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An Efficient Parallel Strategy for Data Forwarding in Event Based Wireless Sensor Networks

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Abstract

An event driven wireless sensor network is characterized by its efficiency in detecting any anomaly and promptly informing the base station within the real time constraints. Balanced Tree Generation is a very common means in Wireless Sensor Networks to balance the load of the sensors so that the energy usage of each node is almost equal and the average lifetime of the network is increased. But it is not effective in reducing the average response time of an event. Here we propose a novel algorithm to reduce the response time by implementing the balanced tree structure with parallel transmissions. Simulation results show that using this algorithm along with data aggregation reduces the simulation time considerably.

Keywords: Querying Routing Tree, Workload-based, Response Time, Sensor Networks

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1. Introduction

A wireless sensor network (WSN) is a network of number of sensor nodes that communicate with each other through wireless links. A basic operation of WSN is gathering data based on queries [1]. WSNs have been used extensively in environmental and habitant monitoring [2][3], structural monitoring [4] and urban monitoring [5].

Monitoring applications require processing and transportation of data through information processing and information fusing.

The requirements differ according to the different types of applications as follows:

- Structural health monitoring: Such applications usually have sparse coverage, static deployment, requiring an event driven communication and connectivity that is sporadic in nature.
- Heavy industrial monitoring: usually have static and iterative deployment with intermittent or sporadic connectivity and may include query driven communication.
- Intrusion detection applications: These applications usually have a changing topology, focusing on barrier coverage, with an undetermined **c**onnectivity. It essentially requires mobile nodes with real time constraints though localization not required.

Summarizing, monitoring networks are composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect an anomaly Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a pattern violation. The immediate and reliable communication of alarm messages is the primary system requirement. These are "report by exception" networks; hence focus on the real time constraints.[6]

A majority of the energy consumption is spent on meeting the strict latency requirements associated with the signaling the alarm when violation occurs as well as confirming the connectivity by intermittent communication among the nodes in case of scheduling to conserve energy.

Reducing the transmission latency leads to higher energy consumption because routing nodes must monitor the radio channel more frequently. Actual data transmission will consume a small fraction of the network energy.

A decisive variable for prolonging the longevity of a WSN is to minimize the utilization of the wireless communication medium. It is well established that communicating over the radio in a WSN is the most energy demanding factor among all other functions, such as storage and processing

[7,8,9,10,11]. The energy consumption for transmitting 1 bit of data using the MICA mote [1] is approximately equivalent to processing 1000 CPU instructions [8].

Given the set of application scenarios one of the evaluation metrics that we address is the response time for the allied constraints.

2. Preliminaries

It requires a robust strategy to communicate across the network with the minimum overhead (that may be the shortest route or the minimum no of packets) with the usual constraints like energy.

Any WSN can be categorized as infrastructure based or infrastructure free based on the backbone structure used for communication. Performance degrades in a dynamic WSN due to excessive communication.

Configuring the network as an event driven and query driven type has its own advantages, for large scale applications, as it typically requires fewer messages to be transmitted. Thus there is a significant energy saving since message transmissions take the bulk of energy consumption as compared to sensing and data processing .

However fault tolerance is more critical in such systems because the management applicOIation stops receiving the data from certain nodes or entire region of the network , it cannot distinguish if a failure has occurred or if there is no application event.

Shortest routes with energy conservation capabilities have been considered in literatures which aim to keep down the total number of messages transmitted.

Data aggregation is one such technique of collecting raw data from sensor nodes, eliminating redundant measurements, and extracting the information content for onward transmission. Data aggregation, in conjunction with data-centric routing, alleviates the problem of congestion while simultaneously saving the limited energy of the sensor nodes. Cluster-based and tree-based protocols have been proposed to support aggregation in WSNs.

Till date different researches have been done which focuses on the transmission of data through a data gathering tree to reduce the energy usage. In different research work like ESPAN[12], LPT[13], DST[14] use dynamic strategies to minimize the energy usage.

Clustering is also used as a technique to reduce the energy cost in WSN. In different works like EEEPSC[15] ,EBLEC[16], CABCF[17] clustering techniques are used to minimize the energy usage and thus increase the network lifetime.

Itinerary based KNN method [18] for query propagation technique discusses planning the itinerary by reducing the number of nodes to communicates with the shortest path strategies. But it also emphasizes the improvement in performance with the use of concurrent KNN query threads.

However no work has been done to minimize the response time of the DGT. In our work we propose an algorithm to minimize the response time by forwarding the sensor packets to different aggregating nodes depending on the location of the event. Since it works on the MCDS[19] the number of messages requirement is also minimum thereby conserving the energy.

The following parts of the paper are divided into the following sections. 3.1 discusses the generation of the tree using the WQRT algorithm [20]. 3.2 discusses the PARALLEL algorithm for distributed databases [21]. 3.3 discusses implementation of our algorithm 3.4 presents the pseudo code for our algorithm and section 4 shows the results obtained by our algorithm.

3. SYSTEM MODEL

We consider an event driven wireless sensor network having nodes that are aware of their locations with respect to their randomly generated ids. We construct a tree which is balanced with the help of the WQRT algorithm on the basis of levels of nodes and total number of nodes. The path used for forwarding of the data sensed, depends on the sensors detecting the event as shown in Fig 1 below

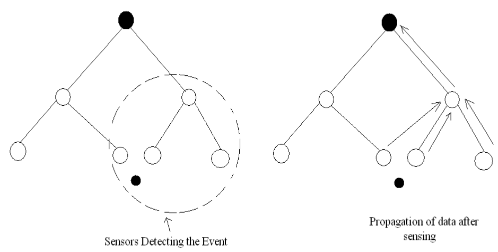

Fig 1. Path of propagation of data

3.1 WQRT

We use the WQRT algorithm to create a data gathering tree and also to balance it. Balancing the workload among nodes causes minimization in the data collisions and thus reduces the energy usage.

The WQRT algorithm at first constructs a tree from a group of sensors taking the sink as the root node as shown in Fig 2. below.

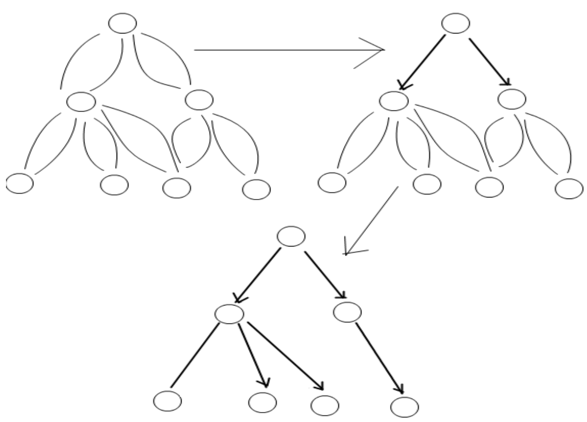

Fig 2. Stepwise Generation of the Tree

It then balances the tree based on the branching factor which is calculated on the basis of the no. of nodes and the maximum depth of the tree as shown in Fig 2 so as to provide uniform load for all the sensors. Balancing also ensures that there is uniform energy depletion in the nodes, thereby conserving energy with improvement in lifetime.

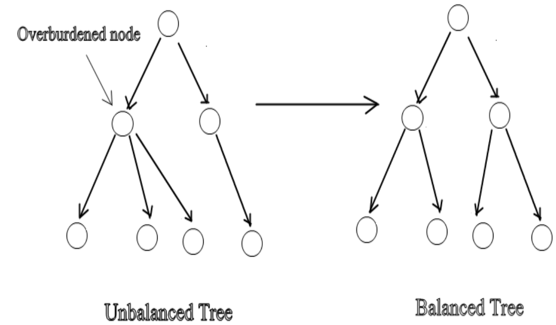

Fig 3. Balancing the load of the tree

3.2 Parallel algorithm

We use the concept of parallelism used in the parallel algorithm for distributed databases. The parallel algorithm reduces the response time considerably for distributed databases [2]. In the parallel algorithm the data is passed on to the node which has data to send and thus provides the greatest reduction in the response time as seen in the graph shown in Fig 4.

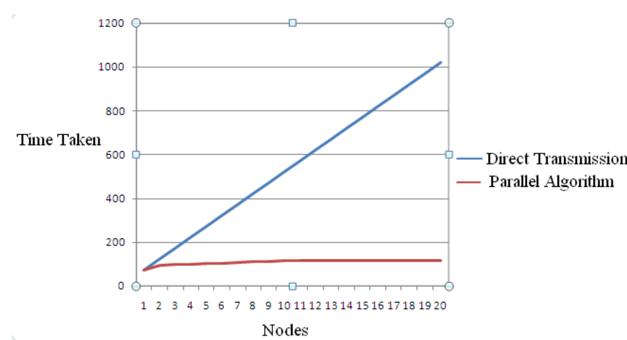

Fig 4. Reduction in response time

Since sensor network is a specialized type of distributed database we have tried to adapt the concept of parallel algorithm in sensor network.

3.3 Assumptions

The following assumptions are made regarding the wireless sensor network in our simulation.

- The range of each node is fixed
- Each node is able to sense and receive data only within its range.
- The time needed for aggregation, transmitting and receiving data is fixed.

3.4 : Pseudocode

1) get node_id,node_coordinate,node_distance

2) for (i ε N)

    2.1) i.level=i.parent.level+1

3) for any node (i ε N)

    3.1) while(i.children>branching_factor)

    3.2) i.children.parent=i.apl

4) while (j ε E)

    4.1) sort(j.level)

    4.2) increment j;

5) while (j ε E & k ε E)

5.1) if k.level= j.level+1 and k.range>=j.distance)

    5.1.1) j → k

    5.1.2) aggregate(k);

5.2) increment j;

5.3) increment k;

The variables and the symbols used in the pseudo code of the algorithm are explained in Table 1 below

Table 1. Notations and Variables used

Node_id	Unique node identifier
Node_coordinates	Either(x,y) or(x,y,z) depending on the place of deployment
Node_distance	Euclidean distance of the node from the sink
N	Set of all the nodes
E	E is the set of all nodes detecting an event
Branching_factor	Optimum number of children for each parent calculated as (No. of nodes)^(1/max depth of the tree)
i.children	children of i
apl	Alternate Parent List is the list of other parents in the same depth as the node and also detecting the event
aggregate(k)	Aggregate the data in node k, here we are using averaging to aggregate

4 RESULTS AND CONCLUSION

The above algorithm gives us a much improvement on the response time of any event. We simulated a system of 5 events for the network with 50 nodes and the results corresponding to the system are shown below in the graph in Fig 5 .

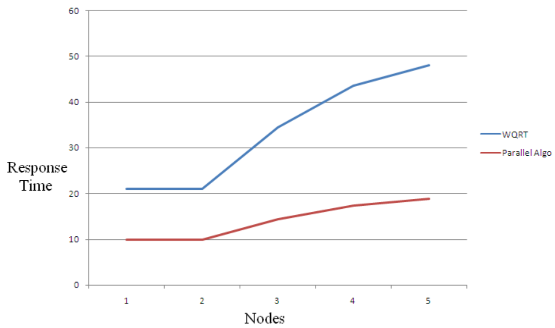

Fig 5: Graph showing the improved performance

By incorporating a parallelized scheme for selecting the forwarding nodes dependant on the location of the event, it is observed that the routing tree organization becomes dynamic without the energy spent to reconstruct it again. The response time drastically outperforms the existing strategies of query routing trees . This strategy has been implemented for few nodes and is a preliminary research that will be implemented for constraints relevant to large scale deployments.

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