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Power Consumption in WSN Based on Data Compression

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Abstract—

Wireless sensor networks are extensively used almost everywhere. WSN's advantages in certain applications and fields are so crucial that no other system can take its place. They are well known for its portable and scalable nature. Word wireless gives us the notion about self capable device working autonomously. Remotely situated sensors are programmed in such a way that they should work independently as a separate unit collaborating with the other nodes spread in the area. Nodes situated remotely are small in size and limit in the resources. Tiny sensor nodes are unable to carry large memory, high processing speed and bigger power source. Power consumption of WSN is important area, because power plays main role in properly working of a sensor node. Sensor nodes situated in remote areas are out of reach so maintenance is always not possible. Thus we need a strategy to make sensor node work as long as possible without interruption. Due to low battery, sensor nodes ability to sense and ability to communicate weaken and it leads to wrong result or no result. So reducing the power consumption at each sensor node can eventually end up decreasing overall power consumption of a network as well as increasing availability of network. This goal can be reached by reducing the power consumption of data transmission. Data compression is the key to decrease power consumption in network. This paper gives an algorithm which works on redundancy removal of data in network eventually compressing the data.

Keywords— Sensor, compression, aggregation, RSS, routing

I. Introduction

Wireless sensor networks (WSN's) are widely used because of its advantages over wired networks. WSN can be scaled and implemented to the area where wired networks cannot reach. Scalability and portability is the key to popularity of WSN. WSN's are extensively used for monitoring purpose especially in the remote areas or the closed environment like chemical plant where human entry is prohibited. WSN's are used in commercial applications as well as for research purpose.

WSN's are low cost; low power consuming networks consists of multiple nodes. Each node is capable of working on its own by taking some intelligent decisions also called as self maintained or self capable networks. These nodes are small portable devices which can be mounted at almost every place. Nodes are small in size and hence are resource constrained. Node consists of less memory, low processing power and limited power supply. Due to wide use in remote areas it is always not possible for maintenance of network and nodes, so network must work uninterrupted without power failure. This is one of the main challenges in WSN which will ensure its maximum availability. This can be achieved by making nodes work for longer time. It is possible only when it will remain battery powered all the time. Thus reduction in power consumption of each node is the main idea behind it, so that availability of whole network must be guaranteed.

Node consumes power mainly for data processing and data transmission, where most power is consumed for transmission. Transmission of data is the research area as it is the main cause of power depletion in sensor node. Power consumption in transmitting a data is based on distance of transmission and the size of data packets. Paper describes impact of size of data packet on overall power consumption of network. Power consumption is directly proportional to the data packet size. Bigger the packet size more power is required for transmission. In this paper nodes are analysed for their power consumption. Data packets can be compressed by doing certain changes in the packet data, one of them is the removal of redundant data. In lots of areas sensed data travelling in network tend to be equal for multiple nodes, like temperature: all nodes send the same value most of the time. This situation can play major role in reducing power consumption.

II. Data Aggregation

Data aggregation is the technique of combining data from different sources to one sink node. The node where data is aggregated is known as aggregator node. This aggregator node can be the final sink node or the intermediate nodes in the routing tree through which data finally reach to the sink node. Data collection can be done in two ways: Data-centric and Address centric. Data centric is the approach of collecting data from different source nodes to the single sink node. Address centric is the approach where shortest possible distance is formed from source to destination node [1]. More specifically data aggregation can be implemented using four approaches: Centralized approach, In-network approach, tree based approach and cluster based approach [2]. Algorithm used here will follow the In-network and cluster based approach.

III. DATA COMPRESSION

A remotely situated sensor node operates mostly on batteries. Lifetime of sensor node depends upon its power source. Reducing power consumption of sensor node is the key to increase lifetime of sensor node. It can be achieved by two ways: sleeping sensor nodes and reduction of transmission data [3]. Sensor nodes when not active can be made to shut down to conserve energy. Sensor node senses physical parameter and then sends a data, periodically to the sink node. This periodic time could be anything from seconds to hours. When sensor node is doing nothing it means it is waiting for its turn to work. During this waiting time, energy can be conserved by making nodes to sleep. Second method which is basis of this paper is reduction of transmission power by reducing the size of transmission data. Almost 80% of power is consumed in transmission of data [4]. Data transmission is the key research area for the conservation of energy.

Data compression in WSN needs data to be collected at some node so that it can be compressed. Thus data aggregation is the first step for data compression. As data compression techniques such as run length coding and Huffman-coding are used worldwide but is not suitable for wireless networks because of its resource constrained nature. In WSN data is compressed within the network on any of the intermediate node rather than at the end terminal nodes. Data compression is followed in two ways at aggregator node. In first approach aggregated data is forwarded by combining all data in a single packet. In second approach aggregator node compares data values from different sources for its equality with each other. If two or more data values are equal then aggregator removes all equal values and keeps only one single value in combination with the ids of nodes from which data is received. All ids and one single data value format will notify sink that all these nodes have same value. So eventually first approach is followed compulsory in both, or we can say second approach may or may not take place. It is because there might not be the equal values found in packets received from the various nodes.

IV. ALGORITHM

Algorithm for data compression must include the way of aggregating a data to the intermediate node. Finding a route to the sink node by electing one or more aggregator node is the first step of data aggregation and data compression. Here in the paper built network consist of one sink node and several end nodes. Sink node starts the communication by broadcasting request message to the end nodes. Algorithm is as follows:

1. Sink broadcasts request message (***SRM***)
2. For each node ***Ni***
    Calculates ***RSS*** value using ***SRM*** and stores as ***STNi***
    STNi* ← *RSS
   End for
3. For each node ***Ni***
    Starts broadcasting ***STNi***
    For each node ***Nj***
    Compares ***STNi*** with ***STNj***
    If (***STNi* < *STNj***)
    Updates nearest node ***NN*** as ***Ni***
    STNi* ← *STNj
    Else
    Do nothing
     End if-else
    End for
   End for
4. As soon as every node has its ***NN***
     Each node ***Ni*** starts sensing and sending data packet to ***NN***
5. Each nearest node ***NNi*** acts as aggregator node
     While each node ***NNi***
     Waits for other nodes to send their data
     Prepares single packet for every received data packet and also its own data value
     If (equal data values)
       Remove all and keep only one
       Send single combined packet to sink node
     Else (unequal values)
       Send single combined packet to sink node
     End if-else
   End for
6. End

Where

SRM = Sink Request Message
NN = Nearest Node
RSS = Received Signal Strength
STN = Sink to node

Theoretical explanation of the above algorithm is as follows:

Step 1: When network is powered on, all the end nodes are in listening state and waits for the sink to send request message. Sink broadcasts the request message.

Step 2: As soon as message is received by other nodes in the network, each of them calculates RSS and stores it as STN. Now every node within the range of sink is having the RSS value of SRM message sent by sink.

Step 3: This step is all about forming a route to sink node either directly or via aggregator node so that each node should follow the route to send their sensed data. Here each node one by one broadcast the message to the other nodes in the network. This broadcasted message consists of sending nodes RSS value stored previously. Each node when received this message compares its own stored RSS with the RSS of received message. Let's consider RSS1 (RSS in the message) and RSS2 (RSS stored in nodes memory), if RSS1 is less than RSS2 then that node updates the nearest node (NN) as the message sending node. This follows for every other node in the network and finally each node is having either a nearest node as sink node or other node in the network. Overall there may be either one or more than one aggregator nodes. Nearest node is nothing but the aggregator node for other nodes.

Step 4: Formation of the network and route to sink with one or more aggregator nodes is the first step towards data compression. Nodes start sending sensed data to the nearest node. In the experiment temperature values are taken for monitoring room temperature.

Step 5: Data compression and aggregator role starts in this step. Nearest node is the aggregator node which waits for the data to arrive from the node below it in the route to the sink node. Aggregator's main work here is to wait until all nodes below sends data to it, remove redundancies if any, create a single packet for all the data values to be sent forward and send the packet. This procedure continues until network is switch off or reset, eventually all the steps from beginning are followed.

As experiment consist of two approaches mainly algorithmic and non-algorithmic for the result comparison. Although said non-algorithmic still it follows the algorithm till step 4, which is route formation and is followed in both the approaches. The prime difference between both the approaches is the data compression.

V. EXPERIMENTAL SETUP

In experimental setup total 5 nodes are used to form the network, out of which one is the sink node. Sink node is used only for data collection and displaying on the LCD screen. Other 4 nodes are sensing nodes and data transmitting, in case of aggregator node data compression and routing.

A. TOPOLOGY

In the proposed network mesh topology is being adopted. It is because messages are exchanged from one to many. But mesh topology is followed only until route is formed after that it follows hierarchical topology as shown in the fig.

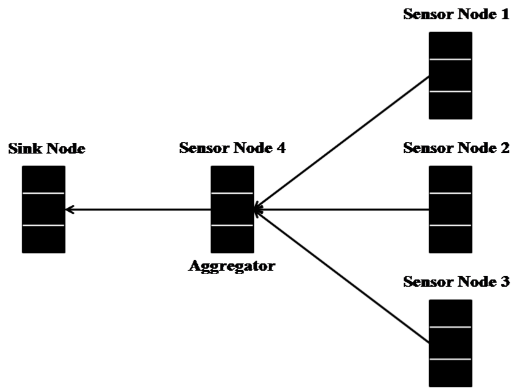

Fig. 1 Node placement for experiment

Figure 1 shows one of the experimental setup used to take the results. There is a single sink node and all other nodes are sensing nodes. These nodes periodically sense a data and send it forward in the network. Except sink node all nodes that are getting data from other nodes to route it forward are aggregator nodes.

B. NODE

Node in the experimental setup is 9 volt battery powered portable wireless device. Node is a unit divided into three sub units according to its functionality as power unit, processing unit and communication unit.

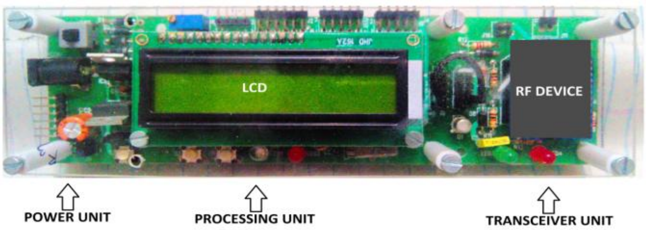

Fig. 2 Sensor node

Figure 2 shows the node structure with all the interrelated components. Power unit consists of circuitry required to provide a power to the whole node. This unit is powered with 9 volt replaceable battery. Processing unit is the brain area of node, where all the logical decisions and mathematical calculations are carried out. Third unit is the communication unit which is mainly a transceiver section with RF device mounted.

C. PROCESSING DATA

Sensors are used to sense the physical environment entities like temperature, humidity, pressure, intensity etc. Experiment consists of the temperature sensor for monitoring room temperature. All nodes are periodically set to take the temperature readings. Temperature taken in the experiment is accurate up to two digits. All the temperature readings are in the degree Celsius (^{o}C). Sensed data is exchanged between the nodes until it reaches the sink node.

D. POWER CONSUMPTION AND CALCULATION

Whenever data is sent from one place to other in a wireless medium, some power is required. This power consumption differs as the size of data packet and distance between source and destination varies. Experiments main aim is to calculate the difference between the power consumed in simple transmission and transmission with the data compression. Overall power consumed to transmit data packet is:

Total power = Power consumed + Remaining power

i.e.

Power consumed = Total Power – Remaining Power

Total power is the power required to send data packet from source to destination. This is small amount of power usually measured in *dbm* (decibel-milliwatt). Remaining power can be determined at the destination end. It is also called as *Received signal strength* (RSS). Signal strength at the source will always be greater than the destination; it is because power loss takes place in the transmission medium. Larger the data packet and more the distance between nodes much weaker will be RSS.

VI. RESULTS

Experimentation is followed by taking results of data compression algorithm and comparing it with the non-algorithmic approach without data compression. All the results are based on received signal strength (RSS). More the received signal strength less the power is consumed in transmission. Temperature values monitored are sent to the sink node. Each time temperature data is received, it is displayed on the LCD screen by sink node. RSS value of each data packet arrived is stored in the variable. To display data received from each node there is a separate section of LCD is dedicated for each node. As data is received old temperature value stored is added with the current received one and then divided by two to take the average. Variable used to store RSS is common for all data packet received from different nodes. New RSS is added to the stored value to determine total remaining power while data is transmitted over a period of time.

All results are taken for 18 minutes in the slot of 3 minutes. Sink receives data packet from each node for every 5 seconds. Considering single 3 minutes slot that is 180 seconds, can accommodate 36 data packets. Thus sink receives 36 data packets in each 3 minutes slot. This procedure is repeated for 18 minutes with 6 different 3 minute slots. Overall sink receives total 216 data packets and also RSS values from those data packets. This whole 18 minutes experiment is followed for both the approaches and then compared.

TABLE I RECEIVED SIGNAL STRENGHT FOR BOTH APPROACH

Sr. No	**RSS Without compression algorithm**	**RSS With compression algorithm**
1	-61.15dbm	-53.62dbm
2	-61.43dbm	-51.59dbm
3	-61.40dbm	-51.37dbm
4	-60.79dbm	-51.96dbm
5	-60.46dbm	-51.34dbm
6	-60.65dbm	-51.76dbm
Average	**-60.98dbm**	**-51.94dbm**

Table 1 shows the final results. Each row consists of RSS value for both approaches. Each value is estimated from added RSS value for each slot. Each value is divided by 36 for getting average RSS required for each data packets received in 3 minutes and then total is divided by 6 to get average value taken by each data packet in 18 minutes. Final value of both approach shows that there is increase in the RSS value which means there is decrease in the consumed power in transmission. After transmission of 216 data packets result show approx of 15% power reduction when compression algorithm is applied.

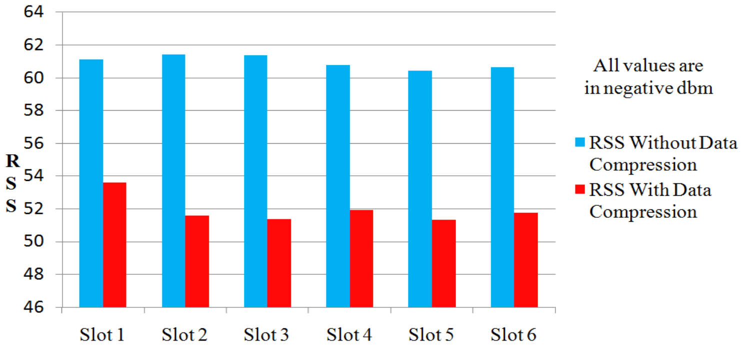

Fig. 3 Comparative graph of data compression and without data compression

Figure 3 shows the clear variation in the power consumption of data compression and without data compression values. Power consumption with data compression depends on data packet size, indicating that more the data is aggregated and more the redundancies more will be the power saving.

VII. CONCLUSIONS

Main aim of paper is to thoroughly understand advantages of data compression in power conservation of network. Data compression is important in many ways; it not only conserves power but also uses less memory. Data compression is although a part of data aggregation but plays a major role in reducing power. Power reduction leads to increased life time of node guaranteeing more reliable network. It is beneficial in many areas specially life critical and emergency areas. In the future power efficient networks will be more demanding not only for reliability but also for the conservation of energy. Such energy efficient networks demand techniques like data compression and data aggregation. Experimental results indicate that power conservation can be guaranteed using data compression. Algorithm specified above is efficient and is good enough for every hardware setup. Data compression is proved to be the effective way of reducing power consumption of overall network. Such approach must be widely used to improve technological advancements in WSN.

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