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Sink position for fast data collection in IoT

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Abstract

As a part of the IoT (Internet of Things), Wireless sensor networks have seen an essential success in many domains. They mainly allow to collect data from an environment and to forward it through multi-hop communication to the base station (also called the sink). If the sink is not well placed in the network, it may affect the latency of the data collection which affects the overall performance of the network.

In this work, we propose a technique to place the sink as close as possible to all the nodes of the network, in order to ensure a rapid data collection. The proposed approach takes into consideration the coordinates of all the nodes of the network when placing the sink.

Extensive simulations have shown better performance of our technique than similar existing works in terms of average latency of communications and average energy consumption.

Keywords: IoT, WSN, sink position, latency of communications

1. Introduction

Wireless Sensor Networks WSNs are composed of a large number of sensors deployed in an area of interest. These sensors collect physical measurements from the environment and forward it through multi-hop communication to the base station/the sink. The sink is usually a sensor or a computer with more capacities than the nodes of the network. It collects all the data of the network and sends it to the final user through Internet or Satellite [1].

Many works in literature try optimizing the latency of communications in WSNs by improving routing protocols such as finding the shortest path towards the sink. Unfortunately, the position of the sink is completely neglected even though all data is forwarded towards it. If the sink is far from most of the nodes of the network, these nodes are going to generate a high latency of communication when sending their data to the sink.

Generally, the nodes are deployed randomly, and the sink is placed in the center of the deployment area as shown in Figure 1.

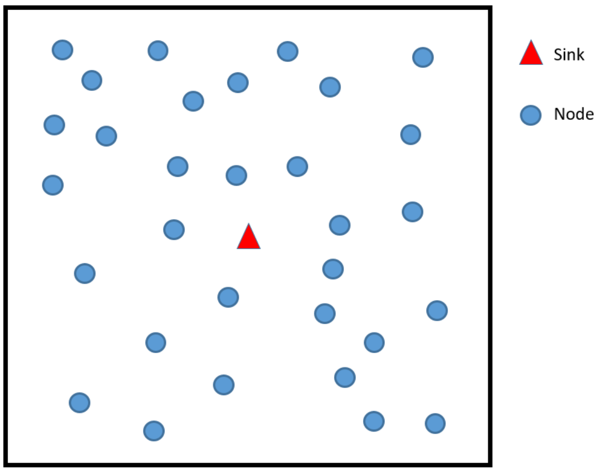

Fig1. An example of a deployment area with a number of nodes and one sink

This placement technique is the easiest one since it doesn't require any computation or previous preparation, but it may affect the latency of communication if the position of the sink is not suitable.

If the nodes were uniformly distributed in the deployment area, then the center of the area may be a good choice since it allows the sink to be as close as possible to all the other nodes.

When the nodes are deployed randomly, the center of the deployment are is no longer a good choice. One side of the deployment area may have more nodes than other sides, for consequence the position of the sink must be adjusted to the position of the nodes of the network.

Figure 2 shows an example of a deployment area where nodes are not uniformly distributed. There are more nodes on the upper left side of the area than the other sides.

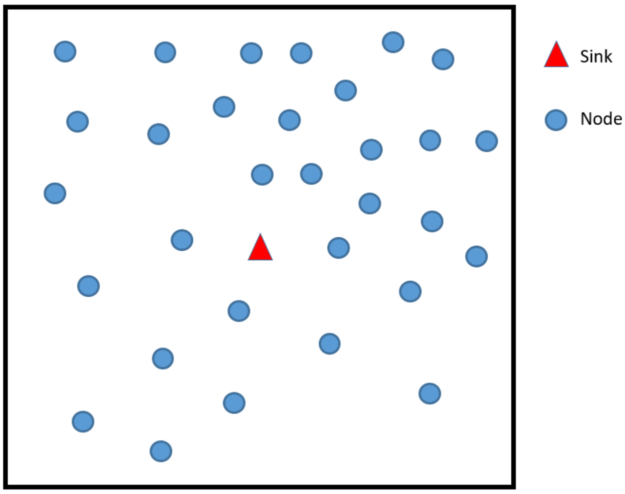

Fig2. An example of a deployment area where nodes are not uniformly distributed

The objective of this work is to propose a technique allowing to find a suitable position of the sink such that it can be as close as possible to all the nodes of the wireless sensor networks in order to minimize the latency of communications.

The remainder of this paper is organized as follows. Section 2 presents some existing sink position techniques. Section 3 presents our sink position approach. In section 4 we evaluate the performance of our approach through different simulations. We conclude in the last section.

2.Related works

In [2] and [3] the authors propose a method which tests every possible position of the sink in the deployment area and maintains the position that generates the best targeted metric, for instance the latency of communications. Even though these two approaches will certainly find the best position, their execution time is very high since they test every single possible position in the deployment area.

The idea in [4] is to determine a circle with the smallest diameter that includes all the nodes of the network. The circle can be formed using at most three nodes selected among the nodes of the network. The sink will be positioned at the center of the circle.

In [5] the authors divided the deployment area into grids and place the sink in the most dense grid. This will allow the sink to have the maximum number of neighbors. These neighbors are used more than the other nodes since they relay all collected data into the sink.

Other works can be found in literature that deal with placing more than one sink as in [6] and [7]. We do not detail these works since we are only interested in placing a single sink.

3.Our Approach

Since the latency of communication is distance sensitive, our idea is to place the sink as close as possible to all the nodes of the network. Since the nodes were deployed randomly in the deployment area, we use the position of every node in order to determine the position of the sink.

We consider a square deployment area where *n* nodes are deployed randomly. Each node is determined by its abscissa (x coordinate) and its ordinate (y coordinate).

The abscissa of the sink is computed as follows

$$Sink_x = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (1)$$

Where, x_i is the abscissa of node i and n is the total number of nodes.

The ordinate is the sink is computed as follows

$$Sink_y = \frac{1}{n}\sum_{i=1}^{n} y_i \qquad (2)$$

Where, y_i is the ordinate of node i and n is the total number of nodes.

By considering the coordinate of each node of the wireless sensor network, we ensure that the sink will be placed as close as possible to every single node. This approach works well when the nodes are uniformly distributed in the area and will place the sink in the center of the area. But it also works when the nodes are randomly distributed which may lead to having some sides of the deployment area that are covered more than other sides.

3. Evaluation and simulation results

We evaluate the performance of our approach by simulating it in the JUNG simulator. JUNG [8] is a set of Java libraries that allow modelling, analysis and visualizing of networks as graphs.

We represent the deployment area by a square of size a^2. We randomly distribute n=100 nodes in this area with the same communication range r=25m following the UDG (Unit Disk Graph model [9]) in which two nodes are considered neighbours if they are in each other's communication range.

We compare our approach with the circle approach and the most dense grid approach. We launch a series of 50 simulations, for each simulation we randomly deploy the nodes and then we compute the sink position of each approach. Once the sink is placed, a random TDMA is used as a MAC approach in which each node has one slot for transmitting its data and other slots to receive data from its neighbours. A geographic routing tree is used as a routing approach in which each node chooses its closest neighbour to the sink as its next-hop. We suppose that each node of the network has data to relay to the sink.

We evaluate two main metrics:

- The average latency of communications which represents the average time needed by the nodes to relay data to the sink.
- The average energy consumption which is the average amount of energy consumed by each node of the network during the simulation.

Figure 3 shows an example of one simulation with the 3 approaches for placing the sink

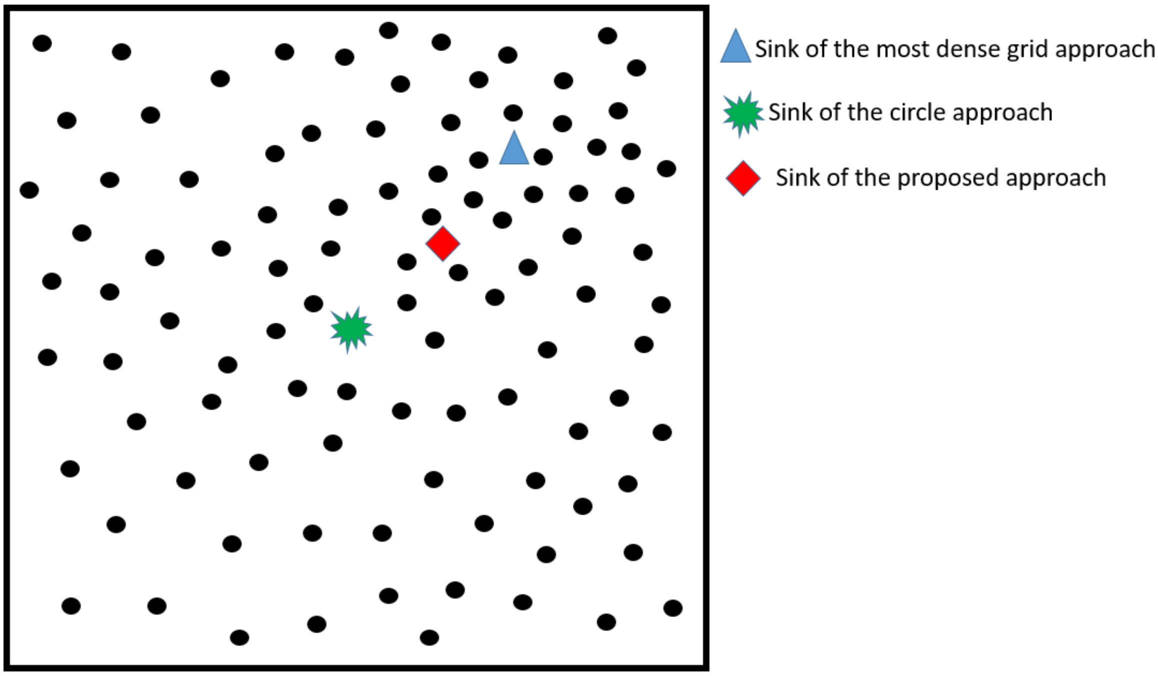

Fig3. An example of 3 sink positions with 3 different approaches

Figure 4 and 5 show that our sink placement approach generates better latency of communications and better energy consumption than the circle approach and the most dense grid approach.

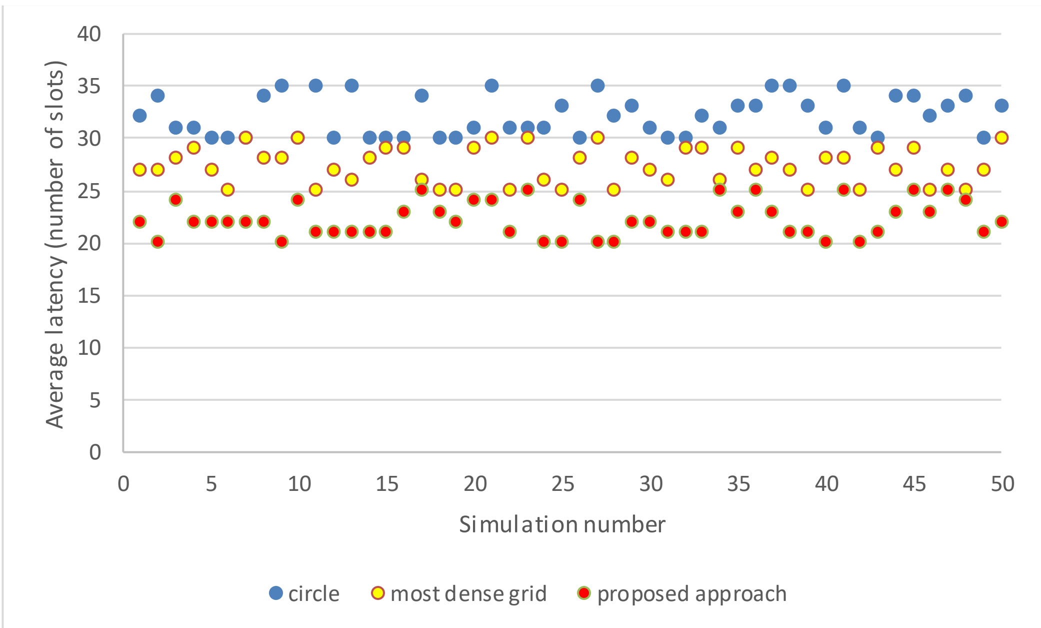

Fig4. Average latency of communications with different sink positions

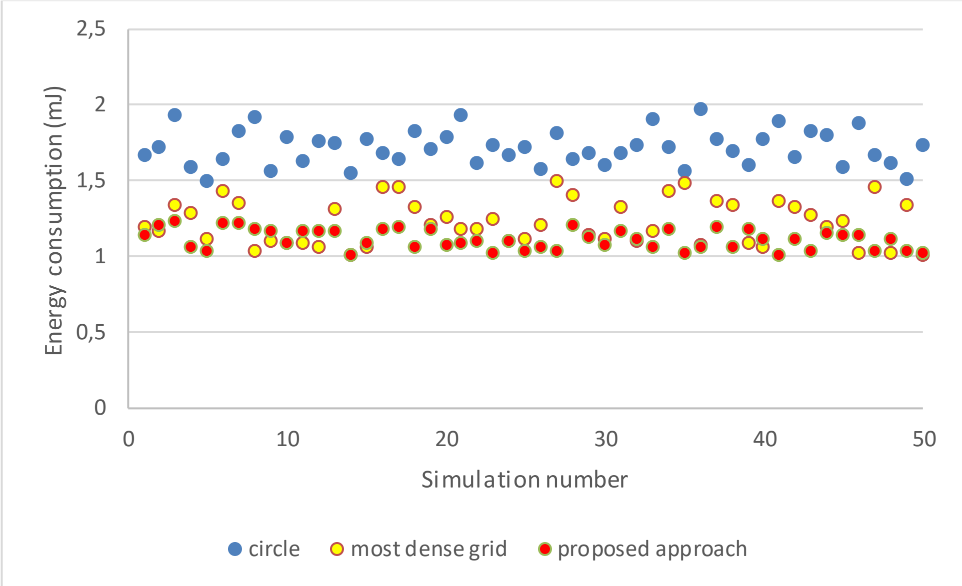

Fig5. Average energy consumption with different sink positions

Our technique uses the position of every node of the network and takes it into consideration when placing the sink. For consequence, the sink is as close as possible to all the nodes. This will lead to create short paths between each node and the sink and thus the latency of communications is better than the latency generated by the other approaches. Moreover, since the routing paths are short, few nodes are implied in each transmission which leads to a better energy consumption than using the circle or the most dense grid approaches.

4. Conclusion

In this paper we present a new single sink placement approach in order to minimize the latency of communications in wireless sensor networks. The idea is to place the sink as close as possible to all the nodes of the networks by using each node's coordinate (its abscissa and its ordinate). This helps minimizing the distance between the sink and the other nodes and for consequence minimizing the latency of communications since it is distance sensitive.

Simulation results have shown better performance of the network using our sink position than the positions of similar existing approaches in terms of average latency of communications and average energy consumption.

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