Energy Efficient Data Collections Structure for Wireless Sensor Networks

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Abstract: ***Wireless sensor networks with hundreds to thousands of sensor nodes can gather information from an unattended location and transmit the gathered data to a desired location, depending upon the application. The sensor nodes are some constraints due to their limited energy, storage capacity and computing power. In this paper a delay aware network structure for WSN's with consecutive data collection and reduction of energy consumption without data losses from node to node data transmission has been introduced. The consecutive data transmitted from node to node within the desired time period using a delay aware network structure based on the network formation algorithm.***

Keywords: Wireless sensor networks, reduction of energy, data transmission, network structure.

1. Introduction

A wireless sensor network is a large collection of sensor nodes with limited power supply and constrained computational capability due to their limited energy. Due to the communication range and high density of sensor nodes, data packet transmitted to sensor networks is usually performed through multi-hop data transmission. Assume the network was N wireless sensor nodes, the nodes are organized into the delay aware network structure using the network formation algorithm. Depending upon the application, the data packets are transmitted from sensor nodes to base station in many to one network structure. A base station acts like an interface between users and the network. One can receive the required information from the network by injecting queries and gathering results from the sink. The consecutive data packet is transmitted from sensor node to base station without data losses within the desired time period through the shortest path. The base station is collects the consecutive data packets from the sensor nodes using a delay aware network structure based on the network formation algorithm. This algorithm is based on the dynamic programming and Hungarian methods. So no losses occurred in the data transmission process and also improve the lifetime of the whole network. In simulation the ad-hoc algorithm are used to reduce the energy

Consumption and delay time during the data collection processes in the network. In fig 1shows the multiple data collection processes, the base station are collected the data packets (HELLO) from the sensor nodes without losses using the algorithm, and also reducing the energy consumption and delay time. Each data packet was different data value but all data packet received in the base station in the same period time. First the data H is transmitted to base station depending on the shortest path and data packet value, similarly the data E, L, L, and O is transmitted to base station without data losses. In this different value of data packets are consecutively transmitted to the base station from sensor nodes within the time period.

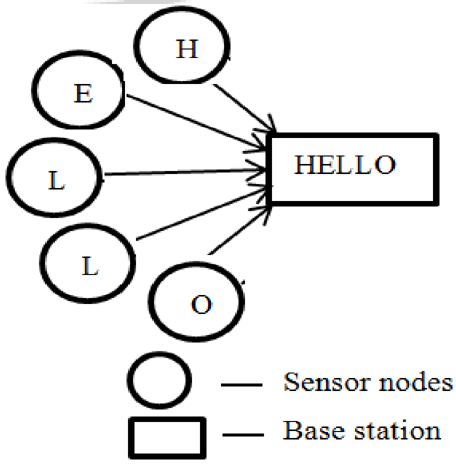

Figure 1: Multiple data collection processes network

2. Network Formation Structure

The energy consumption of an ordinary wireless sensor node is a function of its communication distance. Therefore, the objective of the network formation algorithm is to construct the proposed network structure while keeping communication distances among the connected nodes are short. The idea of the proposed network formation algorithm is to first consider the network are fully connected network and then construct the proposed network structure by removing unnecessary edges.

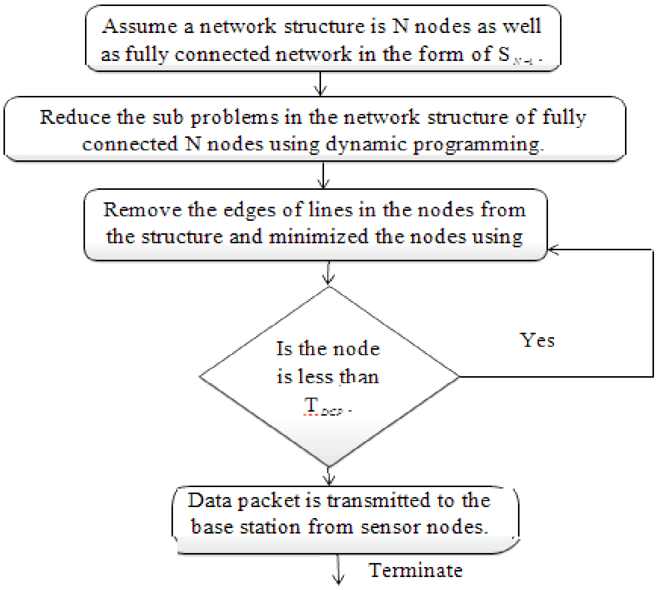

Figure 2: A flow chart of the network algorithm

The procedures of the network formation algorithm are shown as follows. For simplicity, in the following descriptions, it is assumed that $N = N_{max}$.

(i) The algorithm begins by considering a network of N nodes as a fully connected network.

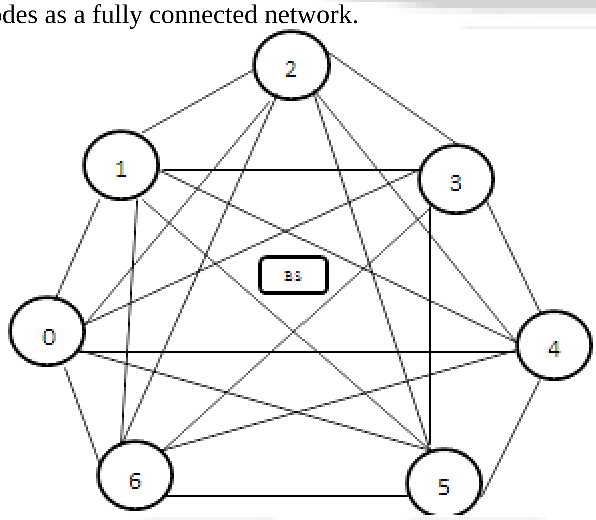

Figure 3: Fully connected network

Such that all the nodes in the network are with the connection degrees $k = N\text{-}1$. All these nodes will form a set S_{N-1} such that $|S_{N-1}| = N$. Denote the Cartesian distance between two nodes in S_{N-1} as the weight of their corresponding edge.

(ii) Denote ϕ (p) as the total number of nodes in the final outcome with their ranks = P, which is expressed as

$$\phi(p) = \sum_{k_2}^{T_{DCP}} \Psi_P, K_2$$

Where, p is the rank of a node. N is the no of nodes in a network.

N_{max} is the Max. no. of nodes that can be accommodated in a network.

T_{DCP} is the duration of a single data collection process.

Ψ is the No. of nodes in a cluster of the proposed structure.

Set $z_1 \to 1$

iii – find $\phi(z_1)$ nodes in S_{N-1} such that the total edge weight among the nodes is maximized, so the sub problems are occurred in the network. The dynamic programming method is used to solve these sub problems.

iv - if z_1 are less than or equal to the total data collection process. Repeat the step - iii. Otherwise the data packet is send to the base station.

v – Similarly if $z_3 \leq T_{DCP}$, repeat the step – iv. Otherwise, terminate the algorithm.

vi – finally the flowchart is checked the nodes of edges in the structure and then send the data packets to the destination of the base station

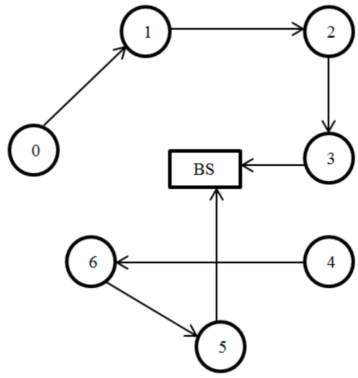

Figure 4: Network Formation Process of the structure. Sensor nodes are represented by the circles while a base station is represented by the rectangle.

The above structure is the network formation process for consecutive data packet transmitted from the sensor node to base station through the shortest path. In this structure there are two shortest paths, one is node 0 to node 3 and base station and another shortest path is node 4 to node 6 and node 5 to base station. These two shortest paths are determined using dynamic programming and Hungarian methods. The network structure is proposed based on these two methods.

2.1 Dynamic programming

Dynamic programming is a very powerful algorithmic to solve every problem just once and then saves its answer in the table, thereby avoiding the work of recounting the answer every time the Sub problem is encountered it is typically applied to optimization problems in such problems there are many possible solutions .each solution has a value, and we wish to find a solution with optimal (minimum or maximum) value. We call such a solution an optimal solution to the problem.. Break problems into sub problems and combine their solutions into solutions to larger problems. Each sub problem is solved using the relation is

L(m) = 1 + Max {L(n)}

Where L(j) is the length of the longest path.

Assume in the fully connected network structure contains n nodes numbered *0, 1,…,N-1*, and has an edge from node n to node m only if $i < j$. Node 0,1,2,3,4,5,6 are sources and node

N-1 is the destination. Where n=8, so the destination of the node is 7. For most problems, each Recursive sub problem can be identified by a few integers, so you can use a multidimensional array. To compute the time complexity, add up the running times of all possible sub problems, *ignoring the recursive calls*. From figure 3 the longest path of the network structure has been found by the dynamic programming method and by reducing these longest paths, the shortest path network is obtained as in figure 4.

2.2 Hungarian Method

This is another method for using the network formation process. The Hungarian algorithm is an algorithm for solving a matching problem in the network structure. It is a generally an assignment linear Programming problems. This Algorithm is actually a special case of the Primal-Dual Algorithm. It takes a bipartite graph and produces a maximal matching. In the fully network structure, the same data packets are transmitted from the different nodes to base station, the collision and data mismatching problems are occurred. These problems are overcome by the Hungarian method. And also find the minimum number of lines between the node to node and nodes to base station of the network. Finally we got the two shortest paths from the fully connected in the network without sub problems and longest paths.

3. Simulation

Simulation section was conducted to evaluate the energy performance of the proposed network structure. The proposed system of the network was compared with the multiple data collection processes. The simulation result shows the consecutive data collection of energy consumption, delay time, and throughput of the network structure using ns2.

3.1 Introduction of NS2

NS (Version 2) is an open source network simulation protocol. It is an object oriented, discrete event driven simulator written in C++ and Otcl. The primary use of NS in network researches to simulate various types of wired/wireless local and wide area networks; to implement network protocols they are Tool command protocol and User protocol datagram, traffic source behavior are File transfer protocol, Telnet, Web, CBR and VBR, router queue management mechanism are Drop Tail, RED and CBQ, routing algorithms such as Dijkstra technique, shortest path technique and many more. The ad-hoc algorithm is used in the ns2 for consumption of energy in network of each node. And also evaluate the delay time and throughput of the network.

3.2 AODV Algorithm

Ad-hoc on demand vector enables "dynamic, self-starting, multi-hop routing between mobile nodes wishing to establish and maintain an ad- hoc network. AODV allows for the construction of routes to specific destinations and does not require that nodes keep these routes when they are not in active communication. AODV defines three types of messages; they are Route Requests (RREQs), Route Replies (RREPs) Route Errors (RERRs).The RREQ messages are used to initiate the route finding process and the RREP messages are used to finalize the routes and also the RERR messages are used to notify the network of a link breakage in an active route. The AODV protocol is only used when two endpoints do not have a valid active route to each other.

Table 1: Comparison of the shortest paths

S.No	Shortest Path	Packet Value	Energy	Delay	Through Put
1.	Node 0-1-2-3-God	200	0.068639	0.05	0.34
		500	0.000826	0.03	0.32
2.	Node 4-6-5-God	200	0.03953	0.07	0.37
		500	0.003252	0.02	0.30

The above table contains the energy, delay and throughput of the consecutive data collection process of the shortest path structure. The data packet 200 is sent to the shortest paths of the network in order to obtain the averaged value of the energy consumption, delay and throughput. Similarly the data packet value is increased by 500 to improve the energy, delay and throughput data's compared to the first data packet value i.e.) 200 of the energy, delay and throughput. The above parameters in table 1 are calculated using the awk codes by NS2 simulation in which the energy consumption is measured from the graph.

3.3 Energy model

Energy consumption for transmitting *N* bit is equal to

$$E_{TX}(K, d) = E_{elec} \times K + \varepsilon_{amp} \times K \times d^2$$

and the energy for receiving *N* bit is equal to

$$E_{RX}(K) = E_{elec} \times K$$

In these equations, *d* is a constant value which relates to the distance between two nodes

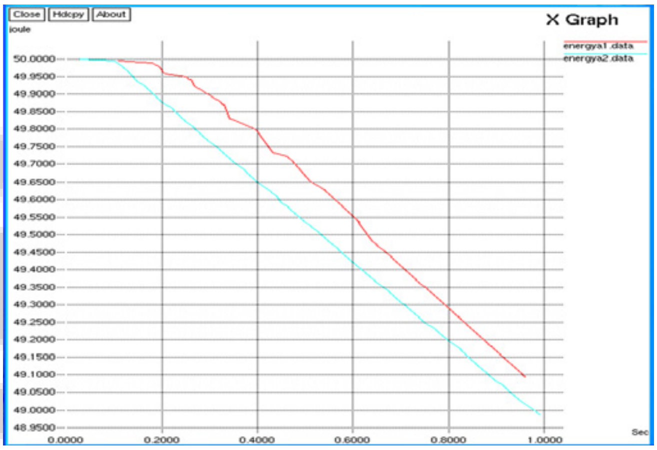

Figure 4: Energy consumption of data collection process with the proposed network structure.

In this simulation shows the energy consumption of a delay aware network structure, the red color of the signal shows the energy consumption of proposed structure compared to the multiple data collection process with data losses.

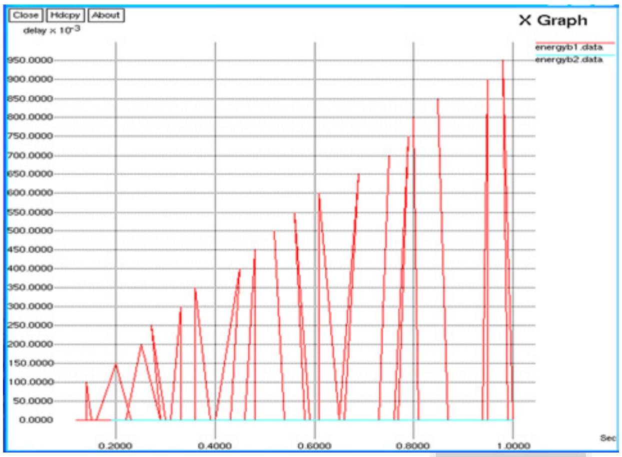

Figure 5: Averaged delay time of networks with the proposed network structure.

The graph shows the delay time of the consecutive data collection process for a delay aware network structure based on the network formation algorithm. And also compared to the multiple data collection processes for the network with data losses.

The data collection process of the delay time can be calculated using the formulae is

Delay = End Time – Start Time

Where,

End Time –data packet transmitted from the node3 to node7.
Start Time –data packet transmitted from node 0 to node 1.

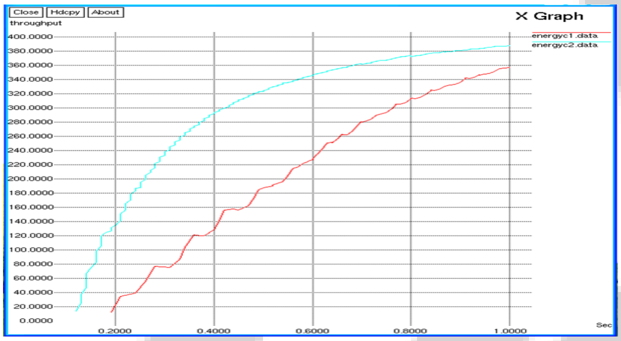

Figure 6: Throughput of networks with the proposed network structure

The above graph shows the results of delay and throughput of the consecutive data collection processes from sensor nodes to base station without data losses in the proposed network structure. If increase the data packet value the energy consumption is decreasing, and also there is no delays occurred in the data collection processes. The simulations are conducted in the ns2 software.

4. Conclusions

In this paper a delay-aware network was proposed for sensor networks with consecutive data collection processes. Comparing with a multiple data collection processes with data losses of networks, the proposed system can finished more data collection processes within the desired time without any losses on the duration of a same period. The formation algorithm based on dynamic programming and Hungarian method is proposed, and also the ad-hoc algorithm is used for the consumption of energy for the network structure. Simulation graph shows the output for reduce energy consumption of the whole network. This proposed system is suitable for various applications for the data collection processes.

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