Chapter 16

A Source Based On-Demand Data Forwarding Scheme for Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks (WSNs) are becoming more important in the medical and environmental field. The authors propose an on-demand routing protocol using sensor attractiveness-metric ($P_a$) gradients for data forwarding decisions within the network. Attractiveness-based routing provides an efficient concept for data-centric routing in wireless sensor networks. The protocol works on-demand, is source-initiated, has a flat hierarchy and has its origin in the idea of pheromone-based routing. The algorithm supports node-to-sink data traffic and is therefore a lightweight approach to generalized multihop routing algorithms in WSNs. The performance evaluation of the proposed protocol is done by extensive simulation using a multi-agent based simulation environment called NetLogo. The efficiency of the attractiveness-based routing algorithm is compared in simulations with the well known Dynamic Source Routing algorithm (DSR). The authors conclude that the $P_a$ based routing algorithm is well suited for easy to set up WSNs because of its simplicity of implementation and its adaptability to different scenarios by adjustable weighting factors for the node’s attractiveness metric.

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INTRODUCTION

Wireless Sensor Networks (WSNs) are special forms of ad-hoc networks, built by small, cheap and robust devices, so called sensor nodes. A collection of these nodes, which combine sensing, computation and communication abilities, forms the swarm intelligence. Normally, this term is referred to as the common intelligence of insect colonies, e.g., ant colonies. Each individual in an insect colony comprises of only a very low intelligence. Insects follow their intuitive rules, and show different behavioral patterns according to the current situation. As an example, an ant excretes a chemical called pheromone during foraging, and always follows the path of highest pheromone concentration. Sensor nodes also follow a simple set of rules. In insect colonies, there are a variety of other tasks besides foraging, including guarding, procreation, etc. Nevertheless, all individuals in the entire colony work towards a common goal. The same case occurs with member nodes of a WSN.

Classical approaches to ant colony optimization algorithms are given in Dorigo (1999) and Dorigo and Caro (1991), and their application in packet switching networks are presented (Di Caro & Dorigo, 1997, 1998a, 1998b). The Ant-Net architecture described was designed for large scale networks where each node can communicate with every other node over the network. The approach to realize a routing protocol for ad-hoc networks by imitating ants has also already been examined in other works (Heissenbuettel, 2005; Liu & Feng, 2005). In contrast to Heissenbuettel (2005) and Liu and Feng (2005) we propose a clear data centric routing concept for WSNs from each node to one sink.

The routing mechanism in Heissenbuettel (2005) is based on vectors containing the forwarding direction (FWD), in which data is broadcasted. The FWD is calculated from the neighbors’ forwarding directions and is re-aligned. The authors show an analogy between polar bonds of atoms and chains of nodes formed by running this protocol. The setting of the FWD only takes place mathematically, which means that the x- and y- components of the FWD vector, or the equivalent norm and angle, have to be maintained. Furthermore, every node maintains a tuple containing the x, y coordinates, buffer fill level and the induced charge, a model parameter. Out of this tuple, a parameter called ‘Sending Decision’ is calculated. This parameter has to exceed a threshold to start a data transmission. The protocol is suitable for highly mobile networks and only uses the information of its nearest neighbors for the routing decisions. It does not consider the energy status of the nodes and requires knowledge of the correct position. The mechanism does not provide an inherent prevention of routing loops.

In Liu and Feng (2005), an ant colony based multi path routing protocol named AMR is proposed, which combines swarm intelligence and node disjoint multi-path routing. The method establishes and utilizes multiple routes of node-disjoint path to send data packets concurrently and adopts the use of pheromone to disperse communication traffic using forward and backward ants for route discovery and maintenance.

Multihop routing protocols for wireless sensor networks have been proposed in several works. Table driven reactive (on-demand) multihop protocols are AODV (Perkins & Royer, 1999), DSR (Johnson & Maltz, 1994; Johnson, 1994), TORA (Park & Corson, 1997), etc. The path discovery procedure terminates either when a route has been found or no route is available after examination of all route permutations. In a mobile ad hoc network, active routes may be disconnected due to node mobility. Therefore, route maintenance is an important operation of reactive routing protocols. Compared to the proactive routing protocols DSDV (Perkins & Bhagwat, 1994), WRP (Murthy & Garcia, 1996), OLSR (Jacquet, 2003) (in proactive routing protocols the routing information from each node to every other node in the network is maintained at all times) for mobile ad-hoc networks, a lower control overhead is a