University of Sindh Journal of Information and Communication Technology (USJICT)
Volume 3, Issue 4, October 2019
ISSN-E: 2523-1235, ISSN-P: 2521-5582
Website: http://sujo.usindh.edu.pk/index.php/USJICT/

Multi-Hop Optimization in Wireless Sensor Networks using Genetic Algorithm

Shauban Ali Solangi, Khalil-ur-Rehman Khoumbati, Dil Nawaz Hakro
Institute of Information and Communication Technology (IICT), University of Sindh, Jamshoro
shauban@scholars.usindh.edu.pk, khalil.khoumbati@usindh.edu.pk, dilnawaz@usindh.edu.pk

Abstract: The research in Wireless Sensor Networks (WSNs) have increasingly been done since many year for its application-specific utilization. Depending on the environment, WSNs have been deployed for the sake data sensing, gathering and transmitting it to the nearest sink. Usually, the WSNs are small in size with limited computational capabilities. Therefore, an efficient routing scheme determine the usage of battery having minimal power. In this study, we develop a scenario with the deployment of sensor nodes and sinks in the WSNs field. The sensor nodes are connected to the nearest possible sink. Then, we apply Genetic Algorithm (GA) with some basic modifications for the evaluation and optimization of the distance and energy consumption. If any node sensed the data and the path is optimized then the distance is reduced by multi-hop scheme, the lifetime of the sensor network is considerably maximized. Multi-hop routing scheme has an edge over the single hop or direct routing scheme where minimal energy is consumed in transmitting the data towards the nearest sink. For the sake of simulation, a variable number of sensor nodes with one or more sinks are deployed and the results are done in MATLAB. Further, these results are compared with TEEN (threshold sensitive energy efficient sensor network) protocol.

Keywords: GA, Lifetime maximization, optimal path, Multiple Hops, WSNs.

I. INTRODUCTION

Advancement of Micro-Electro-Mechanical-Systems (MEMS) led the technology towards the development of small-sized, resource constraint and multifunctional sensor nodes. All sensor nodes are equipped with some inherited capabilities such as sensing and gathering of the data from surrounding areas [1]. The sensor nodes form a complete network as they are deployed in a number of significant quantity namely from hundreds to thousand sensor nodes in an area. They operate and communicate using radio links. Thus, the network is called Wireless Sensor Network (WSN). Therefore, A WSN has a number of sensor nodes, a sink or Base Station (BS) and a database manager/user [2]. Due to small in size and resource constraint the WSNs are to be dealt with efficiently in terms of energy consumption. The energy or battery power determines the life of a sensor node and the life of the sensor nodes determines the life of the sensor network. During working of the WSN, maximum energy takes place when transmitting the data. To reduce the energy consumption multiple hop technique is used as depicted in Figure 1. The multiple hops reduce the transmission distance of the senor nodes and route the data towards the sink successfully. A simple multiple hop communication model as illustrated in Figure 1, node A is transmitting the data towards the sink through four intermediate hops namely B,C,D and E nodes. An intermediate node only relays the data and does not perform any computation when receive and route the data towards the next hop. All nodes are capable to sink, gather, receive and transmit the data towards the sink. Further computations are performed by the sink and user [3]. From the deployment perspective, the sensor nodes can be deployed in an area either deterministic or orderly placement of the sensor nodes or randomly placement of the sensor nodes. The later deployment method is used is this study. The random deployment of the sensor nodes removes the complexity of the nodes` positions.

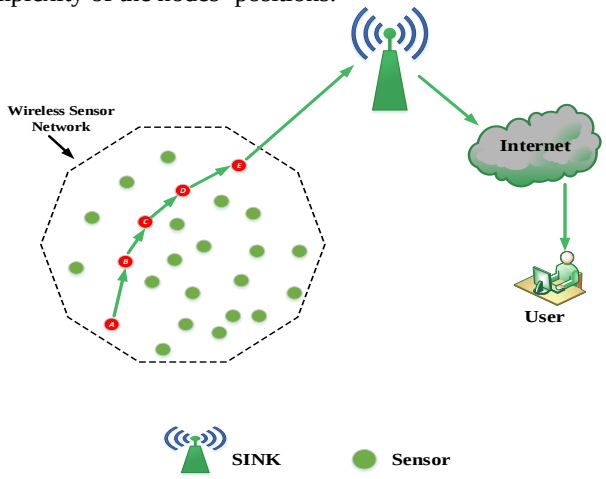


Figure 1: Multi-hop Communication of sensor nodes

The paper in organized as follows; section 1 discuss about the introduction of the WSNs and its composition. Section 2 reflects about the literature review and Section 3 commence with the introduction about the GA and its operators. The

simulations result of the proposed study are given in section 4. Conclusively, Section 5 represents the conclusion and future work and acknowledgment are given in Section 6 and Section 7 individually.

II. Literature Review

More than three decades have witnessed the enormous research contributions in least energy consumption techniques [4-6]. Hence, a number of algorithms and routing schemes have been suggested which aims at low energy consumption only. It has also been suggested that an efficient routing scheme will not only reduce the routing distance but also reduce the energy consumption. For the efficient routing schemes optimization plays an important role among others algorithms. The optimization saves the route complexity and energy expenditure. Notwithstanding, the energy cost the life of the sensor node. Ultimately, the sensor node`s life cost the WSNs life-span [7].

The optimization can be performed with the help of GA. The GA is responsible for the optimal path determination and address the complex route problems. The optimization with the coverage problem solved for attaining QoS (Quality of Service) WSNs to cover the field and improve the signal transmission [8-9]. Similarly, the optimization with multi-objective technique utilizes the GA for the sake of so-called QoS and security. Another optimization paradigm for coverage and QoS has been introduced by [9], [19-21]. The energy consumption based localization of the BS is suggested with clustering method. On the other hand, the optimization is suggested for data dissemination through deployment of WSNs in diverse environment.

The research studies in [10-13] suggested the utilization of more than one sink and optimization have been carried out accordingly. Some research area in the WSNs have been proposed with sink mobility and network lifespan maximization. The optimization of the multiple sinks with a certain number of sensor nodes. Where the nodes are attached with the sinks depending upon the distance and transmission power consumption.

III. Genetic Algorithm

Inspired from life-science, GA (Genetic Algorithm) is the meta-heuristic evolutionary algorithm performs its function through mimicking the process natural selection. Historically, the idea of GA led by an American Professor named John Holland in 1975 [14]. Though, GA possess significant utilization in Artificial Intelligence (AI) with a range of computer related applications. One of the most significant area is optimization. In optimization, GA helps in finding the most optimal and suitable solution from all available solutions. The selection and finding of the solution is carried out by utilization its operators namely selection, fitness function, crossover, and mutation [15-17].

These operators are applied for the selection of the best of the best individual. In GA all sensor nodes are taken a gene or alleles and considered as one population. Nevertheless, the gene are supposed to be as the individuals or solution among the population as illustrated in Figure 2 [1]. The energy of the each and every gene is evaluated by applying a certain fitness value and fitness function. By applying these operator we mean that only fit individuals are to be passed on the basis of residual energy level. Then, we apply crossover and mutation operators on the survived individuals as depicted in Figure 3 (a) and (b) respectively. It is noted that we assume mutation probability 0.7 [2].

After, applying all the operators the energy and strength of the survived genes are re-evaluated so the best individual from the best can be obtained.

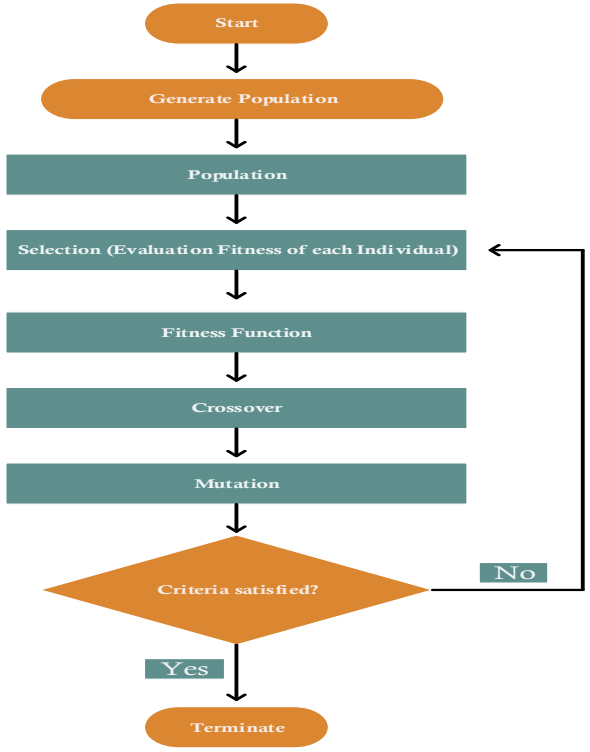
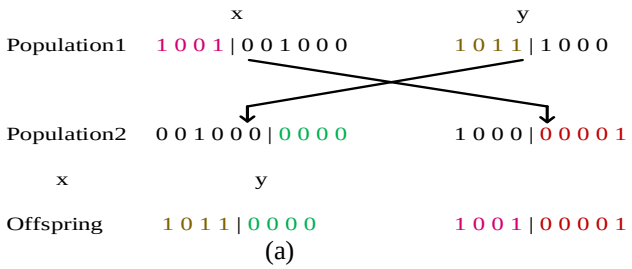
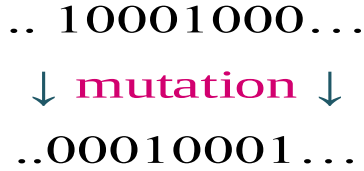


Figure 2: Operator utilization of GA



(a)



(b)

Figure 3: (a) Crossover and (b) Mutation

IV. Performance and Simulation

This study has been carried out through the MATLAB R2018b platform. The scenario comprise of the sink deployment and sensor nodes` randomly placement. The sensor nodes are assumed to be fixed after randomly deployment. The experimental results have been considered

in two steps. First, the all nodes are deployed randomly with the sink without calculating and determining the routing paths in the area of $100 \times 100m^2$ as shown in Figure 4. Second, the multiple hops distance is evaluated and determined by applying GA as shown in Figure 5. The performance of the proposed algorithm shows better outcomes when it is compared with the standard TEEN algorithm. Basically, it is multiple hop communication system which helps to consume minimum energy. All multiple hops are evaluated considering all immediate and intermediate sensor nodes as shown in Fig: 7.

A. Simulation Parameters

The comparison of the proposed algorithm with the standard algorithm [18] are carried out on the basis of the parameters defined in the Table 1. Comparison results of the proposed algorithm and standard algorithm [18] are supplied the same number of the nodes, energy power, energy amplification and individual nodes energy.

TABLE 1: PARAMETERS FOR SIMULATION

Network Size	**No. of Nodes**	**Energy of each node**	**Number of rounds**	**Energy dissipation**	**Energy Amplification $d_i < d_j$**	**Energy Amplification $d_i > d_j$**
100×100 m^2	40 and 100	0.7 J	4000	50 nJ/bit	10 pJ/bit/m	0.0013 pJ/bit/m

For the sake of the optimization all nodes are assumed to route the data towards the nearest neighbor node. They all are supposed to route the data to the determined paths. Specially, energy and distance are two main parameters to compare and evaluate the energy usage and optimal consumption.

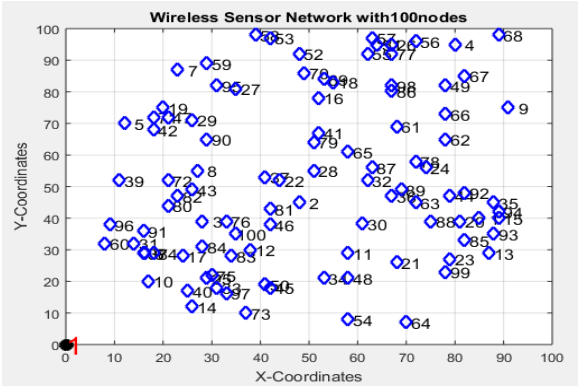


Figure 4. A WSN with sink and SNs

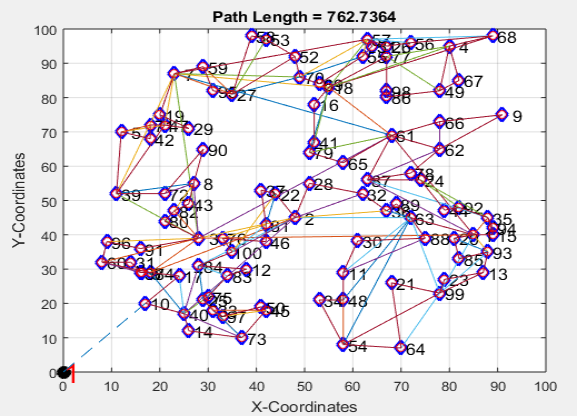


Figure 5. A sink is connected with the nodes in WSN.

The energy level of the sensor nodes and the sink is compared as number of alive nodes and packets transmitted towards the sink as shown in Figure 6.

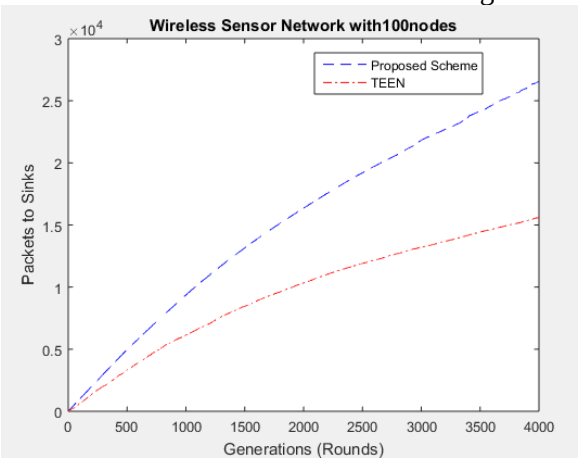


Figure 6. Sink received the packets.

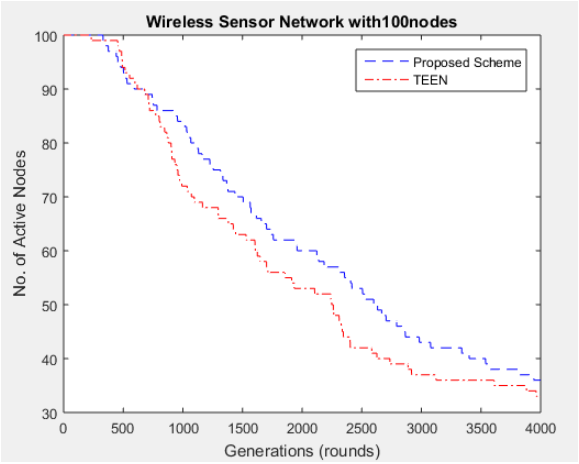


Figure 7. Alive SNs comparison.

Another WSNs scenario is formed with multiple sinks having sinks at all corners in order to receive the data conveniently as illustrated in Figure 8. Where each node have the associated SNs and multiple hops scheme successfully applied as depicted in Figure 8.

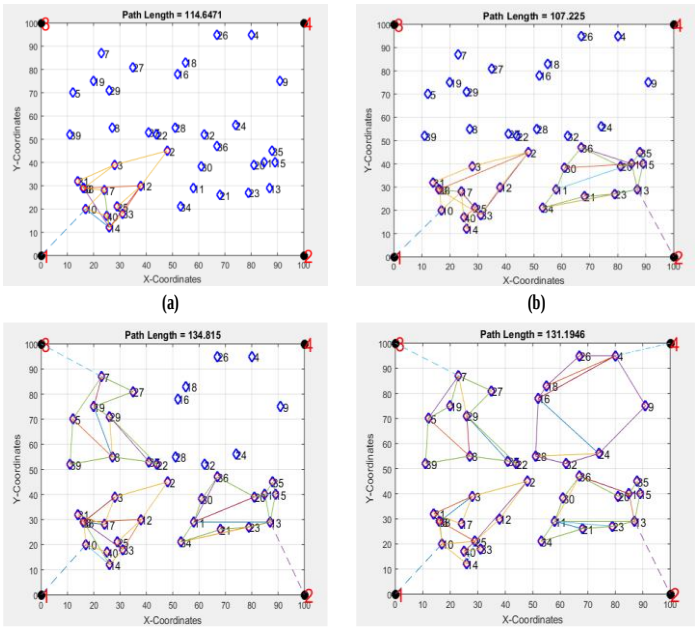


Figure 8. SNs route data to respective sinks

As compared the proposed algorithm with the standard algorithm in terms of maximum number of alive sensor nodes the proposed algorithm outperforms the standard TEEN algorithm [18] as shown in Figure 9.

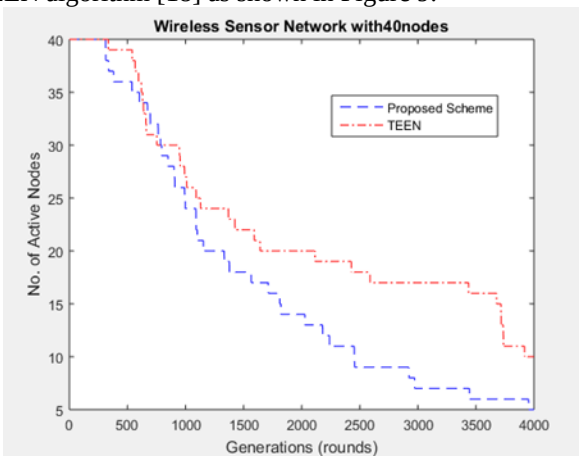


Figure 8. Alive SNs

In Figure 10, the packet transmission ratio is much higher as compare to the standard TEEN algorithm where number of the packet received at the Sink end is greater than the single sink packets reception.

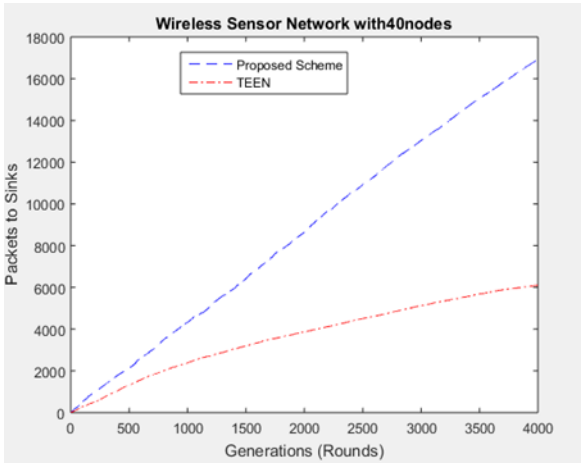


Figure 9: Final comparison results with Proposed and Teen algorithm.

V. CONCLUSION

The optimal energy expenditure and efficient usage of the energy have been proposed. Optimization in multiple hops reduced extra energy consumption. Therefore, an efficient routing scheme determined the usage of battery having minimal power. In this study, we developed a scenario with the deployment of sensor nodes and sinks in the WSNs field. The sensor nodes are connected to the nearest possible sink. Then, we applied GA with some basic modifications for the evaluation and optimization of the distance and energy consumption. If any node sensed the data and the path is optimized then the distance is reduced by multi-hop scheme, the lifetime of the sensor network is considerably maximized. Multi-hop routing scheme has an edge over the single hop or direct routing scheme where minimal energy is consumed in transmitting the data towards the nearest sink. For the sake of simulation, a variable number of sensor nodes with one or more sinks are deployed and the results are done in MATLAB. Further, the simulation results better performance as compared with the overall performance of TEEN algorithm. It is evidently shows that the proposed technique maximize the network performance and its life for maximum amount of time. Thus, the proposed algorithm enhanced the lifetime of the network and outperformed TEEN algorithm [18]. Additionally, the route distance and energy consumption is saved by the proposed technique.

The future directions in optimization are to route efficiently and localization of optimal sink so as to collect and transmit data towards/through a sink rather than a SN.

REFERENCES

[1] Solangi, S.A., Hakro, D.N., Memon, M, Khoumbati, K.-R., and Jalbani, A. H., "Optimization by Genetic Algorithm in Wireless Sensor Networks Utilizing Multiple Sinks," Mehran University Research Journal of Engineering & Technology, Volume 38, No. 4, pp. 923-934, 2019.

[2] Solangi, S.A., Hakro, D.N., Lashari, I.A., Khoumbati, K.-R., Bhutto, Z.A., and Hameed, M., "Genetic Algorithm Applications in Wireless Sensor Networks (WSN): A Review," International Journal of Management Sciences and Business Research, Volume 1, No. 4, pp. 152-166, 2017.

[3] Tahir, M., and Qureshi, R., "A Survey of Energy Conservation Mechanisms for Dynamic Cluster Based Wireless Sensor Networks", Mehran University Research Journal of Engineering & Technology, Volume 37, No. 2, pp.279-296, Jamshoro, Pakistan, April, 2018.

[4] Baranidharan, B., and Santhi, B., "GAECH: Genetic Algorithm Based Energy Efficient Clustering Hierarchy in Wireless Sensor Networks", Journal of Sensors, pp. 1-8, 2015.

[5] Ismat, N., and Qureshi, R., "Energy and Round Time Estimation Method for Mobile Wireless Sensor Networks", Mehran University Research Journal of Engineering & Technology, Volume 37, No. 1, pp. 105-118, Jamshoro, Pakistan, January, 2018.

[6] Jha, S.K., and Eyong, E.M., "An Energy Optimization in Wireless Sensor Networks by Using Genetic Algorithm", Telecommunication Systems, Volume 67, No. 1, pp. 113-121, 2018.

[7] Sasi, S.B., andSivanandam, N., "A Survey on Cryptography Using Optimization Algorithms in WSNs", Indian Journal of Science and Technology, Volume 8, No. 3, pp. 216-221, 2015.

[8] Al-Shalabi, M., Anbar, M., and Wan, T.C., "Genetic Algorithm Based Protocols to Select Cluster Heads and Find Multi-Hop Path in Wireless Sensor Networks", MATEC Web of Conferences, pp. 1-7, 2018.

[9] Khan, F.H., Shams, R., Umair, M., and Waseem, M., "Deployment of Sensors to Optimize the Network Coverage Using Genetic Algorithm", Sir Syed University Research Journal of Engineering & Technology, Volume 2, No. 1, pp. 8-11, Karachi, Pakistan, 2012.

[10] Gupta, T., "Implementation of an Optimization Technique: Genetic Algorithm", International Journal of Advanced Research in Computer Engineering & Technology, Volume 4, No. 12, pp. 4359-4364, 2015.

[11] Memon, M.A., Memon, S., Bhatti, Z., Khowaja, S., and Baloch, B., "Autonomous Robot Path Planning Using Particle Swarm Optimization in Static and Obstacle Environment", Sindh University Research Journal (Science Series), Volume 47, No.4, pp. 653-658, Jamshoro, Pakistan, 2015.

[12] Wei, G., and Xie, X., "Research of Using Genetic Algorithm of Improvement to Compute the Most ShortPath", 3rd International Conference onAntiCounterfeiting, Security, and Identification in Communication, pp. 516-519, 2009.

[13] Wang, F., Wang, C., Wang, Z., and Zhang, X.Y., "A Hybrid Algorithm of GA+ Simplex Method in the WSN Localization", International Journal of Distributed Sensor Networks, Volume 11, No. 7, pp. 1-9, 2015.

[14] Latiff, N.A., Tsimenidis, C.C., and Sharif, B.S., "EnergyAware Clustering for Wireless Sensor Networks Using Particle Swarm Optimization", IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications, pp. 1-5, 2007.

[15] Chen, Y., Wang, Z., Ren, T., and Lv, H., "Lifetime Optimization Algorithm with Mobile Sink Nodes for Wireless Sensor Networks Based on Location Information", International Journal of Distributed Sensor Networks, Volume 11, No. 8, 2015.

[16] Kalayci, T.E., and Uður, A., "Genetic Algorithm–Based Sensor Deployment with Area Priority", Cybernetics and Systems, Volume 42, No. 8, pp. 605-620. 2011.

[17] Norouzi, A., and Zaim, A.H., "Genetic Algorithm Application in Optimization of Wireless Sensor Networks", ScientificWorldJournal, No. 2, pp. 1-15, 2014.

[18] Manjeshwar, A., and Agrawal, D.P., "TEEN: ARouting Protocol for Enhanced Efficiency in Wireless Sensor Networks", IEEE Computer Society, pp. 1-7, 2001.

[19] Singh, M.K., and Nagarathna, P., "Improvement in Life Span of WSN Using Genetic Algorithm with New Fitness Function" Proceedings of IEEE International Conference on Electronics Computer Technology, pp. 1-23, 2012.

[20] Bhulania, P., Gaur, N., and Federick, K.P., "Improvement of Lifetime Duty Cycle Using Genetic Algorithm and Network Coding in Wireless Sensor Networks",6th International Conference on Cloud System and Big Data Engineering (Confluence), pp. 611-618, 2016.

[21] Poe, W.Y., and Schmitt, J.B., "Placing Multiple Sinks in Time-Sensitive Wireless Sensor Networks Using a Genetic Algorithm",14th GI/ITG Conference on Measuring, Modelling and Evaluation of Computer and Communication Systems, pp. 1-15, 2008