An Energy-Efficient Hierarchical Multiple-Choice Routing Path Protocol for Wireless Sensor Networks

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Abstract

The energy efficiency is a substantial key design issues in such networks. An efficient routing protocol is critical to prolong the life of sensor nodes.This work presents a Hierarchical Multiple-Choice Routing Path Protocol (HMRP) for wireless sensor networks. According to HMRP, the wireless sensor network is initially constructed as a layered network. Based on the layered network, sensor nodes have multipath routes to the sink node through candidate parent nodes. The simulation results indicate that the proposed HMRP can increase the lifetime of sensor networks better than other clustering or tree-based protocols.

1. Introduction

Wireless communications and digital electronics have allowed the development of low-cost, low-power, multi-functional small sensor nodes that are small in size and communicate without restriction at short distances [1, 6-7]. In the approaches proposed by Qiangfeng Jiang, et al. [2] and Al-Karaki, et al. [3], the placement of the classical sensors and the network topology are predetermining. Communication in the sensor network is based on the wireless ad hoc networking technology.

This investigation develops an energy-efficient hierarchical mechanism, called Hierarchical Multiple-Choice Routing Path Protocol (HMRP). The proposed system was designed according to the following objectives: 1). Scalability; 2). Simplicity; 3). System Lifetime. The rest of this work is organized as follows. Section 2 describes the benefits and problems of existing routing protocols for sensor networks. Section 3 presents a hierarchical multiple-choice routing path protocol for wireless sensor networks. Section 4 shows the simulation results. Finally, Section 5 draws conclusions and presents future research directions.

2. HMRP

HMRP is based on the hierarchical tree architecture, in which the sink nodes serve as root nodes.

2.1. Layer Construction Phase (LCP)

HMRP forms hierarchical relations with a network construction packet (NCP), which allows nodes to form autonomous relationships without any centralized control. The NCP format is <Seq_Number, Hop_Count, Source_ID, Sink_ID, Packet_Type>. The major activities in this phase are hierarchy setup, candidate information table creation and routing path formation for each node. The sink node (S) first increases the Hop_Count field by one, and broadcasts the LCREQ packet to discover the one hop nodes, i.e., the sink broadcasts the LCREQ packet <1, 1, S, S, L> to its neighbor nodes, displayed in Figure 3. A node not yet attached to the layer determines its candidate parent(s) from the received LCREQ packet by waiting for a short period of time (T_{LCREQ}) to obtain one or more candidate parents, and records them in its Candidates Information Table (CIT).

2.2. Data Dissemination Phase (DDP)

After the first phase is completed, sensor nodes can start disseminating the sensed data to the sink via the parent node. The packet format is as follows: <Seq_Number, Source_ID, Dest_ID, Sink_ID, Data_Len, Payload>. A Received Data Acknowledge (RDACK) packet is sent when the data packet is successfully transmitted to the parent node. The parent node then replies with this packet to notice the source

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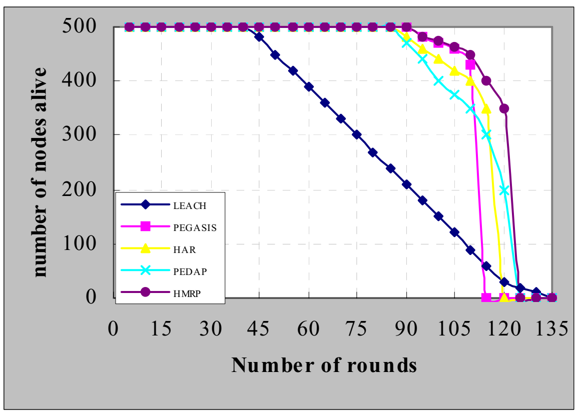
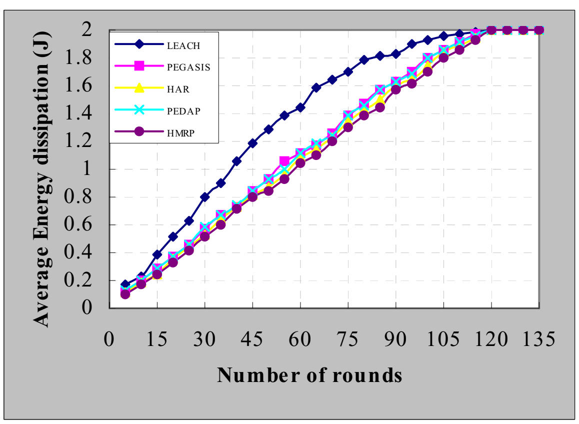
node, and forwards the data packet to next hop. Sensor node x chooses a record (with parent p) in turn by Round Robin Scheduling (RRS) in the CIT when it wishes to send a data packet to a sink.

3. Simulation Results

The energy costs for the various protocols discussed in the previous section were compared with those of the proposed protocol using the first order radio model [4-5]. Fig. 1a illustrates the system lifetime of those protocols. HMRP has a good lifetime improvement to others. Additionally, the system lifetime is defined as the number of rounds for which 75% of the nodes are still alive. Fig. 1b shows the average energy dissipation graph, revealing that HMRP consumes energy consumed more efficiently than the other protocols.



(a)



(b)

Figure 1. a) The system lifetime of HMRP and other protocols. b) The average energy dissipation of HMRP and other protocols.

4. Conclusions

Energy resource limitations are of priority concern in sensor networks. Distributing the load to the nodes significantly impacts the system lifetime. This investigation proposes a hierarchical multiple-choice routing path protocol called HMRP, which minimizes the path loading of the system by distributing the energy consumption among the nodes. In HMRP, sensor nodes do not maintain the whole path information, and so just maintain their CIT. The simulation results indicate that HMRP performs better than LEACH, PEGASIS, HAR and PEDAP. Additionally, HMRP supports multiple-sink-node environments.

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