To Evaluate The Overall Performance Analysis of ELBSEP In The MATLAB Simulation

Sachin Bandewar[1], Pravesh Asati[2]

[1]Student, [2]Asst. Prof., IASCOM, Bhopal

Abstract - The challenging task of wireless sensor network is to increase the lifetime of the network as they are equipped with critical battery power. A wireless sensor network has wide applications and its critical battery power is used in sensing, processing, routing and transmitting data to the base station. So many protocols were proposed to efficiently use the battery power to extend the lifetime of the wireless sensor network. Once wireless sensor network is deployed in disaster areas, inaccessible terrains, polluted environments or high radiation region, battery recharge or replacement is impossible for human and wireless sensor network works until battery power of the entire sensor node get die. For optimizing the battery power of the sensor network, various energy efficient routing strategies are applied.

Keywords- Wireless Sensor Network, Clustering Energy Efficiency, Stable Election, Network Lifetime, ELBSEP.

I. INTRODUCTION

Wireless sensor network is one of the category of wireless network which belongs to adhoc networks. Sensor networks are composed of nodes, actually the node has a specific name that is "Sensor" because these nodes are equipped with smart sensors. Nodes of wireless sensor networks are less mobile than ad-hoc networks so the mobility in case of ad-hoc is more. In wireless sensor network, data are requested based on certain physical quantity, so wireless sensor network is data centric. A sensor consists of an embedded processor, a transducer, small memory unit and a wireless transceiver and all of these devices run on the power supplied by an attached battery. In this introductory chapter the motivation, introduction to sensor and wireless sensor network, its application and architecture and finally the organization of this dissertation report will be discussed.

Motivation behind the Present Work:

The motivation for this dissertation is to create an energy efficient and robust wireless network of sensors which can effectively transmit data with minimal energy loss. Once a wireless sensor network (WSN) is deployed, the network continuously works until battery of the all nodes become dead. Sometime sensor networks are deployed polluted area or high radiation zone where battery recharges or replacement and human manipulation is not possible. So the motivation is achieved by energy efficient strategies by which the energy consumption of battery can be reduced and network lifetime can be enhanced. One of the prominent advantages of wireless sensor network (WSN) is its ability to eliminate the gap between logical world and physical environment,by collecting certain useful data and information from the environment and communicating that information to more powerful logical devices that can process or estimate that information. It is envisioned that now WSNs can minimize or eliminate the need for human involvement in information gathering and processing in certain civilian, industrial and military applications. In future, smart sensor devices will be produced in large quantities and varieties at a very low cost and densely deployed to improve robustness and reliability. They can be miniaturized into a size of cubic millimeter package in order to be stealthy into a hostile environment. The energy or power constraints on the other hand are more important and fundamental. In modern sensors, battery capacity only doubles in around 35 years. Power constraints of sensor node are unlikely to be solved in the near future with the slow progress in sensor node battery capacity and energy dissipation. Moreover, the nature of sensor nodes are untended as well as the polluted or hazardous sensing environment prevents manual battery replacement. For these reasons, the energy awareness represents itself as the important and key research challenge for wireless sensor network efficient protocol design. Several industries and researchers have addressed and proposed energy conservation recently. Most of the researchers focus on particular protocols and investigate whether their energy conservation strategy can be achieved. Generally their approaches and strategies can be evaluated through simulations.

II. TECHNICAL ASPECTS OF WIRELESS SENSOR NETWORK

As soon as this is observed and understand the capabilities and technology of a wireless sensor network, so many of applications comes into mind. It looks like a straightforward combination of modern advanced technology however, actually combining sensors, radios and CPU's into an effective wireless sensor network requires a detailed knowledge of the both capabilities and limitations of each of the modern hardware components, as well as the detailed understanding of modern networking technologies. Each individual sensor node should be designed to provide the set of prominent requirements to synthesize the interconnected sensor network that will emerge as they are deployed in a region, while meeting the strict requirements of size, cost and energy consumption. A main challenge is to lookup the overall system requirements down to individual device capabilities, requirements and activities. To make the wireless sensor network (WSN) vision a reality, the architecture must be developed which synthesizes the required applications out of the underlying hardware strength and capabilities. The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio Signal = Thousands of potential applications

For developing this system architecture the work should be done from the high level application requirements down through the low-level hardware requirements. In this process, first attempt is started to understand what the set of target applications are. To prevent the limitation of the number of applications that it must consider and focus on a set of application categories that are believed to be representative of a large fraction of the potential application.

System Evaluation Metrics:-

Now that it was observed the set of application scenarios that were addressed, these are analyzed that the evaluation metrics that are used to evaluate a wireless sensor network. To do this it is kept in mind the high-level objectives of the network deployment, the intended usage of the network and the main advantages of wireless sensor networks over existing technologies. The key evaluation metrics for wireless sensor networks are lifetime, signal coverage, cost and ease of deployment, response time, security, temporal accuracy and effective sample rate. One result is that many of these evaluation metrics are interrelated. Often it may be necessary to decrease performance in one metric, such as sample rate, in order to increase another, such as lifetime. Taken together, this set of metrics form a multidimensional space that can be used to describe the capabilities of a wireless sensor network. The capabilities of a platform are represented by a volume in this multidimensional space that contains all of the valid operating points. In turn, a specific application deployment is represented by a single point.

Hardware Capabilities:-

Now it is identified that the key characteristics of a wireless sensor node depends on the capabilities of modern hardware. This allows to understand the bitrate, memory, power consumption and cost that can be expected to achieve. A balance should be maintained between capability, size and power consumption in order to place best required applications. This section presents a quick introduction of modern technology and their tradeoffs between different technologies. It can be started with a background of battery or energy storage technologies and continue to the radio, CPU and sensors.

III. LEACH (LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY)

LEACH [4] was proposed by Ningbo Wang, Hao Zhu in "**An Energy Efficient Algorithm Based on LEACH Protocol**" for wireless sensor network.

LEACH [4] is basically a proactive routing protocol. The proactive routing protocols continuously try to send up-to-date sensed data to the base station in the wireless sensor network.

This has as advantage that network connection time is fast, because when the first data packet is sent then routing information data is already available. A main disadvantage of proactive protocols is that they continuously use resources to communicate routing information, even when there is no traffic. In a network hundreds and thousands of sensor nodes dispersed randomly for even distribution of load among nodes. These nodes sense data, transmit it to their associated cluster heads (CHs) which first receive, aggregate it and then send its data packets to the Base Station (BS). Low Energy Adaptive Clustering Hierarchy ("LEACH") is a TDMA - based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs). The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network. LEACH is usually a hierarchical routing protocol in which most sensor nodes transmit data packets to the cluster heads, and the cluster heads usually aggregate it in memory unit and compress this data and forward it to the base station (sink). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round. LEACH usually assumes that each sensing node has a transmission radio powerful enough to directly reach the base station or the nearest cluster head, but by using this transmission radio at full power all the time would waste energy.

All the sensor nodes deployed in an environment are homogeneous and constrained in limited battery power. To distribute the burden or work among nodes, an improve network life clusters are formed. The sensor node devices are made to become CHs on turns [4]. Nodes randomly elect themselves as CHs and it is done in a way that each node becomes CH once in the time period of 1/ �round. CHs selection is done on probabilistic basis [27], each sensor node generates a random number � inclusive of 0 and 1, if the generated value is less than this threshold computed by formula given below [4], and then this node becomes CH.

All nodes that are not cluster heads only communicate with the cluster head in a TDMA (Time Division Multiple Access) fashion, and according to a schedule created by the cluster head. They usually do this strategy using the minimum energy required to reach the cluster head, and only require to keep the switch on their radios during their time slot interval. LEACH strategy also uses CDMA scheme so that each cluster in a network uses a different set of CDMA codes, to minimize the interference between the clusters.

Properties of LEACH Protocol:-

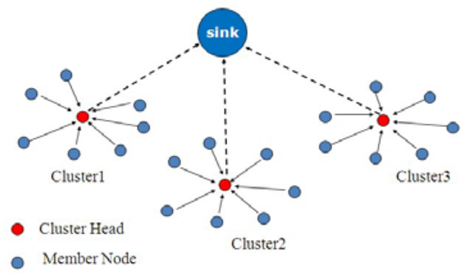
- **Cluster based:** LEACH uses the concept of clustering in which sensor nodes are grouped into clusters. Each cluster has its associated cluster head which receives sensed data from all sensor nodes and cluster head is responsible to send collected data to the sink or base station. An example of the network cluster is shown below in figure 3.1.

- Random selection of cluster head (CH) in each round with rotation.

Cluster membership adaptive. Data aggregation at cluster head.

- Cluster head usually communicate directly with the sink or user.

- Communication within cluster done with the cluster head via TDMA.



CDMA across clusters.

Figure 3.1 Clustering in Wireless Sensor Network

Advantages of LEACH:-

- LEACH [4] strategy is completely distributed, it reduces energy consumption 4 to 8 times lower in case where packets are relayed in multi-hop transmission, and at last, all the nodes in the network die at about the same time due to LEACH fair distribution of CH role.

- In LEACH [4] method, usually the control information from the base station is not required for sensor nodes.

- LEACH [4] reduces 7 to 8 times low overall energy dissipation as compared to direct transmissions and minimum transmission energy routing.

- In a completely distributed sensor network, the sensing nodes do not require any knowledge of global network.

Limitation of LEACH:-

- LEACH is basically not ideal for a large geographical region or areas.

- LEACH protocol generally offers no guarantee at all on the placement of the cluster head nodes.

- During the set-up phase of LEACH, each node sends information about its current location and energy level to the BS.

- Normally the clusters are formed by such that total sum of squared distances between all the non-cluster head nodes and the closest cluster head is minimized.

- LEACH's cluster formation algorithm will end up by assigning more cluster member nodes A. This could make cluster head nodes a quickly running out of energy.

Problem Statements:-

The problem statement is basically not problems in the energy efficient routing protocols rather these are limitations of the routing protocols. In this chapter of the dissertation report, limitations of modern energy efficient routing protocols are pointing out which was analyzed in the chapter of literature survey.

IV. SOLUTION APPROACH

In this section, a new proposed protocol ELBSEP (Energy Level Based Stable Election Protocol) is discussed which is based on energy level calculation as well as three levels of node heterogeneity and threshold estimation. Cluster head (CH) selection is based on energy level of nodes in the proposed protocol ELBSEP unlike LEACH, SEP, ESEP, TEEN and TSEP as cluster head is selected on probability bases. Clustering method [20] provides an efficient and effective way to increase the network lifetime of a WSN. The clustering algorithms discussed in literature review basically utilize two techniques, first the selection of a cluster head (CH) with more residual energy and second the rotation of cluster heads (CHs) on the probability basis periodically, for an equal distribution of energy consumption among sensor nodes in each cluster and enhance the lifetime of the WSN. To forward data packets to the base station, cluster heads usually cooperate with other cluster heads, the cluster heads is selected basically on the probability bases and high residual energy node may not be selected as cluster head (CH) and low residual energy node may be selected as cluster head (CH). To address this problem, an Energy Level Based Stable Election Protocol (ELBSEP) is proposed which is based on residual energy level estimation of sensor nodes as well as it combines the best feature TSEP protocol and also provides mechanism for periodical data packet gathering in WSN.

V. SIMULATION, PERFORMANCE ANALYSIS AND RESULT

Simulation in MATLAB:-

MATLAB as a simulator is used for this implementation and performance evaluation of the proposed protocol ELBSEP. The purpose of estimating simulations is to compare the performance of ELBSEP with SEP, ESEP, LEACH, TEEN and TSEP protocols on the basis of energy consumption, lifetime of the sensor network and throughput. Performance attributes used in this MATLAB simulations are as follows:

1. The number of alive nodes during each round.
2. The number of dead nodes during each round.
3. The number of packets sent from cluster heads to the base station, also called the throughput. For simulation of LEACH, SEP, ESEP, TEEN and TSEP, some initial parameter values are taken as well as the same parameter values for this proposed protocol ELBSEP.

Parameters	*Values*
$E_{initial}$	0.60 Joule
$E_{current}$	0.55 Joule
P_{opt}	0.10
α	1.30
E_0	0.60 Joule
n	200
m	0.20
b	0.80

These are considering that initially the WSN consists of 200 sensor nodes, all sensor nodes are placed randomly in a region and a base station (BS) is located at the outside of that region. For MATLAB simulation, some parameters are initialized like Einitial as 0.60 Joule, Ecurrent as 0.55 Joule, Popt as 0.1, α as 1, n as 200, m as 0.20, b as 0.80 and E0 as 0.60 Joule. On the next MATLAB simulation, the parameters setting are changed to different values.

Simulation and Performance Matrices

	Number of Rounds					
Nodes Dead Percentage %	LEACH	SEP	ESEP	TEEN	TSEP	ELBSEP
1% Nodes	500	550	850	1800	2250	2350
20% Nodes	550	600	1050	2200	2550	2700
50% Nodes	900	1050	1500	2500	3000	3200
80% Nodes	1500	1900	2500	4000	4500	4800
90% Nodes	2000	3000	4000	6000	6500	6800
100% Nodes	10000	10000	10000	10000	10000	10000

Table 5.2 shows the sensor nodes dead during rounds as a chart of nodes dead percentage versus number of rounds. As this can be observed form table that 1 % of sensor nodes get dead during 500 rounds in LEACH protocol, 550 rounds in SEP protocol, 850 rounds in ESEP protocol, 1800 rounds in TEEN protocol and 2250 rounds in TSEP protocol. Finally 1% of the sensor node devices get dead in ELBSEP during 2350 rounds. Chart shows that in the proposed protocol, sensor nodes get dead later as compared to LEACH, SEP, ESEP and TEEN protocol. Table 5.3 shows the how many sensor nodes remain alive during rounds as a chart of nodes alive percentage versus

number of rounds. This chart is the complement of the previous chart. Here also in the proposed strategy of ELBSEP, much more sensor nodes remain alive during number of rounds as compared to LEACH, SEP, ESEP, TEEN and TSEP.

	Number of Rounds					
Nodes Alive Percentage %	LEACH	SEP	ESEP	TEEN	TSEP	ELBSEP
90% Nodes	500	550	850	1800	2250	2350
80% Nodes	550	600	1050	2200	2550	2700
50% Nodes	900	1050	1500	2500	3000	3200
20% Nodes	1500	1900	2500	4000	4500	4800
10% Nodes	2000	3000	4000	6000	6500	6800
0% Nodes	10000	10000	10000	10000	10000	10000

Table 5.4 shows the throughput chart as packet sent to the base station versus number of rounds. Only the proposed protocol ELBSEP sends over 50000 packets. Throughput of ELBSEP is better than the other protocols. As shown in Table 5.4, the maximum throughput (packet sent to the base station) of LEACH, SEP, TEEN and TSEP strategies achieved by them is around 25000 packets and ESEP protocol achieves around 40000 packets during their maximum round. Whereas the proposed protocol ELBSEP gets maximum throughput (packet sent to the base station) over 45000 packets during its maximum round as shown in Table 5.4, which shows that ELBSEP has better throughput as compared to the strategies of LEACH, SEP, ESEP, TEEN and TSEP protocols. Only TEEN and TSEP protocols can send more than 24000 packets and only ELBSEP protocol sends more than 45000 packet during its maximum rounds.

	Number of Rounds					
Throughput (Packets Sent to Base Station)	LEACH	SEP	ESEP	TEEN	TSEP	ELBSEP
10000 Packets	500	450	400	1000	900	1000
13000 Packets	1500	1200	1400	2200	1500	1550
24000 Packets					2200	2500
30000 Packets						4000
45000 Packets						5000

Result

Result metrics used in the simulations are based on the following:

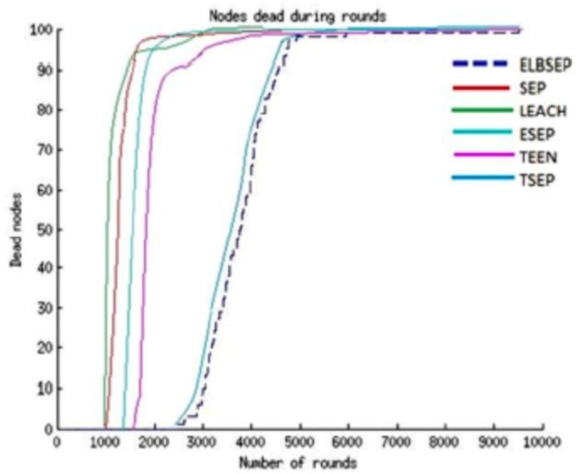
1.) Number of the alive nodes during each round.

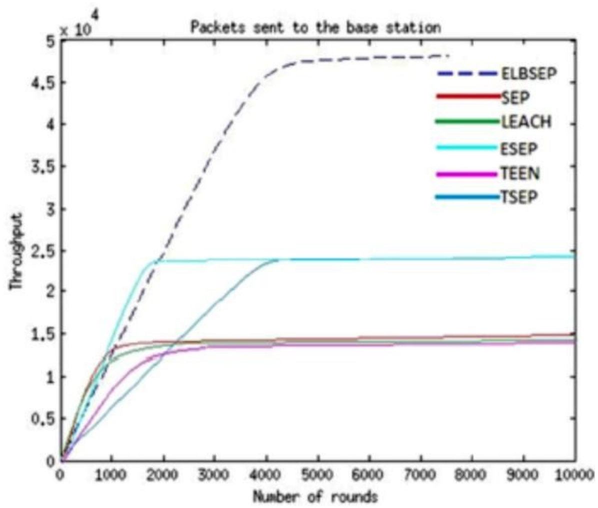
2.) Number of the dead nodes during each round.

3.) Number of packets sent from the cluster heads (CHs) to the base station, called the throughput.

Result Analysis of Nodes Dead Per Round

Figure 5.1 plots the graph of nodes dead during each round. In figure 5.1, the LEACH protocol is shown as the green curve, SEP protocol is shown as the red curve, ESEP protocol is shown as the cyan curve, TEEN protocol is shown as the magenta curve, TSEP is shown as blue curve and the proposed protocol ELBSEP is shown as dashed blue curve. As shown in the figure 5.1 the proposed strategy and protocol ELBSEP has better performance as sensor nodes dies later as compared to other protocol.





Result Analysis of Nodes Alive Per Round

In figure 5.2, same colored curves have been used as in figure

5.1 for LEACH, SEP, ESEP, TEEN, TSEP and ELBSEP. The graph of nodes alive during each round in figure 5.2 is the complementary of the graph of nodes dead during each round. Again the proposed protocol ELBSEP performs better as compared to other protocol as shown in the graph. The graph plotted for nodes alive during each round of ELBSEP is shown as again dashed blue curve in figure 5.2.

Result Analysis of Throughput

The graph of figure 5.3 plots the data packets send to the base station or throughput. Again the same colored curve are used for LEACH, SEP, ESEP, TEEN, TSEP and ELBSEP

protocols. For performance evaluation of ELBSEP in MATLAB, the same initial parameter values are considered and the next parameter values as used in LEACH, SEP, ESEP, TEEN and TSEP. As shown in figure 5.1, the graph plotted for nodes dead during each round in ELBSEP curve shows that the proposed protocol ELBSEP performs better than LEACH, SEP, ESEP, TEEN and TSEP as less nodes die after each rounds as compared to these protocols. As shown in figure 5.2, the graph plotted for nodes alive during each round in ELBSEP curve shows that the proposed protocol ELBSEP performs better than LEACH, SEP, ESEP, TEEN and TSEP as more nodes alive after each rounds as compared to these protocols.

Overall Result Analysis

To evaluate the overall performance analysis of ELBSEP in the MATLAB simulation, the same previous parameter setting are considered to compare ELBSEP with LEACH, SEP, ESEP, TEEN and TSEP. The throughput of ELBSEP as the graph of data packet sent to the base station is around double as compared to TSEP, as shown in figure 3 which is better than LEACH, SEP, ESEP, TEEN and TSEP. The curve of ELBSEP throughput shows the proposed protocol sends more data packets to the base station (around 50 % more) as compared to other protocols discussed above. After comparison of ELBSEP with strategies of LEACH, SEP, ESEP, TEEN and TSEP, it is evaluated that by using the proposed protocol ELBSEP, better energy efficiency, enhanced network lifetime and greater throughput are achieved.

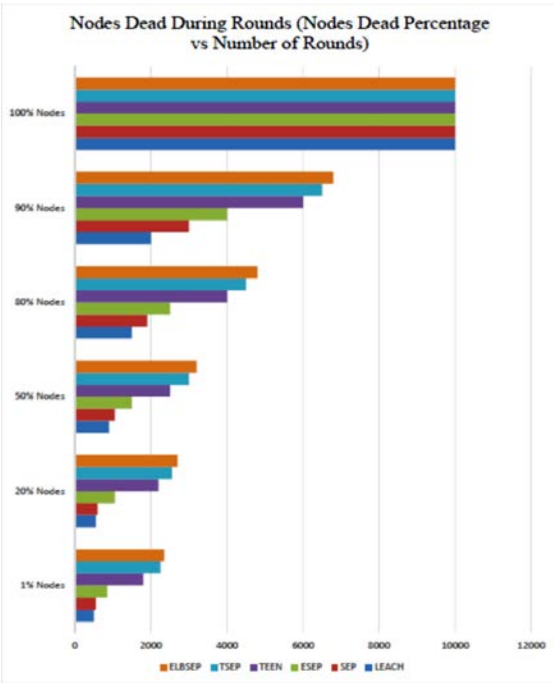
Result Chart

Finally, the charts of the MATLAB simulation of previous results have been presented. In the charts, the LEACH, SEP, ESEP, TEEN and TSEP Protocols are represented as dark blue, red, green, purple and sky blue color consequently. The proposed protocol ELBSEP is represented as light orange color. Figure 5.4 shows the sensor nodes dead during rounds as a chart of nodes dead percentage versus number of rounds. As this can be observed that 1 % of sensor nodes get dead during 500 rounds in LEACH protocol, 550 rounds in SEP protocol, 850 rounds in ESEP protocol and 1800 rounds in TEEN protocol. Finally 1% of sensor nodes get dead in ELBSEP during 2250 rounds. Chart shows that in the proposed protocol, sensor nodes get dead later as compared to LEACH, SEP, ESEP, TEEN and TSEP protocol.

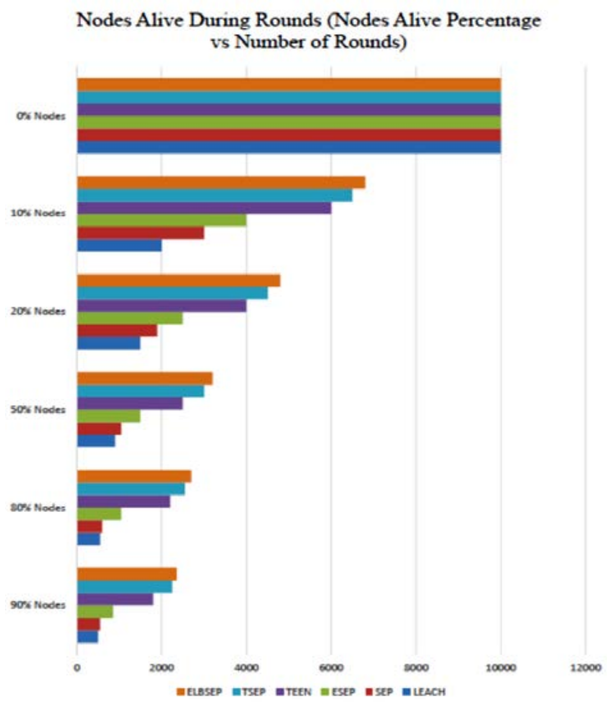
Figure 5.6 shows the throughput chart as packet sent to the base station versus number of rounds. Only the proposed protocol ELBSEP sends over 50000 packets. Throughput of ELBSEP is better than the other protocols.

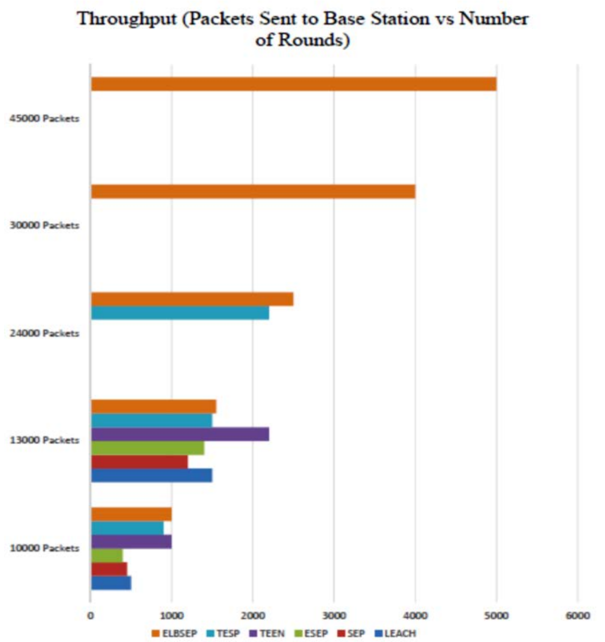
As shown in figure 5.6, the maximum throughput (packet sent to the base station) of LEACH, SEP and TEEN protocols achieved by them is around 25000 packets and ESEP protocol achieves around 40000 packets during their maximum round.

Figure 5.5 shows the how many sensor nodes remain alive during rounds as a chart of nodes alive percentage versus number of rounds. This chart is the complement of the previous chart. Here also in the proposed protocol ELBSEP, more sensor nodes remain alive during number of rounds as compared to LEACH, SEP, ESEP, TEEN and TSEP.



Whereas the proposed protocol ELBSEP gets maximum throughput (packet sent to the base station) over 45000 packets during its maximum round as shown in figure 5.6, which shows that ELBSEP has better throughput as compared to LEACH, SEP, ESEP, TEEN and TSEP protocols. Only ESEP and ELBSEP protocols send more than 30000 packets and only ELBSEP protocol sends more than 50000 packet during its maximum rounds. Finally, the overall performance of the proposed strategy and protocol ELBSEP has better throughput, enhanced network lifetime and more energy efficient as compared to LEACH, SEP, ESEP, TEEN and TSEP protocols.





VI. CONCLUSION & FUTURE WORK

Conclusion

There are many protocols which focus on the energy efficiency of the routing method in wireless sensor network because commonly these networks are usually deployed polluted region or high radiation zone where human manipulation is impossible to recharge or replace the battery or energy source. Once the wireless sensor network is deployed in any region then it works until battery power of the entire sensor node get die, so energy efficiency became a challenging task to enhance the lifetime of the sensor network. Presently there were so many algorithms protocols proposed for energy efficient routing to enhance the lifetime of the whole wireless sensor network.

The modern routing protocols LEACH, SEP, ESEP, TEEN and TESP use their own algorithm for energy efficiency. In this dissertation report, ELBSEP as a reactive network routing protocol are proposed with considering three different levels of sensor node heterogeneity. ELBSEP combines the best features of TSEP and energy level estimation method. Due to the concept of energy level based cluster head selection, hard and soft threshold value, three levels of node heterogeneity and being reactive routing network protocol ELBSEP produces increase in energy efficiency, enhanced lifetime of network and also maximum throughput as shown in the simulation result. In comparison with SEP, LEACH, ESEP, TEEN and TSEP with the proposed strategy of ELBSEP, it can be concluded that the protocol ELBSEP will perform well in small as well as large geographical networks and best suited for time critical applications.

Future Work

However ELBSEP is not suitable where frequent information is received from wireless sensor network. The future direction will be to overcome this limitation in this protocol. Finally, in future, the concept and implementation of the mobile base station can be introduced in ELBSEP to perform the next level of advanced technology of wireless sensor network due to three levels of heterogeneity and being reactive routing network protocol, so it produces increased level in energy efficiency and enhanced network lifetime.

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