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FULL-LENGTH ARTICLE

Computing geometric median to locate the sink node with the aim of extending the lifetime of wireless sensor networks

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Abstract In case of wireless sensor networks (WSNs) the sensed data which are collected by the ordinary senor nodes will have to be forwarded to the sink node (Base Station) in order to be accessible by the remote users. The location of the sink could significantly affect the energy dissipation and throughput of the network. This paper aims to investigate an optimal location for the sink node in such a way that the sum of distances from all the sensor nodes to the sink node is minimized. In an effort to place the sink node within the network our algorithm finds the geometric median of all the location associated with the sensor nodes. In a discrete set of points, the geometric median could be defined as the location which basically minimizes the sum of distances to all the points. Performance evaluation reveals that the proposed location for the sink node extends the network lifetime comparing with other possible location within the network field.

1. Introduction

Wireless sensor networks (WSNs) due to variety of applications [1–3] and future potential [4,5] has gained a tremendous attention among the researchers. Two main components of a WSN are the sensor nodes and the sink node. Despite the fact that wireless sensor networks (WSNs) are capable of having a variety of topologies, for instance star, mesh or ring, the signals generated by the sensor nodes are provided to the end users through the sink nodes. A sink node or a base station is basically a designated device similar to the normal sensor nodes but more powerful. One of the primary tasks of the sink

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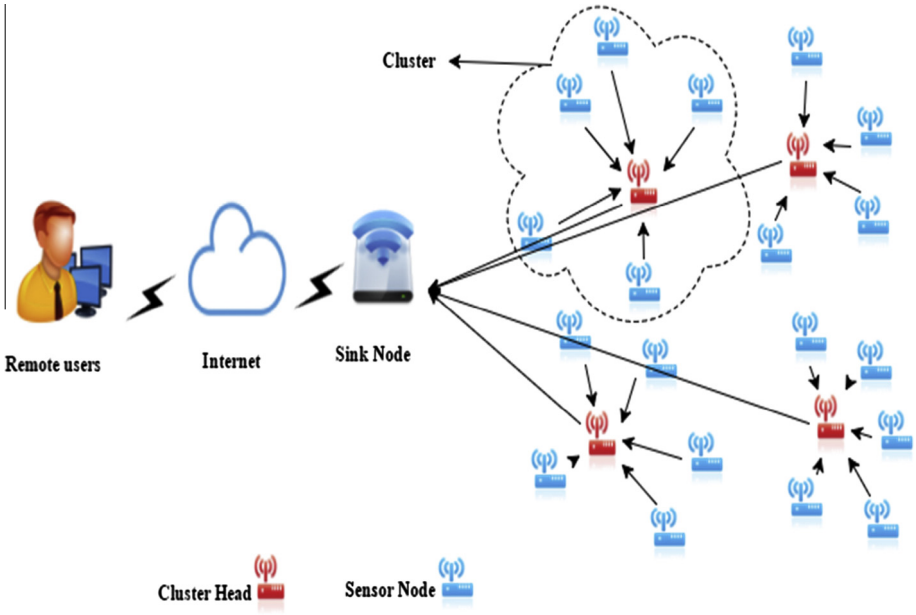

Figure 1 A typical wireless network.

node is to bridge a WSN with the remote users (Fig. 1). Actually being not the same as ad hoc networks, sensor nodes in WSNs are powered by non-rechargeable batteries. Therefore the techniques [6–8] and design of new protocol [9,10] to prolong the lifetime of the network are of great importance. The energy required to route a message to the sink node, for each and every sensor node depends on the distance from the sink node and number hops that message will have to travel. Having several sink nodes, employed effectively within the network field would help to reduce the energy needed for a message to be delivered and prolong the network lifetime. Though, there are some constraints of employing several sink nodes such as the cost of the device or not being practical to have more than one within the field. Due to the fact that, the sensed data, collected by the ordinary SNs are transferred to the sink node, the overall network performance can be influenced by the place of the sink node.

There are several challenges to be faced in order to locate the optimal spot of the sink node within the network field. Few of main issues are as follows:

- There exists a huge solution space which means the sink node can be possibly located at anywhere in the network field.
- Massive number of sensor nodes in the WSNs is another main challenge in locating the sink node.
- There are different routing protocols each having its own energy model and technique to optimize and route data toward the sink node.
- Possible changes in the network topology due to any sort of failure or improvements which might require the sink node to be relocated.
- Optimization of sink node location for different sampling mode such as periodical or event-driven, might require different considerations [11].
- Increment of sensor nodes within the network field requires the sink node to be repositioned in order to improve the lifetime as well as the throughput of the network.

This paper intends to find out an optimal location for the sink node so that the sum of distances from all the nodes to the sink node is minimized. To spot the optimal place our algorithm finds the geometric median of all the locations associated with the sensor nodes. In a discrete set of points, the geometric median could be defined as the location which basically minimizes the sum of distances to all the points. Despite of being a straightforward concept, its computation is a challenge. The remainder of the paper is structured as follows. In Section 2 the related work and proposed solutions are discussed. Section 3 discusses our strategy and algorithm in order to find the optimal location for the sink node. The network model along various parameters that are used in the simulation is presented in Section 4. Section 5 contains the performance evaluation and the result of our simulation and conclusion of the work is given in Section 6.

2. Related work

In [12] the sink has been located on different places and the conclusion indicates that the center of the network as well as the center of the quarter having the highest density of nodes are far better choices for the sink location. In [13,14] the P-median, a well-known NP-hard problem was used to decide the optimal location of the sink node. The result given in [14] shows the optimal placement of the sink would be the center. Authors in [15] fix the sinks location by taking into account the nodes whose data are conveyed through a node close to the sink. In [16] optimal base-station locations regarding two-tiered WSNs have been proposed. The network lifetime was evaluated by the distances of all the nodes and the sink as well as the average rate of bit stream. In [17] the result from the simulation shows that improvements on data rate and power Efficiency can be accomplished by employing different algorithms to discover a layout for the base station. The sink node position was selected to increase the joint weight of data flows in an effort to reduce the energy consumption of the WSN. In [18]

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