Energy Efficient Wireless Sensor Network using Back Propagation Neural Network Algorithm

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***Abstract*: Wireless sensor network is a fast developing research area with a vast variety of applications. The Energy efficiency continues to be a key factor in limiting the deploy ability of sensor networks. Efficient utilization of node's battery energy to improve the network lifetime is the fundamental challenge in Wireless Sensor Network (WSN). The periodic control signal overheads exchanged between the base station & the sensor nodes add substantial amount of burden in energy expenditure. The other major energy issues lies in packet losses and the subsequent retransmissions, while minimizing the control signal overhead charges. To mitigate this problem, this work propose the combined design of non- uniform sampling and reliable routing for efficient energy saving and fast data communication in the system while minimizing control signal overhead charges. This work enhances the reliability in packet transmission by predicting energy robust and near-by nodes in the data forwarding path towards the destination, using back propagation neural network algorithm.it is observed through simulation results the improvement in battery energy consumption without trading off with the speed of data communication which is achieved at the cost of minimal overhead charges.**

***Keywords*: Energy efficient, Neural Network, Reliable Routing, Wireless sensor Network.**

1. Introduction

Wireless sensor networks are a useful solution for environmental monitoring, building control, home automation, surveillance reconnaissance, and so on. A sensor node generally consists of sensors, a low-power processor, battery etc. Different types of control signal exchange between BS and nodes are essential at fixed intervals to set up, maintain and co–ordinate data communications between sensor nodes and BS. Battery energy of the sensor nodes is the scarcest resource in WSN environment. Periodic sampling of all the nodes to determine their energy status results in wastage of power if stationary conditions are applied, locally for some nodes. Hence cross layer protocol design is implemented for efficient energy saving of the node's battery energy to prolong the network lifetime. This considers smart sampling to conserve battery energy of nodes owing to the fact that not all the nodes will be involved in data transmission. Many of the nodes which would not have taken part in forwarding or routing the data packets will have same residual energy states almost all the time. Also it considers such energy robust nodes for packet forwarding which avoids the occurrence of data loss at nodes with exhausted battery energy. This in turn avoids the energy expended for data retransmission. The proposed work considers neural network based smart sampling and data prediction for reliable routing by selecting the shortest path with best nodes for data transmission.

2. Design flow of energy efficient WSN

The design flow of the work is shown in Fig.1, and the proposed back propagation neural data Routing is combined with smart sampling to achieve energy efficient reliable packet routing. We assume around 25 nodes randomly distributed with low rate mobility in the sensor field with homogeneous energy configured in all the nodes. By initiating the beacon signals from base station and collecting the reply from the sensor nodes, the Received Signal Strength information (RSSI) is maintained in the base station. The neighbour node identification is accomplished using the collected RSSI information. Data acquisition with rest node's position and energy status with periodic sampling of control signals is unnecessary if a few nodes are assumed to be stationary and not taking part in routing the data packets. We present reliable routing technique to find shortest path for data transmission using parameters like neighbour node distance and its energy. Back Propagation Neural Network algorithm is used to select the best nodes in path of data transmission. Once the route is established, transmission of data is processed. Proposed work is implemented using MATLAB and its performance is evaluated for power consumption, end to end delay and sampling rate. The range or position estimation of the nodes are accomplished based on the communicating source and destination nodes from small overhead signals collected at the base station from different sensor nodes. The route following shortest path is computed for data transmission using Euclidian distance formula as in (Eq.1).

$$D(s) = x = \sqrt{((Xd + Xs)2 + (Yd - Ys)2} \quad (1)$$

Where, D(s, d) is the distance of coverage from source to next hop nearest node, enroute to final destination. Er(t) = Ei(t)−(0.1∗D) (2) Where, Er(t) is node's residual energy, Ei(t) is node's initial energy and D is the distance of coverage. Eq. (2) is used to compute forwarding node's Energy conditions. The shortest and sound path to final destination is estimated at every hop using (1) and (2), respectively. Before every communication cycle begins, the signal samples are collected from every node by the base station and is used to train the neurons in the input layer of neural network. The proposed protocol considers routing nodes' energy robustness to circumvent the occurrence of data loss due to nodes' insufficient battery energy, required for data forwarding. This in turn, avoids the energy expended for data retransmission. The presented work is implemented and evaluated for reduced power consumption, improved packet delivery ratio increased throughput, and better delay with reduced sampling rate.

Table 1
Simulation Parameters

Parameter	Specifications
Sensor field Size	100*100
Number of nodes	Around 25 nodes
Energy	100J
Propagation model	Two ray ground
Mac Protocol	IEEE 802.11
Operating frequency	2.4 GHz
Data rate	512 kbps
Packet size	1024 kb

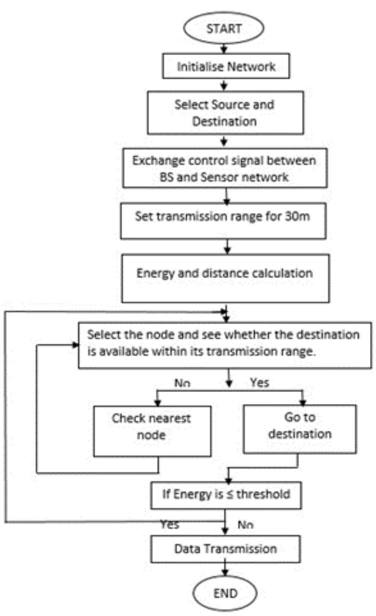

Fig. 1. Work flow diagram of energy efficient WSN

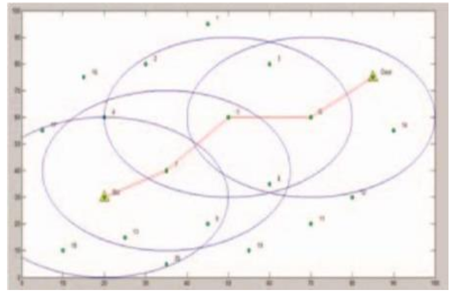

Fig. 2. Reliable path establishment in energy efficient WSN

3. Neural network based reliable

Routing Between the source and destination, a shortest and reliable path is established for energy efficient data transmission as shown in Fig. 2. The packet routing between source nodes and forwarding nodes along the way to destination node is decided based on nodes position and energy estimation. While data transmition occurs and after several cycles of transmissions, the energy of few nodes might get reduced due to which some nodes in the path fails to support data transmission as shown in Fig. 3. The node failure in the path of data transmission interrupts communication, forcing the setting up of an alternate path between source and destination nodes. This is accomplished by combined estimation of sensor node position and energy using neural network computation to offer reliable routing as shown in Fig. 4.

4. Simulation result

The result of the Energy efficient BPNN based smart sampling and reliable routing protocol is compared with the simple neural network based smart sampling method. In addition to this we propose the best forwarding path by neural path prediction. It can be seen from our results depicted in Figs. 5, 6, and 7, that our method of Back propagation neural network (BPNN) improves the performance in terms of energy consumption, delay and sampling rate respectively. Fig. 5 shows energy consumption versus size of network and our method demonstrates significant energy reduction for different sized network compared to existing algorithm. Energy consumed for data transmission per cycle, depends on various factors like transmission range, successfully delivered packets, retransmissions and control packets. Combined optimizations in communication range and sampling rate implemented in our protocol have lead to significant energy reduction for different sized network.

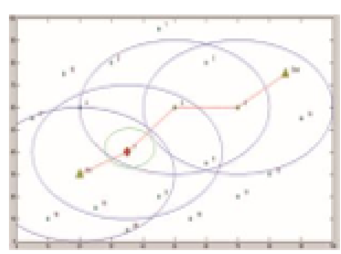

Fig. 3. Node failure in energy efficient WSN

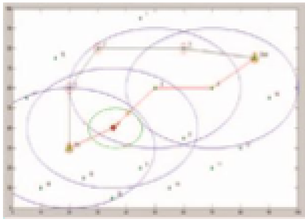

Fig. 4. Alternate reliable path set up in energy efficient WSN

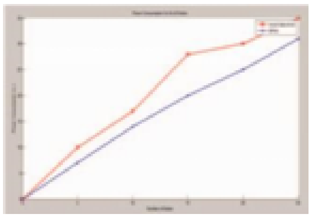

Fig. 5. Energy consumption versus network size

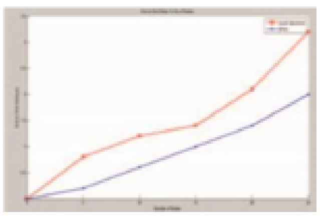

Fig. 6. Average end to end delay versus network size

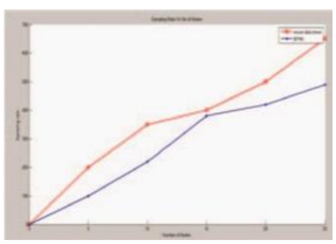

Fig. 7. Sampling rate versus network size.

It can be observed from fig. 6, that the end to end delay is consistently decreased with back propagation neural network (BPNN) algorithm compared to simple neural network (NN) Method. The fast convergence feature of weight adjustment in BPNN learning process plus reliable path predication of our approach result with a minimal end to end delay. It can be very clearly seen from Fig. 7 that; our work effectively reduces the sampling rate by avoiding periodic sampling from nodes of stationary local conditions.

5. Conclusion

Recently, wireless sensor networks are finding its applications in almost all domains of communication systems. The battery energy is the scarcest resource in the nodes of WSN. The presented work is an approach to control and optimize a communication power in the wireless sensor network. Intelligent sampling is used to avoid the energy expenditure caused by unneeded and correlated periodic sampling of nodes with static conditions. Further, BPNN based reliable routing method is used to find shortest path between source and destination by predicting the best nodes in the path. This reduces the packet loss and subsequent retransmissions which might take away the battery energy. The MATLAB coding is used for implementing of the system design. The performance is evaluated with respect to energy consumed, end to end delay and sampling rate when compared with the earlier work. It is verified from the graphical analysis.

References

[1] Kazem Sohraby, Daniel Minoli, and Taieb Znati, Wireless sensor network technology, protocols, and apllications, Copyright_2007 by John Wiley and Sons, Inc.
[2] I. Akylidiz, W. Su, Sankarasubramaniam, and E. Cayrici, “A survey on sensor networks,” IEEE Communications Mazine, vol. 40, no. 8, pp. 102–114, Aug. 2002.
[3] Holger Karl, University of Paderborn, Germany, Andreas Wiling Hasso-Plattner Institute at the University of Potsdam, Germany.
[4] Protocols and architectures for wireless sensor network, Copyright 2005 Jhon Wiley and Sons Ltd.
[5] Basavaraj S. Mathapati, V. D. Mytri and Siddarama R. Patil, “An adaptiveenergy efficient reliable routing protocol for wireless sensor networks,” on ACEEE International Journal on Network Security, vol. 1, no. 1, Jan. 2010.
[6] S. Gowrishankar, T. G. Basavaraju, and D. H. Manjaiah, Sarkar, “Issues in wireless sensor networks,” in Proceedings of the World Congress on Engineering 2008, vol. I WCE 2008, July 2–4, 2008, London.
[7] Luca Mesin, Siamak Aram, and Eros Pasero, “A neural data-driven algorithm for smart sampling in wireless sensor networks,” EURASIP Journal on Wireless Communications and Networking, vol. 2, 2014.
[8] Jamal N. AL-Karakl, The Hashemite university Ahmed E. Kamal, iowa state university Wireless Communications December 2004 “Routing techniques in wireless sensor networks: a survey.” 1536-1284/04 /IEEE.
[9] Neda Enami, Reza Askari Moghadam, Kourosh Dadashtabar, and Mojtaba Hoseini, “Neural network based energy effciency in wireless sensor networks: A Survey,” International Journal of Computer Science and Engineering Survey (IJCSES), vol. 1, no. 1, Aug. 2010.
[10] K. Nattar Knnan and B. Paramasivan, “Enhncing energy efficiency inWireless Sensor Netowrks using optimal gradient routing protocol,” International Journal of Computer and Communication Engineering, vol. 3, no. 6, Nov. 2014.
[11] A. K. Jain, Jianchang Mao and K. M. Mohiuddin, "Artificial neural networks: a tutorial," in *Computer*, vol. 29, no. 3, pp. 31-44, March 1996.
[12] X. Mao, S. Tang, X. Xu, X. Li and H. Ma, "Energy-Efficient Opportunistic Routing in Wireless Sensor Networks," in *IEEE Transactions on Parallel and Distributed Systems*, vol. 22, no. 11, pp. 1934-1942, Nov. 2011.
[13] S. Aram, L. Mesin and E. Pasero, "Improving lifetime in wireless sensor networks using neural data prediction," *2014 World Symposium on Computer Applications & Research (WSCAR)*, Sousse, 2014, pp. 1-3.