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Optimization Approach for Energy Consumption in Wireless Sensor Networks using Delay Aware Dynamic Routing Protocol

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Abstract

An energy-efficient smart protocol design is a key challenging problem in Wireless Sensor Networks (WSNs). Some of the few existing energy-efficient routing protocols schemes always forward the packets through the minimum energy based optimal route to the sink to minimize energy consumption. It causes an unbalanced distribution of residual energy between sensor nodes, which leads to network partition. The prime goal of this approach is to forward packets to sink through the energy denser area to protect the nodes with less residual energy, which is maximizing the Sensor Networks Lifetime. The existing technique Energy Balanced Routing Protocol (EBRP) fails to achieve Throughput, End-to-End Delay, in order to improve the Network Performance. So the efficient routing protocol is needed with the capabilities of both the Energy Efficiency and Energy Balancing. To address these issues, we have proposed Delay Aware Energy Balanced Dynamic Routing Protocol (DA-EBDRP). The proposed routing technique achieves in terms of End-to-End Delay, Throughput, Portion of Living Node (PLN) and Network Lifetime. By simulation results the proposed algorithm achieves better performance than the existing methods.

Keywords - *Wireless Sensor Networks, Delay Minimum, Balancing Energy Consumption and Potential Filed, Energy-Efficient Routing, End-to-End Delay, Throughput, Portion of Living Node (PLN) and Network Lifetime.*

1. Introduction

A. Wireless Sensor Networks (WSNs)

Wireless Sensor Networks are a series of sensors randomly or evenly distributed across a vast area used to monitor disaster areas, terrorist attack areas, forest fires etc. The sensors are located at random locations and relay their information to a central base that is usually far from the region of sensor nodes. Sensors usually have a few basic properties that come along with them: one or more sensors, a radio transceiver for communication, a microcontroller for computation and decision making and a battery for energy.

The network should have the self-organizing capability because the positions of individual nodes are not known initially. Cooperation among the nodes is the main feature of this network. The group of nodes cooperates to distribute the gathered information to their neighbor users in this network. The important application areas of the sensor networks are the military areas, natural disaster and in health. In addition, this network is used to monitor the light, temperature, humidity and other environmental factors for the civil applications.

B. *Energy Balancing in WSN*

Wireless Sensor Networks (WSNs) are installed and deployed to carry out different applications, such as Environmental Monitoring, Targeting, Industrial Control, Disaster Recovery, Nuclear, Biological & Chemical attack Detection Reconnaissance and Battlefield Surveillance. This Wireless Sensor Networks are expected to play more important role in the future generation networks to sense the physical world [1,2,3,4,7].It is very well known that the energy is the most serious and critical resource for battery-powered Sensor Networks. To extend the lifetime of this network as long as possible, the energy efficiency becomes the most important parameter during the Protocol design. In order to achieve and use the limited energy at sensor nodes effectively, the recently proposed routing schemes are attempting to find the minimum energy path to the sink, which is used to optimize the energy usage at nodes.

From the literature survey, however, it is observed that to focus on the efficiency of energy while designing protocols for WSNs is not sufficient. And also identified that the uneven energy depletion which is dramatically reduces the lifetime of networks and decreases the sensors coverage ratio. And Furthermore, these results in [4]point out that one hop away from the sink will exhaust their energy level, there still up to ninety three percent of initial energy left at these nodes beyond away. And this imbalance of energy consumption imbalance is certainly undesirable for the long-term strength and health of the sensor network. These sensor nodes itself consume their energy heavier evenly, then the connectivity between these sensors and the sink could be maintained for a longer time and thus the network partition might be postponed. This beautiful degradation of the network connectivity could be obviously provided substantial gains. And hence, it should be rational to make a suitable trade-off between both the energy efficiency and the balanced energy consumption.

2. Related Work

From our literature survey, it is noted that numerous literatures focus on energy efficient routing protocols which aim is to find an optimal best path to minimize energy consumption either on local nodes or in the whole WSN [6, 7, and 8]. However, some existing routing protocols have facing the problem of energy imbalance.

A few Routing Protocols such as LEACH [9], EAD [10] and HEED [11] offer energy balance within clusters by arbitrarily choosing the cluster head, but however they are limited solutions.

M. Singh and V. Prasanna in [12], define the energy-balance property and then designed, proposed and evaluated an energy-balanced algorithm for single-hop Wireless Sensor Networks.

X. Wu, G. Chen and S.K. Das in [5] developed and proposed a non-uniform node distribution strategy which is achieving nearly balanced energy depletion.

The Energy-Aware Routing [13] was proposed by X. Wu and G. Chen, and S.K. Das which focuses multiple paths, which improves the network survivability. But from our literature survey, it is noted that it quite consume energy to exchange the routing information very frequently. Recently, the author

Fengyuan Ren and et.al, proposed an efficient Energy Balanced Routing Protocol [4]. This scheme employs the steepest gradient search method to decide the route. In this Gradient-Based Routing, the gradient is a state demonstrating the direction toward neighboring nodes through which the destination could be reached. It could be established with different parameters such as Energy Consumption, Physical Distance, Hop Count, Residual Energy and Energy Density. The aim of this scheme is to forward the packets to the designated sink through the dense energy area in order to protect the nodes with comparatively less residual energy.
They have proposed a novel routing scheme called Energy Balanced Routing Protocol which does overcome the problem of energy consumption imbalance is a serious issue in recently proposed energy-efficient routing techniques, and it does demonstrate the advantage of balanced energy consumption between the sensor networks. However, this schemes consumes more cost which leads End-to-End delay.

To address this type of routing loop problem, EBRP [1], efficient enhanced mechanisms have been proposed to find and eliminate loops. From our experimental results, it is observed that this Energy Balanced Routing Protocol (EBRP) improves Network Lifetime. But however, it is observed that this work fails to achieve End-to-End Delay and Throughput. This causes the Network Performance Degradation. To address this major issue, in this research work, we have proposed an efficient and effective mechanism called Delay-Aware Energy Balanced Dynamic Routing Protocol, which improves the Network performance in terms of End-to-End Delay and Throughput. At the same time, this proposed work holds all the positive features of Energy Balanced Routing Protocol.

Chang and Tassiulas [16] proposed an energy conserving routing protocol to maximize the system lifetime by balancing the energy consumption among the nodes in proportion to their energy reserves. These proposed schemes embedded the energy awareness into the protocol and were proposed for a homogenous ad hoc network, where all the nodes are treated identical in terms of functioning and available resources. In addition, those schemes are suitable for static networks because the benefits come from the even
Distribution of traffic among different nodes. When the nodes are moving independently, the savings provided by these algorithms, if any, is negligible because of the difficulty of real-time re-configuration.

Sohrabi and Pottie [17] proposed a self-organization protocol for wireless sensor networks. Each node maintains a TDMA like frame, called super frame, in which the node schedules different time slots to communicate with its known neighbors. At each time slot, it only talks to one neighbor. To avoid interference between adjacent links, the protocol assigns different channels, *i.e.*, frequency (FDMA) or spreading code (CDMA), to potentially interfering links. Although the super frame structure is similar to a TDMA frame, it does not prevent two interfering nodes from accessing the medium at the same time. The actual multiple access is accomplished by FDMA or CDMA. A drawback of the scheme is its low bandwidth utilization. For example, if a node only has packets to be sent to one neighbor, it cannot reuse the time slots scheduled to other neighbors.

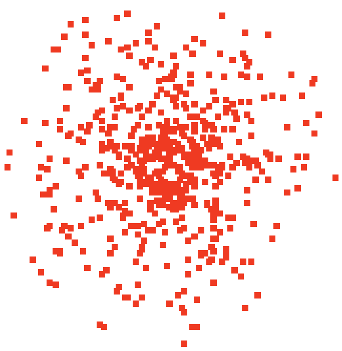
Piconet [18] is an architecture designed for low-power ad hoc wireless networks. One interesting feature of Piconet is that it also puts nodes into periodic sleep for energy conservation. The scheme that Piconet uses to synchronize neighboring nodes is to let a node broadcast its address before it starts listening. If a node wants to talk to a neighboring node, it must wait until it receives the neighbor's broadcast.

The paper is organized as follows. The Section 1 describes with overview of WSN and energy balancing in

WSN. Section 2 deals with the related works. Section 3 is devoted for the Existing Scheme EBRP. Section 4 describes the Proposed Algorithm Delay-Aware Energy Balanced Routing Protocol (DA-EBRP) Section 5 describes the performance analysis and the last section concludes the work.

3. Existing Algorithm – Energy Balanced Routing Protocol (EBRP)

While designing an efficient routing protocols in Wireless Sensor Networks, we need to focus an important two major parameters namely energy balance and energy efficiency. These two parameters are different attributes of routing techniques design goal.



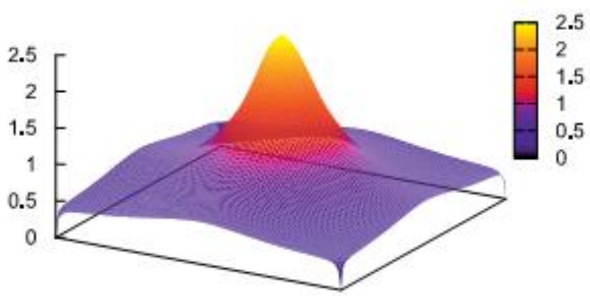


Fig. 1a. Deployment of Sensors **Fig. 1b.** Potential Field.

The energy-efficient routing protocol is trying to extend the network lifetime in terms of energy consumption, whereas the energy-balanced routing protocol aims to maximize the network lifetime through even and uniform energy consumption.

From experimental results, the former increases the network partition which disables the network functioning, even though there might be sufficient residual energy and the latter focusses energy efficiency and it maximizes both the network connectivity and network functioning. The Figures Fig.1a and Fig.1b demonstrates the principles of EBRP and the Sensors' Potential Field. From the Figure Fig.1b, it is noted that this EBRP Scheme works to balance energy consumption.

3.1 Design Models and Properties of Energy Balanced Routing Protocol (EBRP)

In this section, we are discussing the Design models and various properties. i.e. This section focuses how to construct potential fields through depth, energy density and residual energy on each and every node, and how to integrate them into a combined virtual potential field which will drive packets to sink and at the same time this system has to focus balanced energy consumption.

3.1.1 Design Models of Energy Balanced Routing Protocol (EBRP)

Here, we are discussing various design models such as Depth Potential Field, Energy Density Potential Field, Energy Potential Field, and Hybrid Potential Fields.

Depth Potential Field

To provide the routing function such as how to move packets toward the sink, an inverse proportional function of depth which is as the depth potential field V_d. i.e. Vd (d) = 1/ (d+1), where d = D (i) represents the depth of node i. The depth potential difference U_d (d_1, d2) from depth d_1 to $d_2$could be defined as

$$U_d(d_1,d_2)=V_d(d_2)-V_d(d_1)=(d_1-d_2)/(d_2+1)((d_1+1)$$

Since the potential function V_d(d) is monotonically decreasing, while the packets in depth potential field go along with the direction of the gradient, they can reach the sink finally. The Depth of potential field is illustrated in fig.2.The value of the depth difference between neighboring nodes will be 0, 1, or -1 due to the nodes two or more hops away from a node may not become its neighbors. Thus

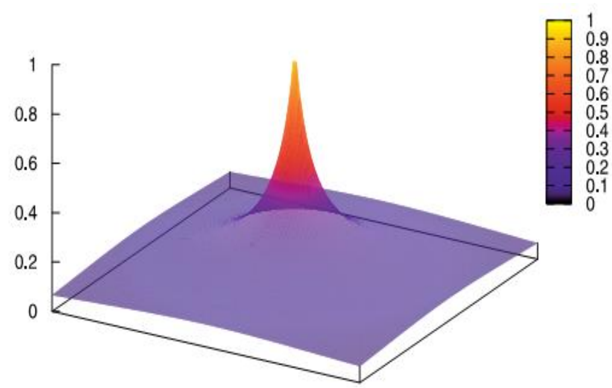


Fig. 2. Depth Potential Field

$$U_d(d_1,d_2)\begin{cases} =0, & \text{if } d_1 = d_2 \\ >0, & \text{if } d_1 - d_2 = 1 \\ <0, & \text{if } d_1 = d_2 = -1 \end{cases}$$

The Depth potential field is shown in the Figure Fig.2.

Energy Density Potential Field and Energy Potential Field

The Energy Density Potential filed can be calculated with V_{ed}(i,t)=ED(i,t), where V_{ed}(i,t) is the energy density potential of a node I at time t. This ED(i,t) will be the energy density on the current position of node i at a time t. Hence, the potential difference E_{ed}(i,j,t) from node i to a node j could be defined as U_{ed}(i,j,t)= V_{ed}(j,t)- V_{ed}(i,t) =ED(j,t)-ED(i,t). Similarly the Energy Potential Field is V_e(i,j,t)= V_e(j,t)- V_e(i,t) =E(j,t)-E(i,t)

3.1.2 Properties of Energy Balanced Routing Protocol (EBRP)

The design and implementation details of this EBRP are discussed in this Section. This EBRP is designed with the various routing Control Message Signals such as Flag, Depth, Energy and Energy Density, Distance with Received Signal Strength Indicator (RSSI), Time to Update. The structure is shown in the Figure Fig. 3. The various control signals of this EBRP are discussed below.

3.1.2.1 Control Message

This is the format of the routing control message, which consists of five parts is shown in Fig. 1. The flag field has 6 bits which is reserved for extensions. This EBRP defines two types of control messages where the first message is the normal updated message and its type field is 00 and the second field carries the information which is used by EBRP, comprising energy density depth and residual energy. And the third is used to confirm routing loops which is called as Check Loop Packet (CLP) with the value of 01.

3.1.2.2 Depth

In this EBRP, initially, the depth of all nodes have been initialized to 0xff and sink default depth is 0. The sink
first will send the update message, nodes which one hop away from the sink could get their own depth level by adding *one "*1" to the depth value to the update message. Similarly all the other nodes will get their own depth by receiving did update message from its neighbors. The procedure for depth calculation is shown below.

Select the Lowest Depth LD from the Routing Table
If (Lowest Depth LD > LD+1)
{
setLocalDepth (LD+1)
}

3.1.2.3 Energy and Energy Density

The EBRP calculates residual energy of the local node with feasible software. Here a Smart System is introduced to measure and estimate the consumed energy while forwarding packets. The System could log the actions that the local node is being performed to evaluate the consumed energy through battery model [14] which is published by the authors R. Musunuri and J.A. Cobb. In this work, it is assumed that the value of residual energy could be easily obtained from the above identified method. This value will be forwarded to the update message, and thus each node does know all its neighbors residual energy and will be maintained them in the routing table. Energy density of the local node could be acquired by adding all residual energy of the neighbors in routing table. Then it is dividing this sum by the area of coverage disk.

3.1.2.4 Distance

The distance between two neighbors could be easily obtained by various techniques, like signal attenuation evaluation or estimation based on Received Signal Strength Indicator (RSSI) [15]. This is noted that the distance used by EBRP might be approximate.

3.1.2.5 Time to Update

The Energy Balanced Routing Protocol EBRP exchanges routing messages to its direct neighbors. To maintain the update pace, this EBRP states both the i. Least Updating Interval (LUI) and ii. Maximum Updating Interval (MUI) between the two consecutive update messages. The MUI is continuously larger than LUI. If no messages from a neighbor in two MUIs intervals, neighbor might be considered as dead node. Thus this EBRP will again calculating the depth and other values. And then this EBRP will send an updated message with the following conditions.

- If the Maximum Updating Interval (MUI) Timer Expires
- If the Elapsed Time exceeds Least Updating Interval (LUI)
- Energy consumption exceeds a certain threshold

4. Identified Problem of the Existing System EBRP

This Energy-Balanced Routing Protocol (EBRP) is designed which focused and monitored the Sensors Networks in terms of residual energy and energy density. The aim of this approach is to forward packets to sink via the dense energy area to protect the nodes with less residual energy, which is maximizing the Sensor Networks Lifetime. However, from our experimental results, it is noted that this scheme finds a best energy density based route between source and destination. But it doesn't focus shortest path, which degrades network performance in terms of Throughput, End-to-End Delay, and Network Lifetime. That is if this Energy Balanced Routing Protocol (EBRP) calculates

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route based on Energy Density and Shortest Path as well, the network performance could be improved in terms of Throughput, End-to-End Delay and Network Lifetime. Thus this research paper designed and proposed an efficient Delay-Aware Energy Balanced Dynamic Routing Protocol (DA-EBDRP), which will improve the network performance in terms of Throughput, End-to-End Delay and Network Lifetime.

5. Proposed Delay-Aware Energy Balanced Dynamic Routing Protocol (DA-EBDRP)

In Wireless Sensor Networks, it is important to save sensors energy. Current research on routing in Wireless Sensor Networks generally and mostly focused on energy aware and energy balanced protocols like EBRP to maximize the lifetime of the network which is discussed in the previous section.

The design of a smart delay sensitive shortest path and Energy balanced routing protocol **DA-EBDRP** for WSNs should allow a flexible trade-off between packet delay, the corresponding energy consumption and energy density. The routing methodology in DA-EBDRP is designed to take advantage of the EBRP and it will focus the shortest path to find the shortest energy density based route.
This proposed DA-EBDRP consists of three Phases. They are

- Energy Balanced based Shortest Route Finding
- Alternate Next Energy Balanced based Shortest Route Finding
- Route Update

5.1 Energy Balanced based Shortest Route Finding
This is the first phase of the DA-EBDRP. The procedure to find the shortest path based Energy Balanced Route of the proposed DA-EBDRP is shown below. This procedure will discover the best energy balanced based Delay Minimum optimal route.

Shortest Path: Short_Path ( )
Updating Message: u_Msg
Neighbouring Node: neighbor_ID
Packetdropratio: PDR_size
Link Capacity: Lin_Cap
CLK: Clk
BW: Bandwidth
Select Parent according to max_d, max-U_m*, max-*U_{ed}*, max-*U_e*, min-u_Msg.DEPTH, MIN-cost, Random*
Short-Path () *which finds & returns the shortest path of local node*
Distance () *which returns the distance of the neighbor;*
Calculate Energy-Density () *which calculates & returns the energy density of local node;*
UpdateRoutingTable () *which updates the routing table;*
SetLocalDepth () *which sets the depth of the local node*
Local-Energy_Density= ***calculateLocalEnergyDensity ()****;*
θ_d *= (Local_Depth+I+PDR_size) / u_Msg.Depth+1*
Short_Path($U_{d=}\,\theta_d > 1\ ?\ 1\text{-}I/\theta_d\ \text{-}1$*)*
Lin_Cap = Short_Path(RERR+CLK size)
θ_{ed} *=u_Msg.Energy_Density/Local_Energy_Density*
Shor_Patht($U_{ed} = \theta_{ed} > 1\ ?\ 1 - I\,/\,\theta_{ed} : \theta_{ed}\ \text{-}1$*)*
θ_e *=u_Msg.Energy / Local_Energy*
Short_Path($U_{e=}\,\theta_e > 1\ ?\ 1\text{-}I/\theta_e\ \text{-}1$*)*
$U_{m=(1-\alpha-\beta).}\ U_{d+\ \alpha}\ U_{ed}+\ _{\beta}\ U_e$
COST = ***Distance****(neighbor_ID)*
D=U_m*/COST*
Lin_Cap = BW+CLK Size - RERR
updateRoutingTable*(neighbor_ID)*
select the Lowest Depth from the routing table as LD
1. if (Local_Depth > LD +1) then
2. ***setLocalDepth****(LD +1)*
3. Endif

5.2 Alternate Next Energy Balanced based Shortest Route Finding

This is the second phase of the proposed work. In this phase, alternate shortest path *Alternate_Sort_Path* will be identified by the sub procedure *Alternate_Sort_Path()*and it will be updated in the Route Update Table. If any nodes under the current working path are reached the lowest energy threshold level, that route will be blocked and the *Alternate_Short_Path* will be activated and subsequently *Alternate_Sort_Path() will be called and another Alternate_Sort_Path* will be discovered. This procedure will improve the reliability of the Sensor Networks and it will improve the network lifetime also.
5.3 Route Update

This phase is used to update the new route if the working route is getting down. This improves reliability and Throughput without delay.

5.4 Pseudo code of Proposed Delay-Aware Energy Balanced Dynamic Routing Protocol (DA-EBDRP)

The above process is controlled by a novel and reliable route monitoring and selecting technique which is shown below.
CALL ***Short_Path (calculateLocalEnergyDensity ())***
Select optimal route
FOR there are sensing data to be sent DO
BEGIN
IF Route Functioning Well
CALL data delivery
ELSE IF
CALL ***Alternate_Short_Path*** *(calculateLocalEnergyDensity* ***())***
Select Alternate optimal route
END

6. Performance Analysis and Discussions

The performance of our proposed DA-EBDRP is implemented with QualNet4.5 Simulator and DA-EBRP is thoroughly studied and evaluated in this section in terms of in terms of End-to-End Delay, Throughput, Portion of Living

Node (PLN) and Network Lifetime. It is also compared with the recently proposed Energy Balanced Routing Protocol (EBRP) and established that our proposed work is performing well as compared with the existing one in terms of Throughput and End-to-End Delay and this proposed work retains all the positive features of Portion of Living Node (PLN) and Network Lifetime.

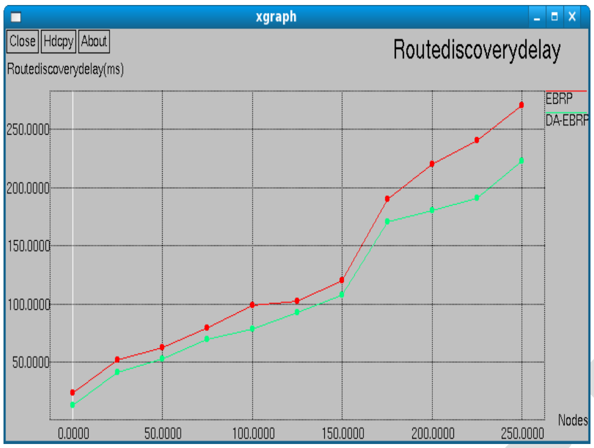

Fig. 4. Route Discovery Delay DA-EBRP vs EBRP

From the Figure Fig. 4, it is noted that our proposed DA-EBRP discovers the shortest path earlier as compared with the EBRP. It is happening because, our work continuously pre-calculating the alternate best shortest path which is maintained by route update table, while communication takes place in the current shortest path. It is also observed that as density of nodes increases, the route discovery time approaches EBRP because considerable time is required to calculate the Energy Density in condensed nodes.

Our proposed work's prime objective is to discover the best shortest path with sufficient energy density to forward packets to sink. That is the reason why, our method consumes less End-to-End Delay to forward the packets to destination as compared with EBRP, which is shown in the Figure Fig. 5.

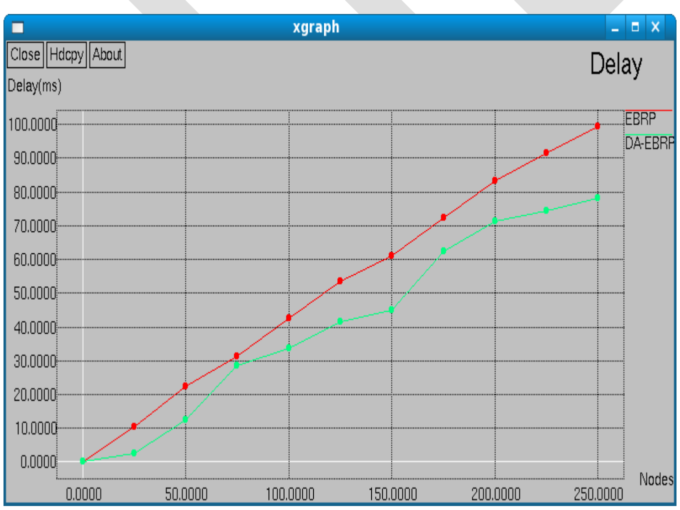

Fig. 5. End-to-End Delay DA-EBRP vs EBRP

This approach improves the throughput level of the system, which is shown in the Figure Fig. 6. But however, from the Figure Fig. 6, observed that as the sending packets are more, our work chooses route based on the energy dense nodes and hence the throughput of our work is almost equal to EBRP for higher volume of data communication.

As far as the Network Life Time is concerned, our proposed work couldn't achieve higher performance for low density nodes. But however, from the Figure Fig. 7, it is established that our proposed work maintains the feature of EBRP when sensor network has more than 200 nodes.

From the Figure Fig. 8, it is observed that our proposed work utilizes all the nodes of Sensor Network and hence our work achieves more living nodes as compared with EBRP for long time simulation. But however, for short time of execution, it couldn't retain more nodes like EBRP because our work focuses energy density and shortest path as well for communication.

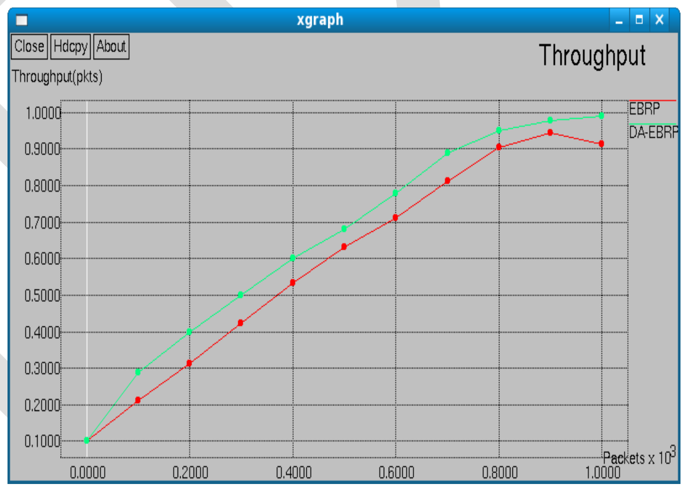

Fig. 6. Throughput DA-EBRP vs EBRP

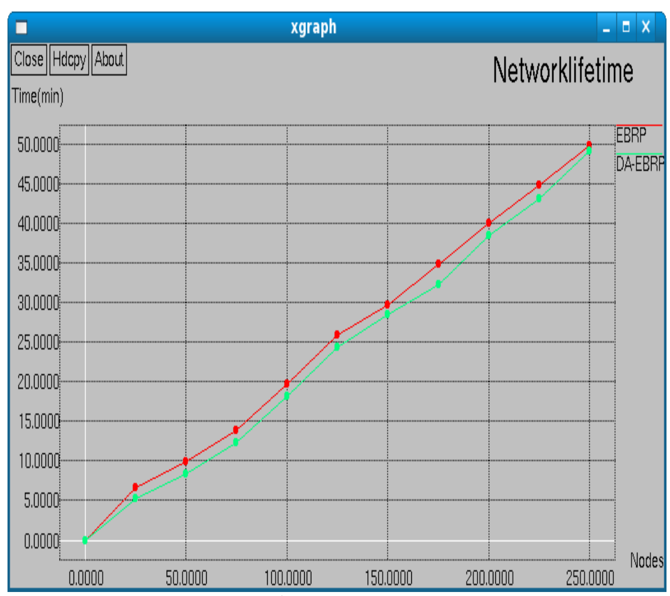

Fig. 7. Network Life Time DA-EBRP vs EBRP

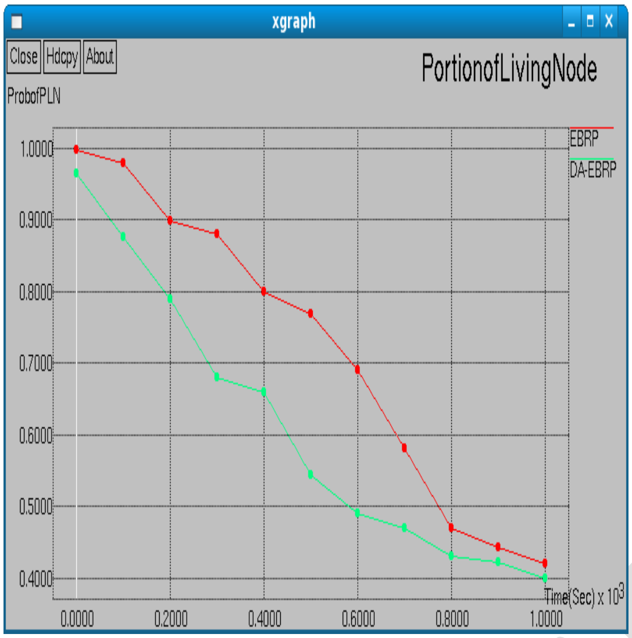

Fig. 8. Portions of Living Node DA-EBRP vs EBRP

7. Conclusions

In Wireless Sensor Networks, recharge or replace the batteries of the nodes may not be possible. That is the energy is a very precious resource and hence energy-efficient protocol design is a major challenging issue. We have discussed various energy-efficient routing protocols and discussed their issues. To overcome these major issues, an efficient Energy-Balanced Routing Protocol (EBRP) is designed. In this work, we were analysed its pros and cons. ie from our experimental results, we established that the EBRP fails to achieve Throughput and End-to-End Delay. To achieve these identified issues, we have developed Delay-Aware Energy Balanced Routing Protocol (DA-EBRP). We have thoroughly studied and investigated this proposed routing technique and compared with EBRP interms of End-to-End Delay, Throughput, Portion of Living Node (PLN) and Network Lifetime. From our experimental results it is established that this proposed work outperforms Energy Balanced Routing Protocol (EBRP) interms of End-to-End Delay and Throughput, which improves the Network Performance. Further, we revealed that this proposed work retains all the qualities of EBRP interms of Portion of Living Node (PLN) and Network Lifetime.

References

[1]. Fengyuan Ren, Jiao Zhang, Tao He, Chuang Lin and Sajal K. Das, "EBRP: Energy-Balanced Routing Protocol for Data Gathering in Wireless Sensor Networks", IEEE Transactions On Parallel And Distributed Systems, Vol. 22, No. 12, December 2011

[2]. Arjan Durresi and et.al., "Delay-Energy Aw are R outing Protocol for Sensor and Actor Networks", Proceedings of the 2005 11th IEEE International Conference on Parallel and Distributed Systems (ICPADS'05), 2005

[3]. Liming He, "Delay-Minimum Energy-Aware Routing Protocol (DERP) for Wireless Sensor Networks", IEEE Eighth ACIS International Conference on Software Engineering, Artificial Intelligence, Networking, and Parallel/Distributed Computing, 2007.

[4]. D. Estrin, R. Govindan, J. Heidemann, and S. Kumar, "Next Century Challenges: Scalable Coordination in Sensor Networks," Proc. ACM/IEEE MobiCom, pp. 263-270, 1999.

[5]. X. Wu and G. Chen, and S.K. Das, "Avoiding Energy Holes in Wireless Sensor Networks with Nonuniform Node Distribution," vol. 19, no. 5, pp. 710-720, 2008.

[6]. Y. Xu, J. Heidemann, and D. Estrin, "Geography-Informed Energy Conservation for Ad-Hoc Routing," Proc. ACM MobiCom, 2001.

[7]. V. Rodoplu and T.H. Meng, "Minimum Energy Mobile Wireless Networks," IEEE J. Selected Areas in Comm., vol. 17, no. 8, pp. 1333-1344, Aug. 1999.

[8]. W. Heinzelman, J. Kulik, and H. Balakrishnan, "Adaptive Protocols for Information Dissemination in Wireless Sensor Networks," Proc. ACM MobiCom, 1999.

[9]. W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy- Efficient Communication Protocols for Wireless Microsensor Networks," Proc. Hawaiian Int'l Conf. Systems Science, 2000.

[10]. Boukerche, X. Cheng, and J. Linus, "Energy-Aware Data-Centric Routing in Microsensor Networks," Proc. Sixth ACM Int'lWorkshop Modeling Analysis and Simulation of Wireless and Mobile Systems (MSWIM' 03), pp. 42-49, 2003.

[11]. O. Younis and S. Fahmy, "HEED: A Hybrid, Energy-Efficient Distributed Clustering Approach for Ad Hoc Sensor Networks," IEEE Trans. Mobile Computing, vol. 3, no. 4, pp. 366-379, Oct.-Dec.2004.

[12]. M. Singh and V. Prasanna, "Energy-Optimal and Energy-Balanced Sorting in a Single-Hop Wireless Sensor Network," Proc. First IEEE Int'l Conf. Pervasive Computing and Comm., 2003.

[13]. R.C. Shah and J.M. Rabaey, "Energy Aware Routing for Low Energy Ad Hoc Sensor Networks," Proc. IEEE Wireless Comm. And Networking Conf. (WCNC), pp. 350-355, 2002.

[14]. R. Musunuri and J.A. Cobb, "Hierarchical-Battery Aware Routing in Wireless Sensor Networks," Proc. IEEE 62nd Vehicular Technology Conf. (VTC-2005-Fall), pp. 2311-2315, 2005.

[15]. N. Patwari, A.O. Hero III, M. Perkins, N. Correal, and R.J. O'Dea,"Relative Location Estimation in Wireless Sensor Networks," IEEETrans. Signal Processing, vol. 51, no. 8, pp. 2137-2148, Aug. 2003.

[16]. J. Chang and L. Tassiulas. "Energy Conserving Routing in Wireless Ad Hoc Networks." Proceedings INFOCOM 2000, Mar 2000.

[17]. Katayoun Sohrabi and Gregory J. Pottie, "Performance of a novel selforganization protocol for wireless ad hoc sensor networks," in Proceedings of the IEEE 50th Vehicular Technology Conference, 1999, pp. 1222–1226.

[18]. Frazer Bennett, David Clarke, Joseph B. Evans, Andy Hopper, Alan Jones, and David Leask, "Piconet: Embedded mobile networking," IEEE Personal Communications Magazine, vol. 4, no. 5, pp. 8–15, Oct. 1997.

[19]. Attahiru S. Alfa, B. T. Maharaj, Shruti Lall, and Sougata Pal "Mixed-Integer Programming based Techniques for

Resource Allocation in Underlay Cognitive Radio Networks: A Survey" journal of communications and networks, vol. 18, no. 5, october 2016.

[20].Evangelos Dimitris Toumpakaris, Adrian Munteanu, and Nikos Deligiannis, IEEE Member"Multiterminal Source Coding With Copula Regression for Wireless Sensor Networks Gathering Diverse Data" IEEE Sensors Journal, Vol. 17, No. 1, January 1, 2017

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