Sindh Univ. Res. Jour. (Sci. Ser.) Vol.46 (2): 103-110 (2014)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

An Energy Efficient Routing Protocol for Wireless Sensor Networks Based on Two Relay Nodes

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Received 12th January 2014 and Revised 9th April 2014

Abstract: Uses of Wireless Sensor Networks (WSNs) in various fields have made it more demanding. One should efficiently manage battery operated sensor nodes, in order to attain longer life of these networks having finite amount of energy. Among different modes of communication Multi-hop mode is more feasible for these types of networks being not transmitting sensed information to sink directly because of node's short range of transmission. Still "Hot Spots" issue arises with this type of communication, as it may leads to several problems like reduces the network operating time and imbalance utilization of energy. While carrying data to BS from other clusters, Cluster Heads (CHs) nearer to Base Station (BS) tend to consume their energy earlier but still their cluster members have sufficient amount of energy. Dissipation of energy is faster even in single hop method, when the distance between Cluster Heads and BS is larger. This thing results to minimize the network's stability period. Stability is the functional time of the network until the first node becomes nonfunctional. This paper provides/presents a protocol for clustered heterogeneous network "Energy Efficient Two Relay Node Routing Protocol (EETRNRP)". For communication in the cluster and between different cluster, two high energy relay nodes are used with sensor nodes per cluster. The simulation results prove that EETRNRP provides efficient usage of node's available energy and thus prolongs the stability and functional time of the network compared to Stable Election Protocol (SEP).

Keywords: Routing protocol, energy efficient, network lifetime, stability, clustering, sensor networks

1. INTRODUCTION

Advancements in Communication and digital electronics have fostered the fast growth of a new generation of multifunctional, low power, inexpensive sensor nodes. A Wireless Sensor Network (WSN) usually consisting of large number of battery operated sensor nodes and a sink or BS. They use radio link for their communication (Saeidmanesh *et al.,* 2009). The main function of nodes is collecting information, process it and transmitting the processed information through BS to the end user. For the deployment of sensor nodes, there are two techniques, depends on the application, i.e. Deterministic and Random. By using preset paths, information are routed in deterministic node deployment while in random node deployment using ad-hoc way these routed paths are made. This become more fascinating in different application like agriculture, medicine fields, military, industries, environmental factors observation, natural environment monitoring etc. because of unattended nature of network sensor nodes and dense deployment.

One of the most important features of Wireless Sensor Network is the consumption of energy. In order to increase the working period of a network, energy consumption should be minimized. Analysis of energy utilization characteristics of node hardware and at different layers, energy effective design of protocols is needed for the low power design of WSN.

Data transmission is mainly responsible for huge amount of energy consumption as it consumes near 70% of energy (Pottie *et al.,* 2000). In order to increase the lifetime of WSN, optimization should be used for transmitting data and designing energy efficient routing protocol along with efficient ways of data fusions should be used (Al-Karaki *et al.,* 2004).

In WSN, discovery of energy efficient path and switching of the incoming data is done by network layer. In WSN, lifetime is inversely proportional to energy consumption, so in order to extend life time of network and to stop network partitioning, properly balanced energy consumption is required. The primary version of this work has been accepted in (Jehangir *et al.,* 2012).

Modern research mainly focus on better utilization of restricted energy resources of WSNs by developing energy saving ways and designing communication protocol for power aware. Hence different techniques such as unequal clustering, sink mobility, introducing high power sensor nodes, transmission power control methods and the concept of multiple sinks are adopted in routing to lower the effects of unbalance energy usage in the network.

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Smaragdakis *et al.,* (Smaragdakis *et al.,* 2004) developed SEP protocol to achieve fair utilization of network energy and increase in stability. It use few high energy advanced nodes along with ordinary normal nodes. Weighted election probabilities are defined for these nodes, with the help of which threshold can be obtained for each advanced node and normal node. It ensures the random selection of clusterheads based on the node residual energyfrom the advanced nodes and normal nodes. Also the chances of selection of CHs from the advanced nodes are more than that from the normal nodes. Once CHs are elected from each type, then the remaining non-selected nodes join the closest CH. The 2 presents an overview of the related work, section 3 describes the proposed work, section 4 discusses experimental setup and results, section 5 gives conclusion of the paper and provides future directions.

2. MATERIAL AND METHODS

The Proposed "Eetrnrp" Protocol

In recent years, research attention is attracted by heterogeneous WSN. The result shows that the lifetime of a network can be maximized by the addition of heterogeneous to the system [Kumar *et al.,* 2010]. There are a lot of advantages of adding heterogeneous node to network, among these three main are stated here, (i) Functional time of a network can be increased; average energy needed for sending data in homogenous WSN is much higher while in heterogeneous WSN it is been reduced. (ii) Reliability while transferring the data; during data transfer, the reliability of wireless network is always an issue. So in heterogeneous networks this problem is reduced by reducing the number of hops, and because of end-to-end communication the reliability became high. (iii) Data latency reduced; number of hops being decreased among source and destination results in fast data transmission.

In the proposed work a clustering technique based routing protocol EETRNRP is presented.

Network Model

In this study a heterogeneous network is considered. It's main characteristics are;

- It has a single static BS and heterogeneous nodes; common sensor nodes and also few relay nodes with higher amount of energy.
- After the deployment of all the nodes in the given location, they are uniformly distributed and stationary.
- The system is set into cluster containing sensor to sense the information, one elected CH (to send information to relay nodes with higher energy) and two energy relay nodes with greater amount of energy (R_{intra} and R_{inter}), whose job is to relay data to the Base station.
- In order to minimize traffic in sensor networks, data aggregation is performed by relay node R_{intra}.

Two Relay Nodes in a Cluster

The aim of using two-relay nodes in a cluster is to use two nodes to do the referred tasks individually. Placing two relay nodes in a cluster provides two paths for data routing. The relay node R_{intra} will manage its own cluster activities and will forward data of the same cluster, and the other relay node R_{inter} will carry out the task of relaying data from further clusters.

The proposed protocol involves three main processes; cluster formation process, sensor node CH and Relay node selection process, and data transfer process. The following sections illustrate the proposed work in detail.

2.1 Cluster Formation

Cluster formation in the proposed protocol depends upon the number of relay nodes. Let total nodes deployed in the system are 'M' and the fraction of these nodes with α-times greater existing energy is represented by 'm'. Therefore total relay nodes in the given system are M×m; the rest M-(M×m) are the normal sensor nodes. In EETRNRPthere are two relay nodes per cluster and hence the number of clusters in the system will be (M×m)/2. The nodes uniform distribution allows on average M(1-m)/(M×m/2) sensors in a cluster. The R_{intra} nodes start thecluster formation process by broadcasting a message. Each sensor node after getting these messages connects to the closest R_{intra} node. Sensor node once become a member of a particular cluster, will remains a part of that cluster for the whole time.

2.2 Cluster Head and Relay Node Election Process

Let the percentage 'p' of sensor nodes to become CHs for the given round in the proposed method is,

$$\mathbf{p} = \frac{\left(\frac{\mathbf{M \times m}}{\mathbf{2}}\right)}{\mathbf{100}}$$

The round starts with CH selection stage, during which CH inside each cluster is selected according to the defined weighted election probability $p_s$of the sensor nodes.

$$p_s = \frac{100 \times p}{M(1-m)}$$

Also in a given round the threshold value defined in [Heinzelman *et al.,* 2000] for the selection of CH among the sensor nodes becomes,

$$Th(s) = \begin{cases} \dfrac{p_s}{\left[1 - p_s\left(r \bmod \left(\frac{1}{p_s}\right)\right)\right]} & \text{if } s \in C \\ 0 & otherwise \end{cases}$$

C defines the group of non- selected sensors in $1/p_s$ rounds, and r is the current round.

The threshold Th(s) applied to sensors ensures that the selection of sensors per round is $M(1-m)\times p_s$. Each sensor node selects a number randomly between 0 and 1. The node becomes a CH when this selected value is less than the threshold value. The nodes which are selected as CHs declare their status as Cluster Heads, and after that each non-Cluster Head sensor node connects to the closest elected CH. Inside the cluster sensor node CH receives join messages from the member nodes and it then creates a TDMA schedule for the nodes, so that the sensor nodes direct their sensed data within the allocated time slot to the CH.The foremost use of electing CH among sensor nodes in each cluster is to lower the communication cost to R_{intra} node. And also the CH responsibilityis revolving among the sensors inside the cluster for different rounds to make sure the balanced use of energy among the cluster member sensor nodes.

Similarly, the weighted probability for the election of R_{inter} nodes as defined in (Ben Alla *et al.,* 2011) is

$$p_h = \frac{R}{(M \times m)}$$

R= desired number of R_{inter} nodes in a round
Also the threshold applied to R_{inter} nodes is set by

$$Th(h) = \begin{cases} \dfrac{p_h}{\left[1 - p_h\left(r \bmod \left(\frac{1}{p_h}\right)\right)\right]} & \text{if } h \in C' \\ 0 & otherwise \end{cases}$$

C'defines the collection of non- elected R_{inter} nodes in $1/p_h$

2.3 Data Transfer Process

At the end of CH selection stage, CH within each cluster creates a TDMA schedule and informs its cluster member nodes about their time slot in which they can transmit sensed information. The CH receives data from cluster member sensor nodes and forwards it to the cluster R_{intra} relay node. The relay R_{intra} node performs data aggregation to reduce the data traffic in the system and if it is possible for the R_{intra} node to communicate with the BS, it then transfer this aggregated data to the BS, and if the BS is not located within the communication range of R_{intra} node then the R_{intra} node will select R_{inter} node from the elected set of R_{inter} nodes for the given round.

The R_{inter} will relay this data hop by hop ($R_{inter} \rightarrow R_{inter}$) till it reaches the BS. Their selection is based on the unexpended energy of the node. The R_{intra} node does not collect data from its neighbor clusters; it is only responsible for managing data of its own cluster members. However the R_{inter} node located inside the same cluster is involved in transferring data from the closest clusters.

Flow charts in (**Figs. 3 (a) and 3 (b))** show the processes of EETRNRP.

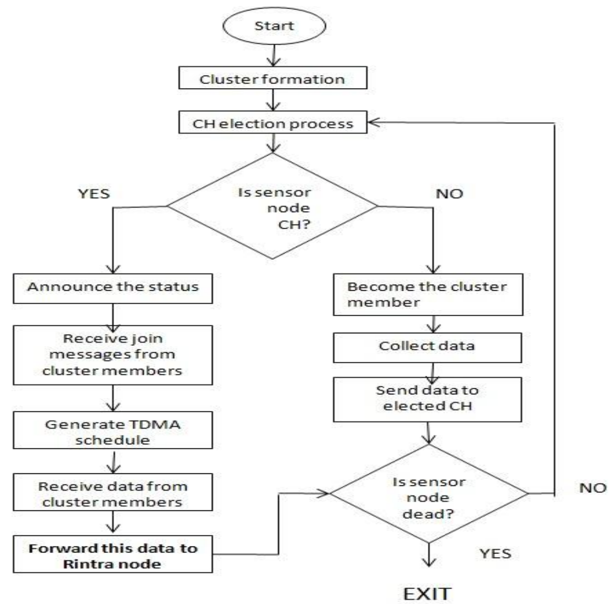

Figure 3(a) Communication and CH election process within the cluster

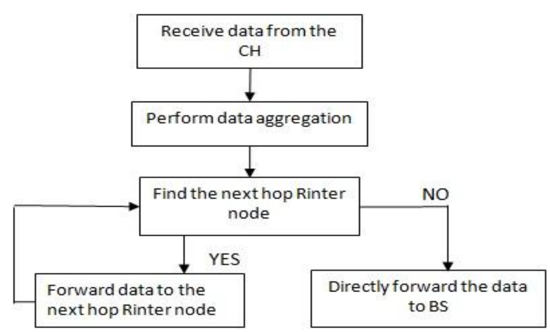

Fig.3(b) Relay nodes communication process

Path Loss Model

In wireless communication networks, estimation of path loss is considered to be very important. It can be represented as the ratio transmitted power of signal to the received power of signal. Two type of path loss model is used in clustered wireless sensor network, i.e. free space model and multi-path fading model.

Traffic Model

Methods for data transportation in wireless sensor networks can be divided as query driven, time driven, hybrid and event drive [Tilak *et al.,* 2002].

Sensor sends data packets to sink in continuous data reporting model. In case of query driven model, data are sent by the nodes on the reception of query from BS. Sensor nodes respond to quick change or when an event takes place. In hybrid model both query and event driven model are combined. These models affect routing protocols. In this model continuous data reporting model is used.

Data Aggregation Method

Data aggregation is a technique in which energy can be saved; in this method data transmission to the BS is reduced by eliminating the un-wanted data packets. The aim of these data routing protocol is to improve the lifetime of a system by efficiently collecting data and aggregating or compressing it. Various aggregation methods are specified like grid-based approach and In-network aggregation [Vaidyanathan *et al.,* 2004], cluster based aggregation method [Dasgupta *et al.,* 2003] and tree-based technique [Lee *et al.,* 2005]. One of the mostly used methods for aggregation is perfect aggregation approach [Kalpakis *et al.,* 2002]. In this method, first the data packets are transferred to CH by sensor nodes and after the reception of these packets, CH send it in a single data packet. In this work, perfect aggregation technique is used.

2.4 Energy Analysis

2.4.1 Network Initial Energy

Let $E_{is} =$ sensor node initial energy

$E_{iR} =$ relay node available initial energy

Where,

$$E_{iR} = E_{is}(1+\alpha)$$

Then network total energy will be,

$$E_{i\,total} = M(1-m)E_{is} + Mm(1+\alpha)E_{is}$$
$$= M(1+\alpha m)E_{is}$$

2.4.2 Energy Model

Simplified model (Heinzelman *et al.*, 2000) representing energy dissipation in the receiver and transmitter hardware is shown in **(Fig. 4).**

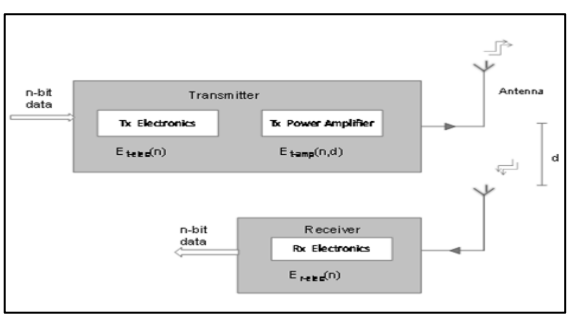

Fig. 4 Model for energy dissipation

Electronics energy dissipation in data reception and transmission is,

$$E_{t-elec}(n) = E_{elec} \times n$$
$$E_{r-elec}(n) = E_{elec} \times n$$

Where, E_{elec} represents the per bit energy used in the sender and receiver circuit, n represents n-bit data (bits/packet).The factors on which this electronic energy depends are modulation, digital coding, filtering and signal spreading. The transmitter amplifier energy dissipation is given by

$$E_{t-amp}(n,d) = n\varepsilon_{fs}d^2 \quad \text{if } d \le d_o$$

ε_{fs} represents the energy loss per bit in the transmitter amplifier in free space model,

Also,

$$E_{t-amp}(n,d) = n\varepsilon_{mp}d^4 \quad \text{if } d > d_o$$

ε_{mp} represents the energy loss per bit in the transmitter amplifier in multipath fading model. The amplifier energy depends on the acceptable bit error rate and also on the receiver distance.

The total energy expenditure for receiving n-bits data is given by,

$$E_{r-total}(n) = E_{elec} \times n$$

The transmitter section uses energy in its amplifier and radio electronics,

$$E_{t-total}(n,d) = E_{t-elec}(n) + E_{t-amp}(n,d)$$

$$E_{t-total}(n,d) = \begin{cases} (E_{elec} \times n) + (n\,\varepsilon_{fs}\,d^2) & \text{if } d \le d_o \quad \text{(i)} \\ (E_{elec} \times n) + (n\,\varepsilon_{mp}d^4) & \text{if } d > d_o \quad \text{(ii)} \end{cases}$$

The threshold distance d_o can be calculated by comparing equations (i) and(ii),

$$d_o = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

Energy used up on the aggregation of M(1-m)/(M×m/2) data packets is given as,

$$E_{aggregate} = \frac{nE_{DA}M(1-m)}{(Mm/2)}$$

E_{DA} represents the energy used for single bit aggregation and M(1-m)/(M×m/2) are the sensors in a cluster. The total energy used by R_{intra} in a given round is,

$$E_{intra}(n,d) = E_{t-total}(n,d) + E_{aggregate} + \left\{\frac{M(1-m)}{\frac{Mm}{2}}\right\} E_{r-total}(n).$$

The R_{inter} node is involved only in data relaying job, so its energy expenditure is given by,

$$E_{inter}(n,d) = E_{t-total}(n,d) + E_{r-total}(n)$$

3. EXPERIMENTAL SETUP AND RESULTS

In section 3, In order to enhance the lifetime and stability of the system and to make sure the efficient use of energy, an Energy Efficient Two relay Node Routing protocol is presented.

Various simulators are available for the performance evaluation of WSN, such as Glomosim, NS2, MATLAB, OPNET, JavaSim and OMNET++.

To evaluate the overall performance of the proposed

EETRNRP protocol, MATLAB simulations have been carried out for three different scenarios. Let 20% of the total nodes (m=0.2) are high energy nodes with 100% more available energy (α=1) than the ordinary sensor nodes. In scenario1 there are 100 heterogeneous nodes deployed in a network of size 100×100 m^2. In scenario2 a large network is considered with 300 heterogeneous nodes placed in an area of size 300×300 m^2. In the third scenario the performance of EETRNRP has been evaluated for different values of heterogeneity. For simplicity, error free links and an ideal MAC protocol is assumed.

Scenario1. In the simulation, the heterogeneous nodes are uniformly distributed over the sensing field of area 100m×100m as shown in **(Fig. 5).** In the heterogeneous network, total number of nodes are 100, among them 80 are sensor nodes and remaining are the nodes having higher amount of energy (10 R_{intra} nodes and 10 R_{inter} nodes). In figure, an ordinary sensor node is denoted by 'o', R_{intra} node by '+', and R_{inter} node by '*'. The BS is placed at the centre of the given area and is represented by '×'.

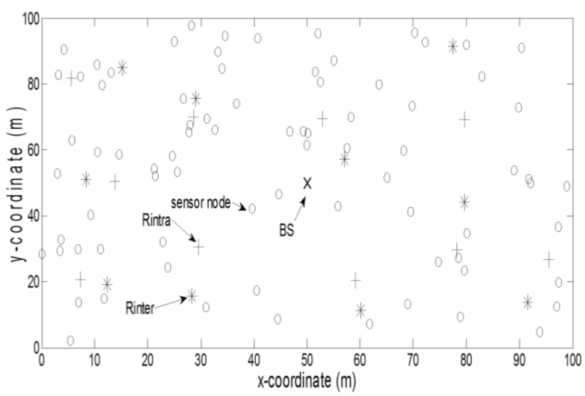

Fig.5. Network Model

Table I. Summary of different parameters used in the simulations.

Parameter	Value
Network Area	(100 ×100)m^2, (300×300)m^2
sensor node energy	0.5J
Relay node energy	1J
E_{elec}	50nJ
BS position	(50,50),(150,150)
Packet size	500bytes
E_{DA}	5nJ/bit
ε_{fs} ε_{mp}	10pJ/bit/m^2 0.0013pJ/bit/m^4

Performance Measures

- *Functional (alive) nodes per round.*
- *Variation of sensor network left over energy per round.*
- *Stability Period*
- *Number of data packets received by the elected CHs, and packets collected at the sink/BS.*

3.1 Simulation Results

(Fig. 6) presents the number of functional nodes in each data round for the EETRNRP protocol and SEP protocol. Their comparison shows that more nodes are functional and in active state in each round in the proposed protocol than SEP. Also in SEP the CHs are directly in contact with the BS, the far away CHs consume their energies earlier due to large distance communication, thus the stability portion is small. The proposed EETRNRP uses multi-hop data transmission technique which reduces the node energy dissipation.

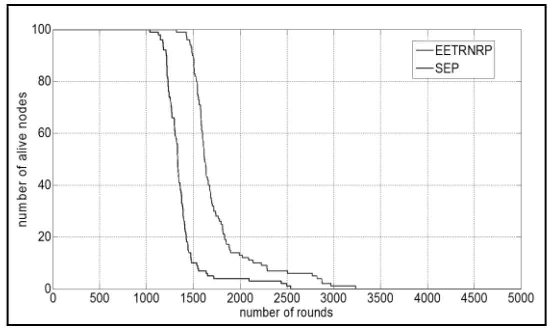

Fig. 6 Total functional nodes Vs rounds in scenario 1.

(Fig.7) shows existent high energy relay nodes in each round for EETRNRP and SEP protocol. The comparison demonstrates that in EETRNRP these nodes are consuming their energies in a useful way. The Relay R_{intra} nodes manage their own cluster activities and the other relay R_{inter} nodes perform the job of relaying data messages from other clusters towards the BS. Thus, in EETRNRP more high energy nodes are alive in each round.

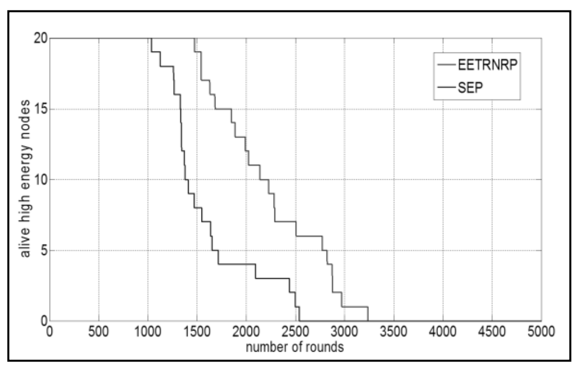

Fig.7 Comparison of EETRNRP and SEP (active high energy relay nodes vs rounds)

In EETRNRP protocols sensor nodes, communication between only cluster and the chosen sensor node CH take place, and this Cluster Head move ahead the data received from the cluster to it R_{intra}. Data aggregation is performed by node with the higher energy, R_{intra}. The communication among BS and sensor node CHs is not direct. The task of sensor node is done by almost all the nodes by a rotation procedure in order to improve energy balancing issue. In case of SEP, there is direct communication involved in data sharing with BS, so for this purpose more energy is required. In **(Fig. 8)** the active sensor nodes/round for the protocols is shown.

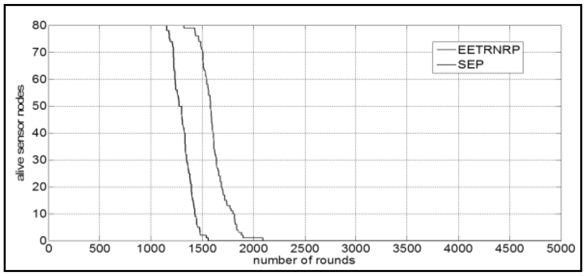

Fig.8 Comparison shows improvement in lifetime of sensor nodes in EETRNRP.

(Fig. 9 and 10) illustrate the packets per round directed to the elected CH nodes for EETRNRP and SEP respectively.

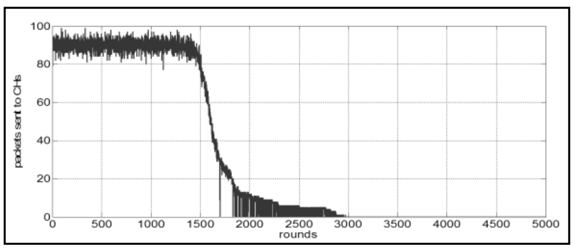

Fig. 9 Packets sent to CHs in EETRNRP

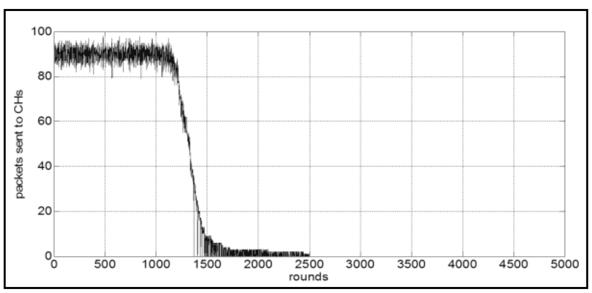

Fig. 10 Packets sent to CHs in SEP

In EETRNRP, respective R_{intra} nodes has forwarded the received packets by sensor CHs. Aggregated packet is transferred to BS using multi-hop strategy by each R_{intra} node, in case the latter is placed outside its range. In **(Fig. 11)** arrival of data packets at BS in each trip in EETRTNRP is shown. In case of SEP the aggregated packets are directly send to the BS by CH. In EETRNRP, the number of data packets sent by the CHs to the BS is more than that in case of SEP, because in EETRNRP more nodes are active in present round. **(Fig. 12)** shows the total number of packets/round arriving at the base station in SEP protocol.

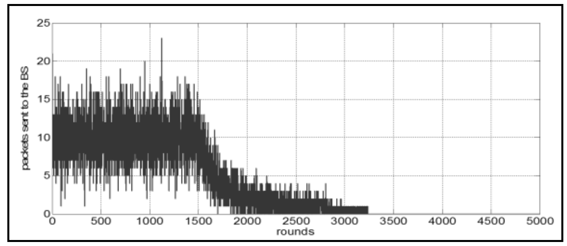

Fig.11 Data packets arrived at sink in EETRNRP

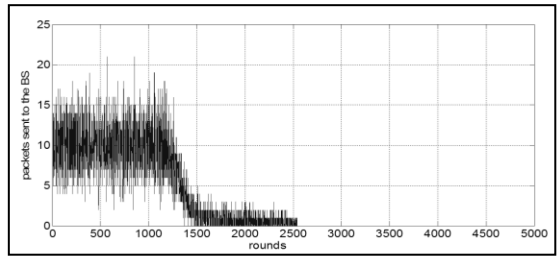

Fig. 12 Data packets arrived at sink in SEP

(Fig.13) shows the comparison of residual energy available per round in both protocols.

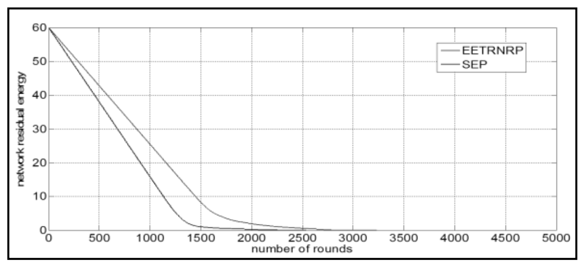

Fig. 13 Residual energy available in the network per round.

More alive nodes in each round verifies the fact that in EETRNRP relay nodes as well as sensor nodes make efficient use of their energies. Thus more energy per round is available in EETRNRP.

Table 2. Summary of Simulation Results for Scenario1

	EETRNRP protocol	SEP protocol
Round for first dead node	1321	1036
Round for all dead nodes	3300	2520
Packets forwarded to CHs	154078	121145
Packets forwarded to BS	18292	14114

As the first node became non-functional, network functional time is being represented by Stability of network while interval of network starting until the last node become non-functional is represented by network operational time. From **(Table 2)**.

Improvement in lifetime =

$$\frac{\text{operational period of EETRNRP} - \text{operational period of SEP}}{\text{operational period of SEP}}$$

$$= \frac{3300 - 2520}{2520}$$

$= 30.9\%$

Improvement in stability =

$$\frac{\text{stable period of EETRNRP} - \text{stable period of SEP}}{\text{stable period of SEP}}$$

$$= \frac{1321 - 1036}{1036}$$

$$= 27.5\%$$

The proposed EETRNRP protocol prolongs the stability period and life span of WSN.

Scenario 2: "Performance of EETRNRP in large networks"

To compare the overall performance of EETRNRP with SEP in large networks, a network with 300 nodes placed over an area $300\times300m^2$ has been considered, other simulation parameters are same as for scenario 1. Since SEP adopts single hop communication, it shows poor performance in large network areas because; all the cluster head nodes have to consume more battery energy to perform the long distance communication, whereas EETRNRP adopts Multihop communication approach between CHs and the BS to save the energy of the sensor network. In this approach nodes can operate for a longer period of time.Simulation results in **(Fig.14 and 15)** show that EETRNRP has better stability, energy efficiency and network lifetime when compared with SEP protocol. It increases the network stability by 75% and prolongs the lifetime by 68% against the SEP.

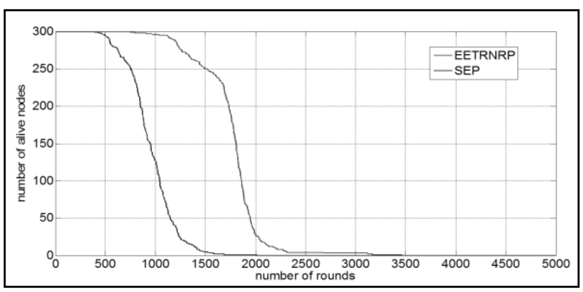

Fig. 14 Alive nodes vs rounds

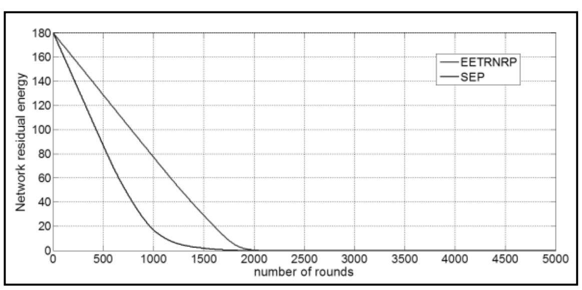

Fig. 15 Residual energy available in the network per round.

The first node dies faster in both protocols for scenario 2 as compared to that in scenario 1. Node density affects the overall network performance. Increasing the network life span by adding more nodes in the network is not a good option. It may result in even earlier network failure **(Table 3)**.

Table 3. Summary of Simulation Results for Scenario2

	EETRNRP protocol	SEP protocol
Round for first dead node	700	400
Round for all dead nodes	3400	2023
Packets forwarded to CHs	430716	254715
Packets forwarded to BS	42158	29300

Scenario 3. A network of 100 nodes with m=0.2is deployed in $100\times100m^2$ area. Simulations are conducted for different values of α (α=1, 1.5, 2, 2.5, 3) to evaluate the stability of the system for the two protocols. The longer stable period of the system implies the better reliability of the routing mechanism in the network. **(Table 4)** provides information about the network stability in terms of data rounds for various values of heterogeneity.

Table 4 provides information about the network

Different values of heterogeneity	**Length of stability portion in rounds**	
(α×m)	SEP protocol	EETRNRP protocol
0.2	1036	1321
0.3	1122	1458
0.4	1187	1534
0.5	1212	1539
0.6	1346	1623

(Fig. 16) shows comparison of stability of the proposed EETRNRP and SEP.

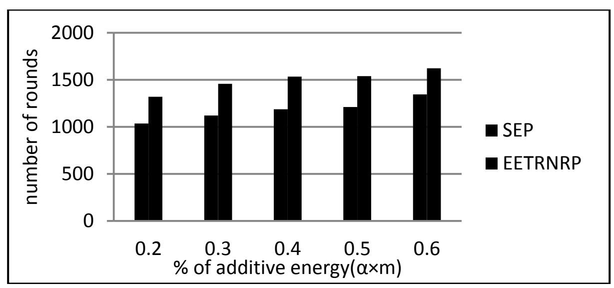

Fig.16 Length of stability in rounds for various values of heterogeneity.

In EETRNRP because of the fixed clusters task in heterogeneous network, stability of the network depends upon the cluster heads functioning time, as these relay nodes are involved in transferring data to the BS, thus increase in energy of the relay nodes further increases the network stability period.

4. CONCLUSION AND FUTURE WORK

Cluster-based routing protocols are appraised to be greatly energy efficient. Energy dissipation of the nodes is minimized effectively in this protocol by only communicating with the CHs nearer to them as compared to the base station. In single hop transmission CHs placed at larger distance from BS will consumes energy more rapidly. While in case of multi-hop, data flows on the multi hop path till it arrives at the BS. Few routes became overloaded resulting in early consumption of energy in CHs located near base station, because of their participation in switching their data packets from further CHs. Selection of path is very important. Also, in order to improve the lifetime and achieve better stability of a network, uniform distribution of data relaying loads is necessary. During packet transmission those areas which lack power resources must be avoided. In the proposed work a clustering technique based routing protocol EETRNRP is presented to improve the network stability and lifetime. Cluster formation in the proposed protocol depends upon the number of relay nodes. Two relay nodes in a cluster provide two paths for data routing through a cluster. The relay node R_{intra} will manage its own cluster activities and will forward data of the same cluster, and the other relay node R_{inter} will perform the function of relaying data from other clusters. The role of CH is rotated among the sensors in a cluster to achieve balance energy usage of nodes. Simulation outcomes show that EETRNRP makes efficient use of the limited energy of the node and it increases the stability period and lifetime of WSN.

Future work will include the modification of EETRNRP in which the two relay nodes in each cluster will work cooperatively during data forwarding process, and to study its impact on energy and lifespan of the network. Another direction of future work would be to consider mobility of high energy R_{intra}nodes within the cluster. As each node in a cluster gets a chance to be elected as CH and the distance to R_{intra} node varies for each node, thus the movement of R_{intra} node to each of the elected CH node will further help in balancing the energy usage of sensor nodes.

REFERENCES:

Al-Karaki. J. N., and A. E. Kamal (2004) "Routing techniques in wireless sensor networks: a survey" *IEEE journal of Wireless Communications,* vol**. (11):** 6-28,.

Ben Alla. S., A. Ezzati, A. B. Hassane, and M. L. Hasnaoui, (2011) "Hierarchical adaptive balanced Energy efficient routing protocol (HABRP) for heterogeneous wireless sensor networks", *Int'l Conf. On Multimedia Computing and Systems (ICMCS)* V. **(4):** 1-9.

Chov.P.H., and C. Park, (2005) "Energy–efficient plateform designs for real-world wireless sensing applications", in *Proc. IEEE/ACM Int'l Conf. on computer aided design,*. 1243–1249.

Dasgupta. K., K. Kalpakis, and A. Namjoshi, (2003) " An Efficient Clustering- based Heuristic for DataGathering and Aggregation in Sensor Networks", in *Proc. IEEE Wireless Communications and Networking,* Vol. **(2):** 1–8.

Gholamzadeh. B. and H. Nabovati (2008) "Concepts for Designing Low Power Wireless Sensor networks",World Academy of Science, Engg &Tech,.

Healy. M., T. Newe, and E. Lewis, (2008) "Wireless Sensor Node Hardware: A review" , *IEEE Sensors,*

Heinzelman W. R., A. Chandrakasan, A. H. Balakrishnan, (2000)"Energy Efficient Communication Protocol for Wireless Microsensor Networks ", in *Proc. 33rd Hawaii Int'l Conf. on System Sciences, 2000.* 1–10.

Jehangir. A., M. Inayatullah babar, N. Khurshid, R.A. khalil, and S. Akbar, (2012) "EETRNRP:Energy efficient two relay node routing protocol for sensor networks , *8th IEEE International conference on emerging technologies*, Islamabad, 461-466.

Karl. H. and Andre. "Protocols and Architectures for wireless sensor networks" *John Wiley &Sons,.*

Kumar. D., R. Patel, and T.C. Aseri. (2010) "Prolonging Network lifetime and data Accumulation in Heterogeneou Sensor networks", *The Int'l Arab Journal of Information Technology,*. Vol. **(7):** 302-309.

Kalpakis. K., K. Dasgupta, and A. Namjoshi, (2002) "Maximum lifetime Data Gathering and Aggregation inWireless Sensor Networks", in *Proc. IEEE Wireless Communications and Networks,*. Vol. **(4):** 1–9.

Lee.M., and V.W.S Wong, (2005) " An energy –aware spanning tree algorithm for data aggregation In wireless sensor networks", *IEEE Pacific Rim Conf. Communications, Computers and Signal Processing,* 2005. PACRIM. 300–303.

Pottie. D. J., (2000) "Wireless Integrated Network Sensors", *Communication of the ACM,* vol. **(43):**.54-58.

Raghunathan. V., C. Schurgers, S. Park, and M.Srivastava, (2002) "Energy aware Wireless Sensor Networks", *IEEE Signal Processing Magzine,* .

Smaragdakis. G., I. Matta, and A. Bestavros, (2004). "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks" in *2nd Int'l Workshop on Sensor and Actor Network protocols and Applications (SANPA 2004).* 1–11.

Saeidmanesh. M., M. Hajimohammadi, and A. Movaghar. (2009) "Energy and distance based clustering method for wireless sensor networks", World Academy of Science Engg &Tech .

Tilak. S., N. B. Abu-Ghazaleh and W. Heinzelman, (2002) "A Taxonomy of Wireless microsensor network models" *ACM SIGMOBILE Mobile Computing and Communications Review,*. Vol. **(3):** 1–5.

Vaidyanathan.K., S. Sur, S. Narravula, and P. Sinha, (2004) " Data aggregation techniques in Sensor Networks",osu-cisrc-11/04-tr60, the Ohio State University,. 1–10.