Power Optimization Techniques in Wireless Sensor Network by using Packet Profile based Scheme

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Abstract

A Network of complex sensor nodes equipped with limited sensing, computing, and radio communication capabilities is called a Wireless Sensor Network (WSN). The sensed data must be gathered and transmitted to a base station where it is further processed for end-user queries. Since the network consists of low-cost nodes with limited battery power, power efficient methods must be employed for data gathering and aggregation in order to achieve long network lifetimes. This paper proposes packet profile based (PPB) scheme to increase the battery power of sensor node. Profile based scheme is based on probability of past information of packet transfer, and save this information as a small data base of each node. This study also compares the result with flooding scheme. The results of this study showed the effectiveness of the approaches proposed in PPB.

Keywords: *Wireless Sensor Network, flooding, profile based, power efficient.*

1. Introduction

Today WSN is an emerging area of research interest with a number of real world applications. WSN consists of large number of sensor node. The sensor node consists of processing capability, memory, RF transceiver, power source and accommodates various sensors [4, 9]. These sensor nodes sense the event that occurs in the network and then pass the packets to the sink following a path. For a WSN to meet real world requirements, it has to be reliable, power efficient, and time efficient. WSN can be used mainly for monitoring, tracking and sensing, for example, in the application like earthquake monitoring, volcano eruption and habitat monitoring, weather forecasting. All these application mainly include the sensor node which are capable of data gathering, processing, transmitting and storing information. In a WSN application, all sensor nodes can transmit and receive the packet. These nodes periodically transmit data to single sink node which is based on many to one communication model. As due to higher bit rate in the downstream direction, the congestion appears at the node. This Congestion leads to the large number of dropping of packets and increase in transmission latency. It also affects energy efficiency. So it must be handled efficiently. There can be two types of congestion in WSN:

1) Node level congestion
2) Link level congestion

Node level congestion is very common in traditional networks and it is due to the buffer overflow in the node which leads to the packet loss and increases queuing latency. Packet loss leads to retransmission and requires more energy. [1]

In link level congestion, as the wireless channel is shared by several nodes, if CSMA protocol is chosen, collisions could occur when multiple active sensor nodes try to seize the channel at the same time. This increases packet service time and decreases both link utilization and overall throughput. This causes the wastage of energy at sensor nodes.

Both node level and link level congestion have great impact on energy efficiency and QOS. In order to efficiently use the WSN, the following issues are related [5]-[7]:

- Overload and speed mismatches
- Freedom from deadlock
- Freedom from livelock
- Latency
- Route recomputation

This paper is organized as follows. Section II presents related work. In Section III, the proposed scheme on the basis of packet transmission weightage factor to reduce packet dropping probability is discussed. Section IV represents the simulation and the results. Section V concludes the paper.

2. Flood Based scheme

The wireless sensor network is composed of a significant number of nodes deployed in an extensive area in which not all nodes are directly connected. Then, the data exchanged is supported by multi hop communication routing protocols which are in charge of discovering and maintaining the routes in the network. Fig 1.

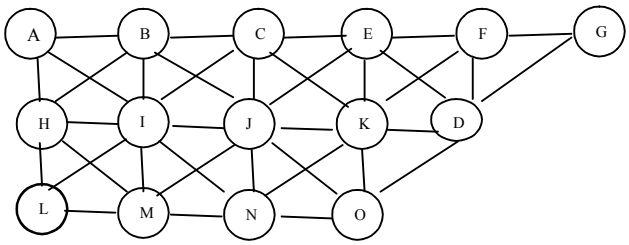

Fig.1: Node in wireless sensor network

To ensure direct communication between a sensor and the sink it may force nodes to emit their messages with such a high power that their resources could be quickly depleted. Therefore the collaboration of nodes to ensure that distant nodes communicate with the sink is a requirement. In this way messages are propagated by intermediate nodes so that a route with multiple links or hops to the sink is established [2], [8]

If node C senses the packet then it broadcast the packet to their neighboring node which ever are in range. Hence C will broadcast the packet to [B, E, I, J, K], if any node is not sink node then every receiving node will broadcast the packet same way until the sink node.

Taking into account the reduced capabilities of sensors, the communication with the sink could be initially conceived without a routing protocol. With this premise, the flooding algorithm stands out as the simplest solution. In this algorithm, the transmitter broadcasts the data which are consecutively retransmitted in order to make them arrive at the intended destination. Following step has to be taken in order to perform flood based routing algorithm:

i) Node sense the packet
ii) Find out the neighboring list of node [all node which are 1m or sqrt (2) m away from each other will be consider as member of neighbor list]
iii) Broadcast the packet to each node available in neighboring list.
iv) If packet reached to their sink node task has been considered to complete.
v) Else every node receiving the packet will repeat the step from ii) to iv).
vi) If any node receives the duplicate packet, it will discard the duplicate packet.

Here are some basic steps of flood based algorithm for the computation of minimum power consumption by each need.

(i) Enter the position of sensor node.
(ii) Find out the minimum distance between sensor node to sink node
(iii) Use following formula for finding power cnsumption PC=position of sensing node × 2 pow (d_{min}).
(iv) Print the value of PC

2.1 Drawbacks of flood based scheme

- Node has to broadcast packet to all the node of neighboring list in range.
- The entire receiving packet node has to again find out neighboring node & broadcast the packet to the entire node until the sink node. Finally, power of each packet will be reduced.
- Nodes redundantly receive multiple copies of the same data message and implosion is detected. Then, as the event may be detected by several nodes in the affected area, multiple data messages containing similar information are introduced into the network.
- Number of hop can be increased.
- Time of successful packet transmission can be increased and subsequently rate of packet loss will be increased.[2]

3. Proposed Packet Profile based (PPB) scheme

To overcome limitation of flooding this study is proposing a new scheme based on packet transfer analysis. Suppose there are wireless sensor network with 15 nodes and historical information about the reliable packet broadcasting and successful delivery of packets to the sink node is as follows: [3].

1/2/1/2/1/7/1/7/1/7/8/1/8/1/8/1/8/1/8/1/8/1/9/1/9/2/3/2/3/2/
7/2/8/2/8/2/8/2/8/2/8/2/8/2/8/2/8/2/9/2/9/2/9/2/9/2/9/2/9/3/
4/3/4/3/8/3/8/3/8/3/8/3/8/3/8/3/8/3/8/3/9/3/9/3/9/3/9/3/9/3/
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5/6/5/10/5/10/5/10/5/10/5/10/5/11/5/11/5/11/5/11/6/5/6/11
/6/11/6/11/6/11/7/2/7/8/7/8/7/8/7/8/7/12/7/12/7/12/7/12/7/
12/7/12…

Now build a probability transition matrix (S) to most likelihood transition.

$$S = \begin{matrix}
X & 2 & X & X & X & X & 3 & 6 & 2 & X & X & X & X & X & X \\
2 & X & 2 & X & X & X & 1 & 8 & 6 & X & X & X & X & X & X \\
X & 2 & X & 2 & X & X & X & 8 & 8 & 3 & X & X & X & X & X \\
X & X & 2 & X & 2 & X & X & X & 8 & 5 & 3 & X & X & X & X \\
X & X & X & 2 & X & 2 & X & X & X & 5 & 4 & X & X & X & X \\
X & X & X & X & 3 & X & X & X & X & X & 4 & X & X & X & X \\
2 & 2 & X & X & X & X & X & 6 & X & X & X & 6 & X & X & X \\
2 & 3 & 2 & X & X & X & 5 & X & 2 & X & X & 8 & 4 & 3 & 1 \\
1 & 2 & 2 & 1 & X & X & X & 5 & X & 2 & X & X & X & 3 & 1 \\
X & X & 2 & 2 & 2 & X & X & X & 7 & X & 2 & X & X & X & 2 \\
X & X & X & 1 & 1 & 1 & X & X & X & 6 & X & X & X & X & 3 \\
X & X & X & X & X & X & X & X & X & X & X & X & X & X & X \\
X & X & X & X & X & X & 1 & 1 & X & X & X & 6 & X & 3 & X \\
X & X & X & X & X & X & 1 & 5 & 3 & X & X & X & 6 & X & 1 \\
X & X & X & X & X & X & X & 4 & 3 & 2 & X & X & X & 2 & X
\end{matrix}$$

By adding all the column of S, get maximum transition state (MTS) in following row vector MTS.

MTS=[7,11,11,8,8,3,11,45,39,23,13,20,10,11,18]

Now make following assumptions about this system modeling:-

- Let each node is one meter far away from each other.
- Node can be in range if they are one meter or sqrt (2).
- Each node has small data base of maximum transition observed from history.
- Each node has 100 unit of power.
- Each node that will process the packet, their power will be reduced by 1unit.
- Each node is taking 1ms to transfer one packet to another node.

Let node C sense the data packet then it will check the list of neighboring node which are in range. If any node is not as sink node then check its data base that which node has highest probability of transition and also available in list of neighboring node. If sink node is available in the list then transfer the packet directly to the sink node. For example node I has highest probability of transition and it is also available in the list of neighboring node of C. Also rather then broadcast the packet to the entire neighboring node, packet is only transfer to node I. node I will perform same way until it achieve the sink node.

Proposed algorithm:

(i) Assign 100 power units to each sensor node.
(ii) Node sense the packet.
(iii) Find out the neighboring list of node [all node which are 1m or sqrt (2) m away from each other will be consider as member of neighbor list]
(iv) Check sink node in neighboring list:
If sink node is available in neighboring list send the packet directly to the sink node, do hop=hop+1and go to step-(viii).
(v) Else search the node in descending order which has highest transition probability in vector MTS and also available in the list of neighboring node.
(vi) If search==true then transfer the packet to that node. And also hop=hop+1.
(vii) Else goto step-(iv)
(viii) Go to step-(ii)
(ix) Hop=unit of power consumption by all node
(x) end

4. Simulation

Blue color circle node represent as sensing packet node. Yellow circle node is neighboring list of B and red circle node is sink node. By using flooding techniques B sense the packet and broadcast the packet to the entire node available in neighboring list. Each packet receiving node has reduced their power by one unit if not reached to sink node. Hence processing power left after processing the first level is shown in figure (2):
A=99, C=99, H=99, I=99, J=99
Again all above node will again broadcast to their neighboring list such as C=B, E, K, J, I and I=L, H, M, J, N for second level processing (see figure 3)and so on.
Neighboring list of A=H, I but H will discard the duplicate packet from A, as it already got the packet from B, and process power A and H will reduce again by one unit, A=98, H=98. If H prepares and broadcast packet to L before I, then transmission of packet to sink node has completed and sink node broadcast the reply to its entire neighboring node and all node receiving node will discard the same packet if they receive. This may happen that before receiving reply message from sink node I has broadcast the packet to its neighboring node and its processing power will quickly reduced by 1 unit , means I=98.

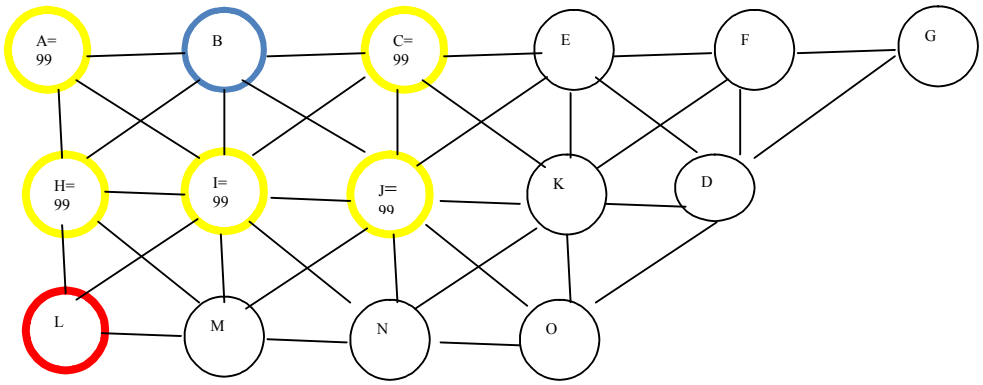

Fig.2: power left after processing the first packet in first level

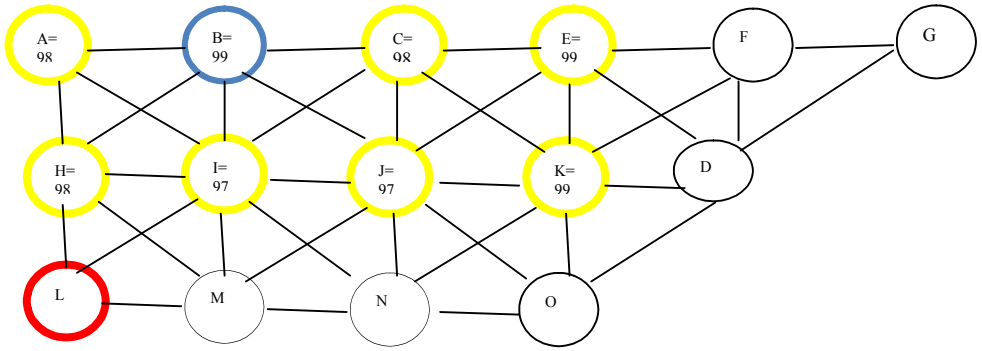

Fig.3: power left after processing in second level

Hence, average power consumption (PC) can be calculated by following formula:

PC=position of sensing node * 2 power (d_{min})

Where d_{min}= minimum distance between sensing node to sink node.

Table 1: Comparison of schemes

Scheme	Sensing node	Minimum No. of hop	Power consume
PPB	1	2	2
	2	2	2
	3	2	2
	4	3	3
Flood	1	2	4
	2	2	8
	3	2	12
	4	3	32

Figure (4) shows the comparison of the graph between the packet profile based technique and the flood based system. Finally, It shows that power consumed by using PPB scheme is much less as compared to the flood based scheme.

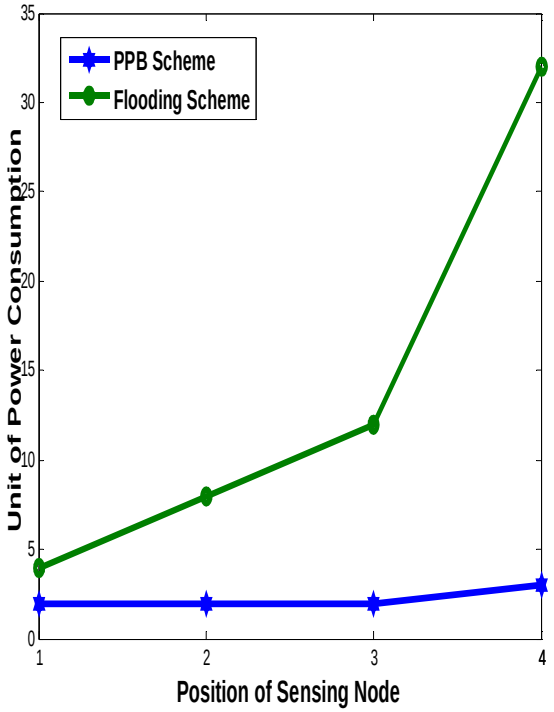

Fig.4: Comparison graph for power

5. Conclusion:

Efficient power consumption is a challenging problem in a battery-powered wireless sensor networks. The fact that each node has a limited battery power and it is impossible or infeasible to recharge the batteries. Therefore, it further reduces power consumption and increase the network lifetime. The network lifetime is directly proportional to the efficient power consumption, thus dysfunctional of any node causes serious damage to the network service considering nodes dual role of data originator and data router.

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