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Reducing Energy Consumption and extending WSN lifetime using CBEEPSS

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Abstract:
An Energy efficient power saving scheme for Wireless Sensor Network (WSN) can be designed and developed via an algorithm to provide reasonable energy consumption and network for WSN to improve the lifetime of system. A cluster-based approach is used to reduce energy consumption in WSN. In this paper, a uniform cluster concept is proposed to reduce data transmission distance of sensor nodes in WSN. As a result the sensor node clustering is done to achieve an ideal distribution. The residual energy is accounted for selecting the appropriate cluster head nodes and the average distance between sensor nodes. To extend the lifetime of sensor node in WSNs and for increasing energy efficiency, new efficient energy saving schemes CBEEPSS (Cluster-Based Energy Efficient Power Saving Scheme) is proposed and developed. Lifetime of WSN is increased by using the uniform cluster location and balancing the network loading among the clusters. The proposed CBEEPSS algorithm achieves low energy consumption and better WSN life-time, as it detects the dead nodes from the sensing area and these dead nodes are recharged with the solar energy and again moved to pool of active node for further operation.

Keywords: - Cluster; Energy consumption, Lifetime of Network; Sensor networks; Wireless Sensor Network.

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1. INTRODUCTION

Recently, there has been a rapid growth in wireless communication technique. Inexpensive and low power wireless micro sensors are designed, deployed and widely used in wireless and mobile environment [1],[3],[4],[5],[6]. A wireless sensor network (WSN) is a network of large number of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on, where each node is equipped with limited on-board processing, storage and radio capabilities. All sensor nodes are used for detecting an event and routing the data in wireless networking. These sensor nodes are small in size that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission and are deployed in sensing area to monitor specific targets and collect the data. Then the sensor nodes send the data to base station (BS) by using wireless transmission techniques. WSNs are used in various applications like health care system, battlefield surveillance system, environment monitoring system, human behavior monitoring, agriculture monitoring and so on.The characteristics of sensor networks and application requirements have a decisive impact on thenetwork design objectives in term of network capabilities and network performance [2].

1.1 .NETWORK CHARACTERISTICS

As compared to the traditional wireless communication networks such as mobile ad hoc network(MANET) and cellular systems, wireless sensor networks have the following unique characteristics and constraints:

Dense sensor node deployment: Sensor nodes are usually densely deployed and can be several orders of magnitude higher than that in a MANET.

Battery-powered sensor nodes: Sensor nodes are usually powered by battery and are deployed ina harsh environment where it is very difficult to change or recharge the batteries.

Severe energy, computation, and storage constraints: Sensors nodes are having highly limited energy, computation, and storage capabilities.

Self-configurable: Sensor nodes are usually randomly deployed and freely configure themselves into a communication network.

Unreliable sensor nodes: Since sensor nodes are susceptible to physical damages or failures due to its deployment in harsh or unfriendly environment.

Data redundancy: In most sensor network application, sensor nodes are densely deployed in region of interest and collaborate to accomplish a common sensing task. Thus, the data sensed by multiple sensor nodes typically have a certain level of correlation or redundancy.

Application specific: A sensor network is usually designed and deployed for a specific application. The design requirements of a sensor network change with its application.

Many-to-one traffic pattern: In most sensor network applications, the data sensed by sensor nodes flow from multiple source sensor nodes to a particular sink, exhibiting a many-to-onetraffic pattern.

Frequent topology change: Network topology changes frequently due to the node failures, damage, addition, energy reduction, or channel fading

1.2. NETWORK DESIGN OBJECTIVES

Most sensor networks are application specific and have different application requirements. Thus,all or part of the following main design objectives is considered in the design of sensor networks:

Small node size: Since sensor nodes are usually deployed in a harsh or unfriendly environment inlarge numbers, reducing node size can facilitate node deployment. It will also reduce the powerconsumption and cost of sensor nodes.

Low node cost: Since sensor nodes are usually deployed in a severe or unfriendly environment inlarge numbers and cannot be reused, reducing cost of sensor nodes is important and will resultinto the cost reduction of whole network.

Low power consumption: Since sensor nodes are powered by battery and it is often very difficultor even impossible to charge or recharge their batteries, it is crucial to reduce the power consumption of sensor nodes so that the lifetime of the sensor nodes, as well as the whole network is extended.

Scalability: Since the number sensor nodes in sensor networks are in the order of tens, hundreds,or thousands, network protocols designed for sensor networks should be scalable to different network sizes.

Energy saving is one of the most important features for sensing the nodes to increased their lifetime in WSN.A sensor node consumes mostly its energy in transmitting and receiving data from source to destination. And the main power supply of the sensor node is battery. In most application scenarios, users are usually difficult to reach a location of sensor nodes. Due to large number of replacement of batteries might be impossible. Sensor node used its battery may make sensing area uncovered because of finite battery energy. Therefore, energy conservation becomes critical concern in WSN. To provide nodes with a long period of autonomy, new and efficient energy scheme and corresponding algorithm must be designed and developed that aims to optimize energy usage are needed, so as to extend the lifetime of nodes and the lifespan of the network as a whole [7][11].

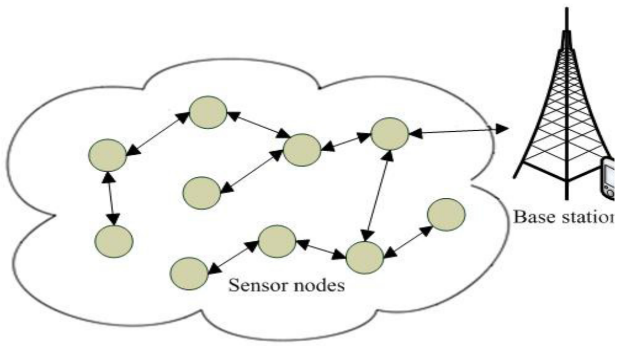


Fig 1.1: Infrastructure of wireless sensor network

The cluster-based technique is one of the approaches to reduce energy usage in WSNs. In this article, Optimize energy clustering algorithm is proposed to provide efficient energy consumption in such networks. The main idea of this article is to reduce the data transmission distance of sensor nodes in WSNs by using the uniform cluster concepts. In order to make an ideal distribution for sensor node clusters, average distance between the sensors nodes is calculated and take into account the residual energy for selecting appropriate cluster head nodes. The lifetime of WSNs is extended by using uniform cluster location and balancing the network loading among the clusters. The proposed CBEEPSS algorithm achieves low energy consumption and better network lifetime of WSNs, as it detects and eliminates the dead nodes from the sensing area and dead node will be charge with the help of solar energy for further operation in the network for extending the lifetime of sensor node.

Low Energy Adaptive Clustering Hierarchy (LEACH) is a hierarchical protocol in which number of sensor nodes will be divided into several clusters. For each cluster, sensor node is selected as a cluster head to avoid excessive energy consumption and its selection is depending upon the predetermined probability. In LEACH, most nodes transmit to cluster heads, and the cluster heads aggregate and compress the relevant data and forward it to the base station (sink). A non-cluster head nodes choose the nearest cluster to join by receiving the strength of the advertisement message from the cluster head nodes. These non-cluster head nodes can only monitors the environment and sends data to its cluster head nodes. Cluster head node processes the data and sends data to the BS which minimizes data transmission distance of the sensor nodes. Therefore, consumption of the energy is reduced. The distribution of cluster head nodes is not uniform, thus some sensor nodes have to transfer data through a longer distance and reasonable energy saving is not obtained in WSN [11].

HEED (Hybrid energy efficient distributed) is a clustering protocol which extends the basic scheme of LEACH by using residual energy as a primary parameter and network topology features (e.g. node degree ,distances to neighbors) as secondary parameter to break tie between candidate cluster heads, as a metric for cluster selection to achieve power balancing. That means the cluster heads are probabilistically selected based on their residual energy and sensor nodes join the clusters according to their power level. The clustering process is divided into lot of iterations and in each iteration, nodes which are not covered by any cluster head double their probability of becoming cluster head. Since this energy efficient clustering protocol enables every node to independently and probabilistically decide on its role in the clustered network. They can't guarantee optimal elected set of cluster heads. The primary goals of HEED are prolonging network life-time by distributing energy consumption, terminating the clustering process within a constant number of iterations/steps, minimizing control overhead, and producing well-distributed cluster heads and compact clusters. HEED distribution of energy extends the lifetime of nodes within the network thus stabilizing the neigh boring node [8].

2. RELATED WORK

Efficient energy saving scheme should be designed and developed to provide reasonable energy consumption and network for WSN to improve the lifetime of system. In WSN, a cluster based approach is used to reduce energy consumption. In this paper, author provide uniform cluster concept to reduce data transmission distance of sensor nodes in WSN. So that the sensor node clusters to create ideal distribution, and taken into account the residual energy for selecting the appropriate cluster head nodes and the average distance between sensor nodes [4]. A sensor network is composed of a large number of sensor nodes, which are densely placed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an on-board processor. Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data [3].Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. The focus, however, has been given to the routing protocols which might differ depending on the application and network architecture. In this paper, author present a survey of the state-of-the-art routing techniques in WSNs [11]. And outline the design challenges for routing protocols in WSNs followed by a comprehensive survey of different routing techniques. Overall, the routing techniques are classified into three categories based on the underlying network structure: Flat, Hierarchical, Location based routing.

Minimizing energy consumption and maximizing network lifetime are important issues in the design of applications and protocols for sensor networks. Energy-efficient sensor state planning consists in finding an optimal assignment of states to sensors in order to maximize network lifetime. For example, in area surveillance applications, only an optimal subset of sensors that fully covers the monitored area can be switched on while the other sensors are turned off. In this paper, author report the optimal planning of sensors states in cluster-based sensor networks. Typically, any sensor can be turned on, turned off, or promoted cluster head, and a different power consumption level is associated with each of these states. And look for an energy-optimal topology that maximizes network lifetime while ensuring simultaneously full area coverage andsensor connectivity to cluster heads, which are constrained to form a spanning tree used as a routing topology [11].

LEACH (Low Energy Adaptive Clustering Hierarchy) [11] is most popular hierarchical routing protocol for sensor networks in which most nodes transmit to cluster heads, and the cluster heads compress and aggregate the data and forward it to the base station. LEACH assumes that each node has a radio powerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy. Nodes that have been cluster heads cannot become cluster heads again for P rounds. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster to transmit its data.Topology control in a sensor network balances load on sensor nodes, and increases network scalability and lifetime. Clustering sensor nodes is an effective topology control approach. In this paper, authors propose a novel distributed clustering approach for long-lived ad-hoc sensor networks. The proposed approach does not make any assumptions about the presence of infrastructure or about node capabilities, other than the availability of multiple power levels in sensor nodes. HEED (Hybrid Energy-Efficient

Distributed clustering)[8] that periodically selects cluster heads according to a hybrid of the node residual energy and a secondary parameter, such as node proximity to its neighbors or node degree. HEED terminates in O (1) iterations, incurs low message overhead, and achieves fairly uniform cluster head distribution across the network.And prove that, with appropriate bounds on node density and intra-cluster and inter-cluster transmission ranges; HEED can asymptotically almost surely guarantee connectivity of clustered networks. Simulation results demonstrate that proposed approach is effective in prolonging the network lifetime and supporting scalable data aggregation.Hierarchical (clustering) techniques can help in reducing useful energy consumption. Clustering is particularly useful for applications that require scalability to hundreds or thousands of nodes. Scalability in this context implies the need for load balancing, efficient resource utilization, and data aggregation. Routing protocols can also employ clustering. Clustering can be extremely effective in one-to- many, many-to-one, one-to-any, or one-to-all (broadcast) communication. Although many protocols proposed in the literature minimize energy consumption on forwarding paths to increase energy efficiency, such protocols do not necessarily prolong network lifetime when certain nodes are "popular," i.e., present on most forwarding paths in the network. Even if dynamic routing (in which data is forwarded to nodes with the highest residual energy) is used, it may cause problems such as unbounded delay and routing loops. With clustering, a popular node is guaranteed to "lose its popularity" as new clusters (and forwarding paths) are constructed. Of course, node popularity due to interest in the data it provides can only be reduced by deploying several redundant nodes, and rotating among them. The essential operation in sensor node clustering is to select a set of cluster heads from the set of nodes in the network, and then cluster the remaining nodes with these heads. Cluster heads are responsible for coordination among the nodes within their clusters and aggregation of their data (intra cluster coordination), and communication with each other and/or with external observers on behalf of their clusters (inter-cluster communication) [8].

SECA (Savingenergy clustering algorithm) [12] is used to provide efficient energy consumption in WSNs. In order to make an ideal distribution for sensor node clusters, authors calculates the average distance between the sensor nodes and take into residual energy for selecting the appropriate cluster head nodes. The lifetime of WSNs is extended by using the uniform cluster location and balancing the network loading among the clusters. The main benefit of SECA is that the energy consumption is reduced and better network lifetime can be carried out.

TEEN (Threshold sensitive energy efficient sensor network protocol)[13]The sensor network architecture is based on a hierarchical grouping where closer nodes from clusters and this process goes on the second level until base station is reached. TEEN is not good for applications where periodic reports are needed since the user may not get any data at all thresholds are not reached. The architecture of APTEEN (Adaptive threshold sensitive energy efficient sensor network protocol) [14] is same as TEEN. APTEEN supports three different query types: historical, to analyze past data values, one time, to take a snapshot view of the network and persistent to monitor an event for a period of time.PEGASIS (Power efficient gathering in sensor information systems) [15] is a data gathering and near optimal chain-based algorithm that establishes the concept that energy conservation can result from nodes not directly forming clusters. This algorithm reduces the energy consumption by creation of a chain structure comprised of all nodes and continually data aggregation across the chain. The algorithm presents the idea that if nodes form a chain from source to sink, only one node in any given transmission time frame will be transmitting to the base station. PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS instead of per round as the power draining is multiple nods. In order to increase network lifetime, nodes need only to communicate with their closest neighbors and they take turns in communicating with the BS. When the round of all nodes communicating with the base station ends, a new round will start and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. Hence PEGASIS achieves energy conservation.

VGA (Virtual grid array protocol) [16] is a GPS-free technique to split the network topology into logically symmetrical, side by side, equal and overlapping frames (grids). And the transmission is occurred grid by grid. VGA provides the capability to aggregate the data and in-network processing to increase the life span of the network.

HPAR (Hierarchical power active routing) [17] discusses about an online power aware routing algorithm in large sensor networks. Path selection takes into consideration both the transmission power and the minimum battery power of the node in the path. It tries to compromise makes use of zones to take care of the large number of sensor nodes.

Energy consuming limitation often is main problem in wireless sensor networks. In this paper author introduce a new algorithm for reduce energy consumption and increase the useful lifetime of wireless sensor networks with cluster member bounds. This paper introduces the new energy adaptive protocol to reduce overall power consumption, maximize the network lifetime in a heterogeneous wireless sensor network. The protocol NCACM (the New Clustering Algorithm with Cluster Members bounds for energy dissipation avoidance in wireless sensor network), determine a confidence value for any node that want be a cluster head with parameters such as nodes remaining energy and distance between nodes and distance between cluster heads in each round then clustering provide. Simulation results show new algorithm has better performance as LEACH and LEACH-E and cause to reduce energy consumption and progress wireless sensor network performance and lifetime [10].

The authors propose an energy-efficient multi-level clustering algorithm called Multi-Level Clustering Algorithm (EEMC), which aims at minimum energy consumption in sensor networks. EEMC also covers the cluster head election scheme. In EEMC, the data collection operation is broken up into rounds, where each round begins with a cluster set-up phase, which means that the nodes execute EEMC algorithm to form a multi-level clustering topology independently, and continues with a data transmission phase, which means the nodes transmit the sensed data packets to the sink node under such a clustering topology. Assuming that base station is remotely located and sensor nodes are stationary, simulation results show that their proposed algorithm is highly effective in the network lifetime of a large-scale network [9]. They also show that the algorithm has low latency and moderate overhead across the network. The EEMC algorithm has the limitation that the regular nodes can join the last level of CHs only, thus incurring high latency in the network. Another notable limitation is that each node be GPS equipped to know its location precisely. If the precise location is not known, the algorithm will fail. In order to overcome these shortcomings, author proposes two new algorithms, LAMC (Location Aware Multi-level Clustering) and PAMC (Power Aware Multi-level Clustering). Simulations are used to analyze the performance of proposed algorithms [9].

3. PROPOSED WORK:CBEEPSS

3.1 CBEEPSS Framework and Design:

A wireless sensor network (WSN) is a network of large number of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on. Sensors have the capabilities of doing sensing, data processing, and wirelessly transmitting collected data back to the base stations by way of multiple-hop relay. Sensor itself supplies necessary operation with limited battery energy. Those operations that consume energy are transmitting and receiving data, running applications, measuring power, and even staying in standby mode. Among others, data transmission consumes most energy. In a sensor network, the network lifetime is important for applications. Energy consumption of each sensor directly affects the network operational lifetime. Those sensors which are close to base stations consume more energy since they should relay data for more sensors, and responsible to reduce their lifespan while being bad. Neighboring sensors of those bad sensors must relay data with stronger power, the energy consumption of these sensors is even quicker.

In Wireless Sensor Networks (WSN), energy is critical resource and constraint of such networks. There are number of researches already done on minimizing the energy consumption of WSN in order to extend the lifetime of entire network. Recently different introduced methods that work over different protocols of WSN. These approaches are based on use of energy harvesting (EH) device. In this project one such efficient method is investigated in which EH devices are designed for WSN: LEACH, HEED. This method aimed to address the analysis and design of WSNs with EH devices by focusing on conventional protocols.

In addition to this method, this approach is further extended by adding the energy efficient routing protocol called CBEEPSS. Routing protocol is also playing major role for the consumption of energy in WSN. Hence in this project basically the current approach of protocols with CBEEPSS is explored. CBEEPSS is Energy efficient version of HEED, the cluster heads are probabilistically selected on the basis of their residual energy and sensor nodes join the cluster according to their power level.

CBEEPSS consumed energy using sliding window approach, where if cluster head didn't get acknowledgement from non-cluster node within sliding window, then it remove that nodes from that cluster as it is and treat as dead nodes.In our proposed scheme, the dead node from the system is detected, and this dead node is again recharged by the solar energy. The greatest gift of nature to our universe is an energy. It is a bonus to the mankind and it exists in different forms like solar, wind, hydro, earthly and sky. This solar energy which is the greatest and most tapped form is the energy from sun. In this approach, use of solar energy based upon the geographical areas where no. of sensor nodes are deployed and radiation levels of the areas, so that it makes the system energy efficient. And by using the uniform cluster location and balancing the network loading among the clusters, the lifetime of WSNs will be extended.

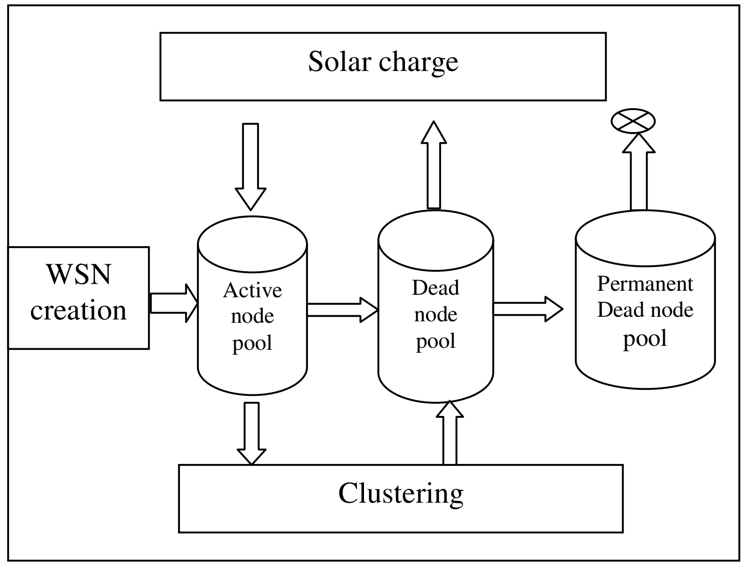


Fig 3.1. System architecture of CBEEPSS

Proposed System

3.2 Overview

CBEEPSS Algorithm:

There are number of sensor nodes needs to generate in order to evaluate the performance of the protocols under the different network conditions. This simulation is to simulate the key parameter which has diversified the estimation of the position of the sensor nodes and the sensing area, antenna directions (Omnidirectional), network parameters such as number of random locators and the number of static sensor nodes, and locator deployment strategy. The following are standard parameters: Initial energy, packet size, negotiation packet, and acknowledgement

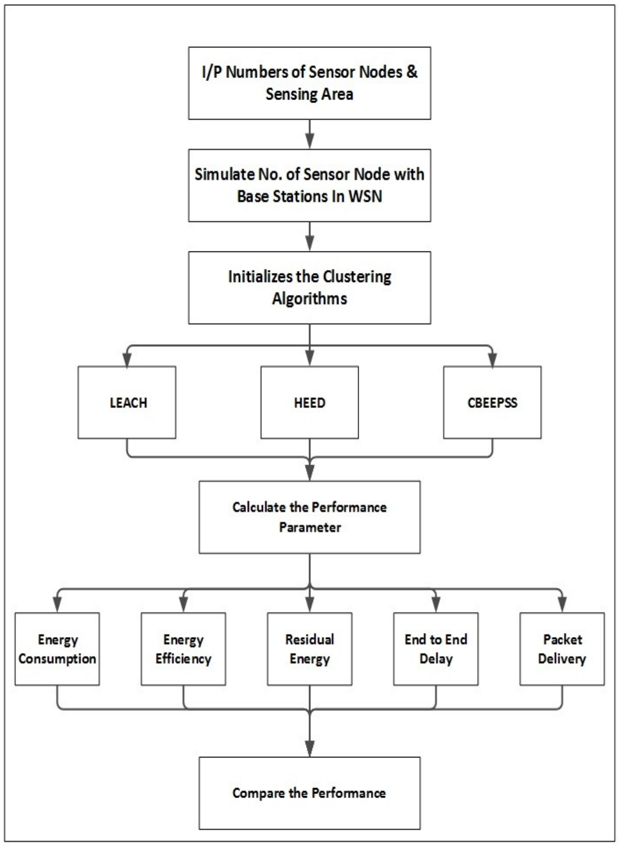


Fig.3.2: The framework of CBEEPSS method.

3.3 Mathematical Model

INPUT: No. of sensor nodes and sensing area position of the sensor nodes and the sensing area, antenna directions (Omnidirectional), network parameters such as number of random locators and the number of static sensor nodes, and locator deployment strategy. The following are standard parameters: Initial energy, packet size, negotiation packet, and acknowledgement packet.The steps involved in proposed algorithm are:

1. Input: network scenario i.e. set of sensor nodes and the sensing area.
2. Simulate no. of sensor nodes with base stations in WSN.
3. Initialize clustering algorithm with Random selection of cluster head node CH.
4. Calculate Euclidian distance beten each sensor node x and CH by following formula
5. D(x, CH) = $\sum_{i=1}^{n}\sqrt{(x-CH)2}$
6. Find minimum distance and then declare it as the closest cluster to each data point
7. **C**i = {j:d(**x**j,CHi)≤d(**x**j,CHl),l≠i,j=1,...,n}
8. Perform number of round of iterations till CH_{prob}=1;
9. Calculate energy parameter of each sensor node x with cluster
10. $E_{Tx}(k,d=d_{xy}) + E_{Tx}(k,d=d_{yz}) < E_{Tx}(k,d_{xz})$
11. If E_{Tx} =0, Remove that node from cluster of cj
12. Recharge the dead nodes from the pool of dead nodes by solar energy which depends upon the intensity of the sun.
13. If the dead node is recharge by solar energy then it moves into the active node pool again.
14. Else if the dead node is not recharge by solar energy within 48 hours then this node declares as a permanently dead node.
15. Compare the performance parameters of the system.
16. End

In proposed scheme, the dead node from the system is detected, and this dead node is again recharged by the solar energy which is the greatest and most tapped form is the energy from sun.And it is based upon the geographical areas where no. of sensor nodes are deployed and radiation levels of the areas, so that it makes the system energy efficient.After recharging the sensor node battery,this dead sensor nodes moves from dead node pool to active node pool. But if the dead node is not recharge by solar energy within 48 hours then this node declares as a permanently dead node. By using the uniform cluster location and balancing the network loading among the clusters,the lifetime ofWSNs will be extended.The simulation results show that the proposed schemeimproves the battery lifetime.

4. EXPERIMENTAL ANALYSIS

4.1 Energy Consumption: Amount of energy consumed in a process or system. It should be less.In addition, the energy consumption for data collection and aggregation of cluster head nodes is considered: $E_{Tx}(L,d) = E_{elec} * L * \varepsilon_{amp} * L$; $E_{Rx}(L) = E_{elec} * L$

Where d is the distance between the two sensor nodes, $E_{Tx}(L,d)$ is the transmitter energy consumption, and $E_{RX}(L)$ is the receiver energy consumption. E_{elec} is the electronics energy consumption per bit in the transmitter and receiver sensor nodes.

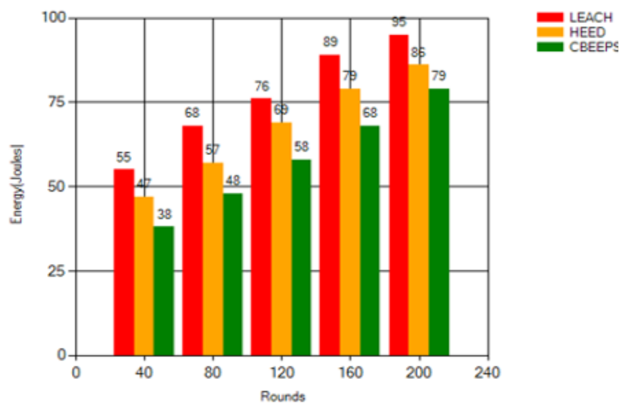


Fig. 4.1 Comparison of Energy Consumption by LEACH, HEED, CBEEPSS

4.2 Energy Efficiency: It is simply efficient energy use. The goal is to reduce the amount of energy required to provide products or services. Efficiency generally refers to how far one can get the particular outcome for the given input with as much less wastage as possible.

$\eta =$ *Useful energy transferred by the network* /Total energy supplied to the network.

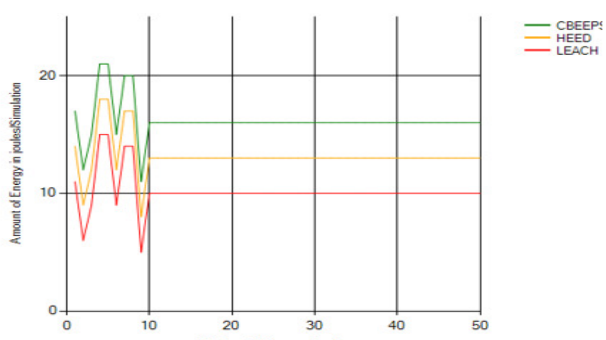


Fig. 4.2 Comparison of Energy Efficiency between LEACH, HEED, CBEEPSS

4.3 Residual Energy: Residual is used to describe what remains of something when most of it has gone. The higher value of end to end delay means the better performance of the protocol.

Residual energy = Total energy – Used energy.

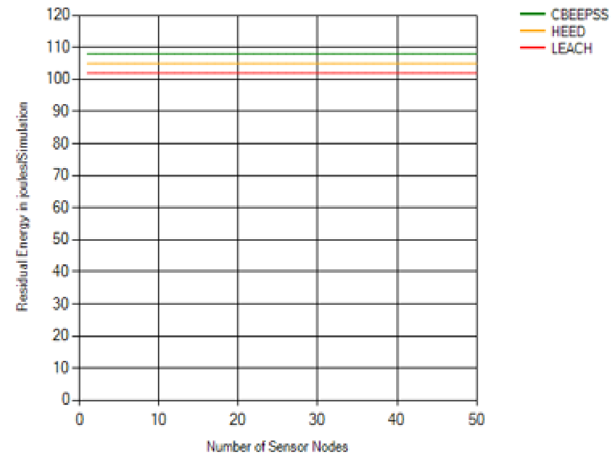
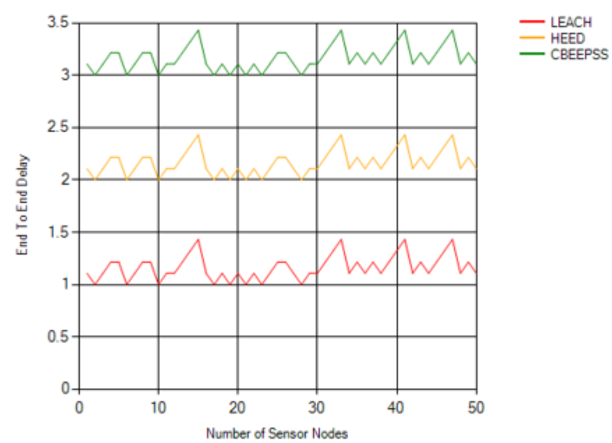


Fig. 4.3 Comparison of Residual Energy between LEACH, HEED, CBEEPSS

4.4 End to end delay: It is also called as one way delay refers to the time taken for a packet to be transmitted across a network from source to destination. The lower value of end to end delay means the better performance of the protocol.

$\sum$ (arrive time – send time) / $\sum$ Number of connections



4.4 Comparison of End to end delay between LEACH, HEED, CBEEPSS

4.5 Packet Delivery ratio: The ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination. The greater value of packet delivery ratio means the better performance of the protocol.

∑ Number of packet receive / ∑ Number of packet send

Fig. 4.5 Comparison of Packet delivery ratio between LEACH, HEED, CBEEPSS

5. CONCLUSION

One of the most challenging issues in the WSNs is saving the energy. To make the sensor node energy efficient with extended lifetime, new energy efficient power saving schemes must be developed. In the proposed scheme, the average distance between the sensor nodes is calculated and have taken into account the residual energy for selecting the appropriate cluster head nodes. By using the uniform cluster location and balancing the network loading among the clusters, the lifetime of WSNs will be extended. To best of our knowledge the proposed CBEEPSS algorithm looks promising with the low energy consumption and better network lifetime of WSN. The mechanism of detecting dead nodes from the sensing area and on the basis of solar radiation, an algorithm is designed for variation in the recharging cycle of the battery of the dead sensor node, andconsequently prolonged the battery lifetime. Compared to wired networks and other wireless networks such as cellular networks, WSNs are still at an early stage of development and a lot of work needs to be done in order to take them to the maturity level. Along with further optimization of the communication protocols, in future the plan is to expand on this study and try different types of batteries, and adjust different environmental conditions such as temperature and humidity and see their effect on the battery lifetime. Also different newly propose cluster-based protocols and algorithms will be investigated and compared as other approaches to save the energy in Wireless Sensor Networks.

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