International Journal of Future Generation Communication and Networking
Vol. 13, No. 3, (2020), pp. 4060–4068

A Relative Simulation Study of Energy Aware Routing Protocols for Wireless Sensor Network

Chetan Rajan Dongarsane [1], D.Maheshkumar [2],Arvind H.S.[3]

[1] *Sanjeevan Engineering & Technology Institute, Kolhapur,Maharashtra,India*
[2] *JSS Academy of Technical Education, Bengaluru,Karnataka, India.*
[3] *JSS Academy of Technical Education, Bengaluru,Karnataka, India.*

[1]chetanndongarsane@gmail.com,[2]dmkjssate@gmail.com

Abstract

In recent research advancements attaining the energy efficiency, lifetime, latency, nodes positioning in other words high reliability along with robustness have become the prime research objectives of wireless sensor network. By this paper there is an effort to provide a comparative analysis of the routing protocols, centring our work on energy parameter. Focusing on the clustering based routing protocols, we simulate and compare Distributed Energy Efficient Clustering (DEEC) and Energy Efficient Sleep Awake Aware (EESAA).We prove how idea of pairing amongst sensor node makes better utilization of energy than conventional clustering based methods also with improved other network parameters.

Keywords: *Clustering, pairing.*

1. Introduction

In collecting and supplying of valuable data to the target Wireless Sensor Networks (WSNs) got an innovatory revolution. Now a day applications like battleground observation, smart office, traffic watching and etc are exclusively depends on WSNs only. WSN is collection of several miniatures, finite-energy sensor nodes arranged arbitrarily in the intended zone such as unapproachable areas for collecting valuable data. Miniature sensor nodes are capable of sense and process valuable data from, and can transmit to end target. It has released many research concerns. These sensor nodes which are cell-operated fixed with finite processing and storing abilities. As WSNs are perceptible to vibrant surroundings, there will be a frequent alteration in connection configuration causes disconnection among nodes cause degradation in the network performance. Deign of energy efficient protocol which can therefore improve the network lifespan is significant for improving performance of WSN. Energy saving along with lengthening network lifespan are main challenges in WSNs. One of the prime methods employed to improve energy consumption in WSN is clustering [9]. In modern years, based on clustering configuration several routing protocols have been suggested. Clustering can be done in heterogeneous and homogeneous network types on the energy basis. In homogeneous type nodes have equal primary energy while with heterogeneous type, nodes have dissimilar primary energy. Clusters are the structural unit of WSNs. As WSN's are very dense in nature it requires them to be fragmented down into clusters to streamline communication among them. It is possible to make a sensor network ascendable by gathering the sensor nodes into sets i.e. clusters. Every single cluster has a spearhead, frequently mentioned as the cluster head (CH). Cluster associated nodes transfer their info to CH, which aggregates it as well as forwards to remotely located base station (BS) from the field. CH's had to expend extra energy compare to remaining nodes for a particular spell. Numerous cluster based protocols like LEACH, PEGASIS, TEEN, VGA etc. [1] are suggested which clarify the proficient utilization of energy in wireless sensor networks. DEEC [2] comes from the idea of clustering-based algorithm where selection of CH is on the basis of probability of ratio amongst networks remaining energy and average energy. Preferably selected CH is the node with extra energy. It extends the network lifespan. In EESAA the energy consumption is minimized by using the pairing concept. Same application sensor nodes and those

ISSN: 2233-7857 IJFGCN

are at least distance apart will configure a pair of nodes for data sensing and communication. Similar to DEEC, on remaining energy basis this protocol will determine its CHs. Sensor nodes collected data is sent to the CHs, who transfer this data to far apart located BS from the field [11].

2. Related Work

Energy is constantly remains a limitation in both types of WSNs, (Homogenous, Heterogeneous). Many methods have been suggested to make use of sensor nodes energy in a superior way. Energy efficiency of the sensors is one of the vital parameter in WSN that straitly affect the network lifespan. For homogeneous WSN's a hierarchical clustering algorithm, named Low Energy Adaptive Clustering Hierarchy (LEACH) presented by Heinzelman, et. al.[8].It is a cluster-based protocol, which comprises distributed cluster creation. LEACH arbitrarily chooses some sensor nodes as CHs and revolves this role to uniformly allot the energy load between the network sensors [3]. Power Efficient Gathering in Sensor Information Systems (PEGASIS) [9] is one of the chain type protocol which comprises cluster creation also practices single node within a chain to send data to the BS rather than several nodes. A.Manjeshwar et. al suggested Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [10]. TEEN uses a hierarchical method together with data-centric mechanism. In which CH broadcasts two thresholds to the nodes. TEEN is unsuitable for applications where cyclic reports are required, rather suitable for time crucial applications. Because if the thresholds are not attained, the user unable to catch any info. Hybrid Energy-Efficient Distributed clustering (HEED)[6] algorithm designed for homogenous (usually Ad-Hoc) WSN. It follows a distributed clustering procedure. HEED is independent of network size and its topology however it considers that the sensors are smart i.e. they can revise their transmission power. Likewise, SEP [8] (A Stable Election Protocol for clustered heterogeneous wireless sensor networks) is protocol to lengthen the time interval previous to first node expires. (i.e. stability period). It is designed with the idea of normal and advanced nodes for the election of CH.

3. The Simulated Protocols

3.1 The DEEC Protocol

Aimed at the heterogeneous wireless sensor network DEEC is a distributed and clustering based energy aware protocol. DEEC stands for "Distributed Energy Efficient Clustering". For two and multilevel heterogeneous networks, DEEC is very effective .It is founded on the basic LEACH protocol apart from the CH selection technique is changed here. Selection of CH's is done on the basis of probability based ratio among the average energy of the system and the residual energy of each node. While DEEC can be executed on the multi-level heterogeneous WSN, it supports the distributed property. All the nodes perform the role of CH in rotation to expend energy uniformly.

Working of DEEC: All the nodes require knowing the entire energy as well as lifespan of the network. Network's Average energy is considered as the reference energy. Hence, at every election round DEEC does not need any overall energy information.

Let s_i symbolize node and n_i is the number of rounds to be a CH. In every round the optimal number of CHs in the network is $poptN$. Depending on nodes energy level, CHs are selected in DEEC. As in homogenous network, when nodes have equivalent energy in every single time period then taking p_i = p_{opt} promises that $poptN$ CHs in each round. In WSNs, nodes who consist of additional energy having more probability to turn into CH than lesser energy nodes however throughout every round the net value of CHs is equivalent to $poptN$. For each node s_i the probability to become CH is p_i [12]. So, node having more energy has higher value of pi as related to the $popt$. During round r network's average energy is indicated by $\bar{E}(r)$, as [12]

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} Ei\ (r) \quad (1)$$

In DEEC probability of CH selection is, as [12]

ISSN: 2233-7857 IJFGCN

$$p_i = [1 - \frac{E(r) - Ei(r)}{\bar{E}(r)}] = popt \frac{Ei(r)}{\bar{E}(r)} \quad (2)$$

During each round, the average total number of CH [12]

$$\sum_{i=1}^{N} pi = \sum_{i=1}^{N} p = popt \frac{Ei(r)}{\bar{E}(r)} \; popt \sum_{i=1}^{N} \frac{Ei(r)}{\bar{E}(r)}$$
$$= Npopt \quad (3)$$

Where G is the bunch of nodes qualified to turn into CH at round r. Means if node becomes CH in current rounds then it fits to G. Each single node opt for an arbitrary number between 1 and 0 during each round. To become a CH the number should be less than threshold as explained in equation 4 [12], else not.

$$T(s_i) = \begin{cases} \frac{pi}{1 - pi(rmod\frac{1}{pi}} & if\ si\epsilon G \\ 0 & otherwise \end{cases} \quad (4)$$

As $popt$ is reference value of average probability pi. All nodes have equal primary energy in homogenous networks thus they use $popt$ to be the reference energy for probability pi. Though in heterogeneous networks, the value of $popt$ is different according to the node's primary energy. For two level heterogeneous network the value of $popt$ is [12]

$$p_{adv} = \frac{Popt}{1+am},\ p_{nrm} = \frac{Popt(1+a)}{(1+am)} \quad (5)$$

Then for two level heterogeneous network use the above p_{adv} and p_{nrm} instead of $popt$ in equation 5 as supposed in [12]:

$$p_i = \begin{cases} \frac{PoptEi(r)}{(1+am)E(r)} & if\ Si\ is\ the\ normal\ node \\ \frac{Popt(1+a)Ei(r)}{(1+am)\bar{E}(r)} & if\ Si\ is\ the\ advanced\ node \end{cases} \quad (6)$$

It is possible to prolong above prototype to multilevel heterogeneous network is [12]

$$p_{multi} = \frac{PoptN(1+ai)}{N+\sum_{i=1}^{N} ai} \quad (7)$$

Using above p_{multi} in equation 7 rather than p_{op}, to get p_i for heterogeneous node.

p_i for the multilevel heterogeneous network is [12]

$$p_i = \frac{Popt(1+a)Ei(r)}{(N+\sum_{i=1}^{N} ai)\bar{E}(r)} \quad (8)$$

We evaluate network's average energy (r) for any round r is [12]

$$\bar{E}(r) = \frac{1}{N} E_{total} (1 - \frac{r}{R}) \quad (9)$$

R represents total number of rounds of network lifespan and is projected as below:

$$R = \frac{Etotal}{Eround} \quad (10)$$

E_{total} is overall network energy

E_{round} is energy spent in each round.

Thus, in DEEC at every election round it does not need overall knowledge of energy. Performance of DEEC is superior in multi-level heterogeneous WSNs.

3.2 The EESAA Protocol

In EESAA (Energy Efficient Sleep Awake Aware**)**, nodes alter among "Sleep" and "Awake" mode throughout a single communication intermission. Primarily nodes in a pair change into Active-mode if it is nearer to BS than its coupled node. Active-mode nodes will collect info from surrounds also send it to CHs. In this era coupled node transceiver will endure silent, and shifts into Sleep-mode. Sleep-mode nodes simply sense the network status and terminate their communication with CHs. In succeeding communication intermission, Active-mode nodes shift into Sleep-mode and vice versa. By this manner, it is to minimalize energy consumption because energy of Sleep-mode nodes saved by preventing networking with the CHs. Also energy of sleep-mode nodes gets conserved by sidestepping eavesdropping as well as idle listening throughout Sleep-mode. Remote nodes stay in Active-mode for each round until their energy resources exhausted [11][13].

ISSN: 2233-7857 IJFGCN

Working of EESAA: In this, CHs are selected after finishing first round on the basis of each node's residual energy. Active-mode nodes involve in CH determination practice. In initial round while entire nodes have equivalent primary energy E_o then CH is selected on the probability basis using distributed algorithm, active-mode nodes will choose them self as CHs. Every node picks out a number among 0 to 1 randomly and relates it to a threshold T_h, calculated as [11]

$$T_h = \begin{cases} \frac{Pd}{1-Pd*(Firstround)\bmod\frac{1}{Pd}} & if\ n \epsilon A \\ 0 & Otherwise \end{cases} \quad (1)$$

where, A is Active mode nodes set in first round. If node selects any arbitrary number which is smaller than T_h, then Node will declare itself as a CH.

For 'K' optimal number of CHs and 'N' total number of nodes, in each cluster the average number of nodes will be [11]

$$\left(\frac{N}{K}-1\right) \quad (2)$$

So as to transfer data, a non-CH node radio dispels E_{TX} to run the transmitter system also E_{amp} for transmit amplifier to attain suitable SNR. Hence, a non-CH node extends for transmission of L_C bit message [11]

$$E_{non-CH} = \left(\frac{N}{K}-1\right)(E_{TX}\times L_C\times E_{amp}\times L_C\times d^2 \text{ to CH} \quad (3)$$

The radio of CH in each cluster expands for the reception of data from non-CH node by [11]

$$E_{rec}=(E_{RX}\times L_c)\left(\frac{N}{K}-1\right) \quad (4)$$

where for reception of data, E_{RX} is energy dissipate by receiver system.

To aggregate data received from its linked nodes energy dissipated by CH is.[11]

$$E_{AGR} = (E_{AD} \times Lc)\left(\frac{N}{K}\right) \quad (5)$$

E_T is transmission energy dispels by CH to transmit aggregated data to the BS is [11]

$$E_T = E_{TX} \times L_A \times Eamp \times L_A \times d^2 \text{ to BS} \quad (6)$$

Where, L_A denotes aggregated data and d^2 to BS is the distance amongst CH and BS. Overall energy dispelled by CH a round is [11]

$$E_{CH}=E_{rec}+E_{AGR}+E_T \quad (7)$$

Overall energy dissipate by CH is the sum of energy dispelled in data reception from its connected nodes, received data aggregation plus transmission of that data to the BS [13].

4. Simulation Test setup

In this segment we examine the both routing protocols. We provide the main variances between both protocols DEEC and EESAA using four parameters. For analyzing and relating the performance we consider the following metrics:

I. **Stability period**: It is a network operation period from beginning till first node expires.
II. **Network lifespan**: It is a period from beginning till final node is active.
III. **Number of CHs**: It specifies the number of clusters produced per round.
IV. **Packet from CH to BS**: It is rate of successful data delivery from CHs to BS.
V. **Energy consumed**: It is energy spent with respect to rounds.

4.1 Simulation Parameters

Sr. No.	***Parameter***	***Value***
1	*Network dimensions*	*100m * 100m*
2	*Packet Size*	*5000bit*
3	*Initial Energy*	*0.5J*
4	*Data Aggregation Energy*	*50pj/bit j*
5	P_d	*0.1J*

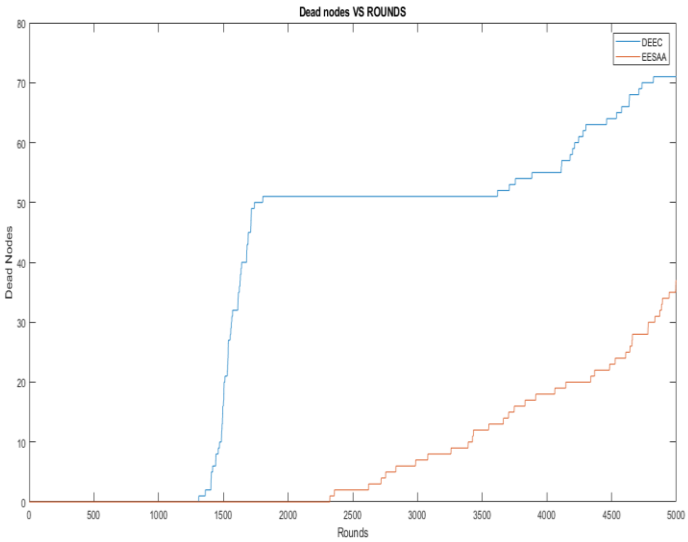
ISSN: 2233-7857 IJFGCN

6	*Number of nodes*	*100*
7	*Transmitter Electronics ($E_{electTx}$)*	*50 nJ/bit*
8	*Receiver Electronics (E_{elecRx})*	*50 nJ/bit*
9	*Transmit amplifier (E_{amp})*	*100/bit/ m2*

4.2 Simulation Results

We assess the performance of both the protocols by performing relative simulations. In simulations a 100m × 100m size sensor field is created. Where sensor nodes (100) having primary energy E_o are arbitrarily placed. We analyze network lifespan of DEEC and EESAA protocols. As the network advances we can observe that how numbers of active nodes are varying. In fig 1 indicates that EESAA has a lengthen stability period as relate to the DEEC protocol. Moreover, first node expires nearby 2350 round indicates stability period of EESAA is nearly 38% superior to DEEC. From fig. 1 it is also illustrated that EESAA has 90% maximum network lifespan as related to DEEC.

Fig -1: Expired nodes for 100m × 100m network having 100 nodes



Due to node's sleep-awake property along with productive CH selection's algorithm, we can observe as of Fig.2 that the first node expires about 2350 and final node expires after 4800 rounds. It means as compare DEEC instable section in EESAA starts far ahead.

Fig -2: CHs per round

ISSN: 2233-7857 IJFGCN

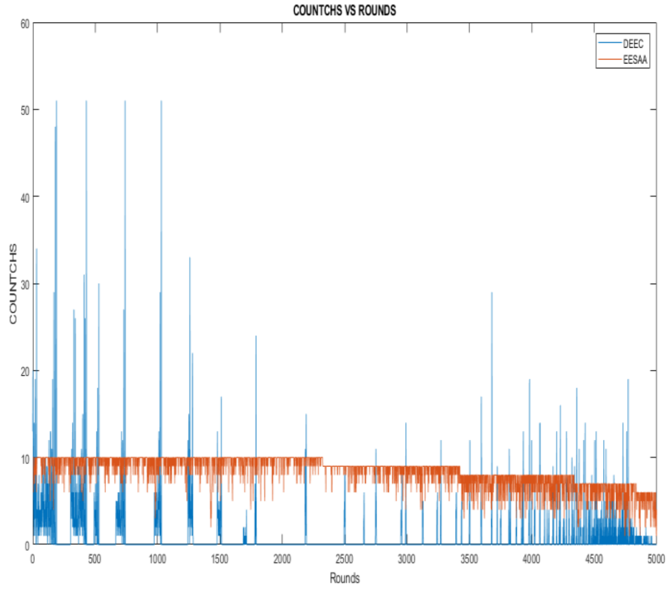


Figure.3 shows EESAA nodes expires persistently. This shows energy dissipation is appropriately distributed between entire nodes in the network hence it raises network lifespan. In fig .3 we can analyse the number of selected CHs during each round for both protocols, also it shows successful data delivery.

Fig.3: Nodes from Packet to BS $100m \times 100m$ Network having 100 nodes

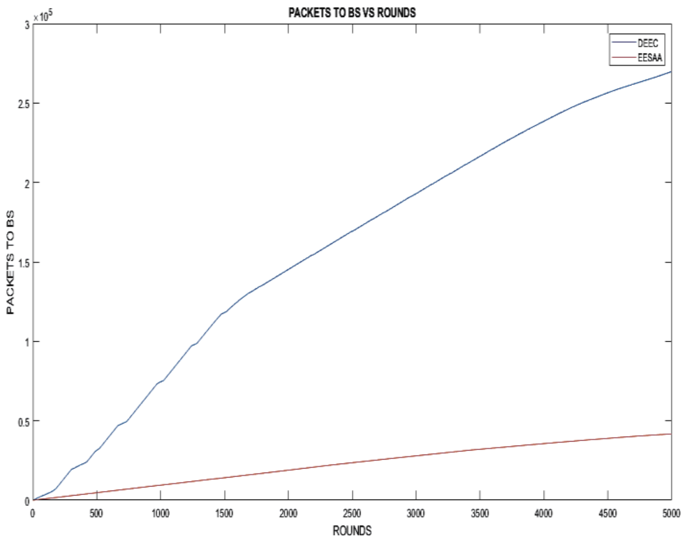


Fig.4 indicates DEEC is relatively weak in decision making of CHs determination. CHs are selected in each round randomly however EESAA has certain outlines and organized CHs selection. EESAA guarantees successful data delivery to BS though it has sleep-awake strategy for nodes and hence a smaller quantity of data is transferred to BS. Also due to improved data rate extended network lifespan of EESAA is achieved.

ISSN: 2233-7857 IJFGCN

Fig. 4: Alive Nodes for $100m \times 100m$ Network having 100 nodes

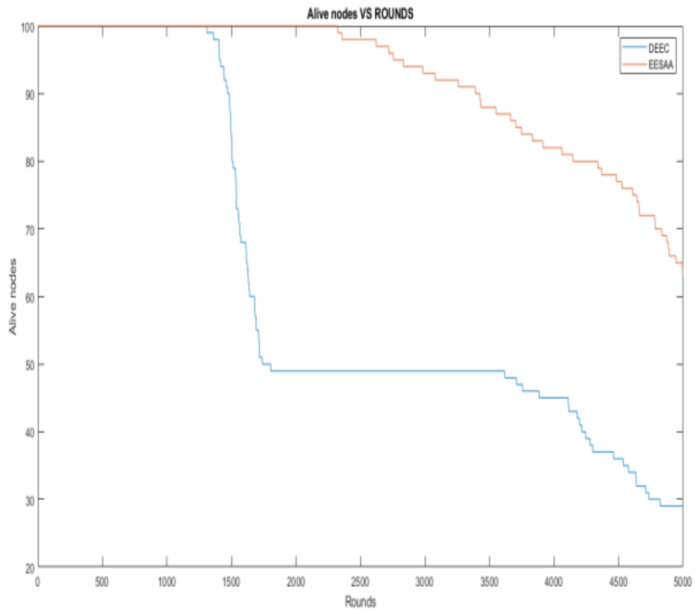
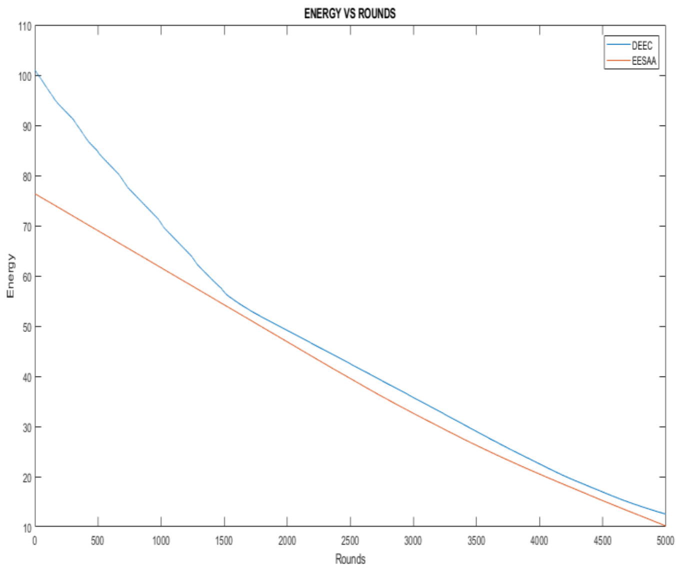


Fig. 5: Energy consumed with respect to rounds



As shown in fig.5 for DEEC up to around 1500 rounds there is marginal difference in energy spent by the nodes as compare to EESAA. Afterwards the rate of energy consumed with respect to rounds is at constant rate but slightly high for DEEC.

ISSN: 2233-7857 IJFGCN

5. Conclusion

By this paper, we showed a broad comparison of two routing protocols for WSNs. In EESAA, CHs are selected on the remaining energy basis. As nodes switches amongst sleep and active modes results in minimization of energy consumption. In EESAA, stability period and network lifespan has been optimized. From simulation outcomes we can observe that there is major development in overall parameters while compared with DEEC. Higher data rate achieved because of extended network lifespan of EESAA.

Based on these outcomes, we will continue to investigate the performance of these routing protocols in more complex situations and will try to combine the finest features in them (which led to their good performance) to design a novel or hybrid routing protocol and test it as well.

6. References

6.1 Journal articles

[1] Zain ul Abidin Jaffri*, Sundas Rauf, "A Survey on "Energy Efficient Routing Techniques in Wireless Sensor Networks Focusing On Hierarchical Network Routing Protocols", International Journal of Scientific and Research Publications, Volume 4, Issue 2, February 2014.

[2] L. Qing, Q. Zhu, and M. Wang, "Design of a distributed energy efficient clustering algorithm for heterogeneous wireless sensor networks," Comput. Commun., vol. 29, no. 12, pp. 2230–2237, 2006.

[3] Jamal N. Al-Karaki, Ahmed E. Kamal, "Routing Techniques In Wireless Sensor Networks: A Survey", IEEE Wireless Communications, Volume: 11, Issue: 6, 26- 28, December 2004.

[4] O. Younis, S. Fahmy, "HEED:,A hybrid, energy efficient,distributed clustering approach for adhoc sensor networks",IEEE Transactions on Mobile Computing vol 3, no 4, pp,660-669, 2004

[5] A.Imene, K.Okba, K.Laid, S.Sylvie, "A new Itinerary Planning Approach Among Multiple Mobile Agents in Wireless Sensor Networks (WSN) to Reduce Energy Consumption", International Journal of Communication Networks and Information Security (IJCNIS), Vol. 7, No. 2, pp.116-122 August 2015

[6] Ossama Younis, Student Member,"HEED, "A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks", IEEE, and Sonia Fahmy, Member, IEEE,2004

6.2 Conference Paper

[7] N. Javaid, T. N. Qureshi, A. H. Khan, A. Iqbal, E. Akhtar, and M. Ishfaq, "EDDEEC: Enhanced developed distributed energy efficient clustering for heterogeneous wireless sensor networks," Procedings Comput. Sci., vol. 19, pp. 914–919, 2013.

ISSN: 2233-7857 IJFGCN

[8] W.Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless sensor networks," in the Proceeding of the Hawaii International Conference System Sciences, Hawaii, January 2000.

[9] S. Lindsey and C. S. Raghavendra, March 2002, "PEGASIS: Power Efficient Gathering in Sensor Information Systems," in the Proceedings of the IEEE Aerospace Conference, Big Sky, Montana.

[10] A. Manjeshwar and D. P. Agarwal, "APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks," Parallel and Distributed Processing Symposium., Proceedings International, IPDPS, pp. 195-202, 2002.

[11] G. Smaragdakis, I. Matta, A. Bestavros,.“SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks”, in: Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA 2004), 2004

[12] L. Qing, Q. Zhu, M. Wang, “Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor network”, ELSEVIER,Computer Communications 29, pp 2230- 2237, 2006.

[13] T. Shah, N. Javaid, T. N. Qureshi, “Energy Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol” ,2012.

[14] T. N. Qureshi, N. Javaid, M. Malik, U. Qasim, Z. A. Khan “On Performance Evaluation of Variants of DEEC in WSNs”, Seventh International Conference on Broadband, Wireless Computing, Communication and Applications,2012.

6.3 Workshop

[15] Ansam ennaciri, Mohammed erritali, Jamaa bengourram “Load Balancing Protocol (EESAA) to improve Quality of Service in Wireless sensor network”, International Workshop on Web Search and Data Mining (WSDM) April 29 – May 2, 2019, Leuven, Belgium, Elsevier proceedings

ISSN: 2233-7857 IJFGCN