Chapter 11
Swarm-Intelligence-Based Communication Protocols for Wireless Sensor Networks

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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, and the behaviour is referred to as swarm intelligence. This chapter presents a study of communication protocols for wireless sensor networks utilizing nature-inspired systems: social insect-based communities and natural creatures. Three types of insects are used for discussion: ants, termites, and bees. In addition, a study of the social foraging behavior of spider monkeys is presented. The performances of these swarm-intelligence-based algorithms were tested on common routing scenarios. The results were compared with other routing algorithms with varying network density and showed that swarm-intelligence-based routing techniques improved on network energy consumption with a control over best-effort service. The results were strengthened with a model of termite-hill routing algorithm for WSN.

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INTRODUCTION

Swarm intelligence (SI) is an Artificial Intelligence technique that simulates the behavioural structures of natural creatures to solve complex optimization problems. The techniques demonstrate the desirable characteristics of interpretability, scalability, robustness and efficiency and can be used to achieve better solutions in Wireless Sensor Networks (WSNs) (*Tina Gui* et al, 2016) Bio-inspired systems are tending to be included in new architectures due to the following reasons;

1. Simple to design and interpret with basic rules
2. Adaptive to medium topological change
3. Efficiently manage limited resources

Social insect communities are formed from simple, independent 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 and modelling insect-based behaviours in their colony for the problem of routing in wireless sensor networks (WSNs). It also discusses the behavioural patterns of spider monkeys and presents from previous research (*Tina Gui* et al, 2016) a search strategy based on population and aimed to improve the network performance and reduce energy consumption.

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., 2011; Zungeru et al., 2012b; Zungeru et al., 2012c; Sardar et al., 2014; Sensarma et al., 2012; 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 neighboring node which is closer to the sink which in turn sends to its neighbor 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.

Insects are relatively simple creatures. Their small size and small number of neurons makes them incapable of dealing with complex tasks individually. On the other hand, the insect 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 insects communicate is by secreting chemical agents that will be recognized by receptors on the bodies of other insects. One of the most important of such chemical agents is the pheromone. Pheromones are molecules released from glands on the insect body. Once deposited on the ground they start to evaporate, releasing the chemical agent into the air. Individual insects leave a trail of such scents, which stimulates other insects to follow that trail, dropping pheromones while doing so (Matthews & Mattheus, 1942).