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DSWS- Distributed Sleep/Wake Scheduling Scheme for DEC Protocol in Wireless Sensor Networks

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Abstract: ***To improve the lifespan by reducing the energy utilization of battery-driven sensors in wireless network applications has grown into a challenging task in the fields of communication. Sleep/wake programming mechanism is evidenced to be an well-organized method to meet the challenges and to maintain good energy conservation in sensor networks. In this study, we take enhanced DEC (Deterministic Energy Efficient Clustering protocol) with distributed sleep/wake scheduling scheme i.e. purely deterministic model that make effective use of clustering to organize the WSN. In this proposal cluster division of sensor nodes is based on coverage sensing metrics and through dynamic selection mechanism, it allows additional node in every group to be active concurrently. The results obtained using the concept of DSWS-DEC outperform various existing in terms of coverage and energy preservation.***

Keywords: Energy efficiency, clustering, data transmission

I. INTRODUCTION

WSN is a self-configuring, which is a collection of spatially dispersed and prearranged autonomous compact sensor nodes that communicate among themselves using radio signals and collect the data from its surroundings. These sensor nodes are deployed either randomly or manually to sense and monitor the region. These sensor nodes are widely utilized in fields like military, health-monitoring, landslide detection, flood and forest fire detection etc. The enhancement in the lifespan of network is achieved by opting good techniques in deploying sensor nodes. Thus, the focus of several authors is on evolving a procedure that can reduce and augment the dynamism ingesting of sensor nodes [1], [2]. The sensors in the network model uses clustering schemes in the routing protocols like LEACH [1], DEEC, and SEP. To lessen the energy depletion of the sensors and to advance the recital of sensor network, DSWS-DEC has been significantly demonstrated in comparison with the existing conventional routing protocols.

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Several studies [2], [3], [4], [5], [6] have used clustering to organize WSNs. Clustering process involves grouping of sensor nodes and electing leader among them. By the time the election process completes, sensor nodes are grouped 2 categories i.e. cluster-heads (CH) and cluster- members (CM). The elected Cluster-heads sends advertisement message to their respective cluster members to grant access for them to send the information to the cluster head

The collected statistics is distinguished by means of data compression techniques and the gathered data is sent to the sink (BS). As discussed in [4], the cluster-head consumes more energy, since it acts as a mediator between CM and BS. The energy gain is observed to be high when the cluster-head is rotated than if it were to be set. In earlier studies, the cluster-head rotation [7] was done in a randomized manner cluster-heads was done in a randomized manner and there is no guarantee for the election to be optimum. For improving election process of cluster-heads DEC protocol [8-10] was introduced. The selection criteria used in DEC protocol is the enduring vitality of the nodes after each round.

To implement sleep/wake scheduling algorithms there are several proposed methods to recognize the numeral of nodes and in particular the node which should be kept in sleep mode [11], and these proposed methods are distributed into centralized sleep-wake scheduling systems [12-14] and distributed sleep/wake scheduling systems [15-18]. Usually, centralized sleep/wake systems are implemented for motionless targets or for the targets moving with recognized and stationary movement patterns. The main drawback of the centralized algorithm is that the receiving antenna of the sleeping nodes should be switched on even though the node is not in active state to accept the messages which results in more energy consumption. Meanwhile the distributed sleep-wake scheduling systems self-organize the nodes to perform the network responsibilities which reduce the message cost and litheness of the sensors towards dynamic conditions is improved [19]. The sensor networks become accessible and can effort autonomously for a extended duration. In projected paper, a deterministic energy-efficient clustering protocol along with distributed sleep/wake scheduling concept is proposed, that promises a more desirable selection of cluster-heads. The energy conservation is maximized by allowing a smallest number of sensors to be in work state and also by considering the coverage and connectivity of the region in which the sensors are deployed. The statement range of the nodes is equivalent to or superior to twice of its radius of sensing region, which is taken as an assumption in this model. It further proved that coverage and connectivity of a region implies each other [20]. The sensing radius of the sensor node is considered in order to switch a node into sleep mode. The coverage performance remains unaltered by allowing the active node to cover the working area of the sleep node. So, the active nodes remain connected and the total region is sensed by these active nodes. Simulation results of the proposed model in comparison with existing DEC protocol improve energy conservation and the desired results are achieved in the wireless sensor networks.

II. WIRELESS SENSOR NETWORK MODELS

The lifespan of network is limited because nodes are tightly power-reserved. Meanwhile, the control of nodes is imperfect; energy conserving protocols should be developed in the field of wireless sensor network to boost the lifespan of the networks. Energy utilization is minimized by arranging the nodes in form of clusters. Cluster arrangement is considered as base in developing many energy conserving routing protocols [3][4]. Even data aggregation can be performed using clustering technique [5][6]. The data from cluster heads is combined to form small groups containing significant data. To enhance the lifetime and lessen the dynamism depletion in a wireless network in [1][6][8] a model based on probability is used. The drawback of such protocols is that, optimum cluster-head election process is not assured. It was noted in [4] that based on energy utilization, a deterministic cluster-head choice procedure can perform better compared to the probabilistic-based algorithm. A model based on probability is cast-off by these procedures is assumed in Eq. (1).

$$T(n_x) = \begin{cases} \dfrac{p}{1 - P_x\left(r \bmod \dfrac{1}{(P_x)}\right)} \times Q \quad if\ n_x \in G'; \\ 0 \qquad\qquad\qquad\qquad Otherwise, \end{cases} \tag{1}$$

Here the remaining energy after every round i.e. residual energy is represented by Q or can be taken as a constant value. According to the Eq. (1) the cluster-head is resolute for every round r, sensor to be cluster head opts values randomly amid 0 and 1. If the arbitrarily preferred numeral is inferior to the edge that is set for the sensor node $nT(n)$then that node becomes a cluster-head. Here P_x is the probability of becoming as CH, signifies a set of non-chosen nodes which are the cluster members (CMs).

According to LEACH, SEP, DEC and other cluster-based procedures, the principle of gathering technique commences with a setup phase that includes CH electing process. The cluster –heads elected transmit an advertisement message to their respective cluster members using the non-persistent carrier-sense multiple access (CSMA MAC) protocols. The advertisement encompasses a header and Cluster head id. The remaining nodes other than the cluster-heads are cluster-members (CMs) and they identify their respective cluster-head and the cluster by considering the minimum distance and signal strength of the advertisement message as criteria. CSMA MAC protocol is used to generate join-request between CMs and their elected CH. Once the communication link is established between CH-CMs, for the intra-cluster communication between the CH and CMs the CHs set up a TDMA channel which is the end of setup phase. The data processing beginning from cluster-members to cluster-head and from cluster-head to sink is done in steady phase. The direct sequencing spread spectrum (DSSS) is a modulation technique used to achieve the inter-cluster communication.

The popular way to conserve energy is switching off some sensor nodes and using the only certain number of nodes for collecting the data and delivering the packets to the sink. To lessen vitality reduction in WSN, [8] an adaptive segregating method using node preparation and topology control is presented. The nodes are divided into clusters based on the connectivity measured between pair-wise nodes which are prioritized based on the location of the sensors. In the each portioned group a node remains in active state whereas the further node is preserved in slumber mode. In [15-18] algorithms based on coverage-preserving were studied. While making, the decision of whether node should be turned on or off is taken autonomously by the network based on the local neighbor information [21].

Any of the two nodes are densely connected within a cluster if the distance is not more than$\sqrt{3}rs$, of their coverage disk. Following the process of purely deterministic model and studies [8], we enhanced existing DEC protocol with Distributed sleep/awake scheduling concept that can produce a better lifetime.

III. MOTIVATION AND MAJOR CONSIDERATION

In DSWS technique, the sensing coverage is taken as standards in the division of sensors into clusters rather than measured connectivity. Meanwhile it has been confirmed that if the radio ranges of sensors are equivalent to or greater than twofold the sensing range, i.e.$r_c \geq 2rs$, complete sensing coverage implies connectivity of the network. In further arguments, in case of $r_c \geq 2rs$, we only essential to deliberate the sensing coverage.

The energy is conserved by segregating the nodes into multiple numerals of clusters and making sure that only few nodes from various different clusters are kept in active state while other are in sleep state. The region sensed by the total nodes should be approximately equal to the region sensed by the active nodes in order to obtain full coverage. Therefore, in every cluster the active sensors coverage region should coincide with any other node coverage region. To merge any two clusters into a large one, neighboring clusters should be connected densely. To decrease the numeral of nodes used during deployment a triangular pattern is considered, so that the distance between any two sensor nodes is maintained as $\sqrt{3}rs$.

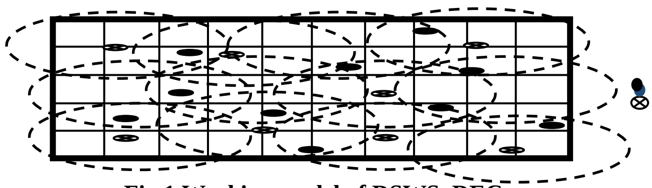

Fig.1 Working model of DSWS_DEC

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For example: Let X and Y be the clusters taken for operating this model, for any node a_i in X and any node b_j in Y, X and Y are said to be neighboring clusters if

$$d(a_i, b_j) \leq \sqrt{3rs} \qquad (2)$$

Let the distance between the nodes a_i and b_i. Of the clusters X and Y respectively be (a_i, b_j) .N_X and N_Y characterizes the total sensor nodes in clusters X and Y. For any $a_i \in X$ and $b_j \in Y$, if $d(a_i, b_j) \leq \sqrt{3}rs$, then the connection value between a_i and b_j is 1, say $c_{ij} = 1$. Thereby, the connectivity intensity is given as

$$C_{XY} = \sum_{i=1}^{N_X} \sum_{j=1}^{N_Y} \frac{c_{ij}}{N_X \times N_Y} \qquad (3)$$

The connectivity strength is calculated along with the cluster-forming process. Clusters X and Y can be fused only when $C_{XY} = 1$, i.e., X, Yare adjacent groups.

A. *Sleep/wake scheduling*

The coverage of total zone is guaranteed because of the dense positioning of nodes in a cluster. It is noteworthy that active node assortment process is independent and unique from each cluster. Therefore, to appraise the connectivity between the cluster and its adjoining clusters, connection value for each cluster (denoted as X)
is intended as follow.

$$CON_X = \sum_{Y \in neighbor(X)} C_{XY} \qquad (4)$$

$$CON_X = \sum_{Y \in neighbor(X)}^{N_X} C_{XY} \qquad (5)$$

The joining rate of every cluster is obtained on summing the connectivity strengths between X and its bordering clusters as shown now in(4).

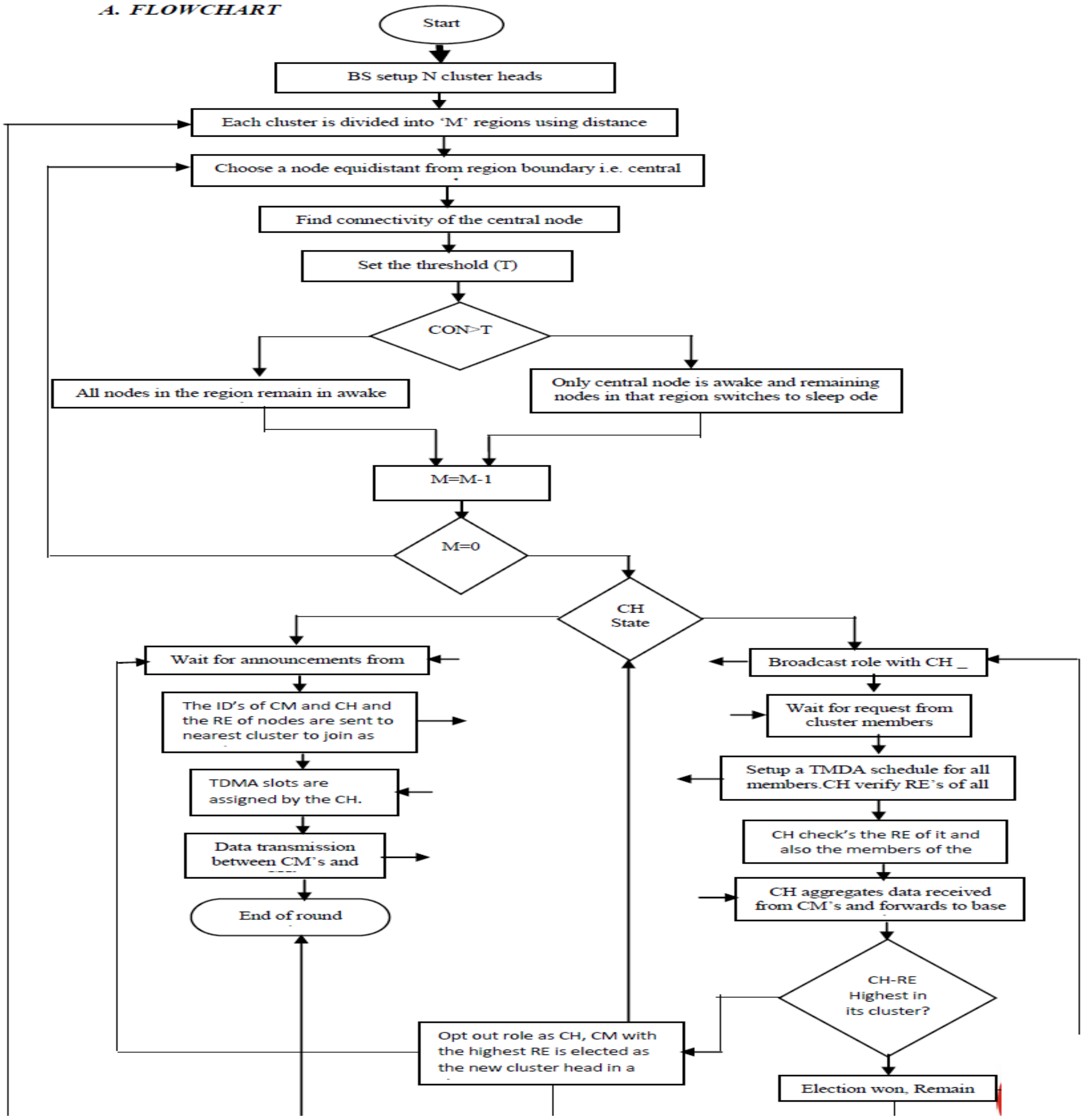
IV. PROPOSED-DSWS-DEC PROTOCOL

We initiate a DSWS-DEC (Distributed Sleep/wake scheduling- DEC) protocol which is purely deterministic and the choice of cluster heads is grounded on the left over energy (RE).

Sleep/wake scheduling phase:
The process of sleep/wake scheduling starts once the cluster formation is completed
The energy is conserved by switching on the sensors with the peak left over energy, which are active nodes and the remaining nodes are switched off.
Every sensor is assigned with works periodically in the data-gathering mechanism.
In beginning stage of sleep/wake scheduling, all the sensors should be active state so as to maintain the network configuration in active.
The nodes sensing action is i.e. the CH transports a work message to the nodes to perform their duties as active nodes.
Meanwhile, a SLEEP note is delivered to remaining nodes by the CH.
The sensors in the inactive mode, after completion of the round will send a WORK_REQ to the cluster head to participate in node(s) selection process
The cluster-head starts the selection process only after receiving the WORK_REQs from

Set-up and steady phase:
Node elected as cluster-heads for the current round transmit advertisement including its parameters to the rest of the nodes
All CH's transmit advertisement using same transmission energy. The remaining nodes other than cluster-head, to get the advertisement keep their receiver on.
Now, all the other remaining sensor nodes choose the cluster-head with minimum distance and communication energy as criteria.
When one or more cluster-head equally satisfy the selection criteria, then cluster head is chosen randomly.
The elected CHs transmit advertisement (ADV) using non-persistent carrier-sense multiple access (CSMA MAC) protocol.
This ADV contains the id and a header.
All non-elected nodes are labeled as cluster-members (CMs) discover their cluster by choosing the CH having minimum distance from sink and the strength of the ADV message.
CSMA MAC protocol is used to generate join-

A. FLOWCHART



B.ALGORITHM

Step 1: Start

Step 2: Base station selects N cluster heads

Step 3: Divide each cluster into M regions based on distance criteria(radius) i.e. d(xi,yi)<=√(3rs)
xi,yi are co-ordinates of nodes(cluster members)
Step 4: Select a central node i.e. equidistant from region boundary
Step 5: Connectivity of central node(Cc) is determined from
all other nodes in the region using
CON=∑(Cci)[i is node number]
Step 6: Set the threshold (T) for connectivity value
Step 7: if CON>T then
Cc=1;
for i=0toMi and i!=c increment by step 1
Mi=0;
endfor
else
Ci=1;
for i=0toMi increment by step 1
Mi=1;
endfor
endif
Step 8: M-=1;
Step 9: if M!=0 then
Repeat steps 4 to 8;
else
A: check CH state
if READY then
B: Broadcast role with CH-ID;
Wait for request from cluster members;
Setup TDMA schedule for all members received;
for i=0toNi increment by step 1
if (RE(CH) > RE(Ni)) then
CHnew =
CH; [Election won]
end of round time;

goto B;
else //Relinquishing role as CH , choosing new CH
RE(CHnmax)=RE(No);
for i=0toNi increment by step1
if(RE(CHnmax) > RE(Ni)) then
CHnew =CHnmax;
endif
endfor
goto A;
Repeat from step3;
endif
endfor
else
Wait for announcements from CH;
nodes send CM-ID,CH-ID,CM-RE and header towards nearest header;
Wait for TDMA schedule from respective CH's;
Data transmission between CM's and CH's;
end of round time;
endif
endif

V.PERFORMANCE EVALUATION

Here we discuss the results of sleep/wake scheduling. The region taken for simulation is a 100 × 100 square area. The transmission radius and sensing radius are set to 40√5 and 20√5, respectively

Parameter	Values
E_{elec}	50nJ/bit
E_{DA}	5nJ/bit/message
E_0	0.5J
k	4000
p_{opt}	0.1
ϵ_{fs}	10pJ/bit/m^2
ϵ_{mp}	0.0013pJ/bit/m^4
n	1000

Table 1 Design Specifications

For the purpose of analyzing, the performance of DSW-DEC protocol, a comparison between different existing protocols of wireless sensor network like LEACH, SEP and existing DEC protocols was done based on the measurements given below [1,3,4].

1) Stability period: This is phase of operation of the network from start till the primary node dies.
2) Network lifespan: This is time interval from start till the last node is alive.
3) Volatility period: The phase of act of network since initial node dies till the final node dies.
4) CH count: The cluster-head numeral produced next to each corpulent.
5) Packet to sink: The rate of effective broadcast of the information packs to sink.

We examined lifespan of 'LEACH', 'SEP', 'DEC' and proposed 'DSWS-DEC' protocols. We study the increase in total of dead nodes as the network operation proceeds. In fig 2 it is observed that DSWS-DEC has an increased time for which the network is stable. The network operates in stable region up to 1800. Stability period of DSWS-DEC is almost 120% 50% and 35%greater than LEACH, SEP and existing DEC correspondingly.

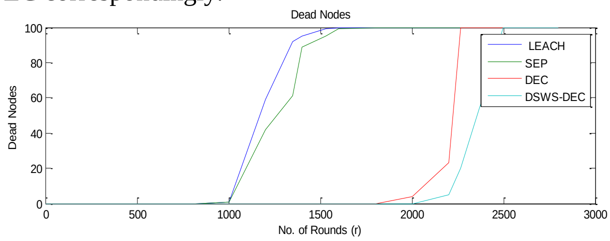


Fig. 2. Dead Nodes for 100M×100M Network with 100 nodes

From fig 2, it is likewise illustrated that DSWS-DEC has 100% 102% and 50% supreme enhancement in lifespan with contrast with LEACH, SEP and existing DEC. It became possible because of the sleep/awake scheduling mechanism and the usage of the effective algorithms in the election process of the cluster-head.

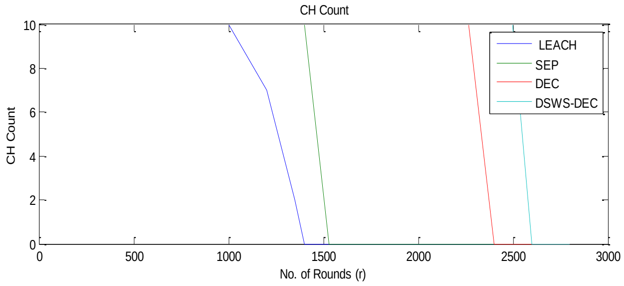


Fig. 3. CHs per round

From fig.3 we observe that for all routing protocols, after each round the numeral of cluster-heads selected. For DSWS-DEC the line indicating the number of cluster-heads selected after every round falls abruptly at 2498 round.i.e. all the nodes energy nearly comes to end (stage of falling to dead). Hence cluster head nodes become normal nodes at the final stage of rounds [22][23][24]. So they fall suddenly at the end of the network. It also shows in Fig.3, SEP, LEACH, existing DEC has high unpredictability in cluster-head election i.e. the numeral of cluster-heads chosen next to each round is random but DSWS-DEC has some designs and measured cluster- heads selection. The analysis which is obtained is far better than other existing protocols

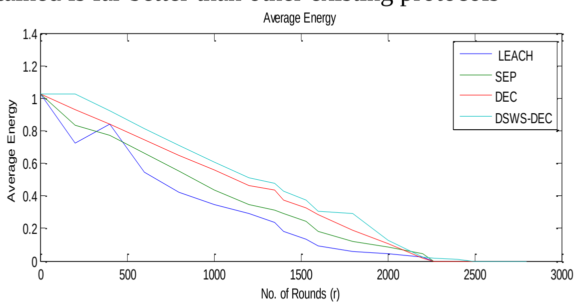


Fig. 4. Average energy

When compared to other routing protocols the instability period in DSWS-DEC starts very late. The analysis from Fig 4 shows that the quantity of lifeless nodes in LEACH and SEP increases suddenly after certain number of rounds but the rate with which the nodes dies is constant in DSWS-DEC. The above study depicts that in this type of network the energy dissipated by the sensor nodes is distributed properly which is the main reason for the upsurge in the lifespan of the WSN.

The transmission of data packets to sink remains done in a better way and with the constant data rates using efficient cluster-head selection algorithm in DSWS-DEC. Due to the sleep awake mechanism for sensors, the data transported to the sink is in less number. When compared to the routing protocols like 'LEACH','SEP','DEC', the rate at which the data is delivered to sink is better in DSWS-DEC. The longer lifetime of the network is due to the high data rate during the transmission which reduces the energy degeneracy of the nodes.The statistics delivered successful is shown in Fig 5.

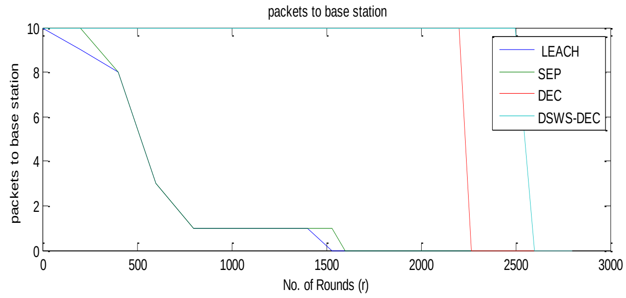


Fig. 5. Packet to BS Nodes for 100M×100M Network with 100 nodes

To be more technical related to energy efficient factor, table 2 and fig. 6 gives the analysis of residual energy utilization among existing DEC and proposed technique DSWS-DEC.

Rounds	Residual energy	
	DEC	**DSWS-DEC**
0	102.5	102.5
400	83.77	92.46
800	65.11	71.2
1200	46.08	50.92
1600	28.35	30.33
2000	10.31	12.45
2400	0	0.99

Comparison between existing DEC and proposed technique DSWS-DEC in terms of Residual energy using MATLAB

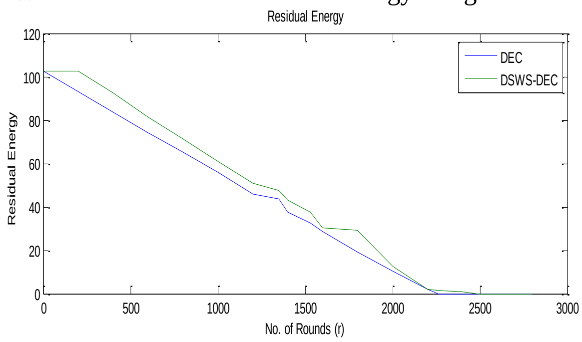


Fig. 6.Analysis of Residual Energy in DEC and Proposed DSWS-DEC

VI. CONCLUSION

In this study DSWS-DEC, a chastely deterministic procedure that better manages and conserves dynamism in sensor networks is presented to enhance the network performance. The advantages of DWSC-DEC algorithm are energy balance and algorithm efficiency. In this proposed model the active duration of nodes are designed grounded on the coverage plus connectivity values of sensor nodes. The important aspect of the proposed study is the efficiency of the algorithm. The energy dissipated during the transmission of packets and the rate at which the data is transmitted determines the efficiency. The presence of the deadlock formed during the cluster makes the algorithm inefficient so they should be avoided. The energy is conserved by making one or more nodes to be active in a cluster and remaining should be in sleep state. These features of DSWS-DEC are required since it maps with an ideal results. DSWS-DEC evidences to be more resistant to all type of conditions and extra steady than the random-based models. Total, the lifetime of the network is enhanced using DSWS-DEC, which is significant when compared with existing DEC and other existing protocols. The main advantage of both DEC and DSWS-DEC protocol is to consider the residual energy of nodes for effective use of energy levels. In the forthcoming work, we intended toward extending DSWS-DEC routing practice towards multi-hierarchy and multi-level system where the communication method is multi-hop or dual-hop instead of a single-hop.

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