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Algorithm for Improved Normalized Residual Energy in Wireless Nanosensor Networks

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Abstract

A Wireless sensor framework may be a portrayed with an arrangement of wireless devices which can pass the information collected by a watched field through remote associations. The information is sent by various center points, and along a gateway, the data is related with various frameworks like remote Ethernet. There are five types of WSNs Terrestrial WSNs, Underground WSNs, Underwater WSNs, Multimedia WSNs, mobile WSNs. There are various challenges in WSN like, Power, cost, security, system architecture etc. In the nanotechnology, Remote nanosensor systems (WNSNs) are a substitution age of detecting component systems found in nano scale, which are suppose to be made inside the returning years. Each nanonode is inside the shift of a little too few nano meters in measure. The nanoscale property of nanonodes opens energizing new applications inside to detecting space. On the other side, nanotechnology is rapidly gaining the importance in our daily lives and Wireless Nanosensor Networks are now attracts researchers. Among various communication strategies, Electromagnetic communication strategy gives many solutions in many applications and it is really important in building wireless Nanosensor Networks. In this paper, we propose the cluster head selection on the basis of node density, so that we can improve the normalized residual energy and reduce average delay. The simulations are performed on MATLAB. The paper show the improvements in normalized residual energy is 35.84% when the node density is 7 node/cm^2 and reduce average delay is 16% when node density is 7 node/cm^2.

Keywords- WNSN, OOK modulation, PBDA, femto-second long pulse.

I. Introduction

Emerging nanotechnology presents great potential to change human society. Nanoscale devices are able to be included with Internet. This new communication paradigm, referred to as Internet of Nanothings (IoNT), demands very short-range connections among nanoscale devices. IoNT raises many challenges to realize it. Current network protocols and techniques may not be directly applied to communicate with nanosensors. Due to the very limited capability of nano devices, the devices must have simple communication and simple medium sharing mechanism in order to collect the data effectively from nanosensors [1]. Nanosensors can gather supportive information which must be sent outside of their detecting surroundings for capacity and additional procedure. In elective words, they'll get the opportunity to convey between themselves in like manner like hubs inside the little and full scale space. Among all feasible correspondence routes among nanonodes, thinks about demonstrate that attractive fascination correspondence inside the 0.1-10.0 rate (THz) band could be a promising methodology for correspondence in WNSNs. in activity inside the rate band will encourage nanosensors expend low vitality though giving property at the nano scale. A graphene-based nano-reception apparatus has been contemplated in light of the fact that the nano scale handset to transmit and get beats inside the rate band. [7]

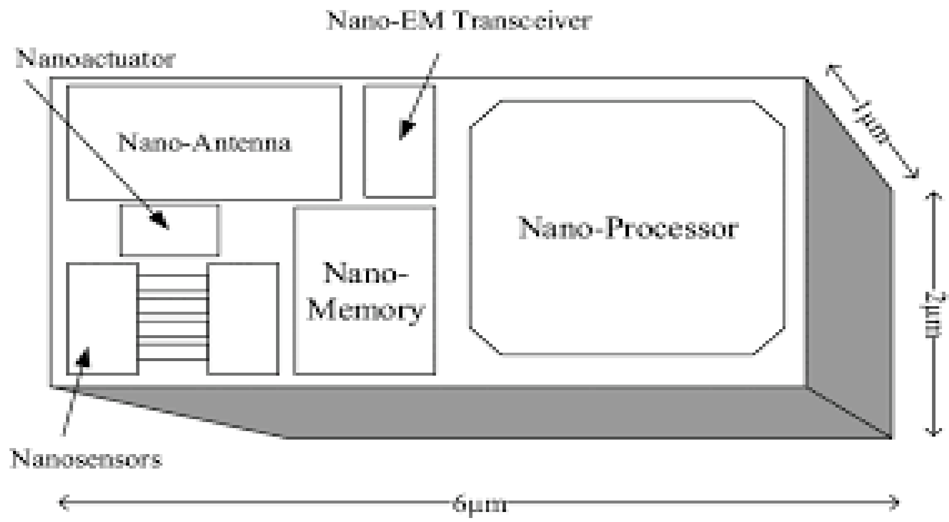

Fig.1 Network Architecture of Nano Network

Nanosensors can gather supportive information which must be sent outside of their detecting surroundings for capacity and additional procedure. In elective words, they'll get the opportunity to convey between themselves in like manner like hubs inside the little and full scale space. Among all feasible correspondence routes among nano nodes, thinks about demonstrate that attractive fascination correspondence inside the 0.1-10.0 rate (THz) band could be a promising methodology for correspondence in WNSNs. in activity inside the rate band will encourage nanosensors expend low vitality though giving property at the nano scale. A graphene-based nano-reception apparatus has been contemplated in light of the fact that the nano scale handset to transmit and get beats inside the rate band.

Introduction to PBDA Algorithm

The PBDA algorithm consists of four phases. The nodes are classified in the first phase; the second and third phases create clusters of B1 and B2 nodes and the fourth phase calculates the distance between two corner nodes based on flooding.

Phase 1: Packets are broadcast via flooding mechanism and classified according to neighbor discovery. Each node broadcasts a packet to calculate the number of neighbor nodes, then the quantity of neighbor nodes split them into classes by density. B1 nodes are subjected to the following steps.

Phase 2: Clusters are established and the cluster heads of B1 nodes are identified. The B1 nodes generate and broadcast a clustering-broadcast packet via flooding mechanism. Only B1 nodes can pass packets- forward- packets are dropped if they are received by B2 or B3 nodes. The clustering-broadcast packet consists of four fields. The first is the *ID* of the B1 node which originally generated the clustering broadcast packet [21]. Here, we assume that every node has a unique *ID*. The second field is the type of the node that transmits the packet. The third field is the residual energy of the node. In this phase, each B1 node chooses the optimal node which has the most residual energy to be the cluster head. The last field, *EDC*, is a code that checks the transmission error. Because PBDA is based on the transmission of 100-femtosecond-long pulses by an asymmetric OOK modulation, the high-bits ``1" may be lost during the transmission process [22]. After receiving the clustering broadcast packets, B1 nodes choose the node with the highest residual energy as the cluster head. B1 nodes then join the cluster by replying a clustering-reply packet to inform the cluster head. i.e., B1 nodes with lower residual energy send clustering-reply packets to CH, which has the highest residual energy. The clustering-reply packet consists of four fields. The *RXID* field represents the *ID* of the node which should receive the packet, that is, the *ID* of the cluster head.

Phase 3: Clusters are established and cluster heads of B2 nodes are chosen. The process is similar with the second phase. After receiving the clustering-reply packet, the cluster nodes continue to send the notify packet. The confirm code is delivered to B2 nodes, informing them to create clusters and choose cluster heads through clustering broadcast and clustering-reply packets. When B3 nodes receive the packets, they discard them. An example of the cluster establishment process. All the nodes are grouped in clusters in this manner. Each cluster includes only one type of node and one cluster head. Certain packets are originally generated by B1 nodes, as well. These packets are transmitted to other B1 nodes on the other side of the network via B2 nodes.

Phase 4: Flooding packets are forwarded through the cluster heads and the distance between the corner nodes is calculated. The third field represents the types of the nodes that only receive the packet and prepare to pass it forward. The *DIS* field reserves the cumulative distance from the original B1 node to the current node; this field is initially set to "0". Each time the flooding packet is transmitted, the *DIS* value increases. Flooding packets continue forwarding through B2 node clusters until they reach the B2 nodes on the other side of the network. The ultimate value of *DIS* is the estimated distance from one side of the network to the other side.

Main contribution

- The main contribution of this paper is the section of cluster head is based on the node density of the nodes.
- As we select the cluster head selection on the basis of node density the time delay between the nodes and the energy consumption of the nodes are reduced.
- The results are improved when compared with the PBDA algorithm.

As in the simple method we select the cluster head on the basis of the residual energy, due to this the delay is large when the packet is transmitted, and the distance was more between cluster nodes and the neighbor nodes. But when the cluster head selection is on the basis of node density then not only the distance between the neighbor node is reduces though the time delay is reduced. So the cluster head selection of the nodes is more accurate when we select the cluster head selection in the basis of node density.

II. Literature Review

Massimiliano Pierobon et al. proposed the routing structure for the wireless nanosensor networks, to optimization of the energy harvesting to the suitable for the operation of the wireless nanosensor networks however, at the same time the throughput of the overall network is increasing. This framework is based on the Medium Access Control (MAC) Protocol for the combine throughput and lifetime optimization in wireless nanosensor networks. The paper conclude the evaluation for the multi-hop routing framework, the key parameter of this paper is to reduce energy consumption , the capacity of the network and the delay of each nanosensor of the wireless nanosensor networks.

Vishrant Rupani et al. has reviewed the wnsns which are basic building blocks of the electromagnetic communication. The author introduced the architecture for interconnection of nanodevices, modeling of the network in all the possible layer. The channel modeling is present in terms of the THz band. The author conclude that the energy is finite in the nanodevice ,therefore short weight channel codes are used to decrease the interface power and energy consumption therefore, network lifetime is increases.

Ayoub Oikhar et al. introduced the mechanism of flooding algorithm for routing in wireless nanosensor networks and then they compared with the counter-based and probabilistic based broadcasting mechanism. A new term is proposed in this paper called MANETs. This is the category of ad-hoc network in which location can be change and configured as itself on the circle. As MANETs are mobile in nature, therefore they use wireless connections so that they can connect various networks. The conclusion of this research paper was that the investigation from the range of transmission affects the performance of the EM-based broadcasting mechanism for nano communication.

Pedtem Johari et al. was proposed the link capacity maximization problem in wireless nanosensor networks given by that the devices and communications are independence in wireless nanosensor networks. In this paper the optimal data is in pocket size that maximize the link efficiency and initialized to holding devices, channel, link and physical layer particularities of WNSNs.

The outcomes are presented to observe the effect on the packet size for the various error control techniques. The conclusion of this paper was to optimal packet size maximum to the link throughput in WNSNs that was observed for some various error control techniques, which includes EPC, FEC and ARQ. The analysis captured the particularities of THz band, nanodevice and their capacities of energy harvesting and data transmission.

Long Jun Huang et al. proposed the energy optimization algorithm for the communication in WNSNs and also introduced an energy model for the consumption of energy. In this the transmitter and receiver are presented the energy consumption. Since the receiver and transmitter are presented on the basis of optimal code-word length and optimal source-word length. Also a coding algorithm is presented is developed for the optimizations of energy problems and efficient energy coding scheme. The EOC will compare with and AWD. The conclusion was that the code-word length of EOC which was greater than the source-word length, that was totally disimilar form NME and the result is better in terms of energy efficiency.

Amrita Afsharinejad et al. have discussed for the first THz band for the path loss model for a plant monitoring. A simplified plant structure model and also probability model for the successful transmission between the nanosensor and micro sensor. A receiver is install on the plant stem for interchange the information between nano sensor and micro sensor. Also the author addressed in order to the path loss model for THz communication. This paper concludes that the border for the path loss of the reference value , that depends upon the shape of the plant and the transmission structure, that can be use for the detection of threshold at the receiver.

Kai kai Chi et al. is focused on WNSNs use on off keying modulation which is used to minimize the energy transmission with respect to the minimization of average codeword weight. In this the author gives a integer non linear programming problem to build a prefix code which have small ACW in the condition of average codeword length therefore, transmission energy consumption is minimum will collect the large throughput than the preset value. Two cost effective algorithm that is known as binary tree based length decreasing (BT-LD) algorithm and binary tree based weight decreasing (BT-WD) were given to establishe a low ACW prefix free codes. The results of paper was when the preset threshold of average codeword length is small the 20% of energy consumption is reduced.

Kaikai Chi et al. are focused on an ON-OFF keying (OOK) modulator. By using this modulator the transmission energy is reduced when an actual low-weights with the low average codeword weight (AWC) source symbols with the various higher bits. To resolve this problem author design a code name as Fixed length Minimum-Communication-Energy (F-MCE) and variable-length minimum-communication-energy (V-MCE) code that were capable to reduced the energy consumption on the transmitter and receiver side in between the ends of two nodes in OOK based WNSNs. The result shows the MCE coding scheme which are efficient to overcome the overall energy consumption in wireless communication for WNSNs. The parameters which are depending on the amount of energy consumption per single bit transmission, symbol length, and energy consumption per bit demodulation, the gains of energy storing differ from few dozen of percent.

Eisa Zarepour et al. discussed about wireless nanoscale sensor networks which operates in terahertz band range from 0.1-10 THz. Energy efficiency, reliability and simplicity is the basic parameter to build a communication protocol network for WNSNs. A carrierless pulse based modulation is adopted because of its simplicity and energy efficiency. The author compare the four carrierless modulations, PPM, PAM, BPSK, and OOK in terms of WNSNs operates in THz band. Also find BPSK which is additionally typical in the terms of decoding logic on the receiver side. The conclusion was the OOK is a simple technique and the reliability performance is small when they compare it with BPSK. BPSK has larger energy efficiency and higher performance but to achieve these it needs complex transceiver rather than other schemes.

Hoa Tran-Dang et al. gives two ranging algorithm, which is based on hop counting method by which the author can estimate the location of each and every nanosensor and also find the distance between the nodes in the network. To transfer the information packet in all nodes and to count the number of hopes between the two nodes in a network, the flooding mechanism can b used. A second algorithm, which is based on cluster to reduce the problem of duplication of information packets and waste of energy consumption. The result of this paper is that if we calculate the dimension of a square then the counter counts the number of hops by counting the number of nodes placed between the two corners of the square.

Sefat Noor Orni et al. proposed cluster based single hop routing algorithm with an energy harvesting model. The proposed model also include two other algorithms: one is to form a cluster and another is to transmit the data from nanosensor to nano routers. The main goal was this paper to invite a decentralize a hop cluster based routing algorithm which is designed with energy harvesting model by improvising prevailing mechanism. The conclusion was the paper that an en efficient energy harvesting algorithm and also develop a routing algorithm for the energy harvesting.

Josep Miquel jornet et al. introduced an energy model for self- powered nanosensor motes. The purpose was this model to define a relation between the energy harvesting process and the energy consumption. Energy harvesting process is recognize in piezoelectric nano generator which develop a model for reproduce the experimental data. The motes in the communication are operating in terahertz band (0.1-10 THz). An energy model was presented for capturing the dynamic behavior of total network traffic and the multiuser interface. The result was the author develops a framework to explore the influence of the packet size and retransmission policy from one end to other packet delay and the throughput of WNSNs.

Murat Kocaoglu and Ozgur B.Akan proposed a modulation technique and a minimum energy scheme (MEC) to get efficient energy in WNSNs. For minimizing the energy MEC maintains a suitable code distance which helps to provide reliability to the network. If the source set number is smaller than the inverse of the symbol error probability then the codewords can be decoded ideally for large code distance with the help of MEC which is shown analytically. The OOK modulation is used to generate the minimum average codeword energy. By using the properties of THz channel they proposed multi carrier scheme for wireless nanosensor communications. The outcomes of the paper were around MEC which satisfies a mimimum Hamming distance for reliability.

Shahram Mohrekesh and Michele C.Weigle introduced the different parameter of energy consumption in pulse-based wnsns which converts the energy harvesting to the supply energy. The author calculate the effects of repetition, packet size and code weight on the optimization problems. This model validate the ideal energy consumption design in theWNSNs. The outcome of this paper gives the optimum energy consumptions when the QoS requirements are complete which are delay and transmission reliability.

Josep Miqel Jornet and Ian F. Akyildz proposed a mechanism for reduce then interference in the Pulse-based nanonetworks. It wass shown by choosing an appropriate the weights of the code, rather than using the channel codes for detecting and correcting the transmission errors. The performance scheme provides reduction in overall interface and information rate in terms of both analytically and numerically. The terahertz band is used for the pulse based communication. A statistically model which provide impulsive interface generated by a Poisson field of nanomechanics operate on TS-OOK modulation. The outcomes of the paper was that, when the low weight channel code are used then overall interface should be reduced.

Ian F. Akyildiz et al. provides a deep knowledge of terahertz Band (0.1-10 THz) communication, which is the basic technology for boost up speed of wireless communication. The device designed and developed for challenges in THz band are reviewed. There are so many challenges in the paper like, capacity analysis, modulation scheme, propagation modeling and physical and link layer solution. Terahertz band is new boundary in the area of research. Terahertz band also validates the different networking schemes at the nano scale level, such as wireless nanosensor networks. The outcomes of the paper were terahertz band technology from the device perspective.

III. Problem Definition

Wireless Nanosensors Networks (WNSNs) are the revolutionary advancements in the growing field of sensing technology. The nanoscale size of sensor nodes used in WNSN puts a lot of hardware constraints that creates the urgency to conserve the energy of nanosensors. The algorithm pulse-based distance accumulation algorithm has significantly improved the localization algorithm. However, the research gap in the aforementioned techniques lies in the fact that clustering used in the technique uses only energy factor for the Cluster Head (CH) selection for the clusters of corner, center and boundary nodes. The node density factor ensures the CH selection of a node which is surrounded by various nodes that ultimately reduces the distance of various nodes from the CH node in a particular cluster. Consequently, energy of a node is reduced significantly.

IV. Proposed Work

The proposed work introduced the algorithm for to reduce average delay in the nodes and to improve the normalized residual energy. All the parameter help to achieve the network lifetime. In the proposed work the cluster head selection is on the basis of the node density, so that the proposed objective can be achieved.

Network Assumptions

- Nodes are distributed randomly
- Initial energy of all nodes is same
- Cluster heads are aware of remaining energy
- Network topology is isotropic

Network Parameters

Following are the parameters that are set for the proposed work, 100 nodes are deployed randomly over an area of 100x100 cm.

Parameter	**Values**
Network size	100x100cm
Pulse energy	100pJ
Pulse inter arrival time	10ps
Deployed nanosensor nodes	200 to 1000
Channel type	Wireless channel
Packet size	128bytes
Modulation scheme used	On-Off keying
Pulse duration	100fs

V. Simulation Results

1) Normalized Residual energy Vs. Node Density

The energy consumption shown in Fig. It is a function of the node density. Since the node density increases, the average residual energy of each algorithm shows a different degree of decrease. The processes by which nodes can receive and transmit packets consume the greater amounts of energy as node density increases, as well. For PBDA, with a small number of nodes, cluster heads also need time to accumulate distance hop-by hop during clustering and more energy is consumed. The improved PBDA performed all over the existing algorithms. Because the cluster head selection of the nodes is on the basis of node density, so the energy consumption is less of the nodes. The proposed algorithm gives the improvement of 35.84% in the energy consumption among the all existing algorithm.

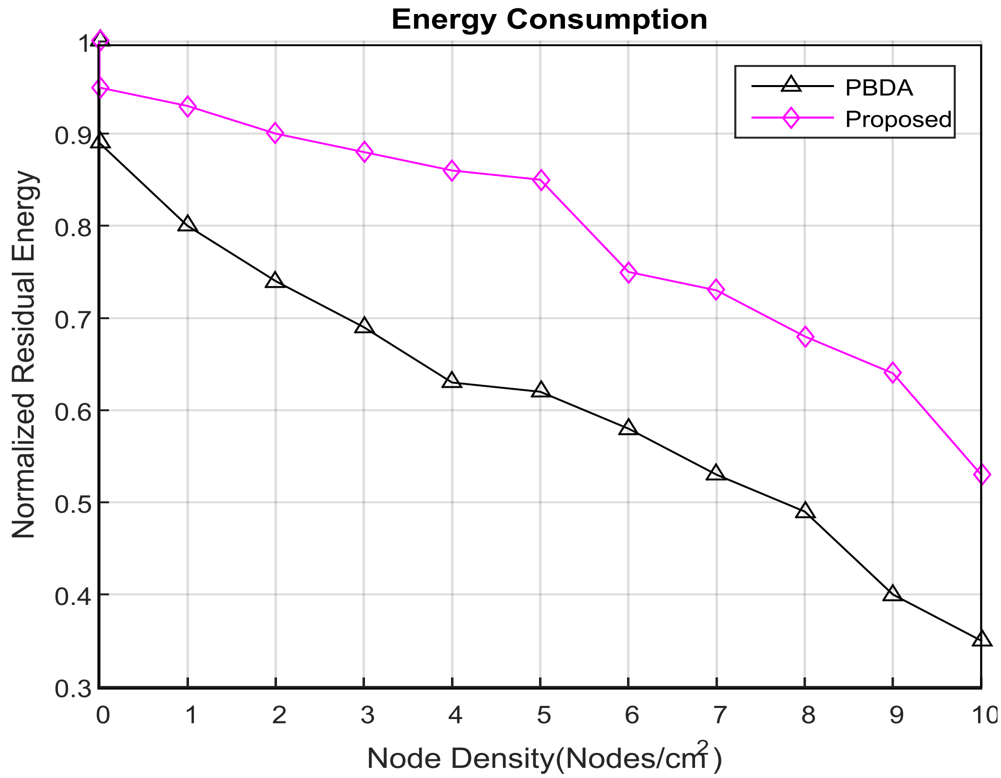

Fig. 2 Comparison of Normalized Residual Energy vs. Node Density

The given table shows the improvement in proposed algorithm node density (7 Node/cm^2) Vs. Normalized Residual Energy .The proposed algorithm outperformed rest through the algorithms. The proposed algorithm gives the improvement of 60%, 30.90% & 35.84% in the energy consumption among the all existing algorithm.

Table 1. Comparison of Normalized Residual Energy vs. Node Density

Algorithm	Normalized Residual Energy[25]	% Improvement
PBDA	0.53	-
Proposed Algorithm	0.72	35.84

2) Node Density vs. Average delay

Fig. shows the average delay as a function of node density for different algorithms. The three algorithms show similar energy consumption in terms of average delay as the node density (i.e., neighbor node quantity) increases. The communication radius remains unchanged, so the process of flooding broadcast nodes or creating clusters takes time. We also found that when the node density is less than (7$Node/cm^2$) PBDA have a larger delay. This is because when the node density is small, simply flooding the broadcast nodes is inappropriate while PBDA undergo an additional clustering process. Distance calculation causes a processing delay in PBDA, but the delay is tolerable compared to the transmission delay of flooding. Overall, proposed algorithm outperforms the other algorithms in a high node density environment. The proposed algorithm gives the improvement of 16% in the average delay among the all existing algorithm.

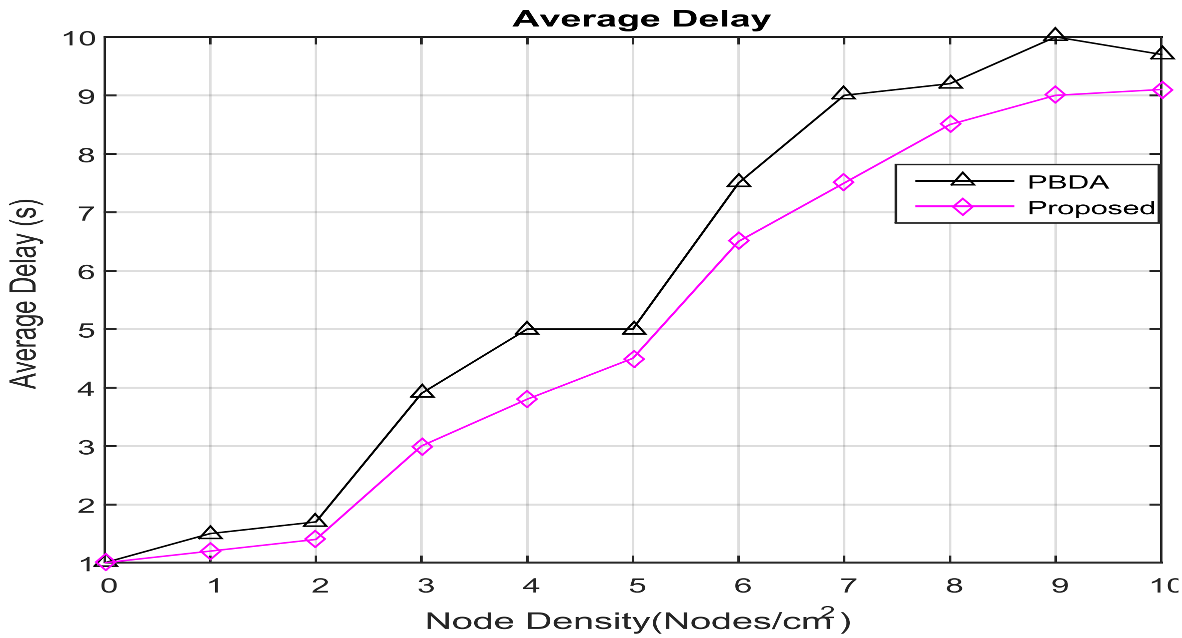

Fig.3 Comparison of node Density and Average Delay

The given table shows the improvement in proposed algorithm node density (7 Node/cm^2) Vs. Average Delay. The proposed algorithm outperformed rest through the algorithms.

Table 2. Comparison of Average Delay vs. Node Density

Algorithm	Average Delay[25]	% Improvement
PBDA	9	-
Proposed Algorithm	7.5	16

VI. Conclusion and Future Scope

Wireless Nanosensors Networks (WNSNs) are the revolutionary advancements in the growing field of sensing technology. The nano scale size of sensor nodes used in WNSN puts a lot of hardware constraints that creates the urgency to conserve the energy of nanosensors. The algorithm pulse-based distance accumulation algorithm has significantly improved the localization algorithm. However, the research gap in the aforementioned techniques lies in the fact that clustering used in the technique uses only energy factor for the Cluster Head (CH) selection for the clusters of corner, center and boundary nodes. The node density factor ensures the CH selection of a node which is surrounded by various nodes that ultimately reduces the distance of various nodes from the CH node in a particular cluster. Consequently, energy of a node is reduced significantly. Considering proper selection of cluster head at the corners and center is the basic idea behind the thesis work which helps to achieving the goal of normalized residual energy and average delay. For this purpose PBDA algorithm is used to make selection process of CH iteratively done which helps in choosing the best possible cluster head selection. By the modulation scheme which we use in this thesis that is called on-off keying modulation scheme. The proposed algorithm is compared with PBDA simulated in MATLAB. Simulation result shows that the proposed algorithm has given improved results in comparison to other basic ones. The proposed algorithm worked for 100 nodes randomly deployed over sensing area 100*100. The simulation shows that there is decrease in localization error with increase in number of nodes. The improvement in the normalized residual energy is 35.84% against the PBDA. The reduction in average delay is 16%. The proposed algorithm outperformed with other PBDA, DV-hope protocol.

References

[1] Oladayo O. Olakanmi, Adama Pamela, Abbas Ashraf., "A Review on Secure Routing Protocols for Wireless Sensor Networks", International Journal of Sensors, Wireless Communications and Control, Vol. 7, No. 2, pp. 79 - 92, 2017.

[2] Amit Rathee, Randeep Singh, Abhishilpa Nandini, "wireless sensor network- challenges and possibilities", International Journal of computer Applications, Vol. 140, No. 2, 2016.

[3] Prashant Tiwari , Varun Prakash Saxena, Raj Gaurav Mishra , Devendra Bhavsar, "Wireless Sensor Networks: Introduction, Advantages, Applications and Research Challenges", International Journal of Technology Innovations and Research, Vol. 14, 2015.

[4] Edwin Prem Kumar Gilbert, Baskaran Kaliaperumal, and Elijah Blessing Rajsingh, "Research Issues in Wireless Sensor Network Applications: A Survey", International Journal of Information and Electronics Engineering, Vol. 2, No. 5, 2012.

[5] Dr. Deepti Gupta, "Wireless Sensor Networks 'Future trends and Latest Research Challenges", Vol. 10, No. 2, pp. 41-46, 2015.

[6] Ian F. Akyildiz, Josep Miquel Jornet, "Electromagnetic wireless nanosensor networks", Elsevier Journal in Nano Communication Network, Vol. 1, No.1, pp. 3-19, 2010.

[7] Vishranti Rupani, Sunera Kargathara, Jigisha Sureja, "A Review on Wireless Nanosensor Networks Based on Electromagnetic Communication" International Journal of Computer Science and Information Technologies, Vol. 6, No. 2 , pp.1019-1022, 2015.

[8] Jianjun Lul, Marcus Bowles, "Review on the Application of Nano-sensor Technology to Logistics Management", International Conference on Computing and Networking Technology, pp. 409-414, 2012.

[9] Ayoub Oukhatara, Mohamed Bakhouyab, Driss El Ouadghiria, Khalid Zine-Dine, "A Performance Evaluation of Broadcasting Algorithms in Wireless Nanosensor Networks", IEEE conference on multimedia computing and system, pp. 616-620, 2016.

[10] Pedram Johari and Josep Miquel Jornet, "Packet Size Optimization for Wireless Nanosensor Networks in the Terahertz Band" IEEE international conference on communications, pp.1-6, 2016.

[11] Long-Jun Huang, Xin-Wei Yao, Wan-Liang Wang, and Shi-Genshen, "EOC: Energy Optimization Coding for Wireless Nanosensor Networks in the Terahertz Band", IEEE Journal, Vol. 5, pp. 2583-2590, 2017.

[12] Armita Afsharinejad, Alan Davy, Brendan Jennings, Conor Brennan, "Performance Analysis of Plant Monitoring Nanosensor Networks at THz Frequencies", IEEE Journal on internet of things, Vol. 3, No.1, pp. 59-69, 2016.

[13] Kaikai Chi, Yi-hua Zhu, Xiaohong Jiang, Victor C.M. Leung, "Energy-Efficient Prefix-Free Codes for Wireless Nano-Sensor Networks Using OOK Modulation", IEEE transaction on wireless communication, Vol.13, No. 5, pp. 2670-2682, 2014.

[14] Kaikai Chi, Yi-hua Zhu, Yanjun Li, Daqiang Zhang, Victor C. M. Leung, "Coding Schemes to Minimize Energy Consumption of Communication Links in Wireless Nanosensor Networks", IEEE Journal Internet of Things, Vol. 3, No. 4, pp. 480-493, 2016.

[15] Eisa Zarepour, Mahbub Hassan, Chun Tung Chou, Siavash Bayat, "Performance Analysis of Carrier-less Modulation Schemes for Wireless Nanosensor Networks" IEEE International Conference on Nanotechnology, pp. 45-50, 2015.

[16] Hoa Tran-Dang, Nicolas Krommenacker, Patrick Charpentier, "Localization Algorithms Based on Hop Counting for Wireless Nano-Sensor Networks", International Conference on Indoor Positioning and Indoor Navigation, pp. 300-306, 2014.

[17] Shefat noor Orni,Hasan Mohammed Tanvir, "Single Hop Routing Protocol and Energy Harvesting Methodology for Self-Powered Wireless Body Area Network" IEEE International Conference on Control System, Computing and Engineering, pp. 168-173, 2017.

[18] Josep Miquel Jornet and Ian F. Akyildiz, "Low-Weight Channel Coding for Interference Mitigation in Electromagnetic Nanonetworks in the Terahertz Band", IEEE International Conference on Communications, pp. 1-6, 2011.

[19] Murat Kocaoglu, Ozgur B. Akan, "Minimum Energy Channel Codes for Nanoscale Wireless Communications", IEEE Transactions on Wireless Communications, Vol. 12, No.4, pp. 1492-1500, 2013.

[20] Shahram Mohrehkesh and Michele C. Weigle, “Optimizing Communication Energy Consumption in Perpetual Wireless Nanosensor Networks”, IEEE Conference in Global Communications, pp. 545-550, 2013.

[21] Chang Kyung Sung, Malcolm Egan, Zhuo Chen, and Iain B. Collings, “Performance of Wireless Nano-Sensor Networks with Energy Harvesting”, IEEE Vehicular Technology Conference, pp. 1-5, 2014.

[22] Ian F. Akyildiz , Josep Miquel Jornet , Chong Han, “Terahertz band: Next frontier for wireless communications”, International Conference on Security and Cryptography, pp. 1-5, 2010.

[23] Josep Miquel Jornet and Ian F.akyildiz, “Channel Modeling and Capacity Analysis for Electromagnetic Wireless Nano networks in the Terahertz Band”, IEEE Transaction on Wireless Communications, Vol. 10, No. 10, pp. 3211-3221, 2011.

[24] Ferdinand Peper ,Kenji Liabintz, Jun-nosuke Teramae, Tetsuya Shimokawa and Naoki Wakamiya in “Low Complexity Nanosensor Network Through Spike-Encodes Signaling”, IEEE Journal on Internet On Things, Vol. 3, No. 1, pp. 49-58, 2016.

[25] Lina Zhaou, Guangjie Han and Li Liu, “Pulse Based Accumulation Localization Algorithm For Wireless Nanosensor Networks”, IEEE Journal in special section on coverage of sensor networks, cloud computing and Big Data in industrial Internet of Things, Vol. 5, pp. 15380-14390, 2017.

[26] Thrasyvoulos Spyropoulos, Konstantinos Psounis and Cauligi S. Raghavendra, “Efficient Routing in Intermittently Connected Mobile Networks: The Multiple-Copy Case”, IEEE/ACM Transactions on Networking, Vol. 16, No.1, pp. 77-90, 2008.

[27] Sung-Chan Choi, Seong-Lyong Gong, and Jang-Won Lee, “An Average Velocity-Based Routing Protocol with Low End-to-End Delay for Wireless Sensor Networks”, IEEE Communications Letters, Vol. 13, No. 8, pp. 621-623, 2009.

[28] Di Ma, Meng Joo Er, Bang Wang, and Hock Beng Lim,” A Novel Approach Toward Source-to-Sink Distance Estimation in Wireless Sensor Networks”, IEEE Communications Letters, Vol. 14, No. 5, pp. 621-623, 2010.

[29] Ahmed Mostefaoui, Mahmoud Melkemi, and Azzedine Boukerche, “Localized Routing Approach to Bypass Holes in Wireless Sensor Networks”, IEEE Transaction on Computers, Vol. 63, No. 12, pp. 3053-3065, 2014.

[30] Shih-Chang Lin and Chih-Yu Wen, “Device-Based Asynchronous Ranging and Node Identification for Wireless Sensor Networks”, IEEE Sensors Journal, Vol. 14, No. 10, pp. 3648-3661, 2014.

[31] Lingkun Fu, Peng Cheng, Yu Gu, Jiming Chen and Tian He, “Optimal Charging in Wireless Rechargeable Sensor Networks”, IEEE Transaction On Vehicular Technology, Vol. 65, No. 1, pp. 278-291, 2016.

[32] Z. Mary Livinsa and Dr. S. Jayashri, “Localization with Beacon Based Support Vector Machine in Wireless Sensor Networks”, International Conference on Robotics, Automation, Control and Embedded Systems, pp. 1-4, 2015.

[33] Ni Zeyu and Liu Wenqing, “One Robust Time Synchronization based on Timeaverage and Maximum-likelihood Estimation for WSN”, International Conference on Information Science and Control Engineering, pp. 354-358, 2015.

[34] Sami Alwakeel, Agung Prasetijo, and Najla Alnabhan, “An Adaptive Energy-Saving Routing Algorithm for Mobile Wireless Sensor Networks”, pp. 104-108, 2015.

[35] Ammar Meer, Anas Daghistani and Basem Shihada, “An Energy Efficient Hybrid Interference-Resilient Frame Fragmentation for Wireless Sensor Networks”, IEEE Annual International Symposium on Personal, Indoor and Mobile Radio Communications, pp. 1024-1029, 2015.

[36] Hui-min Cui, Ya-fang Wang and Li-na Liu, “Improvement of DV-HOP Localization Algorithm”, International Conference on Modelling, Identification and Control, pp.1-4, 2015.

[37] Yeong-Sheng Chen, Der-Jiunn Deng and Chun-Chien Teng, “Range-Based Localization Algorithm for Next Generation Wireless Networks Using Radical Centers”, Vol. 4, pp. 2139-2153, 2016.

[38] Yanhui Lv, Sitong Meng, Deyu Zhang and Yunfei Huang, "A Range-based Distributed Localization Algorithm for Wireless Sensor Networks", International Conference on Information Science and Control Engineering, pp. 1235-1239, 2016.

[39] Jain-Shing Liu, Chun-Hung Richard Lin, and Jichiang Tsai, "Delay and Energy Tradeoff in Energy Harvesting Multi-Hop Wireless Networks With Inter-Session Network Coding and Successive Interference Cancellation", IEEE journal of Special Section Of Energy Harvesting and Scavenging: Technologies, Algorithms And Communication Protocol", Vol. 5, pp. 544-564, 2017.

[40] Ranjan Kumar Mahapatra and N.S.V. Shet, "Experimental Analysis of RSSI-based Distance Estimation for Wireless Sensor Networks", IEEE conference in Distributed Computing, VLSI, Electrical Circuits and Robotics, pp. 211-215, 2016.

[41] Kaiyisah Hanis Mohd Azmi, Stevan Berber,and Michael J. Neve, "Channel Parameters and Distance Estimation in Wireless Sensor Networks Based on Maximum Likelihood Estimation Method", International Conference on Computer & Communication Engineering, pp. 400-405, 2016.

[42] Umma Hany, Lutfa Akter and Md. Farhad Hossain, "Degree-Based WCL for Video Endoscopic Capsule Localization", IEEE Sensors Journal, Vol. 17, No. 9, pp. 2904 - 2916, 2017.

[43] Eva Tuba, Milan Tuba and Marko Beko, "Node Localization in Ad Hoc Wireless Sensor Networks Using Fireworks Algorithm", International Conference on Multimedia Computing and System, pp. 223-229, 2016.

[44] Meng Joo Er, , Shi Zhang, Baihai Zhang, Chiang-Ju Chien, , and Feifan Wang, "A Novel Localization Approach Towards Anchor to Node in Wireless Sensor Networks", International Conference on Automatic Control, pp. 143-148, 2016.

[45] Muhammad Faisal Hayat Jahan Zaib Bhatti and Tomasz Hoły´nski, "A Normalized Residual Energy Clustering for Wireless Sensor Networks", International Conference on Telecommunications and Signal Processing, pp. 64-68, 2017.

[46] Badia Bouhdid, Wafa Akkari and Abdelfettah Belghith, "Energy-Aware Cooperative Localization Approach for Wireless Sensor Networks", International Conference on Intelligent Computer Communication and Processing, pp. 429-435, 2017.

[47] Shailendra Aswale and Vijay R. Ghorpade, "Reliable and Energy-Aware Routing in Wireless Multimedia Sensor Network", International Conference on Wireless Communications, Signal Processing and Networking, pp. 1382-1387, 2017.

[48] Avinash More, "Residual Energy Based Distributed Coverage Protocol for Wireless Sensor Networks", International Conference on Communications, pp. 12-17, 2017.

[49] Lulu Ru and Linghua Zhang, "A Weighted Centroid Localization Algorithm for Wireless Sensor Networks Based on Weight Correction", International Conference on Advanced Infocomm Technology, pp. 165-169, 2017.