International Journal of Research in Engineering, Science and Management
Volume-1, Issue-8, August 2018
www.ijresm.com ISSN (Online): 2581-5782

Threshold Based Load Balancing Protocol for Energy Efficient Routing in WSN

Ranjeet Kumar[1], M. V. Satyanarayana[2], P.A. Vijaya[3]
[1]*Lecturer, Department of ECE, GPTL-DTE, Raichur, India*
[2,3]*Professor, Department of ECE, Malnad College Of Engineering, Hassan, India*

***Abstract*— As the Internet services spread all over the world, many kinds and a large number of security threats are increasing. Therefore, intrusion detection systems, which can effectively detect intrusion accesses, have attracted attention. This paper describes a novel fuzzy class-association rule mining method based on genetic network programming (GNP) for detecting network intrusions. GNP is an evolutionary optimization technique, which uses directed graph structures instead of strings in genetic algorithm or trees in genetic programming, which leads to enhancing the representation ability with compact programs derived from the reusability of nodes in a graph structure. By combining fuzzy set theory with GNP, the proposed method can deal with the mixed database that contains both discrete and continuous attributes and also extract many important class association rules that contribute to enhancing detection ability. Therefore, the proposed method can be flexibly applied to both misuse and anomaly detection in network-intrusion-detection problems. In this paper, Our proposed cluster based routing algorithm has exploited threshold level based load balancing and role transfer techniques along with multi-assistant cluster heads to cope with the aforementioned power hungry issues. Merger of multihop and direct routing has ameliorated the energy utilization efficiency of our protocol. Initial empirical results have demonstrated the better performance of our idea: TLPER, with respect to above mentioned parameters.**

Key Words— load balancing, sensor network, energy efficient routing, cluster head, assistant cluster head, threshold level exploitation

I. Introduction and Motivation

MEMS technology is one that quietly changing the way of our lives and revolutionizing the technology style. Advances in MEMS technology have given the concept for the development of large-scale Wireless Sensor Networks (WSN). Synergistic mating of wireless communication, sensors and network technology come up with this emerging and pervasive field of wireless sensor network. This idiosyncratic technology has its application in Glacier monitoring [1], volcano monitoring and tunnel monitoring and rescue, sniper localization [2], ocean water and bed monitoring, rescue of avalanche victims [3], tracking vehicles, wildlife monitoring [4], cattle herding, vital sign monitoring [5] and cold chain monitoring [6].

Apart from all these inseparable involvement, less computing power, stringent constraint energy and limited bandwidth circumscribed WSN's application as well as hiring the existing protocols from its ancestor: Adhoc and wireless technology. So an entombed protocol deeming above mentioned limitations is highly appreciated in WSN. The Fig. 1, portrays different applications of wireless sensor network in acquiring the data for bridge monitoring system.

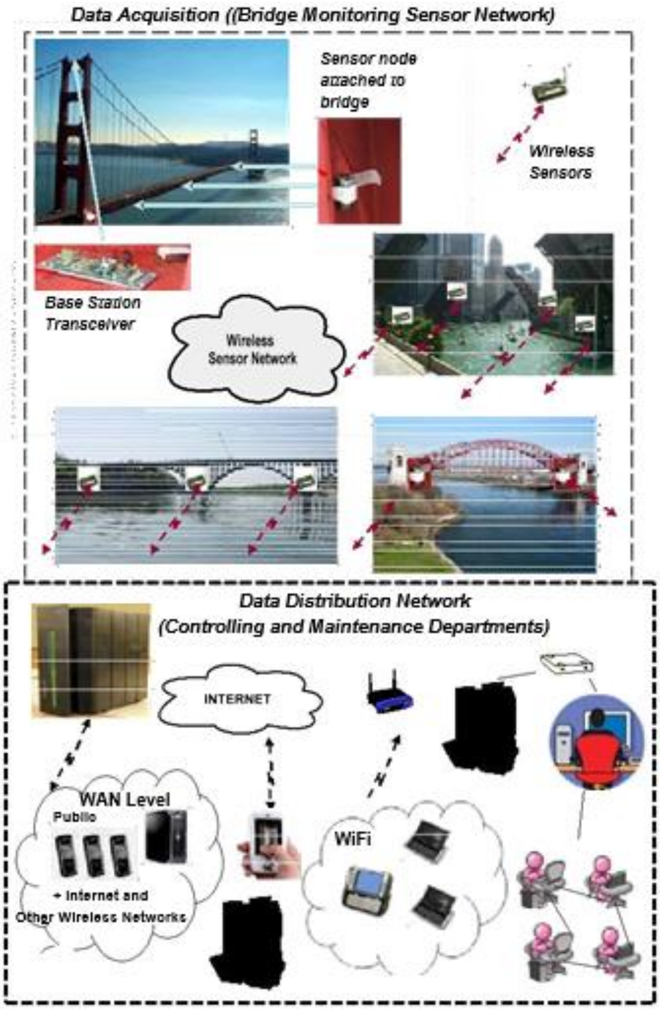

Fig. 1. Different application of wireless sensor network in bridge monitoring system

There are also other challenges that influence the design of routing protocol: deployment strategy, deployment architecture and data reporting models are among those important parameters. Regarding deployment strategies, Flat, hierarchical, and location based are three main sensor nodes' deployment architectures. In flat routing all sensor nodes have same role and responsibilities [7].

International Journal of Research in Engineering, Science and Management
Volume-1, Issue-8, August 2018
www.ijresm.com ISSN (Online): 2581-5782

Different protocols that adopted flat routing are direct diffusion, SPIN (Sensor Protocols for Information via Negotiation) [8], GBR (Gradient Based Routing) [9]. Hierarchical-based routing aims at clustering e.g. LEACH (Low-Energy Adaptive Clustering Hierarchy) [10], TEEN/APTEEN [11] [12].

Location-based protocols use the location information for routing. Algorithms that use location-based protocol are GAF (Geographical Adaptive Fidelity) [12], GEAR (Geographic and Energy Aware Routing) [13]. The Fig. 2 shows the cluster based and layered based node deployment architectures.

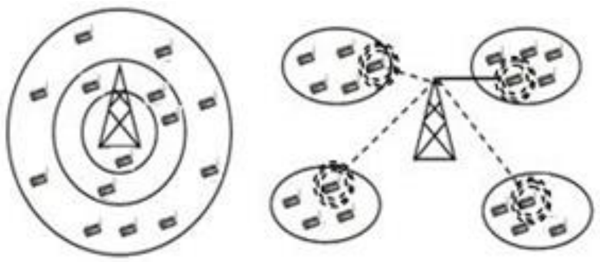

Fig. 2. Cluster based architecture (Right), Layered based architecture (Left)

In deployment architecture, Clustering is more beneficial technique to obtain improved results. In clustered structure, CH performs more responsibilities than other cluster members. Clustering owes more benefits that include load balancing, less energy consumption, reusability of resources and improved network life time. By exploiting these factors, our designed protocol is based on clustering technique with multi-assistant cluster heads (ACH) which not only helps in lessening the energy consumption but also balancing the load, hence increasing the network life time. More-over, ACH working in inter-cluster and intra-cluster routing also helps in fault tolerance.

In WSN, node deployment and data reporting models are application specific so as the designed protocols. The deployment can be either deterministic or stochastic. Different types of data reporting models are used in WSN. It can be time-driven (continuous), event-driven (discrete), query-driven, or hybrid. In time-driven delivery model periodic data monitoring is done. In event-driven and query-driven models, sensor nodes response immediately when drastic changes occur in sensed attribute due to some abnormal condition or a query is generated by the BS. In our defined scenario, we assumed deterministic deployed and event driven model.

Routing has been a field of great interest for the researchers resulting in large no of routing techniques empowering one or the other aspect of routing parameters and network scenarios. Accessing the BS directly from the sensor node is called one-hop model. Such type of routing fits better in small networks as having no scalability feature. On the other hand accessing the BS in a multihop fashion of communication via transit nodes is categorized as multihop model. In Cluster based model, whole network is partitioned into clusters. Each cluster has a cluster head (CH) that acquires the sensed data from cluster member nodes, aggregates and forwards it to other cluster heads or to the base station. The Fig. 3 shows two scenarios of multihop and a possibility of direct routing.

LEACH (Low-Energy Adaptive Clustering Hierarchy) by Heinzelman et al. has introduced a CH selection and Rotation technique. They have proposed two layered architecture, one-layer for intra-cluster communication and other for inter-cluster communication. Through empirical results, it has been proved that the network life time increases by the rotation of cluster head as well as better management of load-balancing issue.

In [14] Ma et al. has proposed a dynamic positioning technique for designating the cluster head. Results show the better location of CH comes up with the balanced network and also prolonging the network lifetime.

Irfan et al. [15] has introduced the idea of temporary cluster heads which performs better as compared to LEACH and enhanced version of LEACH in load balancing and efficient energy utilization.

EECR, TEEN, APTEEN and PEGASIS are also presents cluster based routing solutions.

Rest of the paper is organized as follows. In section two, proposed solution with the working of TLPER is discussed in detail. Simulation and result discussion is in third section. Concluding remarks and Acknowledgement ends up the paper.

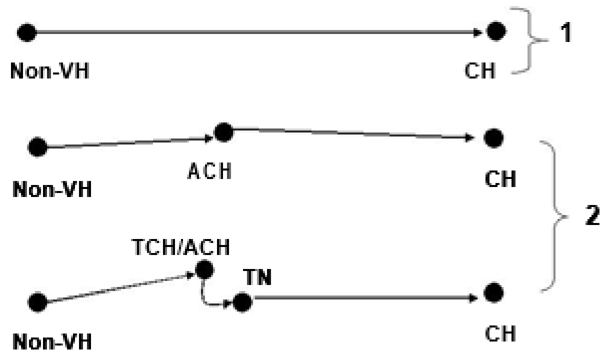

Fig. 3. 1-Direct Hop, 2- Multihop

II. Proposed Solution

In WSN, routing is really a challenging issue. A sensible and foresightedly planned routing protocol can have a vital role to add life to the network. Our proposed solution specifically target the scalable, fault tolerant and load balancing feature by synergistic mating of multihop and direct routing, energy efficient, load balancing and role transfer threshold and multi Assistant Cluster Heads (ACH). Homogenous sensor nodes, same initial energy level, deterministic deployment, centrally preselected cluster heads (CH) and preselected ACHs are the characteristics of our assumed scenario. Figure shows the flow chart of the working of proposed solution.

A. *Cluster Formation*

Exploiting the self-organizing capability of sensor nodes, each node may know its neighboring nodes as well as its Vicinity Head (VH). The term Vicinity Head applies to CH and ACH. As the deployment is deterministic, so at initial stage, selection of CH and ACH is on hand.

Due to the homogenous nature of nodes, the node having the more neighbors is designated as Vicinity Head (VH). Cluster

International Journal of Research in Engineering, Science and Management
Volume-1, Issue-8, August 2018
www.ijresm.com ISSN (Online): 2581-5782

Head is the main head of the vicinity of cluster while ACH is the assisting head of sub vicinity of the same cluster. In initial and later on, rotation of VHs (CH and ACH) communicate their designation to neighboring nodes. Each node attaches itself to the VH on the basis of received signal strength (RSSI). If a node receives invitation from more than one Vicinity Heads then the following criteria is followed:

$Sweight_i \quad Sweight_j$

Where *Sweight* is weight or strength of received signal of the invitee VH.

If $Sweight_i \quad Sweight_j$ then the selection is on the basis of

$Eweight_i \quad Eweight_j$

Where *Eweight* is the weight of energy level of invitee VH. If $Eweight_i \quad Eweight_j$

Then a random selection is made.

More-over, for CH_i,

We may have ACH_{i1}, ACH_{i2}, ACH_{i3}, ACH_{i4}

Communication and processing factors deplete the node's energy gradually which emerges the dynamicity of network with respect to the rotation esp. of vicinity heads (CH, ACH). Here we have introduced parallel rotational strategy of vicinity heads to cope with such network dynamicity aspect.

B. Parallel Rotational Strategy of Vicinity Heads

One of main energy consumption factor is rotation of vicinity heads. Finding the next best replacement of the current vicinity head and then propagating its designation to the neighboring nodes not only add its role in lessening the network life time but also introduce more end-to-end delay (E2E delay). In this paper, we have introduced parallel rotation strategy that if not maximize but in a little extend contribute in adding more life to the network and lessening E2E delay. Fig. 5 and Fig. 8 demonstrate the load balancing support to the network by their differential feature which ultimately comes up with increasing the network life time as well as fault tolerance to the network.

1. Threshold level exploitation

Setting up checks on working levels is exploited in parallel rotational strategy of vicinity heads (VH). The upper level check providing the load balancing capability to the network is termed as Load Balancing Threshold (LBT). The lower level check assist parallel rotation of VHs and Cluster Heads (CHs) is named as Role Transfer Threshold (RTT). Due to the deterministic deployment strategy and self-organizing capability of WS nodes, each node may know its vicinity head.

2. ACH rotation

On reaching the LBT, ACH establishes a communication link with the most energy carrying node and designate it as a transit node for communication with forwarding Node (i.e. CH of same cluster or ACH of neighboring Cluster) or destination node. Now on occurrence of LBT, ACH keeps on communicating with the forwarding nodes/destination node via transit node until RTT. On reaching RTT, ACH then broadcast an updating status message of designating TN as a ACH. This saves the network partitioning issue. More-over it not only maximizes the network usability but also the energy of X-ACH will remain to that extend to at least participate in communication and sensing process. Figure 8 shows this complete process of parallel rotation of Vicinity Heads. Node's uninformed and sudden death is also a possibility that is not considered here.

3. CH rotation

More or less same strategy is adopted by CH as of ACH for the rotation of its designation. Let CH_i is ith cluster head and N_{jk} are neighboring nodes of ith cluster head. The node which fulfills the condition "$EN_k \ EN_j$" will be designated as the cluster head in subsequent turns. But how to come up with the knowledge of maximum energy carrying node in the neighbor of CH. Threshold based Updated Info Communication (TUIC) strategy is proposed to minimize the beacon exchange and hence saving constraint factor of energy.

4. How TUIC strategy works?

On the basis of Fig. 7, we can have the idea of tentative minimization in energy of. neighboring nodes with the ratio of vicinity head. Here ratio between energy consumption of Non-Vacinity Head (NVH) and Assistant Cluster Head (VH) is 1:5 and between ACH and Cluster Head (CH) is about 1:2.3. It would be a better strategy to somewhat applying the unsupervised machine learning to train the network for the said purpose. For the safe calculation and to prevent from re-requesting for the updated info energy levels, CH request for the energy levels info from the neighboring nodes that fulfill the threshold energy level criteria (estimated by the prior training of network or from above mentioned calculation graph). So only those minimum nodes will reply which have this maximum energy Level.

C. Forwarding Node Selection in Inter-Cluster and Intra-Cluster Routing

The introduced strategy of ACH and TN assists in energy efficient cluster based routing along with load balancing feature resulting in better network utilization and its life.

Based on ultimate destination node, there are three possibilities for ACH in selection of forwarding node/Destination:

1- Base Station

2- Cluster Head of its cluster

3- ACH of neighboring cluster, and two possibilities for CH in selection of forwarding node/Destination:

1-Base Station

2-ACH of its Cluster

Above mentioned routing strategy is in the normal routing process. When the LBT reaches, the routing strategy would be different then. On occurrence of event, node senses the environmental physical quantity and forward the packet to its vicinity head, ACH. Assistant Cluster Head then directs the packet to the cluster head, which forwards it to the ACH in the direction of destination. This ACH transmits the received packet to the ACH of neighboring Cluster. On reaching the LBT, the communication between ACH to CH and vice versa

International Journal of Research in Engineering, Science and Management
Volume-1, Issue-8, August 2018
www.ijresm.com ISSN (Online): 2581-5782

is happened via transit node and on reaching RTT, transit node take over the control of Vicinity Head and itself act as a Vicinity Head. X-ACH and X-CH then function as a normal node.

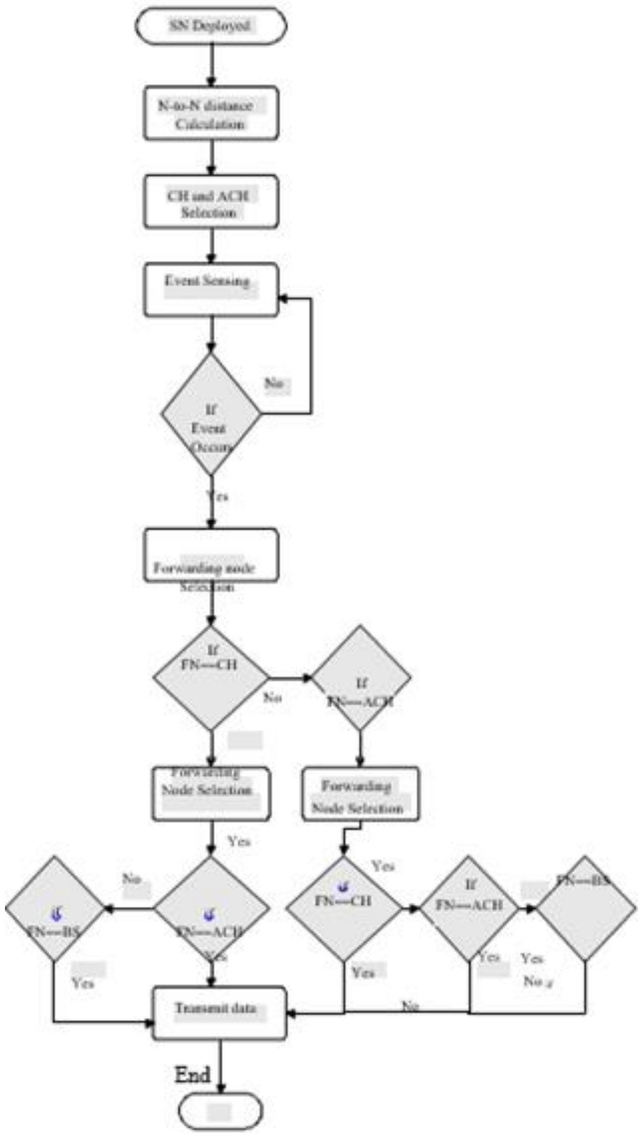

Fig. 4. Flow Chart of Proposed Algorithm

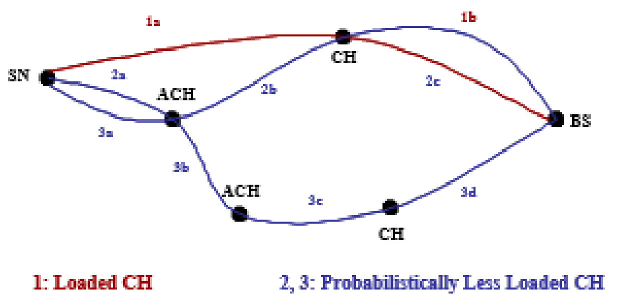

Fig. 5. Comparison of load balancing support in loaded CH (i) and loaded CH with assistant cluster head

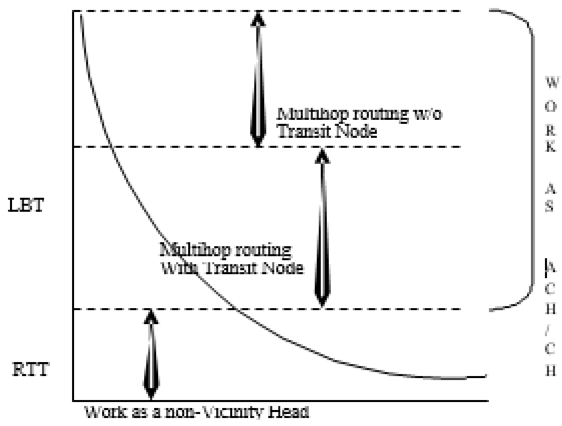

Fig. 6. Threshold level exploitation

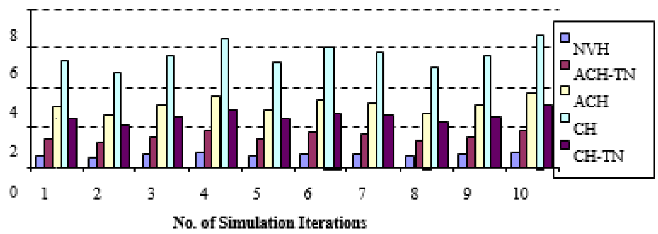

Fig. 7. Energy consumption ratio finding (Graph)

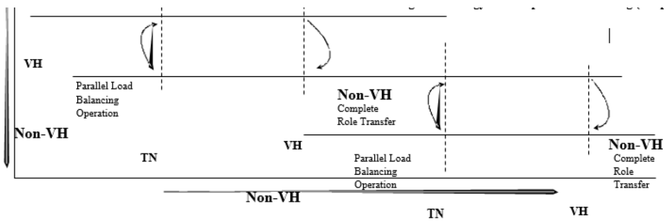

Fig. 8. VH and Non-VH

One issue that can be apparently seen in TLPER is addressed as follows: During rotation of VHs, the possibility of maximum nodes utilization is there but at the same time, the centralized management of VH's may snail from left to right and from top to bottom and vice versa. This makes boundary area nodes difficult to access the vicinity heads. This issue may arise with the boundary cluster nodes as the inner cluster's central positions creep along with relevant nodes. So, to cope with the situation arises with the boundary cluster nodes, here we introduce Pioneer Oldship Exploitation (POS) technique in conjunction with TUIC strategy. The first time selected ACH will take over the charge and elect fresh ACH among the neighbors which satisfy the condition of

$Eweight_i ! Eweight_j$

Where *Eweight* is the weight of energy level of neighboring node.

If

$Eweight_i \, Eweight_j$

Then a random selection is made for the selection of ACH. The Fig. 4 summarizes forwarding node selection process.

International Journal of Research in Engineering, Science and Management
Volume-1, Issue-8, August 2018
www.ijresm.com
ISSN (Online): 2581-5782

III. RESULTS AND DISCUSSION

We have simulated our proposed algorithm, TLPER, in VCSIM [16], to evaluate its performance. Results have been compiled and compared in comparison with Low-Energy Adaptive Clustering Hierarchy (LEACH). The Fig. 7, Fig. 9, Fig. 10, Fig. 11, Fig. 12, Fig. 13 and Fig. 14 illustrate some of the initial results drawn from simulation of our proposed Threshold based Load Balancing Protocol for energy Efficient Routing. For the simulation an area of 100x100 meter is considered with node density of 100. 20m Node to Node distance, 3 Joule Initial energy of node and the MAC type is SMAC, are the simulation parameters. Network life time is calculated on the death of first node. Performance Metrics: The performance metrics considered are:

Energy Consumption
Per Node
Cluster Head
Assistant Cluster Head
Network Utilization
Load Balancing Effect on Energy Consumption.

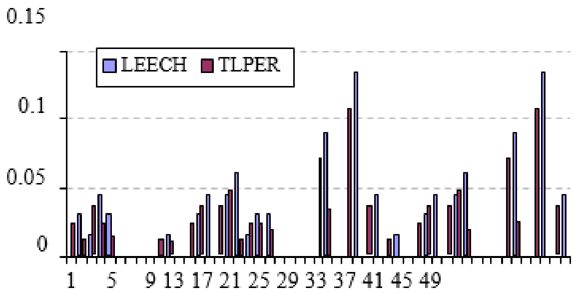

Fig. 9. Energy consumption per node in one simulation

The Fig. 3 and Fig. 14 show the energy consumption and residual energy of LEACH and TLPER on per node basis. The Fig. 10 dictates the lesser total energy consumption of TLPER compared to LEACH. Energy consumption of former is higher especially that of Cluster Head as compared to later because it has to bear all the load arrived from communicating nodes. But at the same time, the combined energy consumption of TN and CH in TLPER is also to be considered in comparison to energy consumption of CH in LEACH. It is intuited from Fig. 13 that the proposed algorithm also perform better if evaluated on the said criteria.

Fig. 10. Step-1

Fig. 11. Step-2

Fig. 12. Step-3

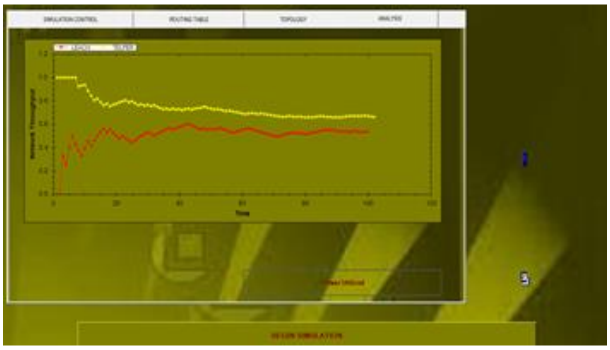

Fig. 13. Step-4

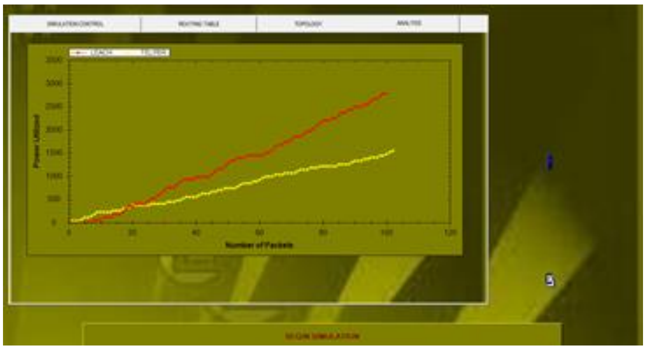

Fig. 14. Step-5

More-over, total energy of proposed algorithm is comparatively lower to that of competitive algorithm in a typical simulation. On the other hand, outperform working of TLPER is also apparent from Fig. 11 regarding total packets entertained by CH-TN + CH in different number of Simulation Iterations. Hence, load balancing has its important effect on overall energy consumption is the concluding statement derived from the results in Fig. 13 and Fig. 14. Network utilization is another yard stick for efficiency of a routing protocol regarding its load balancing and energy consumption. Fig. 13 demonstrates network utilization chart based on energy consumption per node and it is apparent that TLPER perform better than LEACH in this regards.

IV. Conclusion

Our proposed cluster based routing algorithm has exploited threshold level based load balancing and role transfer techniques along with multi-assistant cluster heads to cope with the power hungry issues. Both multihop and direct routing are embedded in TLPER. It has been intuited from the results that TLPER gives better network utilization and lesser per node energy consumption resulting in prolonging the network life time as compared to LEACH.

References

[1] R. O. J. K. H. K. Martinez and J. Stefanov,“Glacsweb: A sensor web for glaciers.” Berlin Germany: EWSN 2004, January 2004.
[2] G. Simon and M. Maroti, “Sensor network-based countersniper system.” Baltimore, USA: SenSys, November 2004.
[3] A. S. F. Michahelles, P. Matter and B. Sciele, “Applying wearable sensors to avalanche rescue,” no. 27(6), 2005.
[4] P. Juang, H. Oki and D. Rubenstein, “Energyefficient computing for wildlife tracking: Design tradeoffs and early experiences with zebranet,” ASPLOS X. San Jose, USA: IEEE, October 2002.
[5] H. Baldus and G. Muesch, “Reliable setup of body sensor networks.” Berlin, Germany: EWSN2004, January 2004.
[6] R. Riem-Vis, “Cold chain management using an ultra-low power wireless sensor network.” Boston, USA: WAMES 2004, June 2004.
[7] Raja Adeel Akhtar, Abid Ali Minhas, Sohail Jabbar, “Energy Aware Intra-Cluster Routing For Wireless Sensor Networks”, *International Journal for Hybrid Information Technology*, Vol. 3, No. 1, January 2010.
[8] J. Kulik, W. Heinzelman, and H. Balakrishnan, “Negotiation-Based Protocols for Disseminating Information in Wireless Sensor Networks, *Wireless Networks*, Vol. 8, pp. 169-185, 2002.
[9] Jabed Faruque, Ahmed Helmy, “Gradient-Based Routing in Sensor Networks”, ACM SIGMOBILE *Mobile Computing and Communications*, 2003.
[10] Wendi Heinzelman, Anantha Chandrakasan, and Hari Balakrishnan, “Energy-Efficient Communication Protocols for Wireless Micro sensor.