An Improved Energy Efficiency Algorithm in Wireless Sensor Network using Query Optimization

M.Sivakumar[1] Prof. K. Senthil Prasad[2]
[1,2]Assistant Professor
[1,2]Department of Computer Science and Engineering
[1,2]SVS College of Engineering, Coimbatore, India

Abstract— Wireless Sensor Networks (WSN) is an essential guide foe anyone interested in wireless communications for sensor networks, home networking, environment monitoring, target tracking, and surveillance. In wireless sensor network sensor nodes have very limited supply of energy, and also should be available in function for extremely long time (e.g. a couple of years) without being recharged. So consider the energy resource of sensor node and the life time of the sensors, to optimize the query plan, based on user specified accuracy for wireless sensor network. This proposed method aims at optimization of periodical query, with careful consideration of accuracy, along with energy consumption in data communication. User may specify a value/time accuracy constraint, according to which an optimized query plan can be created to minimize the energy consumption. The main objective is to propose an energy efficient algorithm to reduce data transmission and to increase the life time of wireless sensor network.

Key words: Wireless Sensor Network; query processing; query optimization; energy efficiency; Value/Time

I. INTRODUCTION

Wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location [1]. The sensor field constitutes sensor nodes. Typically, a sensor node can perform tasks like computation of data, storage of data, communication of data and sensing/actuation of data [2]. The communication device of sensor node sends and receives information over a wireless channel, and the power supply is necessary to provide energy.

In wireless sensor networks, power consumption efficiency is one of the most important design considerations. Therefore, these intertwined components have to operate and balance the trade-offs between as small energy consumption as possible and also need to fulfil their tasks. One of the main characteristics of wireless sensor network as power consumption constraints for the nodes using batteries or energy harvesting. The base station post-processes all the data received from individual sensors and then produces the answer to the user who issues the query [3]. Sensor data can be viewed as a table with a single column per sensor type, and new tuples are appended to the tables when they arrive at the base station. Power consumption is the major consideration of designing sensor network algorithms. Hence, it is important to understand the energy consumption of various operations of sensors, to optimize the design of query processing strategies. Wireless sensor networks should try to minimize the number of communication and sensing operations, so that the sensor node energy consumption has been reduced.

The rest of this paper is arranged as follows. Section 2 introduces the value based query optimization algorithm. Section 3 introduces the time based query optimization algorithm. Section 4 presents experiment. Simulations and performance analysis will be presented in section 5. Finally, conclusion is drawn in Section 6.

II. VALUE BASED OPTIMIZATION ALGORITHM

Value Based Optimization Algorithm is used for query optimization, which can be performed based on the value accuracy constraint.

```
SELECT temperature FROM sensors AS s WHERE
s.location= Area_C ACCURACY value = 1 SAMPLE
ON 00:00:00 INTERVAL 1s LOOP 17
```

Fig. 1: Query example1

In this above Query example1 collect temperature Value from Area_C region, and also the special clause for Accuracy clause value=1◦c. Once the timer will alive its start from 00:00:00 s after 1s its collect temperature value from sensor node. Continuously the loop will be executed 17 times interval between 1s. Once the temperature value can be generated by the sensor node, it transmits that value to the base station, and the accuracy of the temperature reading is within one degree above or below the real data [10].

In such a way that the value accuracy constraint to optimize the query execution instead of every reading directly delivery to sink from sensor node. (i.e.) when new temperature reading was sensed by sensor node, it compare to the previous reading, in that new reading is above or below the accuracy value, we choose to report only updates. Data communication can be minimized, so energy of sensor node was saved. In this method particularly used for where the attribute value changes sharply and smoothly, and also it is never worse than the direct delivery.

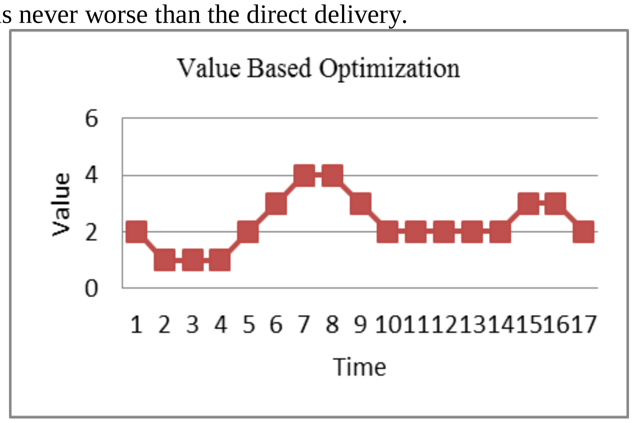

Fig. 2: Value-based optimization

Figure2. Illustrate the basic idea of the above Query example 1 in that query simply specifying the Accuracy constraint value =1◦c, instead of direct delivery of every 17 readings at each interval. In my proposed method value based optimization algorithm needs to send the temperature reading has only 9 times, so largely reduced the data transmission. The query was specified value accuracy constraint Δv, series of the attribute reading r_0, r_1, r_2 ….. , timings t0, t_1, t_2 …... series of values v_0, v_1, v_2 ….. , to be delivered to sink or base station as the representation of real reading serious, main problem is how to choose value vi (i=0, 1, 2…) as representation of set of readings. In this value based optimization algorithm create two methods; one is fixed value and another one is adaptive average method

A. *Fixed Value Method*

In this algorithm, the value sets a fixed point V, before the execution of query the set of values (v, v_1, v_2 ….. v_K), v_K=v + kΔv. when new reading has arrival ri ∈[v_K, v_{K+1}] r_i replace with vK detailed algorithm shown in below

Algorithm: fixed value based optimization
Input : Query.
Output : optimized temperature reading
Variable : r_0, v_k, CV (current value).

1) Read the r_0 value.
2) Find k.
3) Read the k value from the sensor node (v_k).
4) Assign the v_k value to CV and report the CV to base station.
5) For (i=1; i<loop; i++)
6) Sleep(interval)
7) Read the new reading r_i value.
8) Compare the current value from previous value v_k .
9) Report (CV, i-1).

In this method, sensor node will generate the serious of unnecessary report and ping pong effect. An adaptive average method is proposed to avoid those problems.

B. *Adaptive Average Method*

This algorithm is run time method, value has been read during the execution time period. In that reading value is more accurate. Suppose a set of readings (r_0, r_1 … r_i), we define r_{MAX} = MAX (r_0, r_1 … r_i), r_{MIN} = MIN (r_0, r_1 … r_i), r_{AVG} = AVG (r_0, r_1 … r_i), and r_{MAX} - r_{MIN} < Δv. When at the next time point a new reading r_i +1 is available, if r_{MAX} – Δv < r_i +1 AND < r_{MIN} + Δv, then adjust r_{MAX}, r_{MIN}, and r_{AVG} with r_i +1; otherwise, report r_{AVG}. Detailed algorithm is shown in below

Algorithm: Adaptive average value based optimization
Input : Query
Output : optimized temperature reading
Variable : r_0, r_{MAX}, r_{MIN}, r_{AVG}, counter

1) Read the r_0 value.
2) Assign r_0 value to r_{AVG}, and report (r_{AVG}, 0).
3) Assign counter value as 1.
4) For (i=1; i<loop; i++)
5) Sleep(interval)
6) Read the new reading r_i value.
7) If(r_{MAX} – Δv < r_i AND < r_{MIN} – Δv)
8) Calculate r_{MAX}, r_{MIN} value.
9) r_{AVG}=(r_{AVG}*counter+ r_i)/++counter
10) Report (r_{AVG}, i-1).

III. TIME BASED OPTIMIZATION ALGORITHM

In this time based query optimization algorithm, optimization can be done based on the time Accuracy QOS constraints. Consider this Query example2.

```
SELECT temperature FROM sensors AS s WHERE
s.location= Area_C ACCURACY time = 1 SAMPLE
ON 00:00:00 INTERVAL 1s LOOP 17
```

Fig. 3: Query example2

This query as same as Query example1 but only different is Accuracy clause value replace by time as 1 second. Accuracy of temperature readings acceptable by application is within 1 second above or below the real sampling time. The application does not need the exact time point. In that query raises to optimize multi query execution. Wireless sensor network having multiple queries for a couple of application simultaneously [11]. If some of the attributes and predicates values are same in the multiple query execution it consider as a one query, same attribute reading can be shared by multiple queries, in this way to optimize for both sensing and data communication especially for result returning to sink, so energy can be saved in that optimization algorithm. Detailed proposed algorithm is given below

Algorithm: Time based optimization.
Input : Multiple queries.
Output : optimized temperature reading.
Variable : i, j, n, t_i, t_j, t_{ij}, t_n, r_n, t_{Ai}, t_{Bj} .

1) Assign i, j, loopB =0.
2) for(n=0; n<loopA+loopB;n++)
3) Receive (Q2) and assign i=n.
4) Suppose Q2 is not alive t_n= t_{Ai} and increment the i value
5) Suppose Q1 is not alive t_n= t_{Bj} and increment the j value
6) if(t_{Ai} AND t_{Bj} are overlapping) t_n= t_{ij} and increment the i, j, n value.
7) Else t_n = MIN (t_{Ai}, t_{Bj}).
8) If (t_n= t_{Ai}) increment i otherwise increment j.
9) Sleep until the n second.
10) Read the value of r_n.
11) Report (r_n).

IV. EXPERIMENTS

The performance of proposed algorithm were compared and analyzed for queries with and without optimization, here consider the energy cost by performing optimization as EOP and without optimization as ENOP then energy saving as ES.

$$ES=ENOP-EOP \quad (1)$$

Without losing any generality, the size of all data in same size denoted by K. if suppose K amount of data can be communication between node u to v the energy cost e= (u, v). That energy consumption includes both u and v transmitter and receiver respectively.

$$E (K) = ETx (K) + ERx (K). \quad (2)$$

In that energy model is based on [8, 9]. Assume linear relationship for energy spent per bit at

1) Transmitter circuitry,
2) Receiver circuitry,
3) d^2 path energy loss due to channel transmission.

To transmit a K bit message a distance d using the radio model, energy used by transmitter and power amplifier and receiver circuitry, ET and ERx can be expressed as in equation (3).

$$ETx\ (K, d) = K\ (eT_c + eT_a\ d^2) \quad \textbf{(3)}$$

$$ERx\ (K) = KeR_c. \quad \textbf{(4)}$$

eT_a, eT_c, eR_c are hardware dependent parameters therefore can be changed as in equation (5).

$$E = K\ (eR_c + eT_c + eT_a\ d^2). \quad \textbf{(5)}$$

V. RESULT

In this section, the simulation results in ns2 shows Figure7. When increasing the value accuracy constraint, power consumption is decreased, when performing optimization. In that non-optimization condition power consumption is approximately constant. In that result an adaptive-average algorithm is better performance than fixed value approach.

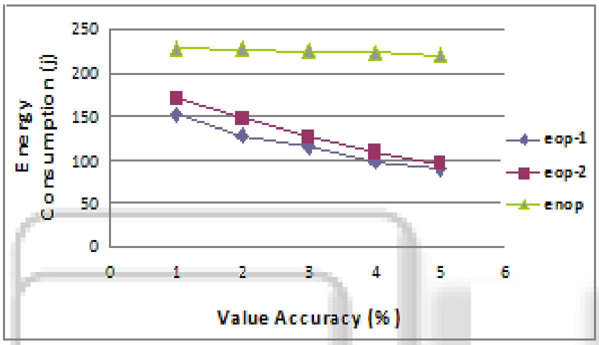

Fig. 4: Value accuracy (%) vs energy consumption (j)

Figure4. Shows the impact of time accuracy constraints to power consumption. In the simulation, Enop and Eop-1 use the same network deployment. For Eop-2, a new network layout is used, in which node distance is 2/3 on average of the previous one, meaning that the overall number of hops is lessen.

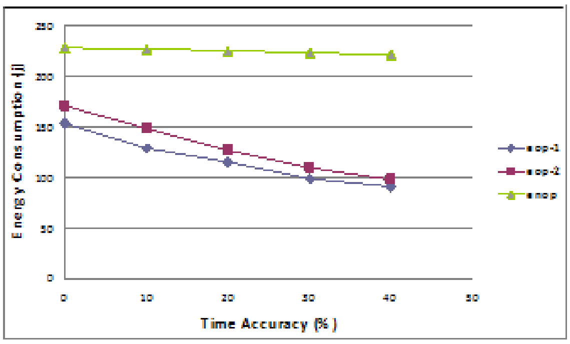

Fig. 5: Time accuracy (%) vs Energy consumption (j)

As shown in the above figure.5, power consumption decreases when employing a higher time accuracy setting (i.e. loose the constraint). Also when network coverage is small, less power is needed for collecting the same amount of data

VI. CONCLUSION

The proposed work concentrates on Multi query processing. The main objective is to reduce energy consumption during query processing in order to prolong the network lifetime. In the proposed work, based on the value/time accuracy constraint, two algorithms are proposed such as value based and time based optimization. Multiple queries having same attribute & predicates value, consider these queries can be transmitted to base station at once, so unnecessary communication and retransmission can be avoided and hence the energy consumption of the whole network may be largely reduced. Compare the performance of simulation experiment between with query optimization and without query optimization in sensor node. In summary, proposed work consume less energy than direct delivery method. In both value-based and time-based optimization algorithm, energy saving is at the order of accuracy constraints.

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