so (Matthews & Mattheus, 1942). This use of the environment as a medium for indirect communication is called stigmergy. This process will continue until a trail from the termite colony to the food source is established. While following very basic instincts, termites accomplish complex tasks for their colonies in a demonstration of emergent behaviour. In the foraging example, one of the characteristics of the pheromone trail is that it is highly optimized, tending toward the shortest path between the food source and the termite nest or hill. This creation of a trail with the shortest distance from the nest to the food source is a side effect of their behaviour, which is not something they have as an *a priori* goal.

In this chapter, we will focus on how termite colonies use pheromone trails to accomplish complex tasks and show the similarity between termite colonies and WSNs. We also show the relationship between the stigmergic behaviour utilizing pheromones and the process of representation in a complex system which in our case is the WSN. From the WSN perspective, social insect communities have many desirable properties as surveyed in (Zungeru et al., 2012b; Saleem et