A Power Estimation method for energy efficient wireless sensor network

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I. Abstract:

Wireless sensor networks (WSN) are composed of large number of sensor node with restricted energy. The energy is one of the most important terms in wireless sensor networks problem. Sensor node in WSN consists of unit processor, memory unit and mainly power source. Wireless sensor node is battery operated; therefore the biggest challenge in field of wireless sensor is the lifetimes of WSN node which can be improve by achieving communication with low power consumption. So in this proposed work, a path metric that accurately captures the expected number of link layer transmission required for reliable end to end packet delivery with minimum number of retransmission are considered , we analytically computed Estimated cost with direct data transmission within the node & with shortest path between those nodes . Power is analyzed in terms of minimum cost which is the function of distance, number of packets used for transmission along with numbers of permissible hops. Comparative results are shown between time vs delay, time vs direct estimated cost & estimation with shortest minimum retransmission path, with variable data packets rate & number of hops. So with the proper selection of data packet rate and number of hops for end to end transmission considerable reduction in power consumption can be obtained.

Keywords- DPEC, SPEC

II.Introduction:

The Wireless sensor network can be formed by using the combination of number of wireless sensor node, these sensor nodes being a micro-electronic device, equipped with a limited power source. In some application scenarios, replacement of power resources might be impossible, thus the Sensor node lifetime shows a strong dependence on battery lifetime. In many applications like a multi-hop ad hoc sensor network, each node plays the dual role of data generator and data router. The failure of any nodes can cause significant topological changes in network and might require re-routing of packets and re-organization of the network. Hence, power management and power conservation take on additional importance; so many people are mostly focusing on the design of power-aware algorithms and protocols for sensor networks.

In other mobile and ad hoc networks, power consumption has been an important design factor, but it's not the primary consideration, as the facilities are available such that the users can replaces power resources whenever necessary while emphasis is more on QoS provisioning than the power efficiency. In sensor networks though, power efficiency is an important performance metric, directly influencing the network lifetime. Application specific protocols can be designed by appropriately trading off other performance metrics such as delay and throughput with power efficiency.

Power consumption can be broadly divided into three domains:
i) Sensing the data
ii) Communicating the data, and
iii) Data processing.

i**) Sensing the data**: Sensing power varies with the nature of applications. Sporadic sensing might consume lesser power than constant event monitoring. The complexity of event detection also plays a crucial role in determining energy expenditure higher ambient noise levels might cause significant corruption and increase detection complexity.

ii) Communicating the data: Out of the three domains, a wireless sensor node consumes maximum energy in data communication. It contains the data transmission and reception. In case of the short-range communication with low radiation power, transmission and reception energy costs are nearly the same. Transceiver consist of Mixers, frequency synthesizers, voltage control oscillators, phase locked loops (PLL) and power amplifiers, which all consume valuable power. It is important that in this computation we not only consider the active power but also the start-up power consumption in the transceiver circuitry

iii) Data processing: Energy expenditure in data processing is much less compared to data communication. The local data processing is crucial in minimizing power consumption in a multi-hop sensor network. Complementary metal oxide semiconductor (CMOS) technology used for the micro-processor but it has in-built limitations on energy efficiency. The most straightforward application of a Wireless Sensor Network is to monitor remote environments where hundreds of sensors configured themselves to form a network and immediately report upon detection of any event. In some classes of applications highly dense sensor deployment and reasonably accurate localization may be required, Use of WSN can be an efficient, low-overhead method of data delivery if it reasonably assume enough network density, proper localization & High link reliability independent of distance within the physical radio range.

The goal of power control mechanisms is to dynamically adjust the nodes' transmission range for maintaining some property of the communication network and to save network energy for maximizing network lifetime.

Related work and Background

A new WSN node energy model [1] has been proposed, based on the event- trigger mechanism. It can be used to analyze the energy status of WSN nodes and systems & to evaluate the communication protocols which can be used to deploy wireless nodes for WSN applications.

A WSN node model [2] is proposed and analyzed for the energy consumption in wireless sensor networks. They estimated the lifetime of sensor node and found that the proposed battery powered sensor node has the estimated lifetime of about 6.5 months for 10 times sensor firing per hour.

Maximization of energy efficiency & the network lifetime can be improve by using transmission algorithm [3],which is based on binary decision based transmission and a channel-aware back off adjustment. In the binary-decision based transmission decision on whether to transmit or not is absolutely dependent on the current channel conditions and it is only initiated when the channel quality exceeds a specified threshold, so that unsuccessful transmissions causing a waste of energy can be avoided whenever possible. The Markov decision process (MDP) formulation is used to obtained the optimum threshold for successful transmission, along with channel-aware back off adjustment is introduced to favour nodes with better channel conditions

The energy-optimal Error-Correcting Codes (ECCs) based comprehensive energy model [5] of a sensor node saves 15%–60% node energy for the application and deployment-related parameters like distance, bit error rate, path loss exponent, the modulation scheme and ECC parameters

A novel cooperative communication scheme EECC [6] to improve data transmission performance for wireless sensor networks is proposed where cooperative reply is performed at each hop by the best suited node elected from those that have successfully overheard the transmitted packet. EECC is not a routing protocol but rather works as an augment to minimize the impact of packet losses on network performance. Extensive analytical and experimental results confirm that in lossy networks1 this scheme is very effective in improving both end-to-end delay for data transmission and energy efficiency

Useless communication can be reduced by revising the flooding Method and it applied in the the route discovery of the typical DSR (Dynamic Source Routing) protocol ,it is found that the amount of power consumed was reduced by decreasing useless communication to the fullest possible extent but delay got increased .Tthe energy-efficient maximum lifetime algorithm (EEML) in wireless sensor networks [8] improves energy utility by changing the activity of wireless Communication module of sensor nodes, energy model and state transition of sensor nodes. Results show that EEML performs better than DD and EER (Energy Equivalence Routing) algorithm for wireless sensor network with high-density deployment and low traffic

A more accurate power consumption model[9] for wireless sensor node is used to optimally choose the data rate and RF out power for minimizing Energy per useful bit (*Ebit)* & it is found that that the *Ebit* can be decreased significantly by optimally selecting the data rate *R*, RF output power *Pout* .

An architectural level optimization[10][11][12]which brings a major power reduction due to the fact that any changes made at this level of abstraction will be reflected back to the lower levels, all other levels must be also considered in an overall power reduction strategy.

The modulation strategy[13] to minimize the total energy consumption required to send a given number of bits. The total energy consumption includes both the transmission energy and the circuit energy consumption. For uncoded systems, by optimizing the transmission time and the modulation parameters , shows that up to 80% energy savings can achievable over non-optimized systems.

III. Proposed Method:

Generally the radio subsystem requires the largest amount of power. Therefore it is advantageous to send data over the radio network only when required. Additionally, it is important to minimize the power consumed by the sensor itself. Transmission of data based on sensor event-driven data collection model requires an algorithm to be loaded into the node, To determine when to send data based on the sensed event. The hardware should be designed to allow the microprocessor to judiciously control power to radio, sensor and sensor signal conditioner All components of the sensor node required particular power level but large amount of power consumption within transmission-reception of the signal in wireless sensor network, The complete proposed method can be subdivided in following parts,

a) Computing Direct Path Estimated Cost (DPEC).
b) Computing shortest path Estimated cost (SPEC).
c) Results
i) Comparison between cost of DPEC & SPEC.
ii) Relation between time with DPEC & SPEC.
iii) Comparison of delay vs Time for each iteration in SPEC .
iv)Comparison between cost & data transmission with variable data packet rate & hops for DPEC & SPEC.

i) Computing Direct Estimation cost:
In this proposed work we considered Wireless Sensor Network with the random deployment of immobile wireless sensor nodes and the first step is to find the direct distance between the source node & destination node for direct data transmission if the source and destination nodes are in close proximity .Let us consider node 'p' & 'q' are source & destination node respectively ,Then Euclidean distance between node p and q is the length of line of segment connecting them i.e.l(p ,q).In Cartesian co-ordinates p= (p_1, p2, p3........p_n) and q= (q_1, q2, q3......q_n) are the two points in Euclidean n-space,then distance d(p,q)=d(q,p) between points from p to q or between points from q to p is can be calculated as.

$$d(p,q)=d(q,p)=\sqrt{(q_1-p_1)^2+(q_2-p_2)^2+\ldots(q_n-p_n)^2} \quad \ldots..(i)$$

The position of a point in Euclidean n-space is Euclidean vector so p and q are Euclidean vector.From this equation we can compute the Estimated cost between any source node and destination node of the wireless Sensor network, as we considered the distance is the main factor which can decide a transmission cost called as direct estimated cost.

ii) Computing shortest path Estimated cost : As we know that major power consumption occurs during data transmission, so instead of transmitting the data directly with more power it will be better to transmit the data with minimum number of retransmission via closer nodes ,so it is necessary to find out the shortest path between the source & destination ,while the link cost between source &destination reflects the rate of communication energy consumption.

In shortest path selection a source node find its distance from all the near by nodes here also Euclidean distance formula is used ,once a closer node with minimum distance is obtained it will check itself for destination node,if its not a destination node then that closer node forms the link with source node and find again a closer nodes in the path towords destination node,it's a repetitive process and lastly at the end a shortest path will be obtained .Now as mentioned earlier we considered distance is the main factor on which cost is depends i.e.

Cost = Traffic (packet rate) × Distance (meter)….(ii)

So cost of DPEC is compared with the cost of SPEC and if cost of SPEC is less then data is transmitted through that path otherwise direct data transmission is used i.e. whichever is cost effective. Also here we considered the effectiveness of variable data packet rate and maximum allowed hops for cost effectiveness i.e. for saving of transmission powers.

IV. Results:

Following fig.1 shows the time vs cost in DPEC

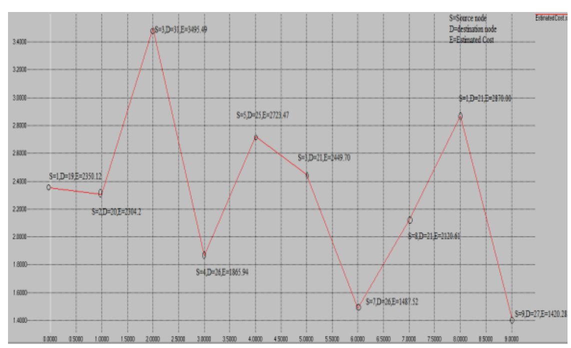

fig.1: time vs cost in DPEC

Here nine iterations are considered and corresponding cost for each source to destination is mentioned

With the same deployment of WSN, time vs cost in SPEC is plotted and comparative analysis shows that ,cost requirement i.e. power saving is more in SPEC,as shown in fig.2

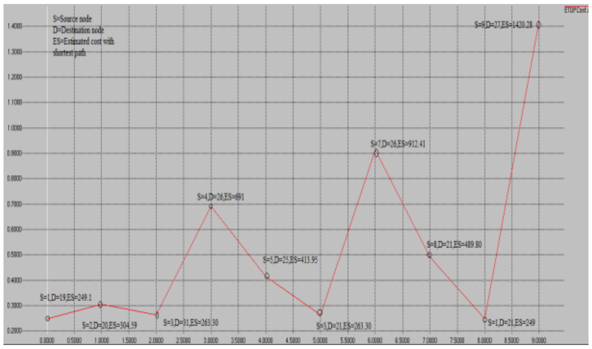

fig.2: time vs cost in SPEC

The Delay Vs time comparision in SPEC is as shown below.

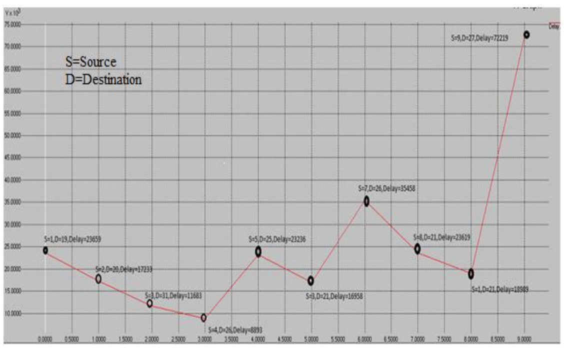

Fig.3: The Delay Vs time comparision in SPEC

In analysis part we assume variable data packet rate and numbers of hops ,found corresponding best packet rate and hop count that can provide maximum reduction in power requirement.

Comparative table for variable packet rate given below:
For no. of packet=20

S->D	DPEC	SPEC	Efficiency %
1->17	1508.06	526.43	65.09
2->24	65.32	65.36	
3->27	3475.55	477.81	86.25
4->32	1871.57	130.68	93.01
8->27	3506.87	462.03	86.82
2->26	1873.71	373.36	80.07
7->32	1663.28	2648.70	
6->28	79.73	102.57	
5->25	194	334.14	
6->29	1241.01	1593.59	

Table1:cost variation for data packet rate(20 packets/ms)

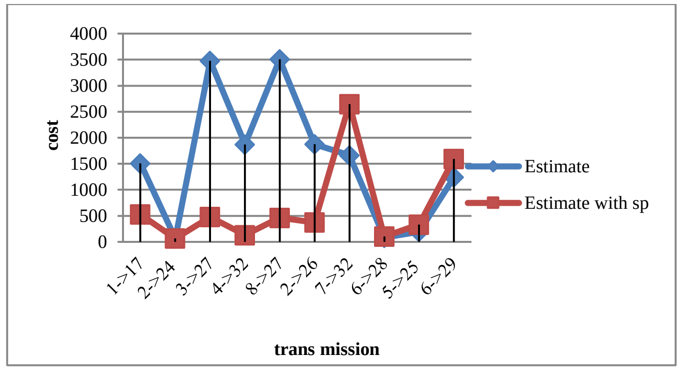

Fig.4: comparison between DPEC & SPEC
For 20packets/ms

For no. of packet=30

S->D	DPEC	SPEC	Efficiency %
1->17	2502.65	107.14	95.71
2->24	2982.05	1998.18	32.99
3->27	2171	735.05	66.14
4->32	2404.33	1189.73	50.51
8->27	1715.71	679.81	60.37
2->26	2951.0	1998.14	32.28
7->32	2503.28	584.05	76.66
6->28	2050.13	188.11	90.82
5->25	2581.15	675.21	73.84
6->29	1759.17	568.65	67.67

Tabel 2: cost variation for data packet rate (30 packets/ms)

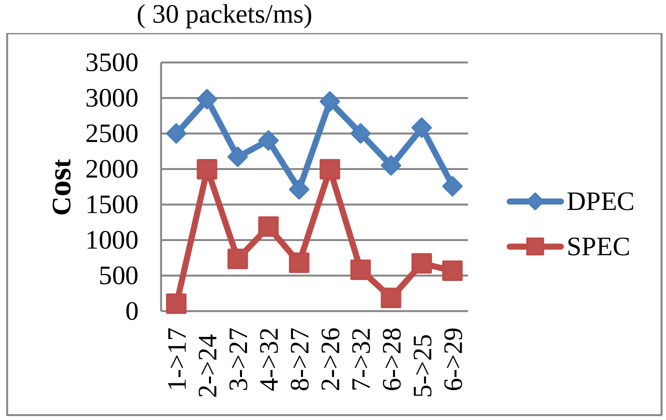

Fig.5: comparison between DPEC & SPEC
For 30packets/ms

Comparative table for variable number of hops given below:
Max hop=20

S->D	DPEC	SPEC	Efficiency %
2->24	195.95	1785.52	
3->27	2502	378.44	84.87

4->32	2792.31	2559.60	
8->27	2841.66	393.67	86.14
2->26	2697.74	360.76	86.62
7->32	3329.26	436.09	86.90
6->28	3217.47	3220.96	
5->25	1605.67	164.38	89.76
6->29	1415.71	3220.96	

Tabel 3: cost variation for Max hop 20

Max hop=25

S->D	DPEC	SPEC	Efficiency %
1->17	2021.57	161.85	91.99
2->24	992.03	769.31	22.45
3->27	3581.65	427.98	88.05
4->32	2167.83	841.15	61.19
8->27	3265.54	2262.77	30.70
2->26	*1525.53*	769.31	49.57
7->32	1880.71	2527.33	
6->28	2300.81	1130.01	50.88
5->25	3192.60	1347.64	57.78
6->29	2997.36	1130.01	62.29

Table 4: cost variation for Max hop 25

V.Conclusion:

In proposed Power Estimation method for energy efficient wireless sensor network, from our simulation result and comparative analysis between DPEC & SPEC ,we can conclude that with the proper data packet rate and number of hops selection with shortest path cost reduction can be achieved .

VI.Future scope:

In this work we mostly concentrate on power utilization during communication between nodes but for more accurate power estimation and management we have to consider on each parameters related with Wireless Sensor Network like node designing ,modulation techniques used & alternate source of power back- ups.

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