

Efficient Movement of a Relay Node in Wireless Sensor Networks to Optimize the Energy

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ABSTRACT

In wireless sensor network there may be one or more sensor nodes whose task is to process data. As we know that these sensor nodes have limited amount of storage capacity, performing complex task may result in consumption more of energy. In other words, it leads to battery drainage. Hence relay nodes which are mobile in nature are proposed. These relay nodes are designed in such a way that they are low cost and easily disposable when worn out. There are two main aspects that are used in our approach: firstly, we do not build any complex wireless sensor network, hence it is easy to analyze and secondly, we use the movement of relay nodes to reduce the energy utilization. Our framework consists of an optimal routing of the mobile relay, in which it moves to the sensor nodes depending on the file size. Experimental results show that our algorithm significantly reduces the energy consumption when compared with the existing solutions.

Key words: Wireless Sensor Network, Storage Capacity, Battery Drainage, Mobile Relay, Energy Utilization, Optimal Routing.

1. INTRODUCTION

WSNs, which can be considered as a special case of ad hoc networks, as they enable reliable monitoring and analysis of unknown and untested environments. These networks are "data centric", i.e., unlike traditional ad hoc networks where data is requested from a specific node, data is requested based on certain attributes. Therefore a large number of sensors need to be deployed to accurately reflect the physical attribute in a given area. Routing protocol design for WSNs is heavily influenced by many challenging factors, which must be overcome before efficient communication can be achieved. These challenges can be summarized as follows:

- **Ad hoc deployment** - Sensor nodes are randomly deployed which requires that the system be able to cope up with the resultant distribution and form connections between the nodes. In addition, the system should be adaptive to changes in network connectivity as a result of node failure.

- **Computational capabilities** - Sensor nodes have limited computing power and therefore may not be able to run sophisticated network protocols.
- **Energy consumption without losing accuracy** - Sensor nodes can use up their limited energy supply carrying out computations and transmitting information in a wireless environment.
- **Scalability** - The number of sensor nodes deployed in the sensing area may be in the order of hundreds, thousands, or more. Most of the sensors can remain in the sleep state until an event occurs, with data from only a few remaining sensors providing a coarse quality.
- **Communication range** - The bandwidth of the wireless links connecting sensor nodes is often limited.
- **Fault tolerance** - Some sensor nodes may fail or be blocked due to lack of power, physical damage, or environmental interference. Therefore, multiple levels of redundancy may be needed in a fault tolerant WSN.
- **Connectivity** - High node density in sensor networks prevent them from being completely isolated from each other. Therefore, sensor nodes are expected to be highly connected.
- **Transmission media** - In a multi-hop sensor network, communicating nodes are linked by a wireless medium. Therefore, the traditional problems associated with a wireless channel also affect the operation of the sensor network.
- **Security** - Security is an important issue which does not mean physical security, but it implies that both authentication and encryption should be feasible. But, with limited resources, implementation of any complex algorithm needs to be avoided.

2. PROTOCOL STACK FOR WIRELESS SENSOR NETWORKS

The protocol stack of sensor network which is shown in the following figure combines power efficiency and least cost path routing.

The architecture consist of

1. Physical layer- is responsible for transmitting and receiving signals.
2. Data link layer- consists of medium access control [MAC] which is used to prevent packet collision.
3. Network layer- is responsible for routing the packets.
4. Transport layer- is responsible for delivery of packets.
5. Application layer- is used for creation of packets by making use of software.

All these layers are backed by management plane, mobility management plane and task management plane. The power management plane monitors the sensor's power level among sensor node.

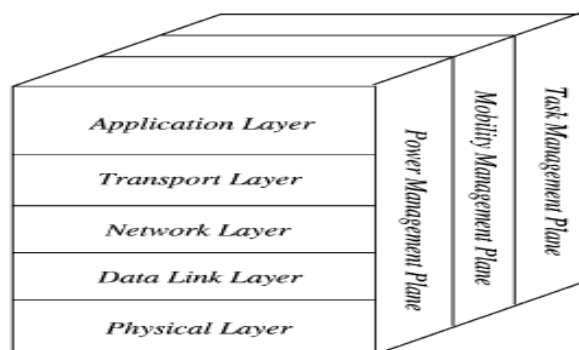


Fig 1: Protocol Stack

3. STRUCTURE OF A SENSOR NODE

The sensor node consist of a

1. Sensing unit
2. Processing unit
3. Memory unit
4. Self power unit
5. Wireless transceiver

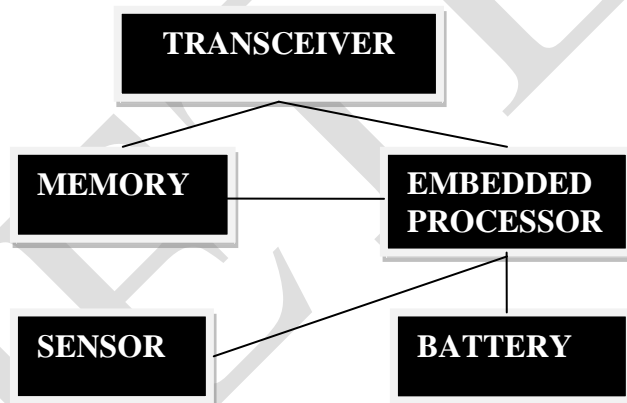


Fig 2: Sensor Node Structure

- **Sensing unit:** it consists of a sensor and analog to digital converter [ADC]. The analog signal produced by sensor is converted to digital and is fed into processing unit. The sensing unit is responsible for collecting the data externally and interacts with central processor.
- **Processing and memory unit:** the processing unit is responsible for performing some computations it executes some instructions which is responsible for setting up the connection with another node. The memory unit is used for storing the data.
- **Self power unit:** it is responsible for powering the node and keeping it alive. The main task of the sensor node is to identify events, to process data, and then to transmit the data. The power of a node is consumed mainly in the transmitter and receiver unit. The sensor node can be supplied by a self-power unit, self-power unit battery, or solar cells.

4. RELATED WORK

Three approaches are considered in this related work. They are base stations, data mules, and mobile relays. All these three approaches use both mobility and wireless transmission technology to reduce the energy consumption.

- Base Station- In this approach, base station is generally mobile in nature. It collects the data from the sensor nodes by moving around the wireless sensor networks [1], [2] and [3]. The data must be collected from the visited node [4], [5] before nodes undergo buffer overflows. The disadvantage with this approach is that they require high latency.
- Data Mules- Here the data will be transferred to the sink by picking up the data from the sensor nodes [10]. The disadvantage with this approach is that they incur very large delays.
- Mobile Relays- In this approach the wireless sensor networks consists of one or several sensor nodes which are static so that the mobile relay moves to each and every sensor nodes to collect the data and transfer it to the sink. The advantage of this approach is that the relay node moves only when the sensor nodes have the data [12].

The following diagram shows the architecture of a wireless sensor network with sink, sensor nodes and data mule.

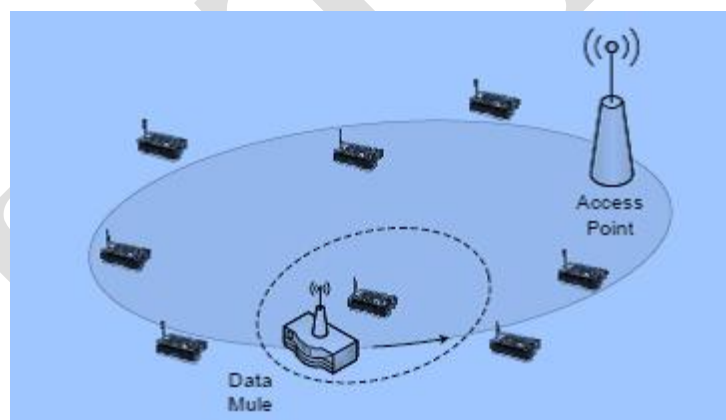


Fig 3: System Architecture of a WSN

5. PROPOSED SYSTEM

The main objective is to optimize the energy consumed by the sensor nodes so that the lifetime of the sensor nodes can be increased. Hence we make use of relays which are in motion. As mentioned these relay nodes do not transfer data directly to the sink, instead they move to every sensor node's location, collect data and then pass it on to the sink for further processing.

Figure 4 shows the proposed architecture of a wireless sensor network. In previous approaches, the mobile relay node moves either to the left or right depending on the file size uploaded to the sensor nodes.

For example, suppose if the file size in sensor node1 is greater than the file size in sensor node2 then the mobile relay moves to sensor node1 and collects the data. Similarly a comparison happens between sensor node3 and sensor node4 and finally between sensor node5 and sensor node6. Here they make use of three positions i.e., when the relay node is between sensor node 1 and 2, it is taken as position 1, position 2 is considered when the relay node is between sensor node 3 and 4 and position 3 is considered when the relay node is between sensor node 5 and 6. Although this technique reduces the energy of a sensor node but still it is an issue that needs to be taken care off.

In our approach, we initially consider 6 sensor nodes. Here instead of relay node moving to right of left of sensor nodes, the relay node first senses which sensor node has greatest file size. Then according to that, the relay node moves to that sensor node and collects the data. This is first iteration. In the same way a comparison happens for the left over sensor nodes and the relay node moves to the next greatest file size. And the iteration continues. In the final iteration, the one with the least file size will directly move to the sink.



Fig 4: Proposed Network

Some of the advantages are:

- Consumption of energy is achieved by both mobile relay node and wireless transmission technology.
- The architecture is very simple and easy to understand.
- Optimal position of a relay node can be achieved by constructing an optimal tree where sensor nodes are considered to be static. For this case we use optimization algorithm.
- Mobile relay node performs only single relocation.

6. PROBLEM DEFINITION

A. Optimization Algorithm

Here in this algorithm, we compute the optimal position of a relay node. Initially the algorithm starts by uploading the files to all the sensors in the network. After uploading, the relay node moves to that sensor node which has the greatest file size and gathers the data and sends it to the sink. The process continues. Optimization algorithm is shown in figure 5. The network consists of source nodes s_i , one mobile relay node mi .

Algorithm: To compute the optimal position of a relay node.

Input: A variable file size uploaded to all source nodes {fs}

Output: Optimal position of a relay node mi .

Procedure optimal_position

1. if fs_1 in $x_i > fs_2$ in remaining sensor nodes then
2. Consider case mi moves to x_i
3. end if
4. Repeat until TRUE
5. Repeat step 1 to step 3 for left over sensor nodes
6. Return fs

Fig 5: Algorithm to Compute the Optimal Position of a Relay Node in a WSN

6. PRACTICAL ANALYSIS

We carried out the experiment with 6 source nodes which are in the communication range. The mobile relay node first senses which sensor node has got the greatest file size and then moves to that sensor node, collects data and sends it to the sink. Similarly the relay node does a comparison for the left over sensor nodes and then moves to the sensor node that has the second greatest file size and it continues.

In the last iteration, the one with the least file size moves directly to the sink. In this way energy can be consumed to a greater extent. The following figure shows the analysis made. Figure 12 shows the resultant of the entire sensor node in descending order.

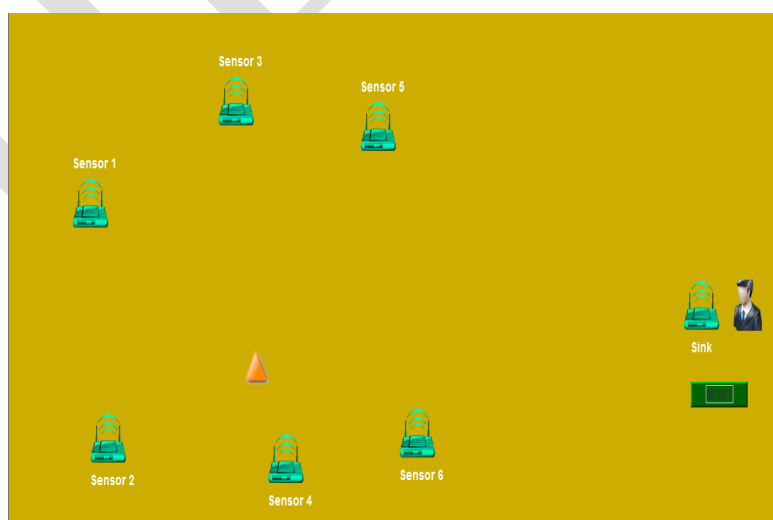


Fig 6: Movement of Mobile Relay Node towards the Greatest File Size



Fig 7: Movement of Mobile Relay Node towards Second Greatest File Size

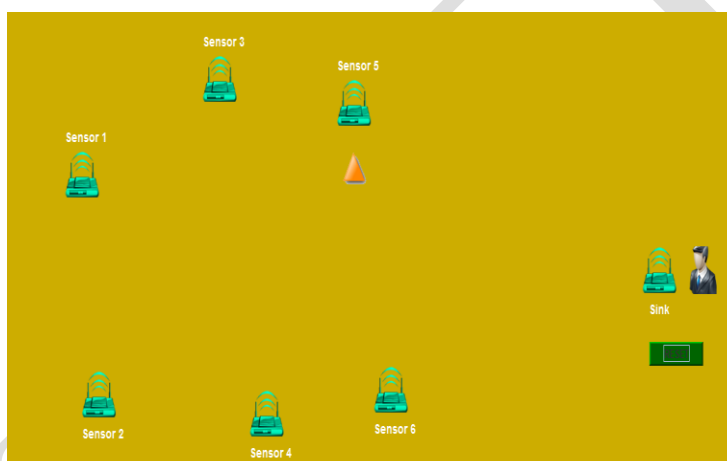


Fig 8: Movement of Mobile Relay Node towards Third Greatest File Size



Fig 9: Movement of Mobile Relay Node towards Fourth Greatest File Size



Fig 10: Movement of Mobile Relay Node towards Fifth Greatest File Size



Fig 11: Movement of Mobile Relay Node towards Sink

Result				
fid	file name	file size	received from	date
7	4	1415	sensor node 4	25Nov2014
8	1	745	sensor node 1	25Nov2014
9	5	582	sensor node 5	25Nov2014
10	6	541	sensor node 6	25Nov2014
11	3	529	sensor node 3	25Nov2014
12	2	510	sensor node 2	25Nov2014

Fig 12: Movement of Mobile Relay Node towards all Source Nodes in Descending Order

7. CONCLUSION

In this paper, an approach was proposed to minimize the energy consumption of sensor nodes by making use of a relay node. The optimization algorithm is applicable for a variety of data-intensive wireless sensor networks. Here our approach considers only static sensor nodes but it can be further extended to dynamic sensor nodes.

As a future enhancement one can extend the number of sensor nodes in a network by considering fixed or variable sized file.

8. REFERENCES

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