Adaptable Packet Length for Power Hungry WSN

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Abstract— Wireless Sensor Networks are constrained to a set of resource constraints such as battery power, bandwidth and lifetime. Power is a very serious issue and lot of work is being done in this regard. Reduction of the MAC overhead and adoption of a dynamic packet length with data aggregation leads to power optimization in WSNs. In this paper we implement an algorithm on NS3 wherein clustering of the nodes is formed by K-means clustering algorithm. We then adopt a dynamic packet length technique to minimize the power for transmission of data from nodes to cluster heads by adopting packets with different header lengths , say a smaller MAC for packets from node to cluster head and medium sized MACs for packets from cluster head to base station. The data received from the nodes at the cluster head is aggregated into the cluster node's data. The aggregation scheme consists of doping the node's data into the parity bits of the turbo encoded cluster head's data. The power saving that can be achieved with this scheme is shown using NS3 simulations. [1-3]

Keywords— MAC header, Header Compression, Data Aggregation, BER, Power, NS3, KNN algorithm.

INTRODUCTION

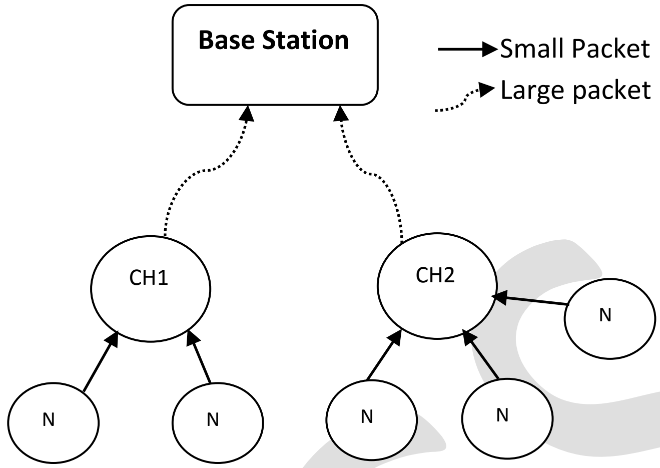
Clustering algorithms like LEACH and its variations have become very predominant in optimizing the battery life time of sensor networks. The power in WSN mote is drained more heavily due to the large MAC overhead, which actually ensures that data is transmitted securely over a wireless channel. The packet overhead (Header or preamble) is large; at times it is much greater than the data to be sent. The nodes in WSN generally have to transmit a small variation in the measured physical parameters (temperature, pressure). [1] So there is lot of research activity going on to reduce the MAC header.[2]

Packet length variation has proved to give better power optimizations for sensor networks. The DPLC, a Dynamic Packet Length Control scheme is more efficient in terms of channel utilization. This algorithm incorporates two types of messaging, small message aggregation and large message fragmentation, to facilitate upper-layer application programming. [3]

In this paper we propose an algorithm wherein we reduce the power by first forming cluster and then aggregation of data at the cluster head. Here we are adopting different packet lengths, smaller packets from individual nodes to cluster head and medium or large packets from cluster head to base station. The cluster head replaces (by aggregation) its encoded parity bits with data of its neighbors in a predefined order and sends the aggregated data to base station. The aggregation technique consumes some amount of energy but here we are concentrating on saving energy required for communication. As the cluster head aggregates data of the nodes in its cluster and sends it to base station we are saving the power of all nodes in cluster by avoiding them to send individual packets to base station owing to the fact that the nodes only send a small change in physical parameter. Also since the aggregation is done in predefined order, decoding at the base station would be much faster.[6]

The rest of the paper is organized as follows: in section III Proposed Algorithm, section IV covers Power Consumption modeling on Network Simulator-3, section V gives Results of simulations using Network Simulator-3. The Section VI describes the conclusion.

Adaptable Packet Length Variation Algorithm



CH1 & CH2 – Cluster Heads.
N1, N2, N3, N4 & N5 – WSN nodes.

Fig1. Packet Sizes in Clustered WSN

Zigbee [4, 5, 7] the most used protocol in wireless sensor networks, uses the 802.15.4 protocol for the communication layer. In the MAC data frame structure shown in fig 2 & 3 we see that payload is only 122 bytes with 25 bytes of MAC header. MAC bits significantly contribute to the size of the data packet. If the data to be sent by a node is less, then MAC bits overhead will be large.[7]

The source address (or destination address) can be either 2 byte (16bits) or 8 byte (64bits). Two byte address gives 65536 nodes in the network which is also a huge network. In the paper we propose a variable(adaptable) packet size to minimize the power wherein the size of the packet sent from nodes to cluster head station is restricted with an address of only two bytes.

2Bytes	1Byte	4-20Bytes	0-122Bytes	2Bytes
Frame Control	Data Sequence Number	Address Information	Data Payload	Frame Check Sequence

Fig 2 MAC data frame structure

0/2Bytes	0/2/8Bytes	0/2Bytes	0/2/8Bytes
Destination PAN Identifier	Destination Address	Source PAN Identifier	Source Address

Fig 3 Address info field structure

The data encoding technique used in the paper is turbo encoding technique with a code rate of 1/3 as shown in Fig 4. A general Turbo encoder is the parallel concatenation of two or more systematic codes. Here we are using two Recursive Systematic Convolution encoders. As shown in the Fig 4, a data block which is k bits long enters the encoder.

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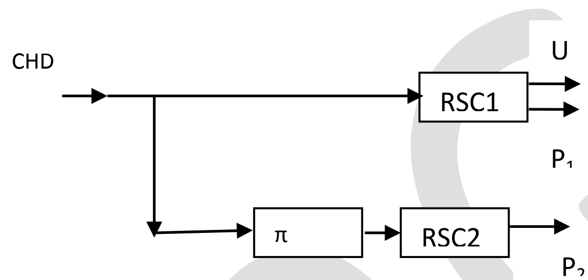
The output of the first encoder block is systematic bit U which is same as the data bit and a parity bit P_1. The data sequence is then fed in a parallel RSC through an interleaver π. The interleaver scrambles the original data sequence in a pseudo-random fashion and feeds its output into a constituent encoder to produce the second parity P_2. The information sequence U together with the parity bits P_1 and P_2 are concatenated to form the code word. The pseudo-random interleaver and P_2 parity help to achieve a better BER with increase in overall code rate of the encoder to 1/3. We replace the P2 parity bit by the data of the nodes in a cluster which improves the code rate to ½ but reduces the BER which will be compensated by more decoder iterations at the base station. [6,8,9,12]

The cluster head will transmit the data of the nodes in its cluster by using the puncturing technique which is elaborated in fig 4 & 5. The turbo encoder structure is shown in fig 4.



CHD- Cluster Head Data
RSC1 & 2 Recursive Systematic Convolution encoder
U- Systematic bit.
P1 , P2 – Parity bits.
Π- Interleaver

Fig 4 Turbo encoder

The turbo encoded data of cluster head has the following structure,

U_1, U_2, U_3… are the Systematic bits,

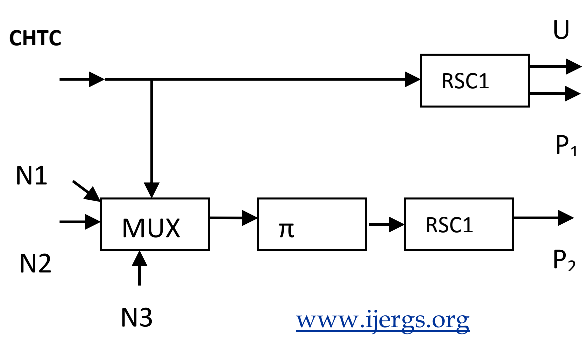
P_{11}, P_{12}… are the parity bits of first encoder

P_{21}, P_{22}…are the parity bits of second encoder.

The cluster head's encoded output would be

$U_1P_{11}P_{21}U_2P_{12}P_{22}U_3P_{13}P_{23}U_4P_{14}$…

The cluster head will transmit the data of the nodes present in its cluster by using the aggregation technique which is elaborated in fig 5.



CHTC- Cluster Head Turbo Encoded Data
RSC1 & 2 Recursive Systematic Convolution
U- Systematic bit.
P_1 , P_2 – Parity bits.
Π- Interleaver
MUX- Data Aggregator
N1, N2, N3- Nodes data.

Fig 5 Data aggregation model implemented at the CH's transmitter end.

Consider 3 nodes in a particular cluster namely as N1, N2 & N3. Now alternately puncture (replace) the parity bit P_2 with data of neighboring nodes. For three nodes (N1,N2 & N3) the position for the replacement of parity bits of these nodes are fixed ie data of N1 node will be at position 3,12,21… , whereas the data of node N2 will at positions 6,15,24… etc. The final payload of cluster head is as shown below.

$U_1P_{11}N_{11}U_2P_{12}N_{21}U_3P_{13}N_{31}U_4P_{14}N_{12}U_5P_{15}N_{22}\ldots$

Since the positions are fixed the decoding time reduces due to increase in apriori information reducing the power at base station.

Here we are showing that power is saved at two levels

1. Smaller packets with minimum MAC bits are sent from nodes to cluster head. The MAC size is restricted to two bytes, destination address (CH 1Byte) and CRC (1Byte) instead of 25 bytes.

2. Medium sized packets from CH to BS with better data rate (1/2). The MAC header only need to carry the cluster head ID (Identification number) which will be few bits. Since the network is divided into clusters the source address will be few bits so the packet will be medium sized.

KNN Clustering and Adaptive Packet Length Algorithm Simulation in NS3

Clustering techniques have been used in WSN mainly to minimize the power. Here we are implementing K-means algorithm in NS3 to implement cluster and the packets sent from node to cluster heads will be with smaller payload by restricting the address field whereas the packets sent from cluster head to base station will be medium sized packets with data aggregation of all the nodes in its cluster.[10]

a) Set up the WSN in NS3

1. Create a network of N number of nodes.
2. Assign one node as sink (BS) and other nodes as source.
3. Assign the position to the nodes, and IP addresses.
4. Deploy the battery to the nodes and use radio energy model. (CC2500 standard)
5. Randomly select some nodes as cluster heads.
6. Call KNN clustering algorithm.
7. Call an application program that creates the packet (2000 bytes) of user defined data and transmits it.
8. Compute the energy consumed for 10 iterations (1 packet is sent per iteration).
9. Compute the impact on consumed transmission power.

b) KNN CLUSTERING ALGORITHM

KNN (K Nearest Neighbor) algorithm takes the Euclidean distance between neighboring nodes and forms the cluster. [11]

1. Enter n, the number of sensing nodes.
2. Calculate the distances using Euclidean distance formula.

$$d(a,b) = \sqrt[2]{((x_b - x_a)^2 + (y_b - y_a)^2)}$$

3. Sort the distance and determine k nearest neighbors based on the k-th minimum distance.
4. Repeat the same procedure for all nodes.

c) Dynamic Length Packet Creation

1. Nodes create the packets with only two bytes of MAC header (Source address and CRC) and broadcast it to the cluster head.
2. CH will not decode but aggregate the data by replacing its turbo encoded parity bits with data of nodes attached to it. Adds only source address (cluster ID) which will be few bits and CRC bits as MAC header.

RESULTS

On simulation of our algorithm on NS3 for a network of 8 nodes we found the following clusters formed according to KNN algorithm.

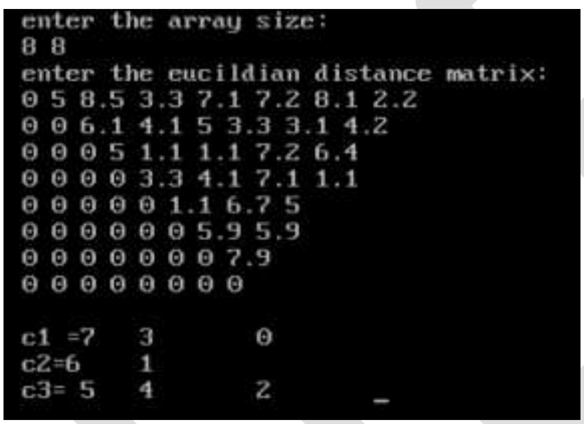


Fig 6 Cluster formation using KNN algorithm

We then simulated it in two scenarios firstly direct data transmission from nodes to base station and secondly with our algorithm i.e adaptable data aggregation. We found an average power saving of 92% for the individual nodes. NS3 simulation results showing remaining energy of nodes battery without encoding, with encoding and with Variable MAC size is given by the graph below.

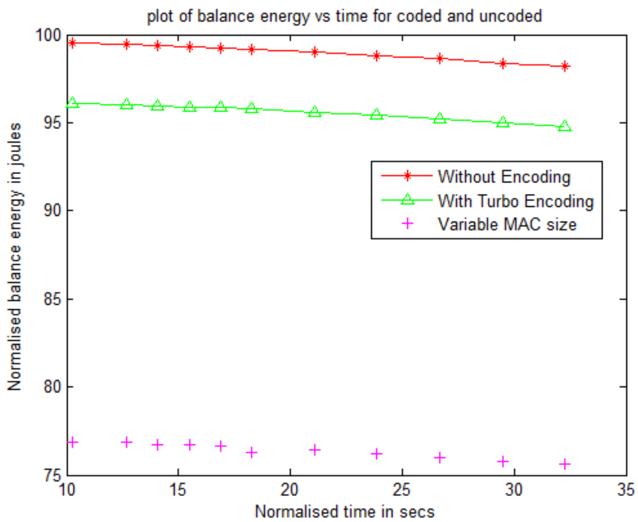


Fig 7 Remaining energy various conditions

As shown in the Fig. 7 there is considerable power saving by reducing the MAC size which in effect increases the life time of the node.

CONCLUSIONS

In this paper we show that by adopting different packet length we can minimize the power required to transmit data from nodes to base station which increases the life time of the node inturn increasing the network life time. We also show that the data aggregation carried out at cluster head has improved the code rate at a slight reduction in BER.

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