

An Energy–Efficient Heuristic based Routing Protocol in Wireless Sensor Networks

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Abstract— Energy consumption is the critical issue to determine the lifetime of Wireless sensor networks (WSNs), due to limited batteries power resource of sensor nodes. The optimization of energy consumption is involves reduction of energy consumption in order to prolong the lifetime of the network as much as possible. However, to minimize the overall energy consumption of the sensor network, different types of routing protocols have been proposed. This paper proposes an energy efficient routing protocol using the A-star search algorithm to find the optimal path from the source node to the sink node. Simulation results with Matlab show that our proposed protocol is efficient in terms of total energy consumption and network lifetime compared with fuzzy approach.

Keywords: Wireless sensors network (WSNs), Routing protocol, A-star algorithm

I. INTRODUCTION

Recent advances in wireless communications and micro-electro-mechanical systems (MEMS) have highlighted the significance of wireless sensor networks (WSNs) as essential reporting devices[1]. A WSN is composed of hundreds or even thousands of sensor nodes are densely deployed in a field of interest to monitor specific phenomena. The sensor nodes can be engaged in a different of sensing tasks, such as humidity, light, vibration, sound, temperature etc[2]. These sensors are very constrained in terms of communication bandwidth, limited computational, small memory and finite on-board battery power. Due to the resource constrained characteristics of sensor nodes, energy-efficient data forwarding is supposed to be a critical challenge in WSN. Moreover, the energy consumed for communication considered as the chief sources of energy consumption in WSNs [3]. The energy consumed for communication and required transmission power grows exponentially with the increase of transmission distance. Generally, the routing protocols utilized to select the best paths between source and destination node in order to ensure balanced energy consumption and to maximize network lifetime. Most of routing protocols are periodically choice the same optimal path to transmit the data packets to the sink which impact on the WSNs lifetime [3-5]. As a result, the network will be partitioned and the network will not be able to accomplish its intended critical function.

In order to solve the problem of network partition in WSNs, researchers have proposed a variety of methods. In [6], the authors proposed a shortest path routing algorithm for extending the lifetime of the network depended on link costs that reflect both the residual energy levels and the communication energy consumption rates. In [7], the authors presented uniform balancing energy routing protocol to select the sensor nodes for routing path whose have remain energies greater than a threshold value and distributed the energy load among any sensor nodes to maximize the whole network lifetime. The authors in [8], proposed an Energy- Efficient Multi-path Routing Protocol (EEMRP). It has the capability of searching multiple node-disjoint paths and utilizes a load balancing method to assign the traffic over each selected path. Both the residual energy level of nodes and the number of hops are considered to be incorporated into the link cost function. FML-MP (a fuzzy multi-path maximum lifespan routing scheme), an online multi-path routing scheme that strives to achieve a good distribution of the traffic load is developed in [10]. The authors in [9] presented a novel algorithm for routing analysis in WSNs utilizing fuzzy logic at each node to determine its capability to transfer data based on its relative energy levels, distance and traffic load to maximize the lifetime of the sensor networks.

This paper propose an Energy-Efficient Heuristic Routing (EEHR) protocol using A-star heuristic search algorithm to find an optimal forwarding path from the source node to the sink node when the energy level of sensor nodes is above the threshold level .Otherwise, the our proposed method find another route path available to avoid the low energy sensor's in order to prolong the lifetime of the WSN. The rest of this paper is organized as follows. Section 2, the proposed routing method is presented. Performance evaluation is presented in Section 3. Finally, conclusion is presented in Section 4.

II. THE PROPOSED ENERGY-EFFICIENT HEURISTIC ROUTING (EEHR) PROTOCOL

In this paper, the network model utilized and the proposed EEHR protocol is presented in details.

A. network model

The proposed method assumes that WSN has following properties:-

- 1) All sensor nodes are randomly distributed in the area
- 2) Every sensor node is assumed to know its own position as well as that of its neighbours and the sink.
- 3) All sensor nodes have the same maximum transmission range and the same amount of initial energy.

The lifetime of the network is one of the important measures of WSN. The proposed model is avoiding the low energy sensor nodes from the routing path in order to prolong the lifetime of the WSNs. whenever the remaining energy value of any sensor node is less than the threshold value, communication links between various sensor nodes and the base station will break. Since the lifetime of each sensor node depends on energy consumption, it is important to preserve residual energy of these nodes in such a way that overall network lifetime is extended.

B. EEHR protocol

By creates a tree structure, the A-star heuristic search algorithm utilized to find an optimal forwarding path from the source node to the sink node. The tree node is explored based on its evaluation function $f(n)$. Moreover, the proposed method select the optimal path when the energy level of sensor nodes is above the threshold level .Otherwise, it's find another route path available to avoid the low energy sensor's in order to prolong the lifetime of the WSN .The function we used is given as:

$$f(n) = NC(n) + 1/MH(n) \quad (1)$$

Where $NC(n)$ is the node cost of node n , which take the remaining energy value for node n and $MH(n)$ is the distance between the node n to the sink node. The flow chart of the proposed method is shown in fig 1.

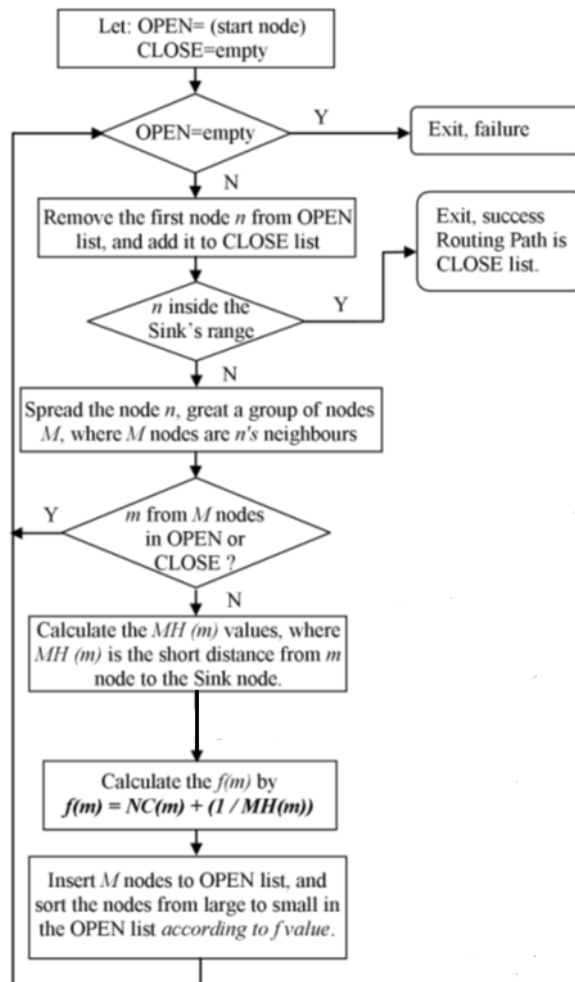


Fig.1 Flow-chart of the EEHR Protocol

III. PERFORMANCE EVALUATIONS

A. Simulation Setup.

The simulations are carried out in MATLAB. 100 sensor nodes are randomly deployed in a 100m×100m field with sensed transmission limit of 40m. A data sink node is located at (90, 90). All sensor nodes have the same initial energy of 1 j. The proposed method uses the first order radio model that is largely used in the area of routing protocol evaluation in WSN [11]. According to this model, transmission and receiving costs are characterized by the expressions $E_{nT}(k)=E_{elec} * k + E_{amp} * k * d^2$ and $E_{nR}(k)=E_{elec} * k$, respectively .

where k is the number of bit per packet, d is the distance from the sender node to the receiver node, Eelec and Eamp are per bit energy dissipation in transmitting or receiving circuitry and energy required per bit per meter square for the amplifier to achieve acceptable signal to noise ratio (SNR) respectively. Simulations are done using the values 50nJ/bit and 100pJ/bit/m² for Eelec and Eamp, respectively. Table 1 presents the systems parameters in details.

TABLE 1 SIMULATION PARAMETERS FOR THE A-STAR PROTOCOL

PARAMETER	VALUE
Topographical Area	100 m x 100 m
Sink location (meters)	(90 , 90)
No. of nodes	100
Limit of transmission distance	40 m
Initial energy of node	1 J
E_{elec}	50 nJ/bit
E_{amp}	100 pJ/bit/m ²
Packet data size	2k bit
No. of transmission packets	2×10^4

B. SIMULATION RESULTS

To demonstrate the effectiveness of the proposed method in terms of maximizing network lifetime and balancing energy consumption, the protocol is compared with Fuzzy approach used in [10]. The number of alive nodes as a function of rounds by using different approaches is shown in Fig. 2.

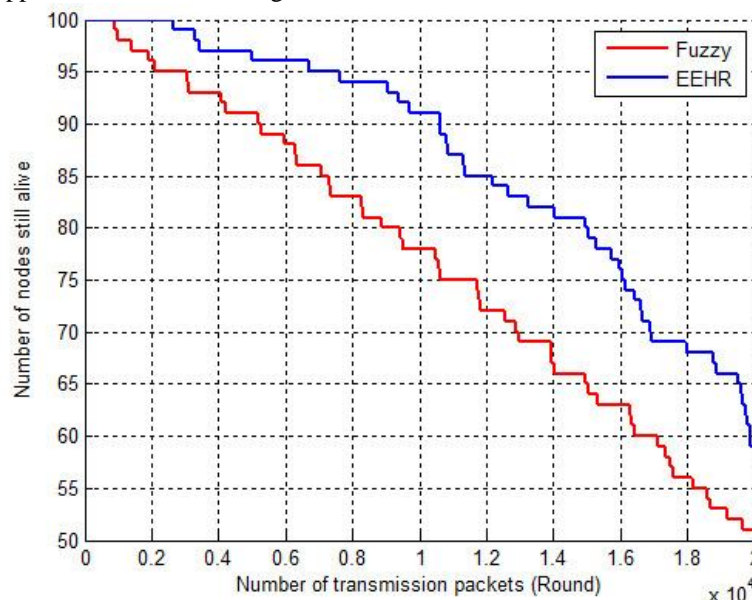


Fig. 2: Number of alive nodes as a function of rounds.

The different duration of time corresponding to the first dead node computed using two different approaches is listed in Table 2. From Fig.2 and Table 2, it is clear that, using the proposed method the lifetime of a WSN is longer than the lifetimes of a WSN using fuzzy approach.

TABLE 2 NUMBER OF ROUNDS WITH THE FIRST DEAD NODE FOR THE APPROACHES (FUZZY AND A-STAR)

APPROACHES	LIFETIME OF THE FIRST DEAD NODE (ROUNDS)
A-star	2407
Fuzzy approach	883

Fig. 3 shows the average remaining energy of a WSN as a function of transmission rounds for the two approaches. As the round number increases, the proposed method performs better than Fuzzy approach. This indicates that, better energy balance in a WSN is achieved by the proposed method.

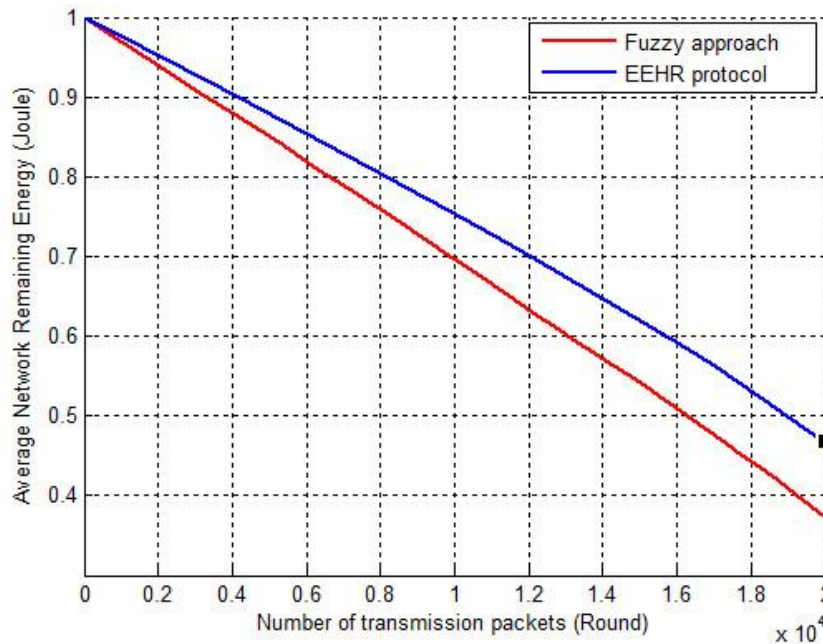


Figure 3: Average network remaining energy as a function of transmission round.

IV. CONCLUSION

This paper used A-star heuristic search algorithm to propose the EEHR protocol in order to find the optimal routing path. EHR protocol avoids the low-energy nodes and chooses another path in the network. Our routing degrades the chance of network partition and extends the lifetime of the network. Simulation results demonstrate the effectiveness of the proposed method with regards to enhancement the lifetime of WSNs when compared with Fuzzy approach.

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