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Energy Efficient Routing Mechanism for Harsh Environment in Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks (WSNs) are increasingly used in different applications. Their usage became ubiquitous of late as they are useful with different sensing technologies. Technological advancements made them efficient to monitor different environments and in some surveillance applications. However, nodes in network are constrained with limited energy resources. Therefore, it is requited to have mechanism to conserve energy. Certain parameters like quality of link and status of a node play their role in sensing applications. As they run in hostile environments, it is important to increase the life span of WSN. End to end delay has to be minimized. For reducing energy consumption, clustering technique is used to maximize the energy efficiency which leads to increase the life span of WSN. This project proposes a new approach with a routing metric known as Predicted Remaining Deliveries (PRD) along with other metrics like link quality, end to end delay and energy efficiency. Experiments revealed that the proposed metric PRD shows better utility when compared with existing methods. It also focuses on the congestion control besides improving packet delivery ratio.

Key words: Wireless sensor networks, routing metric, congestion control, energy efficient.

1. INTRODUCTION

WSN is a network made up of devices called sensors. It is used in civilian or military environments. WSN gathers data related to temperature, heat, light, pressure and so on. Its applications are plenty. They include assisted living, monitoring household, surveillance in military scenarios and environment monitoring to mention few [1]. Sensor nodes have constrained resources like 8MHz processing power, few hundred KBs storage and battery supplied energy. Due to constraint in energy, WSN needs to conserve energy for increasing its life span. In the contemporary era, WSN plays vital role in Internet of Things (IoT) technology also. Thus it can become part of many IoT applications.

A typical WSN appears as in Figure 1. However, duty cycled WSN may use customized models.

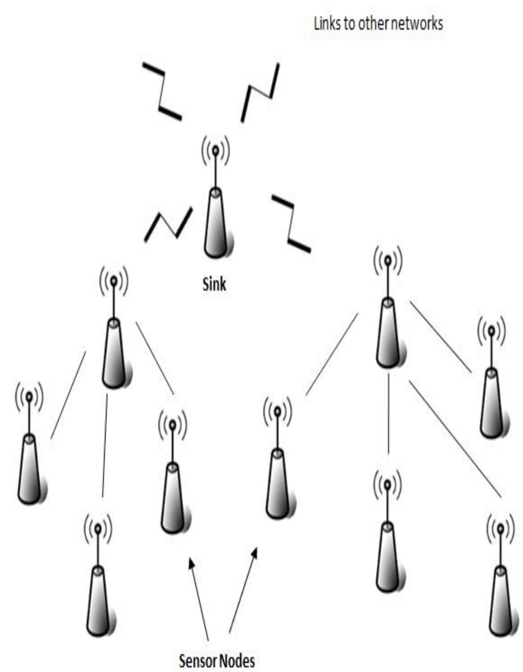

Figure 1: A typical WSN

WSN is useful in many environments and applications. The utility of WSN is realized in entertainment, environment monitoring, industrial applications, smart buildings, climate control, smart grids, energy control systems, precision agriculture, security, surveillance, animal tracking, healthcare monitoring, smart transportation, logistics, monitoring of civil structures and urban terrain tracking. WSN supports many topologies. They include mesh, star and tree. In star topology nodes are directly connected to base station. Generally, nodes need to send sensed data to base station. A cascaded form of star topology appears as tree topology. Each sensor is connected to a node higher to it in the process of reaching destination. With tree topology expansion of network becomes easier besides detecting errors. The mesh topology helps nodes to converse in given communication range. A node may act as transceiver. They are known as WSN in underground, WSN under water, WSN in terrestrial region, multimedia WSN and duty cycled WSN. All these are self-descriptive. With respect to duty cycled network, both sender and receiver will come in contact with each other at specific time to achieve communication efficiency and decrease energy consumption.

As found in the literature WSN schemes include duty cycle scheduling as explored in [2], compressive sensing [4] besides energy efficient routing strategy as provided in [5]. Other routing mechanisms are in [6] [7] [8] and [9]. This paper will explain design of a routing metric, for the applications of WSN in harsh environment, for example intertidal environment. Link quality of each sensor node may differ under water and above the water. Because of tides and waves, sensor nodes may suffer from change of the quality of the link in the intertidal environment. Whenever the tide raises the quality of the link varies greatly. And even two neighbouring nodes at close distance, suffers from poor quality of link when tide rises. Thus sensor nodes link quality often changes with time. On the other hand, both the queuing length and the number of packet relays in the buffer can increase because of change of environment and state of the node. It leads to increase of end-to-end delay. In WSN, energy and longevity play a major role due to the limited battery source. For reducing energy consumption, clustering maximizes energy efficiency and longevity. Optimization strategy is as follows.

Step 1: Network Formation: Network is created by initially setting nodes. Nodes, in this case, are set as static nodes. Nodes are deployed randomly to form the sensing environment.

Step 2: Group (Cluster) Formation: Group of nodes form a cluster. As in LEACH protocol, nodes form a cluster automatically.

PDR metric determines performance of WSN.

PDR is analyzed with its properties like consistency, loop freeness, hop-by-hop routing and lightest paths.

Energy efficiency is evaluated and found that our method outperforms other methods.

PRD is realized and evaluated. According to this, the proposed mechanism is better than existing.

2. LITERATURE SURVEY

The survey of literature provided many insights. Kumar et al. [1] focused on the utility of WSN in various industries and the usage of diversified protocols based on the main usage of the network [2] explored WSN that exploits duty cycled approach for efficient communication and energy conservation. Huang et al. [3] focused on the way in which MAC protocols are evolved over time [4] studied the importance of compressive sensing in WSN applications. This study revealed the efficiency enhancements wit compressive sensing phenomenon.

[5] threw light into various routing protocols available for WSN including their pros and cons. [6] also focused on the similar lines as done in [5] with insights on different routing strategies being used. With respect to sensing and communication efficiency [7] investigated the importance of collection tree protocol in information dissemination in WSN. A novel metric to measure throughput is explored by [8] where WSN with multi-hop routing phenomenon is considered for empirical study [9] studying routing mechanisms in networks with multi-radio with mesh topology supporting multiple hops.

Localization approaches in WSN are given higher attention by [10]. They could understand the subtle differences among different methods in the literature. Energy efficiency with an adaptive approach is studied by Lin et al. [11] while [12] investigated micro-sensing concept with architectures of protocols that are application level [13] threw light on design principles behind the important metrics associated with routing. [14] Focused on the aspect called joint mobility in WSN while Anderson et al. [15] studied communication channels in wireless networks in terms of propagation measures. Paris [16] thought of improving performance with cross-layer metrics and mesh topology networks. Wang et al. [17] studied networks with link-awareness for better performance in clustering. They observed energy conservation with their approach.

In case of routing, [18] investigated on candidate selection for making an opportunistic forwarding of data in WSN.[19] also investigated on path routing in mesh networks and found that multi-rate sort of routing improved performance. [20] Observed that link positions are having their influence on the performance of network. [21] Investigated on the duty cycled mechanisms in WSN for realizing opportunistic routing. In [22] similar work is carried out with cross-layer approach while [23] followed context awareness in cross-layer mechanism.

[24] followed a distributed approach to find clustering process and energy saving mechanism in WSN which ad hoc deployment. [25] Investigated in delay-aware routing that could improve energy conservation. Similar lines of research is found in [26] as well while a metric related to link quality and resource awareness is introduced in [27]. A new method for clustering [28] and delay-awareness in the routing mechanism are other improvements found in the literature. It is understood that there is room for further research in energy efficient means of routing in WSN.

3. DESIGN

3.1 Problem Statement

Energy of node is used in order to take routing decisions. When nodes in key positions are drained with energy, they witness disconnection from the network and the network routing failures and failure of the whole network may occur. Thus, this project takes care of energy efficiency and congestion control.

3.2 Architecture Diagram

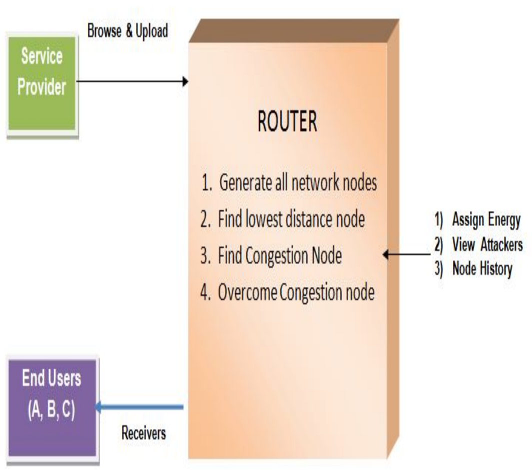

Figure 2: System Architecture

As shown the figure 2 system architecture, there are three components. They are called as service provider, end user and router. The end users are in the form of different nodes. First, a network is created with many nodes. From many nodes available, one node can be selected to send data. Service provider can choose a file and transfer it to different destinations. It will travel via router with energy efficiency and attack resiliency. It also considers congestion control in order to have better performance.

4. ROUTING MECHANISM

Dijkstra's approach as outlined in [10] is used to have routing mechanism. It has four phases. They are known as neighbour discovery, parent selection, score computation and metric calculation.

4.1 Neighbour discovery

It is the process in which a sensor node will be able to find the presence of its neighbour nodes by sending Hello message. By collecting neighbour information, the node can maintain a list of neighbours for better communication.

4.2 Metric calculation

This computation needs data from neighbour nodes. Towards this end, a node will send message to neighbour nodes. The message consists of information like ID of the node, delay, ETX and the residual energy. Received messages are observed and the information is updated in the neighbour table. The Equation (1) is used to calculate the PRD value

$$PRD_{ij} = \frac{E_{res}(i)}{ETX_{ij}.\,E_{tx}\left(l, d_{ij}\right).\,D_{ij}} \quad (1)$$

Where e_{ij} PRD value isPRD_{ij}, sensor node n_i having remaining energy$E_{res}(i)$, difference between the ETX values of nodes n_i and n_j isETX_{ij}, distance among n_i and n_j nodes isETX_{ij}, link e_{ij}end to end delay is D_{ij}, transmitting a single packet consumes $E_{tx}(l, d_{ij})$ of energy.

4.3 Score calculation

Score computation as two parts. They are known as the link score and route score. The former is the score of individual link between nodes while the latter is the sum of all links in a given path. Equation (2) and equation (3) gives $C_{lk}$and C_{rt} values

$$C_{lk}(i, j) = {}^{1}/_{PRD_{ij}}, j \epsilon F_i. \quad (2)$$

$$C_{rt}(i) = \min\{C_{rt}(j) + C_{lk}(i, j)\}, j \epsilon F_i. \quad (3)$$

Where in the routing path Link score of e_{ij} is$C_{lk}(i, j)$, and n_i node route score is$C_{rt}(i)$.

4.4 Parent selection

The route score is updated by each node with respect to neighbours and finds the best one. After much iteration, once scores are updated with all information, and then the parent node is selected in order to forward data. The paths for routing are determined based on the scores.

4.5 Congestion Control Algorithm in Wireless Sensor Networks

Dynamic Alternate Path Selection is proposed in [29]which is the mechanism for congestion control. It considers many parameters for improving performance. For instance, it takes congestion level of a node, channel interference and buffer occupancy. Both reliable data transfer and congestion control are considered to be important in this method. It also takes the remaining power of the nodes for decision making. The algorithm is distributed in nature.

5. PERFORMANCE ANALYSIS

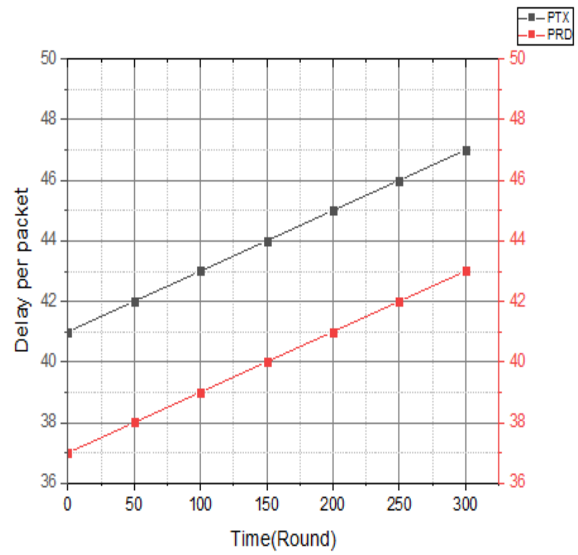

Figure 3: Delay per packet

Figure 3 shows the out performances of PTX and PRD in terms of Time and Delay per packet.

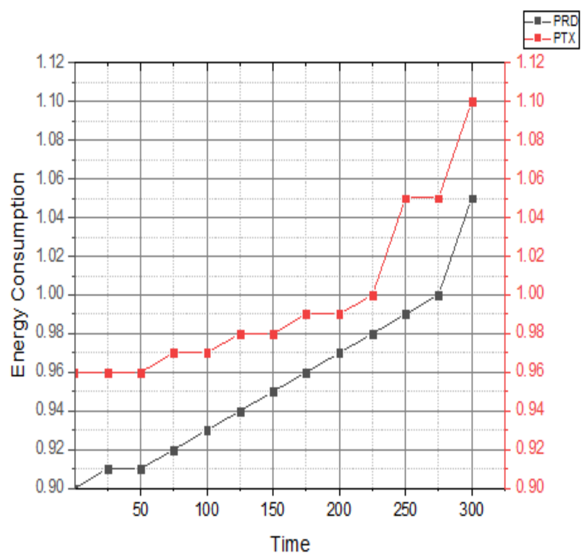

Figure 4: Energy Dissipation versus Time

Figure 4 exhibits the amount of Energy Dissipation versus Time as the use of PRD and PTX. Total energy consumption is estimated through sensor nodes per second. When compared with PRD, PTX consumes more energy in the network lifetime. Simulation study showed that the proposed metric PRD shows better utility when compared with the PTX.

6. CONCLUSION

Energy consumption and lifetime plays a major role in WSN due to the limited battery source. For reducing energy consumption, clustering is used. It also improves lifetime of network. We proposed a metric based on link-delay and energy aware routing. The metric is named as PRD which takes care of path selection. This metric finds delivery remained with respect to unit delay. Thus it is capable of forwarding packets to reduce energy and congestion. It strikes balance between longevity and energy consumption. Performance Evaluation of PRD revealed that the metric PTX providing lesser performance when compared with that of PRD. The proposed method also reduces overhead, ensures load distribution, resilience to attacks, efficiency, and reliability improves PDR. This also takes care of congestion control and balancing of traffic.

REFERENCES

1. A. Kumar S., K. Øvsthus, and L. M. Kristensen, “An industrial perspective on wireless sensor networks—A survey of requirements, protocols, and challenges,” IEEE Common. Surveys Tuts. vol. 16, no. 3,pp. 1391–1412, 3rd Quart., 2014. https://doi.org/10.1109/SURV.2014.012114.00058
2. R. C. Carrano, D. Passos, L. C. S. Magalhaes, and C. V. N. Albuquerque, “Survey and taxonomy of duty cycling mechanisms in wireless sensor networks,” IEEE Commun. Surveys Tuts., vol. 16, no. 1, pp. 181–194, 1st Quart., 2013. https://doi.org/10.1109/SURV.2013.052213.00116
3. P. Huang, L. Xiao, S. Soltani, M.W. Mutka, and N. Xi, “The evolution of MAC protocols in wireless sensor networks: A survey,” IEEE Commun. Surveys Tuts., vol. 15, no. 1, pp. 101–120, 1st Quart., 2013. https://doi.org/10.1109/SURV.2012.040412.00105
4. S. Qaisar, R. M. Bilal, W. Iqbal, M. Naureen, and S. Lee, “Compressive sensing: From theory to applications, A survey,” J. Commun. Netw., vol. 15, no. 5, pp. 443–456, 2013. https://doi.org/10.1109/JCN.2013.000083
5. J. Yan, M. Zhou, and Z. Ding, “Recent advances in energy-efficient routing protocols for wireless sensor networks: A review,” IEEE Access, vol. 4, pp. 5673–5686, 2016. https://doi.org/10.1109/ACCESS.2016.2598719
6. N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados, “Energy-efficient routing protocols in wireless sensor networks: A survey,” IEEE Commun.SurveysTuts., vol. 15, no. 2, pp. 551–591, 2nd Quart., 2013. https://doi.org/10.1109/SURV.2012.062612.00084
7. O. Gnawali, R. Fonseca, K. Jamieson, D. Moss, and P. Levis, “Collection tree protocol,” in Proc. 7th ACM Conf. Embedded Netw. Sensor Syst.,2009, pp. 1–14. https://doi.org/10.1145/1644038.1644040
8. D. S. De Couto, D. Aguayo, J. Bicket, and R. Morris, “A high-through put path metric for multi-hop wireless routing,” Wireless Netw., vol. 11,no. 4, pp. 419–434, 2005.
9. R. Draves, J. Padhye, and B. Zill, “Routing in multi-radio, multi-hop wireless mesh networks,” in

Proc. ACM 10th Ann. Int. Conf. Mobile Comput. Netw., 2004, pp. 114–128.

10. G. Mao, B. Fidan, and B. D. O. Anderson, “Wireless sensor network localization techniques,” Comput. Netw., vol. 51, no. 10, pp. 2529–2553,2007. https://doi.org/10.1016/j.comnet.2006.11.018
11. S. Lin, J. Zhang, G. Zhou, L. Gu, J. A. Stankovic, and T. He, “ATPC: Adaptive transmission power control for wireless sensor networks,” in Proc. ACM 4th Int. Conf. Embedded Netw. Sens. Syst., 2006, pp. 223–236.
12. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, “An application-specific protocol architecture for wireless microsensor networks,” IEEE Trans. Wireless Commun., vol. 1, no. 4, pp. 660–670, Oct. 2002.
13. Y. Yang and J. Wang, “Design guidelines for routing metrics in multi hop wireless networks,” in Proc. IEEE INFOCOM, Apr. 2008, pp. 1615–1623.
14. J. Luo and J.-P.Hubaux, “Joint mobility and routing for lifetime elongation in wireless sensor networks,” in Proc. IEEE INFOCOM, vol. 3. Mar. 2005, pp. 1735–1746.
15. J. B. Andersen, T. S. Rappaport, and S. Yoshida, “Propagation measurements and models for wireless communications channels,” IEEE Commun. Mag., vol. 33, no. 1, pp. 42–49, Jan. 1995. https://doi.org/10.1109/35.339880
16. S. Paris, C. Nita-Rotaru, F. Martignon, and A. Capone, “Cross-layer metrics for reliable routing in wireless mesh networks,” IEEE/ACM Trans. Netw., vol. 21, no. 3, pp. 1003–1016, Jun. 2013.
17. S.-S. Wang and Z.-P. Chen, “LCM: A link-aware clustering mechanism for energy-efficient routing in wireless sensor networks,” IEEE Sensors J., vol. 13, no. 2, pp. 728–736, Feb. 2013. https://doi.org/10.1109/35.339880
18. Z. Zhong, J. Wang, S. Nelakuditi, and G.-H.Lu, “On selection of candidates for opportunistic any path forwarding,” ACM SIGMOBILE Mobile Comput.Commun.Rev., vol. 10, no. 4, pp. 1–2, 2006.
19. R. Laufer, H. Dubois-Ferriere, and L. Kleinrock, “Multirate any path routing in wireless mesh networks,” in Proc. IEEE INFOCOM, Apr. 2009, pp. 37–45.
20. G. Jakllari, S. Eidenbenz, N. Hengartner, S. V. Krishnamurthy, and M. Faloutsos, “Link positions matter: A non commutative routing metric for wireless mesh networks,” IEEE Trans. Mobile Comput., vol. 11, no. 1, pp. 61–72, Jan. 2012. https://doi.org/10.1109/TMC.2011.79
21. E. Ghadimi, O. Landsiedel, P. Soldati, S. Duquennoy, and M. Johansson,“Opportunistic routing in low duty-cycle wireless sensor networks,”ACM Trans. Sensor Netw., vol. 10, no. 4, p. 67, 2014. https://doi.org/10.1145/2533686
22. J. Zuo, C. Dong, H. V. Nguyen, S. X. Ng, L.-L. Yang, and L. Hanzo, “Cross-layer aided energy-efficient opportunistic routing in ad hoc networks,” IEEE Trans. Commun., vol. 62, no. 2, pp. 522–535,Feb. 2014.
23. Z. Zhao, D. Rosário, T. Braun, and E. Cerqueira, “Context-aware opportunistic routing in mobile ad-hoc networks incorporating node mobility,” in Proc. IEEE Wireless Commun. Netw. Conf., Apr. 2014,pp. 2138–2143. https://doi.org/10.1109/WCNC.2014.6952640
24. O. Younis and S. Fahmy, “HEED: A hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks,” IEEE Trans. Mobile Comput., vol. 3, no. 4, pp. 366–379, Oct./Dec. 2004.
25. Ijar, Researcher & , G.M.Nishibha& , Mrs.Manchu.M. (2016). Energy Efficient And Delay Aware Routing Method For Wireless Sensor Networks. International Journal of Advanced Research Trends in Engineering and Technology (IJARTET). 3. 83-86.
26. R. Vidhyapriya and P. T. Vanathi, "Energy Aware Routing for Wireless Sensor Networks," *2007 International Conference on Signal Processing, Communications and Networking*, Chennai, 2007, pp. 545-550. https://doi.org/10.1109/ICSCN.2007.350661
27. V. C. Gungor, C. Sastry, Z. Song and R. Integlia, "Resource-Aware and Link Quality Based Routing Metric for Wireless Sensor and Actor Networks," *2007 IEEE International Conference on Communications*, Glasgow, 2007, pp. 3364-3369.
28. D. Wei, Y. Jin, S. Vural, K. Moessner and R. Tafazolli, "An Energy-Efficient Clustering Solution for Wireless Sensor Networks," in *IEEE Transactions on Wireless Communications,* vol. 10, no. 11, pp. 3973-3983, November 2011. https://doi.org/10.1109/TWC.2011.092011.110717
29. Aaron Don M. Africa,” A Comprehensive Study on Application Development Software Systems”, International Journal of Emerging Trends in Engineering Research, Volume 7, No.8 August 2019. https://doi.org/10.30534/ijeter/2019/03782019
30. “DAIPaS; A Performance Aware Congestion Control Algorithm in Wireless Sensor Networks”, CharalambosSergiou and Vasos Vassiliou, 2011 International Conference on Telecommunication.