



Genetic Algorithm based Path Optimization for Extending the Network's Lifetime in Multi-Hops Wireless Sensor Networks

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Abstract: *Wireless Sensor Networks consists of a number of spatially distributed energy constraint nodes. Since sensor nodes are energy constraint, so our aim is to maximize the network lifetime by utilizing the energy of nodes very efficiently. This paper focuses on reducing the involvement of the most power hungry node so as to maximize the network lifetime. In this context we propose Genetic Algorithm based path optimization technique focusing on the minimal energy consumption of the most hungry node of the network.*

Keywords: *wireless sensor network, network lifetime, Genetic Algorithm, Variable Rate, routing algorithm.*

I. INTRODUCTION

A typical Wireless Sensor Network (WSN) may consist of tens to thousands of small sensing nodes known as sensor nodes that collect information or detect special events and communicate it to the destined base station in a wireless fashion [1]. With each sensor node having sensing, processing and transmitting capability, has given rise to a wide range of applications in industrial, military, intelligence, environment and habitat monitoring, agriculture monitoring, health monitoring [2], machine health monitoring, healthcare applications etc.

The primary challenge in designing Wireless Sensor Networks (WSN) is to expand the lifetime of sensor nodes of the network due to the fact that it is not practical to replace the batteries of thousands of sensor nodes since nodes are often deployed in a hostile or impractical environment. Therefore, computational operations and communication protocols should be made as energy efficient as possible [3]. Since the communication of sensor nodes is major source of energy-consuming than their computation, so maintaining the communication is our primary concern whilst attaining the desired network operation. Therefore, the studies on energy efficient routing scheme for wireless sensor networks have become very important. Therefore the data routing algorithms must be designed to maximize network lifetime [4]. In this context, the network lifetime is taken as the time until the first node runs out of battery [5].

The GA based optimization technique can extend the network lifetime in a multi-hops Wireless Sensor Network by randomly selecting the best path amongst number of different paths available for a source node i.e. the path that conserves the energy of intermediate nodes, to communicate with the base station, so as to minimize the energy consumption of the most power hungry node

The remainder of the paper is organized as follows. The network model is discussed in section 2. The energy consumption model used in our proposed work is discussed in Section 3. Then the Proposed Scheme is discussed in Section 4. Then the simulation and its result analysis are followed in section 5. Finally, the conclusion and future directions are explained in the last section.

II. NETWORK MODEL

We are considering the following assumptions to evaluate the performance of our sensor network model: WSN network scenario that consists of fixed randomly located nodes, generating traffic according to a significant sensed phenomenon. The data packets generated by the sensor nodes move towards the infinite energy source sink. As in [6] each sensor node is having a fixed radio coverage D , hence the nodes are uninformed of the presence of other nodes that are more than D meters away from them. We are considering the same clustering technique as in [7] where the whole network is partitioned in equal parts by equal angle distribution i.e. the center of the deployed network is taken as the center of circle and the network is uniformly divided with the angle of $2\pi/Kopt$ for clustering [8]. Once the partitioning is done it is used along the whole work duration of the network and the nodes are informed to join the nearest cluster by sink.

The data collection scenario that we are considering is generating packets with Poisson packet arrival at an average rate of r pkt/s as in [9]. The two element considered in the design of our GROUP are Sensor node and Base Station. The Sensor nodes operate in two modes Sensing mode and Leader mode. While Sensing mode the Sensor node perform the sensing task and relay the sensed data to the Leader node through a multi-hop chain. In the Leader mode the Sensor node gathers the data from the other nodes in the chain and sends them to the Base Station. The network scenario we are considering is depicted in Figure1:

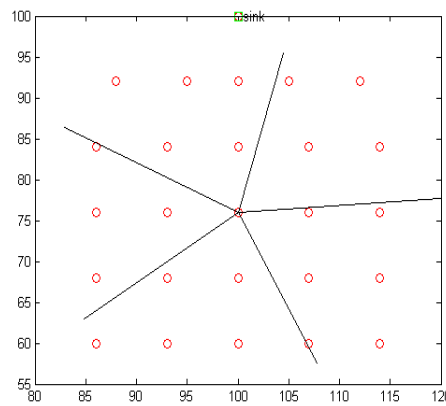


Fig. 1. Network scenario

III. ENERGY MODEL

We now focus on analytic expression of nodes energy consumption to evaluate the energy consumption of our proposed scheme. We adopted the same energy model as described in [10] and is shown in Fig. 2.

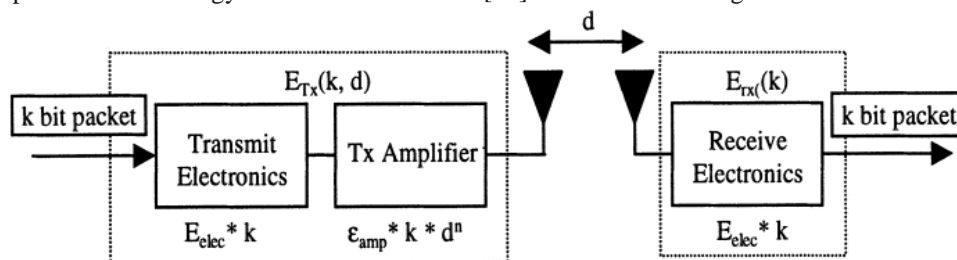


Fig. 2 Energy Model

The average energy consumption at each node is divided into two different parts, namely, E_{tx} and E_{rx} . Where E_{tx} represents the average energy consumption during the data transmission phase, i.e. the energy required by the transmitting node to run radio electronics and power amplifier and E_{rx} represents the average energy consumption during the data reception phase, i.e. the energy required by the receiving nodes to run the radio electronics only as shown in Fig. 2. The free space (i.e. d^2 power loss) channel model is used where d is the distance between the transmitter and the receiver. The power amplifier must be set in a way to balance the power loss and ensure a specific power level at the receiver end. Thus the energy required to transmit a k -bit packet over a distance d , is:

$$E_{tx}(k,d) = E_{tx-elec}(k) + E_{tx-amp}(k,d) \\ = k * E_{elec} + k * E_{amp} * d^2 \quad (1)$$

And the energy required to receive a k -bit packet is:

$$E_{rx}(k,d) = E_{rx-elec}(k) \\ = k * E_{elec} \quad (2)$$

Here, E_{elec} is the energy required by the electronic circuitry for coding, frequency synthesis, modulation and filtering of signal occurring before sending it to the transmission amplifier.

As transmitting and receiving a message both are valuable operations; thus the protocols should try to minimize the transmission distances, the number of transmits as well as receive operations for each message.

IV. PROPOSED SCHEME

Genetic Algorithm is a heuristic search algorithm based on the evolutionary idea of natural selection and genetics [11]. It starts with an initial population of individuals, i.e. a set of randomly generated candidate solutions represented by chromosomes. Individuals evolve towards the better solution with selection, crossover, and mutation operators, from generation to generation. Genetic Algorithm terminates when the required criteria is reached.

We are taking total 1000 chromosomes as the initial population for processing the Genetic Algorithm and we process it for 10 generations while taking elimination percentage equals to 50%. The fitness value of each parent chromosome is calculated via using nutrient function. The nutrient function will find the maximum number of times a node is repeated in current path function i.e. fitness value of the corresponding individual. We try to find the minimum of the function, so as to conserve the energy of the most hungry node of the network and hence, increase the network lifetime. Then after the evolutionary process new chromosomes called child chromosomes are created and fitness value of newly formed chromosomes' is calculated. In the next step, fitness value of parent and child chromosome is compared and individuals with better fitness are selected over the bad ones for the next generation population.

At the end of our simulation we will get the best route that will provide individual paths for each node with minimum intervention of most hungry node of the network. So the network lifetime is extended via conserving the energy of the most hungry node of the network.

V. SIMULATION

This section presents the performance evaluation of Genetic Algorithm based path optimization scheme proposed in this paper by using MATLAB as a simulation tool. The network configuration used for validation of proposed scheme is as described in [6] and shown in Fig. 3

We deploy total number of 25 nodes with each node having radio coverage equal to 15 meters in an approximately regular grid with 5 clusters, i.e. maximum hops distance from any node to the sink node equal to 5. The average rate of traffic generation at each node is 0.01 pkt/s with data packet size of 97 byte. The average energy consumption evaluated over all the 25 nodes², is expressed in Joule per second. The parameters used are shown in table I.

Table I: Parameters

Parameters	Value
Area	100m X 100m
Nodes	25
Chromosomes	1000
Packet Size	97 bytes
Connectivity range	15 meters
Clusters	5
Generations	10

An example of the best route discovered by using the proposed Genetic Algorithm based scheme is shown in Fig. 4, focusing on the extending the lifetime of the considered multi-hops WSN.

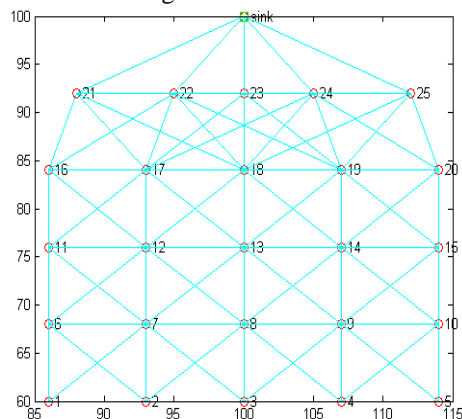


Fig. 3 Network Configuration

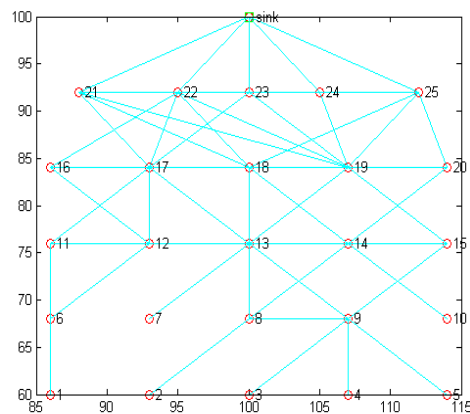


Fig. 4 An example of best route

We provide performance of VR (variable rate) scheme at node connectivity degree equals to 3.8 [10] and proposed Genetic Algorithm based optimization scheme in terms of energy consumption of most hungry node as a function of number of clusters in Fig. 5 and Fig. 6 respectively so as to provide comparison among these. It is worth noting that in VR scheme the energy consumption increase with the increase in number of clusters. On the other hand in GA based scheme the energy consumption varies with the variation in number of clusters.

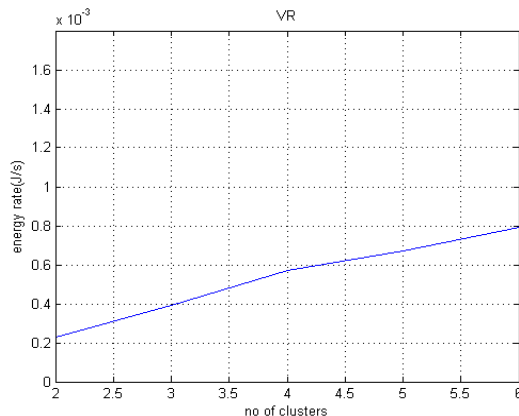


Fig.5 Performance of VR in terms of energy consumption of most hungry node.

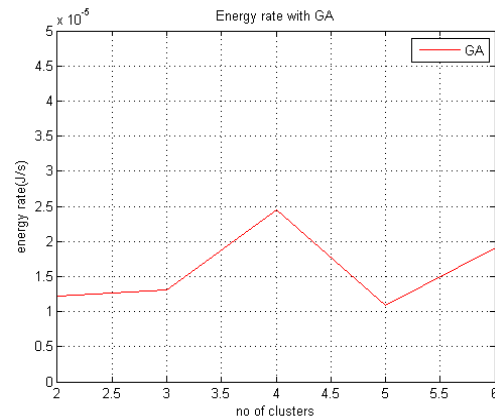


Fig.6 Performance of GA in terms of energy consumption of most hungry node.

Then, the performance comparison between VR and GA in terms of average packet delays is shown in Fig.7 and Fig.8 respectively. Although, we have not included delays in objective function, in our proposed optimization framework, however we expect that reducing the energy consumption will also entails the good performance of the network in terms of delays.

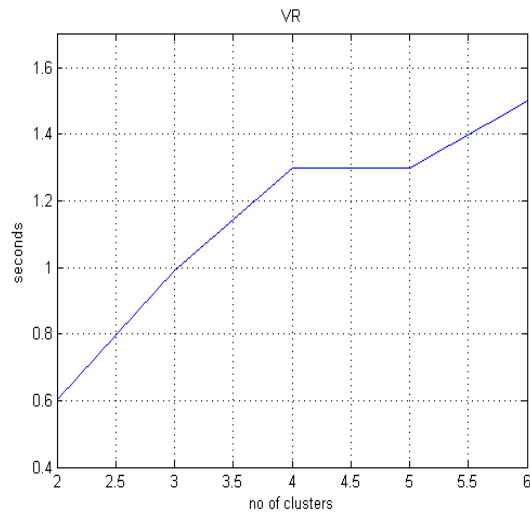


Fig. 7 Performance of VR in terms of delay

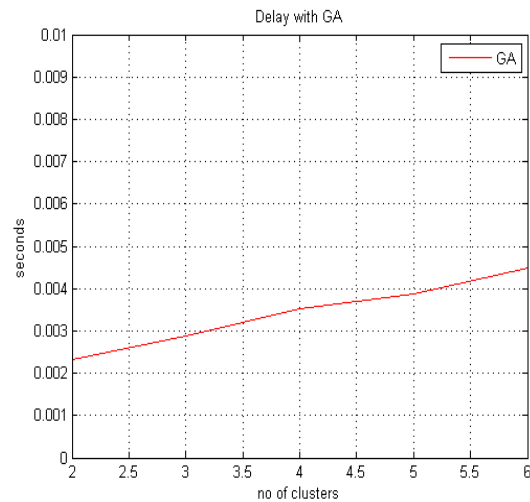


Fig. 8 Performance of GA in terms of delay

VI. CONCLUSION

In this paper we presented a genetic algorithm based path optimization scheme for wireless sensor networks. In the proposed scheme an optimized solution for path selection to transmit data from source to the destination that will conserve the energy consumption of the most power hungry node and hence, lead to extend the network lifetime. The performance comparison between the proposed GA based optimization scheme and VR confirms the validity of our proposed scheme.

REFERENCES

- [1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," in *IEEE Communications Magazine*, pp. 102–114, Aug. 2002.
- [2] Daniele Puccinelli and Martin Haenggi "Wireless Sensor Networks: Applications and Challenges of Ubiquitous Sensing" in *IEEE Circuits and Systems Magazine*, pp. 19-29, Sep.-2005.
- [3] I. Demirkol, C. Ersoy, and F. Alagoz, "MAC Protocols for Wireless Sensor Networks: A Survey," *IEEE Comm. Magazine*, Vol. 44, No. 4, pp. 115-121.
- [4] Jian Shen, Faliu Yi, Sangman Moh*, and Ilyong Chung "Energy Efficiency of MAC protocols in Wireless Sensor Networks" in ICISA international conference on IEEE, pp. 1-10, 26-29 april 2011.
- [5] Holger karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", 2005.
- [6] A. Abrardo, L. Balucanti and Alessandro Mecocci, "Optimized Dual Low Power Listening for Extending Network's Lifetime in Multi-Hops Wireless Sensor Networks". *IEEE in WTS*, pp.- 1-7 on 13-15 april 2011.
- [7] Yongming Qin, Qiuling Tang, Ye Liang, Xiuyu Yue, Xian Li "An Energy-Efficient Cooperative MIMO Scheme for Wireless Sensor Networks Based on Clustering" *Computational Science and Engineering (CSE)*, 2011 IEEE 14th International Conference on 24-26 aug. 2011.
- [8] H. Gou and Y. Yoo, "An Energy Balancing LEACH Algorithm for Wireless Sensor Networks," *Proc. International Conference Information Technology (ITNG 10)*, IEEE Press, Dec, 2010, pp. 822-827.
- [9] Yong Ma and James H. Aylor. "System lifetime optimization for heterogeneous sensor networks with a hub-spoke topology". *IEEE Transactions on Mobile Computing*, 3(3):286-294, 2004.
- [10] Poonam Lohan and Rajni Chauhan, "Geography-Informed Sleep Scheduled and Chaining Based Energy Efficient Data Routing in WSN" 2012, *IEEE SCECS* pg.1-4.
- [11] Randy L. Haupt, S. E. Haupt, "Practical genetic Algorithm", 2nd edn., Wiley Press.