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A Comparative Study on Different Routing Protocols

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Abstract— Wireless sensor networks emerged as a significant platform for a wide range of monitoring tasks ranging from environmental to military applications. Its growth is rising and this is the reason why there is a huge field to explore in this area. Sensors depend wholly on their battery for power, which cannot be rejuvenated or substituted. In order to maximize the lifetime of sensor nodes, it is suitable to dispense the energy dissipated all over the wireless sensor network. So the design of energy aware routing protocols is crucial in increasing the network lifetime. This paper gives a detailed review of these three energy efficient protocols- LEACH, TEEN AND SEP. A comparative study of these three protocols has been performed and the results show how TEEN is better than the remaining three protocols in terms of energy and lifetime. Here lifetime is taken in terms of number of dead nodes.

Keywords—WSN, routing protocols, dead nodes.

I. INTRODUCTION

During the past decades, computers have expanded in terms of processing power and has diminished in size. This quick progression prompted a quick market in which computers would take an interest in a greater amount of our day by day exercises. Due to recent innovations in technology, the execution of low cost sensors has turned out to be monetarily and in fact attainable. Wireless sensor network is formed by combination of huge number of sensors [1]. Wireless Sensor Networks comprise of sensors which are distributed in a particular manner. Sensors work with each other to sense some physical phenomenon and after that the data gathered is handled to get significant results. Wireless sensor network (WSN) comprise of sensor nodes and these sensor nodes communicate with other nodes or specifically with the base station to transmit the data packets [1]. The sensor nodes comprise of detecting, handling power and transmission units and location finding system.

Applications of wireless sensor network can be classified into three sub-sections: monitoring of object, monitoring of an area, monitoring of both area and object. Wireless sensor network has been utilized as a part of a few zones like military applications, mobile tracking applications, medical applications etc. The lifetime or existence of wireless sensor network is limited because the sensor nodes deal with the battery life and it is difficult to energize the battery at regular interval because of the deployment of wireless sensor networks at far and distant places [1]. That's why in wireless sensor network the investigation is mainly focused towards energy efficient communications and extending the lifetime of the network. Routing protocol in wireless sensor networks may be different depending on the network design and mandatory function. So to extend network lifetime, routing protocol having high energy efficiency is required [1]. The perfect wireless sensor is organized and adaptable, fault tolerance, takes less power, brilliantly programmable, effective, able to gain information very quickly, trustworthy and correct over long duration, takes less cost to buy and required no genuine support. The methods to effectively route the gathered information among nodes are the extreme vital topic in WSNs because of the low powered sensor nodes. Many routing protocols have been proposed on the basis of routing techniques and attributes in WSNs [2].

The rest of the paper is structured as follows:

Section 2 shows the related work. Section 3 describes the design challenges of wireless sensor networks. In section 4, most popular routing protocols in wireless sensor networks are discussed. Section 5 represents the implementation and results. And in the last section, the main conclusions of this work are shown.

II. RELATED WORK

There are various research works which deals on the perfection of routing protocols in wireless sensor networks. These protocols are improved on the basis of design of the network and the purpose. There are various factors which are considered for the development of routing protocols. Energy efficiency is the most vital component that straightforwardly influence the lifetime, dependability, throughput of the system. In [1], a comparative study on energy-efficient routing protocols in WSN has been done. It classified the routing protocols in three categories:-

(i) How to create a path
(ii) Structure of a given network and
(iii) Operation performed by the protocol

The first category can be sub-divided as proactive, reactive and hybrid. The next category can be sub-divided into data-

centric or based on the attributes, hierarchical and location-based. The last category can be sub-divided into query, bio-inspired, negotiation, coherent, non-coherent, QoS, multi-path and mobility. Along with this, the pros and cons are also discussed in [1].

A review on various routing protocols based on network structure has been discussed in [2] to increase the lifetime of the sensor network. Some of the multipath routing protocols which are mostly used to improve network usage have been described in [2].

In [3], a new protocol named as LEACH-FP has been proposed which uses the concept of Fermat point. This will balance the energy consumed in the entire network and thus it will help in extending the lifetime of the whole network.

In [4], conventional protocols like LEACH, SEP, TEEN, DEEC are used for evaluating the performance of a new protocol named I-SETS (Improved Stable Election Threshold Sensitiveness Protocol).

In [5], LEACH protocol for micro-sensor networks has been developed to attain better performance in terms of network lifetime, latency. It distributes the energy among the nodes present and rotates the cluster head position.

Our paper is focused on the comparative study of energy efficient routing protocols in wireless sensor networks that consist of all the categories of routing protocols in wireless sensor networks and it can give information to the user on how to prefer the most suitable energy efficient routing protocol [1].

III. DESIGN CHALLENGES FOR WIRELESS SENSOR NETWORKS

The wireless sensor networks have a number of design issues, such as bandwidth, energy supply etc. The major attributes of wireless sensor network is to bring out effective data communication and also boost the network lifetime. In spite of plenty of innovations, the design of routing protocols for wireless sensor networks is yet difficult due to various sensor network parameters and necessities [1]. Due to the constraint of network resources such as bandwidth, storage space and power, the design challenges of wireless sensor network include the following aspects:

a) Restricted energy resources.
b) Position of the sensor.
c) Hardware assets.
d) Immense sensor deployment.
e) Network uniqueness.
f) Data gathering.
g) Scalability.
h) Fault tolerance.
i) Network dynamics.
j) Communication media.

IV. ROUTING PROTOCOLS

A. *LEACH - Low Energy Adaptive Clustering Hierarchy Protocol*

LEACH is one of the earliest hierarchical routing protocols proposed for WSNs to increase lifespan of network. In this routing protocol sensor nodes arrange themselves into clusters. It organizes the nodes by itself and performs re-clustering functions for each and every round [3]. In each cluster one node acts as CH while other remaining nodes act as member nodes of that cluster. CHs assemble the data collected from all nodes, aggregate this data and send all meaningful data and compress information to BS. Because of these added responsibilities, CH dissipates extra energy and if it remains CH permanently, it will die very fast, same as in static clustering. The LEACH protocol tackles this problem by adopting randomized rotation of CHs in order conserve energy of the individual nodes [3, 6]. Thus LEACH maximizes lifetime of network and also lessen the energy dissipation by compressing that before transmitting to BS. LEACH performs the operations in rounds and each round has two stages. These are setup phase and steady state phase. In first phase, that is the setup phase the Cluster Heads and clusters are created. All nodes are managed into multiple clusters. Some nodes do not negotiate with other nodes and elect themselves as Cluster Heads. CHs elect themselves on basis of suggested percentage *P* and their previous record as a CH. All nodes which were not CHs in previous1/*p* rounds generate a random number starting from zero to one and if the value of this number is less than the threshold value i.e. *T* (*n*) then all these nodes become CHs. Threshold value is set through this formula.

$$T(n) = \begin{cases} p/[1-p\times\{r \bmod (1/p)\}], & n \in G \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

Where,

p= percentage of number of CH among all the nodes,

r = no. of the present round,

G= set of nodes that have not been elected in the past 1/p rounds of election.

LEACH selects the best path which consumes minimum energy. Another criterion of selecting intermediate CH is to keep overall distance towards BS minimum because distance is directly proportional to energy dissipation. So, a path which has the lowest value of hop-count from CH to BS is selected. LEACH protocol randomly selects cluster head in every round leading to the depletion of energy quickly.

B. TEEN (Threshold Sensitive Energy Efficient Sensor Network) Protocol

TEEN is a hierarchical clustering protocol. It groups sensors into clusters with each one led by a CH. The sensors surrounded by a cluster give description about the sensed data to their CH. The CH sends aggregated data to higher level CH and keeps doing it till the data reaches the BS. Thus, the sensor network design in TEEN depends on a hierarchical grouping where nearer nodes form clusters. This procedure goes to the second level until the BS i.e. sink is reached. This protocol is characterized by the following main features:

- Time critical data reaches the user almost immediately.
- The soft threshold can be different as it relies on the sensed attribute criticality and the target application.
- Small value of soft threshold provides a supplementary picture of the network, at the cost of improved energy consumption.

At every cluster change time, the attributes are transmitted once again and so, the user can modify them as needed [7].

C. *STABLE ELECTION PROTOCOL (SEP):*

SEP is a heterogeneous aware protocol which is based on weighted election probabilities of each node to become cluster head according to their respective energy. SEP ensures that the cluster head election is randomly selected and distributed based on the fraction of energy of each node considering a uniform use of the nodes energy [7]. This protocol is based on two levels of heterogeneity. A fraction m of total n nodes is set with an added energy factor α, which are called advanced nodes. Probabilities of normal nodes and advanced nodes to become CHs can be defined as:

pnrml = popt/(1+m.α) and padvc = popt/(1+m.α) respectively,
popt= optimal probability of each node to develop into CH.

CHs election in SEP is done arbitrarily based on the probability of each type of node. Nodes sense data and transmit this information to related CH (cluster head) which pass on it to BS (Base Station) [4].

V. IMPLEMENTATION AND RESULTS

We used Matlab 8.1 for doing the comparative study on LEACH, TEEN and SEP. The network parameters which have been used are shown in table 1.

TABLE I

SIMULATION PARAMETERS

Parameters	**Value**
Network Area	200*200
Initial energy	0.5J
Sink Location	(0 0),(0 100),(100 0)
Eelec (transmission & reception energy per bit)	$10*10^{-12}$ nJ/bit
Eamp (amplification energy at transmitter per bit)	$1.3*10^{-12}$ nJ/bit
Eda (data aggregation energy per bit)	$5*10^{-9}$ J
Percentage of nodes that are advanced, m	0.1

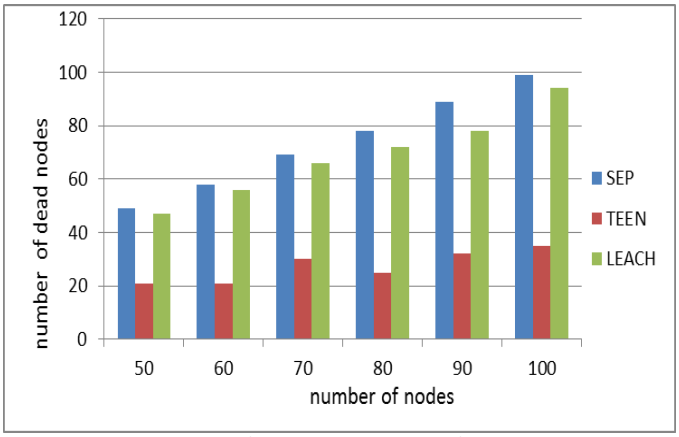

Figure 1: Total number of nodes v/s number of dead nodes when total number of rounds = 500.

Figure 1 shows the comparison of different protocols i.e-LEACH, TEEN and SEP w.r.t. to the total number of nodes to the desnumber of dead nodes. The x-axis represents the number of nodes and the y-axis represents the number of dead nodes.Here total number of rounds is 500. We have taken different values of no. of nodes as 50, 60, 70, 80, 90, 100. We found that number of dead nodes keep on increasing while we keep on increasing the total number of nodes.

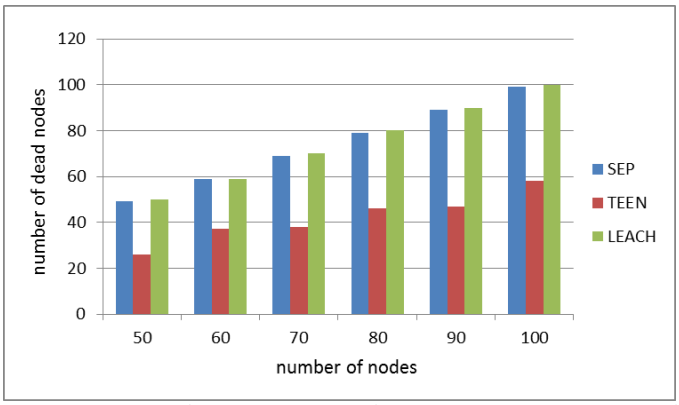

Figure 2: Number of nodes v/s number of dead nodes when total number of rounds = 1000.

In figure 2, x-axis represents the number of nodes and the y-axis represents the number of dead nodes.Here total number of rounds is 1000. In this figure, the no.of dead nodes increases compared to the last figure in each protocol.

We can see that the number of dead nodes keep on increasing in each protocol. i.e-SEP, TEEN and LEACH.

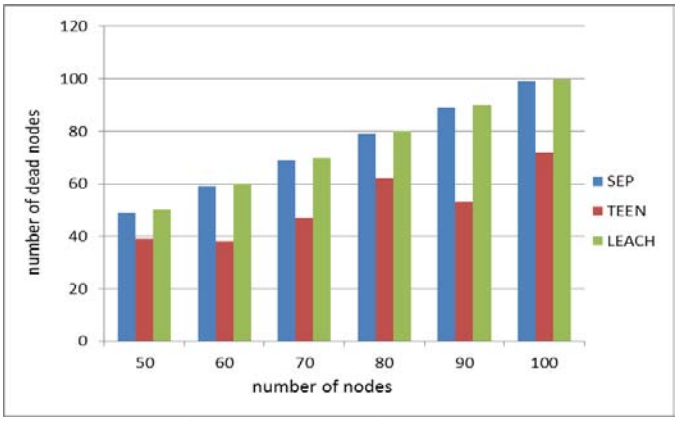

Figure 3: Number of nodes v/s number of dead nodes when total number of rounds = 1500.

In figure 3, x-axis is represented by the total number of nodes and the y-axis is represented by the number of dead nodes. Here total number of rounds is 1500. Comparing figure 3 with figure 2 we see that the in each protocol, no.of dead nodes keep on increasing compared to the last figure.

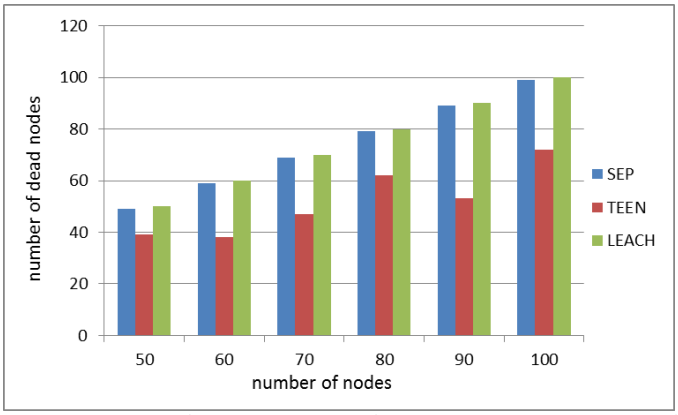

Figure 4: Number of nodes v/s number of dead nodes when total number of rounds = 2000.

Analyzing all the above figures, we see that the number of dead nodes increases as we increase the total number of nodes in each graph by setting the number of rounds as constant.i.e-for fig.1, number of rounds is 500. Similarly, for fig.2, fig.3, fig.4, have number of rounds as 1000, 1500 and 2000 respectively.In each protocol we can see that the number of dead nodes are increased as we move towards higher number of nodes. But since, the number of dead nodes are less in TEEN as compared to the other protocol so we can say that it is the best one among the three of them.

VI. CONCLUSION

Routing in wireless sensor network is another area of exploration. This paper gives a comparative study of the energy efficient routing techniques in wireless sensor networks. In our work we have presented the comparative study of three routing protocols and their brief classification and we have found how TEEN has proven to be better than the rest of the protocols. We concluded that as we increase the total number of nodes by keeping the number of rounds as constant, the number of dead nodes also increases in each protocol. But as we compare all three of them, we find TEEN as the best. Since the number of dead nodes is less in this protocol as compared to the other two, so this is the best one. This paper can further be extended by performing comparative analysis of these protocols on the basis of latency, QoS, throughput etc. Since energy efficiency is a matter of concern and has to be dealt with seriously.

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