Enhancing the Network Lifetime of Cooperative Wireless Sensor Networks with Increased Threshold and Energy Harvesting Technique

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***Abstract*—Wireless sensor networks (WSN) contains number of small size, low power, smart sensor nodes. All these nodes are connected with each other and this network is spread over unapproachable area. Nodes do not have sufficient power and storage area. The main aim of WSN is data transmission within provided energy. But as nodes contain limited battery power the aim cannot be reached, and life time of WSN get decreased. Hence solution for the problem is harvesting electromagnetic energy released by data transmission to recharge rechargeable batteries and to increase life time of wireless sensor networks. In this research to increase the lifetime of WSN using electromagnetic radiation energy harvesting with increased threshold is proposed. The present data packet transmission depends on current SNR in channel, previously harvested energy and current battery level. To get over the power limitations along with increased network lifetime of WSN water filling power management technique is used. To observe the progress successful data transfer and threshold is calculated and plotted using MATLAB. And plotted graphs shows improved results compared with existing technology.**

Keywords*—WSN, smart sensor nodes, life time of WSN, harvested energy, threshold, SNR.

I. INTRODUCTION

Wireless sensor network is able to gather data, process it and communicate with the help of nodes. With the extensive use of wireless sensors, the management of their energy resources has become a topic of research [1]. WSN consists of randomly placed independent sensors to inspect industrial and environmental changes and simultaneously transfer data to the base station [4].

Whenever communication takes place, sensors of the nodes uses their battery power which results in draining of battery. And main aim of research is to recharge those batteries so that communication can take place efficiently. To increase the life time of the sensors as life time of the network can be increased, was the challenge for designers. So the research gives guidance to mitigate the energy problems in progress of wireless sensor networks. It includes architecture of wireless sensor, power management scheme and electromagnetic energy harvesting technique.

The further work is organized as follows. Section II gives the system model. Section III introduces a brief overview of techniques used to improve the network lifetime with increased threshold. Section IV provides the simulation result. Conclusions and future scope were drawn into Section V.

II. SYSTEM MODEL

This section gives performance of network in the form of matrices. And with the help of water filling technique proposed system recompense the harvested energy by the wireless transmission in the network.

A. Energy harvester model

Relay nodes are able to harvest the energy emitting from the transmission of the source nodes, from other relays or from its own transmission. Fig.1 shows the energy harvester module and in this work it can harvest energy at the transmitter side. Because more energy get consumed at transmitter side, remaining circuit consumes very less energy [3]. The data to be transmitted get sub divided in to k number of slots. In slot k transmitter knows current channel SNR γ_k, previously harvested energy H_k and current energy stored in the battery B_k. For simplification in each time slot only one packet transmission takes place. And each time slot allows n number of symbols to transmit. Time get indexed by the slot index $k \in K = \{1, \dots \dots K\}$. And there is always backlogged data available for transmission [5].

Input bit source get transmitted by transmitter using energy stored in the W_k, is the encoded data. Then the packet transmitted in slot k is given by $\sqrt{T_k X_n}$.

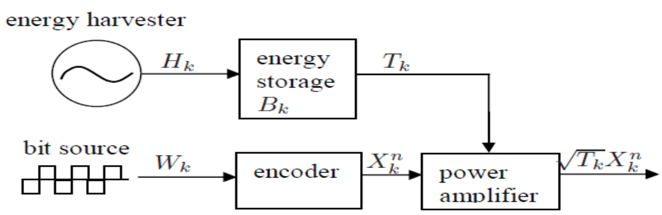

Fig. 1. Over all block diagram of energy harvester module

The time is divided in to m communication periods T_m which consists of duration 't_s'. Figure 2 shows how communication is taking place in between communicating slots.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

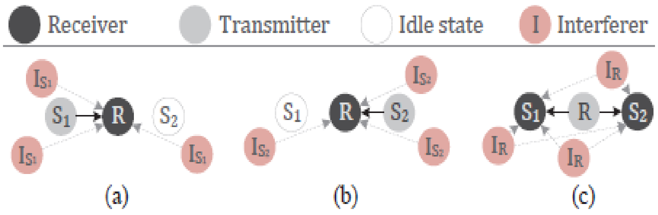

Fig. 2. Communicating Slots

There are three different communicating slots. In first time slot source S_1 is transmitting to the nearby relay, relay takes data from the source where other sources are considered as interference which try to send data to the same relay. When transmission is taking place electromagnetic radiation (EMR) energy emitted by transmitter get harvested by energy harvester. In second time slot, all sources S_2 are transmitting to the nearby relay node and S_1 are in the idle state as shown in the Figure 2(b). And finally in Figure 2(c) relay will act as transmitter and other nodes will act as relay to get the required information [10].

B. Distribution of nodes in WSN

In this proposed system we are considering that sensor nodes are randomly distributed in area under observation. In this situation distance between two communicating nodes can be measured if they are in communication radius.

$$d_{i,j} = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} \tag{1}$$

Where x_i, y_i first nodes location and x_j, y_j are location of second node. And if required nodes are not required locations, nearby nodes are used as relays for communication.

III. LIFETIME OF NETWORK

Life time of a network depends upon amount of energy harvested and success rate of data transfer. If amount of successful data transfer is high energy is released in high quantity so energy harvesting rate is high which leads network for working longer duration.

A. Probability of successful data exchange

The data is considered to be successfully decoded and transmitted only if SNR is higher than the threshold. And in our work we have increased the threshold for noise to higher level compared to previous systems and due to which SNR is increasing which leads data transfer probability to increase rapidly. Signal to interference noise ratio [3] is given by

$$SINR = \frac{P_t h d^{-\alpha}}{I_d + N} \tag{2}$$

Where P_t is the transmit power, h is the amplitude of Rayleigh fading, d is the distance, α is the path loss exponent I_d is the interference and N is the additive White Gaussian noise.

The probability of successful message transfer is given by

$$P_{ex} = (P_{s_1 \to r} P_{s_2 \to r})(P_{r \to s_1} P_{r \to s_2}) \tag{3}$$

Where s_1 and s_2 are sources and r is relay.

$$C = \frac{-2\pi^2 \gamma^{\frac{2}{\alpha}}}{\alpha \sin(2\pi/\alpha)} \tag{4a}$$

$$D = \frac{\gamma N}{P_t 2^{\alpha}} \left(\frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2} + \frac{2}{(P_{act}\lambda_R)^{\frac{\alpha}{2}}} \right) \tag{4b}$$

Where λ_1, λ_2 and λ_R are intensities, and γ is the threshold
So the probability of successful data exchange is given by

$$P_{ex} = \exp[C - D] \tag{4c}$$

B. Lifetime of network using energy harvesting

Battery level of relay nodes without considering energy harvesting ($L_{-eh}(m)$) is given by

$$L_{-eh}(m) = L_1 - m t_s (2P_r + P_t P_{act}) \tag{5}$$

Where m is the communication period, L_1 initial battery level, t_s is time slot duration, P_r is the receiver power, P_t is the transmit power, P_{act} is probability of active relay.

The average harvested power used for enhancing network lifetime by considering energy harvesting [6] is given by

$$E\{P_{eh_3}\} = \frac{\in P_t P_{act} \lambda_R 2\pi}{(\alpha - 2)(2\sqrt{P_{act}\lambda_R})^{2-\alpha}} + \in P_t \tag{6a}$$

Where, ∈ is the conversion efficiency

The battery level of relay with taking energy harvesting in account [7]

$$L_{+eh}(m) = L_{-eh}(m) + m t_s \left[\sum_{i=1}^{3} E\{P_{eh_i}\}\right] \tag{6b}$$

Where, $E\{P_{eh_i}\}$ is the average harvested power

The relay's lifetime without taking energy harvesting in account [3]

$$m_{max_{-eh}} = \frac{L_I}{t_s(2P_r + P_t P_{act})} \tag{7}$$

The relay's lifetime with taking energy harvesting into account [11] is given by

$$m_{max_{+eh}} = \frac{L_I}{\left[2t_s P_r + t_s P_t P_{act} - t_s \sum_{i=1}^{3} E\{P_{eh_i}\}\right]} \tag{8}$$

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

C. Water filling power allocation technique

The channel behavior or the state of channel when communication is taking place between transmitter and the receiver is acknowledged by taking channel state information (CSI) into account. Channel state information is predicted by considering current, previous and next conditions of channels along with amount of energy harvested. The efficient message transfer is taken place by using water filling algorithm with energy conservation in every slot [5].

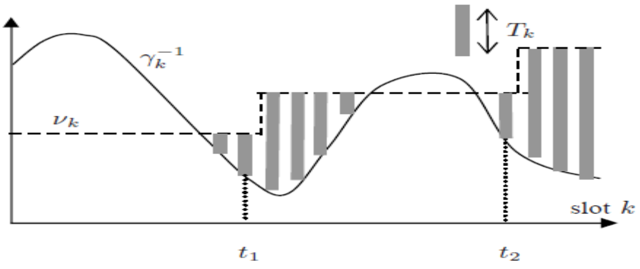

Fig. 3. Structure of optimal power allocation

The maximum allocated power using water filling algorithm is given by [8]

$$P_{max} = B_1 + \sum_{i=1}^{K-1} H_i \quad (9)$$

Where P_{max} is maximum allocated power, B_1 is energy stored in battery, K is the last slot and H_i is the harvested energy.

IV. RESULTS

In figure 4 we have taken 50 randomly placed sensor nodes deployed over N*N area and each node is connected with each other. Distance between them is calculated using equation (1).

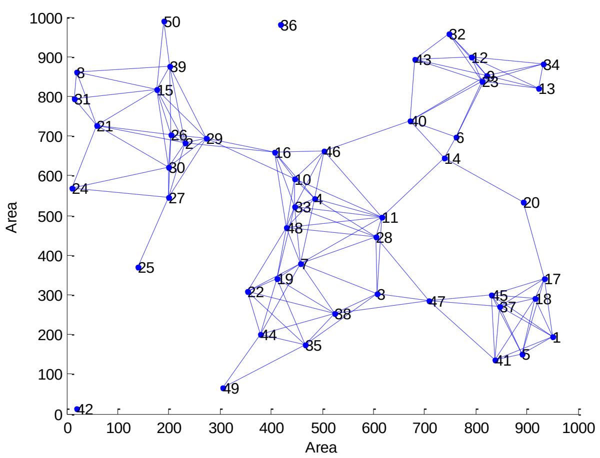

Fig. 4 Nodes plotting

Figure 5 shows that as threshold increases probability of successful message exchange decreases. Probability for successful data transfer is higher when noise level is lower (10dBm). And for high noise level (40dBm) probability is lower than 10dBm. Further increase in threshold will take probability to zero.

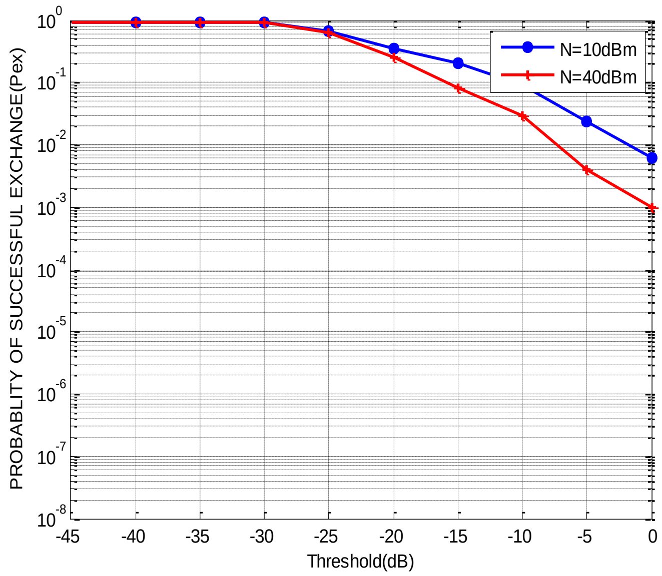

Fig. 5. Probability of successful message exchange Vs threshold

Figure 6 shows the variation in the threshold for noise levels with variation in communication slots. As threshold increases necessity of communication slots decreases.

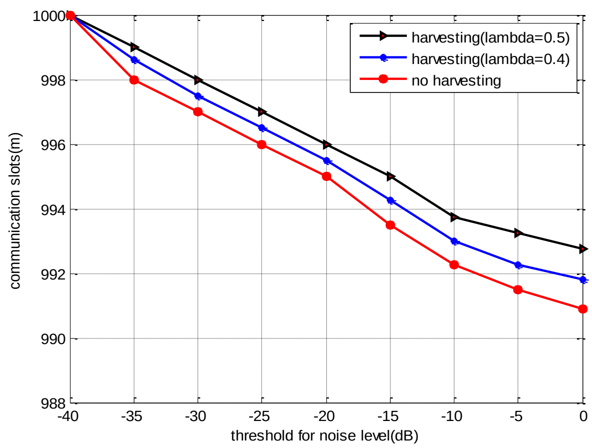

Fig. 6 Threshold Vs communication slots

Figure 7 gives the variation in noise and power level. As power level increases noise level decreases and vice versa. And this variation is observed with respect to number of channels with respect to SNR. As threshold for noise level increases no of bits to be transmitted per allocated channel increases, number of communication slots decreases. Whenever data is transmitting through the channel signal power is used for current transmission and harvested power get stored for further transmission.

Proposed system provides improved results compared with existing systems. As WSN is widely used networks with low cost and large benefits it provides different areas for research.

International Journal of Engineering Research & Technology (IJERT)
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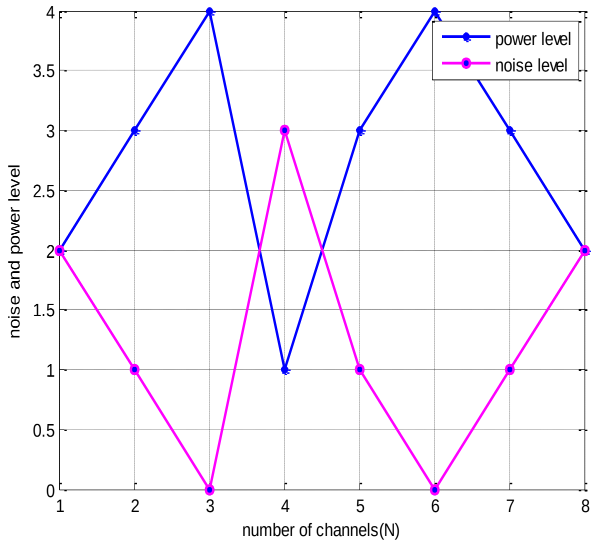

Fig. 7. Power level Vs Noise Level

V. CONCLUSION

In this research threshold for noise level is increased to reduce number of communication slots and to increase power level with increased SNR, which leads reduction in noise level. And due to energy harvesting lifetime of network get increased. Parameters like threshold, communication slots, power level, successful message transfer is calculated and plotted using MATLAB. In future research can be done on two way energy harvesting with increased threshold.

ACKNOWLEDGMENT

We would like to thank anonymous referees for their valuable comments and suggestions to improve the quality of paper.

REFERENCES

[1] Saba Akbari, “Energy Harvesting for Wireless Sensor Networks Review”, PROCEEDINGS OF THE FEDCSIS. WARSAW, 2014, vol. 2, pp. 987–992, 2014.

[2] Chau Yuen, Z.G. Wan, and Y.K. Tan “Review on energy harvesting and energy management for sustainable wireless sensor networks” pp. 362-367, 12 Nov. 2016.

[3] V.Prathibha, Dr.T.Aruna, “Enhancing The Network Lifetime Of Cooperative Wireless Sensor Networks Using Energy Harvesting Technique”, IEEE Transactions On Vehicular Technology, vol. 64, No. 2, Feb. 2015.

[4] B.Medepally and N. B. Mehta, “Voluntary energy harvesting relays and selection in cooperative wireless networks,” IEEE Trans. Wireless Commun., vol. 9, no. 11, pp. 3543–3553, Nov. 2010.

[5] Chin Keong Ho and Rui Zhang, “Optimal Energy Allocation for Wireless Communications with Energy Harvesting Constraints” IEEE Trans. Wireless Commun, pp. 1-27, 9 May 2012.

[6] Jing Yang, and Sennur Ulukus, “Optimal Packet Scheduling in an Energy Harvesting Communication System”, IEEE Transactions On Communications, VOL. 60, NO. 1, pp. 220-230, JANUARY 2012.

[7] Kaya Tutuncuoglu, and Aylin Yener, “Optimum Transmission Policies for Battery Limited Energy Harvesting Nodes”, IEEE Transactions On Communications, VOL. 11, NO. 3, pp. 1180-1188, MARCH 2012.

[8] Liang Liu, Rui Zhang, and Kee-Chaing Chua, “Wireless Information and Power Transfer: A Dynamic Power Splitting Approach", 30 June 2013.

[9] Ming Xiao, Jörg Kliewer, and Mikael Skoglund, “Design of Network Codes for Multiple User Multiple-Relay Wireless Networks”, IEEE Transactions On Communications, vol.60, No. 12, pp. 3755-3766, Decmber 2012.

[10] Prodromos-Vasileios Mekikis, Aris S. Lalos, Angelos Antonopoulos, Luis Alonso, and Christos Verikoukis, “Wireless Energy Harvesting in Two-Way Network Coded Cooperative Communications: A Stochastic Approach for Large Scale Networks”.

[11] Shabnam Ladan, N. Ghassemi, Anthoni Ghiotto, and Ke Wu, “Highly Efficient Compact Rectenna for Wireless Energy Harvesting Application”, IEEE Microwave Magazine, January 2013.

[12] Shixin Luo, Rui Zhang, and Teng Joon Lim, “Optimal Save-Then-Transmit-Protocol for Energy Harvesting Wireless Transmitters”, pp. 1-13, 6 Feb. 2013.

[13] A. Nasir, X. Zhou, S. Durani, and R. A.Kennady, “ Relaying Protocol Of Wireless Energy Harvesting And Information Processing”, IEEE Trans. Wireless Commun, vol. 12, no. 7, pp. 3622-3636, 2013.