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WIRELESS SENSOR NETWORK DESIGN ENHANCEMENT TO GET MAXIMUM CHANNEL AVAILABILITY

Vanita[1], Meenakshi[2]
[1]HOD ECE, [2]M.TECH SCHOLORS, MRKIET REWARI

ABSTRACT: A wireless sensor network is a collection of sensor nodes with limited power supply and constrained computational and transmission capability. Due to the limited transmission and computational ability, and high density of sensor nodes, forwarding of data packets takes place in multi-hop data transmission. Therefore routing in wireless sensor networks has been an important area of research in the past few years. The sensor nodes run on non-rechargeable batteries, so along with efficient routing the network should be energy efficient with efficient utilization of the resources and hence this is an important research concern. Advances in wireless Technologies and evolution of low cost sensor nodes have led to introduction of low power wireless sensor networks. Due to multiple functions and ease of deployment of the sensor nodes it can be used in various applications such as target tracking, environment monitoring , health care, forest fire detection, inventory control, energy management, surveillance and reconnaissance, and so on. The main responsibility of the sensor nodes in a network is to forward the collected information from the source to the sink for further operations, but the resource limitations , unreliable links between the sensor nodes in combination with the various application demands of different applications make it a difficult task to design an efficient routing algorithm in wireless sensor networks.

I. INTRODUCTION

Wireless Sensor Network:- A wireless sensor network is a collection of sensor nodes with limited power supply and constrained computational and transmission capability. Due to the limited transmission and computational ability, and high density of sensor nodes, forwarding of data packets take place in multi-hop data transmission. Therefore routing in wireless sensor networks has been an important area of research in the past few years. The sensor nodes run on non-rechargeable batteries, so along with efficient routing the network should be energy efficient with efficient utilization of the resources and hence this is an important research concern. Advances in wireless Technologies and evolution of low cost sensor nodes have led to introduction of low power wireless sensor networks. Due to multiple functions and ease of deployment of the sensor nodes it can be used in various applications such as target tracking, environment monitoring , health care, forest fire detection, inventory control, energy management, surveillance and reconnaissance, and so on . The main responsibility of the sensor nodes in a network is to forward the collected information from the source to the sink for further operations, but the resource limitations , unreliable links between the sensor nodes in combination with the various application demands of different applications make it a difficult task to design an efficient routing algorithm in wireless sensor networks. Designing suitable routing algorithms for different applications, fulfilling the different performance demands has been considered as an important issue in wireless sensor networks. In this context many routing algorithms have been proposed to improve the performance demands of various applications through the network layer of the wireless sensor networks protocol stack , but most of them are based on single-path routing. In single-path routing approach basically source selects a single path which satisfies the performance demands of the application for transmitting the load towards the sink.

Though the single path between the source and sink can be developed with minimum computation complexity and resource utilization, the other factors such as the limited capacity of single path reduces the available throughput. Secondly, considering the unreliable wireless links single path routing is not flexible to link failures, degrading the network performance. Finding an these factors single path routing cannot be considered effective technique to meet the performance demands alternate path after the primary path has disrupted to continue the data transmission will cause an extra overhead and increase delay in data delivery. Due to of various applications. To overcome these performance issues and to cope up with the limitations of the single path routing strategy, multi-path routing strategy also known as alternate path routing came into existence. As the name suggests there will be multiple paths established between the source and the destination through which the data can reach the destination. Now how these links are used are totally based on the individual routing strategy. Some routing algorithms use the best path to send the data, keeping the other alternate paths as a backup and use it if the primary pathfails, some use all the paths concurrently to send data and so on. In the past few years multi-path routing approach is extensively used for different network management purposes, such as providing a fault tolerant routing, improving transmission reliability, congestion control and Quality of Service(QoS) support in the wired and wireless networks, but the unique features of the wireless sensor networks and the characteristics of the short range radio communications introduce new challenges that should be addressed in designing the multi-path routing protocols.

Routing in WSN:

Since transmission of data from the targeted source to the sink is the main task of the wireless sensor networks, the method used to do the data forwarding is an important issue which should be considered in developing these networks.

more challenging compared to traditional wireless networks such as ad-hoc networks . First, considering the high density of nodes, the routing protocols should route data over long distances, regardless of the network structure and size, in addition to the above requirement some of the active nodes may fail during the operations due to the environmental factors or energy depletion of sensor nodes or hardware faults, but these issues should not interrupt the normal operations of the network. Moreover, as mentioned earlier the wireless sensor nodes are restricted in terms of power supply, processing capability and available bandwidth, routing and data forwarding should be performed with effective network resource utilization. Further, considering the performance demands of the wireless sensor networks are totally application dependent, routing algorithms should satisfy the QoS demands of the application for which the network is being deployed. For example, challenges in designing the routing algorithms for environment monitoring will be different from issues that should be considered for health care monitoring or target tracking.

Multipath Routing in Wireless Sensor Networks

The restricted capacity and transmission capability of multi hop path and high dynamics of wireless links single path approach is not able to provide efficient data rate in transmission in Wireless Sensor Networks. To overcome these issues now a day's multi-path approach is used extensively. As mentioned before multi-path routing has demonstrated its efficiency to improve the performance of wireless sensor and ad-hoc networks. In the following, we review the gain in performance that can be achieved by using multi-path approach.

Basic Principles in Designing Multipath Routing Protocols

There are several components in multi-path routing protocol to construct multiple paths and distribute the traffic over the discovered paths. The performance gains of the multi-path routing protocols are highly dependent on the ability of the proposed protocol to construct high quality, reliable paths. We describe these components in details.

Routing in WSN:

A wireless sensor network (WSN) can be defined as a network of (possibly low-size and low complex) devices denoted as nodes that can sense the environment and communicate the information gathered from the monitored field (e.g., an area or volume) through wireless links; the data is forwarded, possibly via multiple hops relaying, to a sink (sometimes denoted as controller or monitor) that can use it locally, or is connected to other networks (e.g., the Internet) through a gateway.

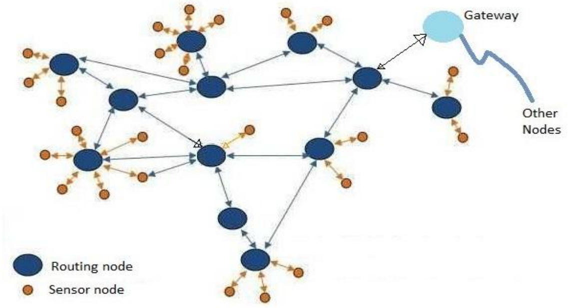


Fig : Typical WNS

Classification of sensor network

Classification of sensor network on basis of their mode of functioning and the type of target application are:

Proactive Networks

Nodes in this network periodically switch on their sensors and transmitter, sense the environment and transmit the data of interest. Thus, they provide a snapshot of the relevant parameters at regular intervals. These types of networks well suited for applications requiring periodic monitoring of data.

Reactive Networks

In this scheme the nodes react immediately to sudden and drastic changes in the value of a sensed attribute. These types of networks are well suited for time critical applications. Recent advances in wireless sensor networks have lead to many new protocols specifically designed for sensor networks where energy awareness is an essential consideration. But approaches like Direct Communication and Minimum Transmission Energy do not guarantee balanced energy distribution among the sensor nodes. In Direct Communication Protocol each sensor node transmits information directly to the base station, regardless of distance. As a result, the nodes furthest from the BS are the ones to die first . On the other hand, in case of Minimum Transmission Energy routing protocol data is transmitted through intermediate nodes. Thus each node acts as a router for other nodes' data in addition to sensing the environment. Nodes closest to the BS are the first to die in MTE routing. So far, cluster-based technique is one of the approaches which successfully increases the lifetime and stability of whole sensor networks. We classified most important energy efficient routing techniques based on various clustering attributes like cluster formation and data gathering process. Figure is a hierarchical diagram of different routing protocols which are widely used in WSN.

II. DIFFERENT TYPE OF PROTOCOL IN WSN

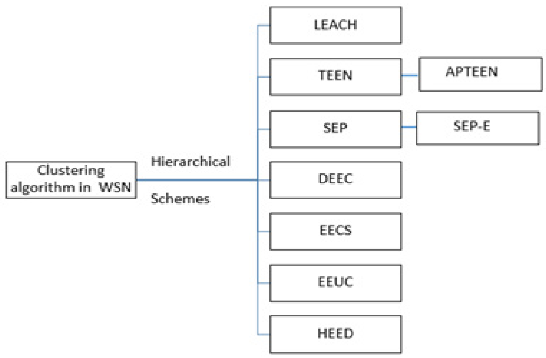


Figure: Classification of widely used clustering schemes in WSN

LEACH

W. R. Heinzelman, A. P. Chandrakasan and H. Balakrishnan proposed Low Energy Adaptive Clustering Hierarchy (LEACH) protocol in 2000. It is one of the most popular hierarchical routing algorithms for sensor networks. The idea is to form clusters of the sensor nodes based on the received strength of the signal and use local cluster heads as routers to the BS. This will save energy since the transmissions will only be done by such cluster heads rather than all sensor nodes. Optimal number of cluster heads is estimated to be 10 percent of the total number of nodes. All the data processing such as data fusion and aggregation are local to the cluster. Cluster heads change randomly over time in order to balance the energy dissipation of nodes. This decision is made by the node choosing a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n) = \frac{P}{1 - P * (\frac{1}{P})}, \quad n \in G$$
$$= 0, \qquad \text{Otherwise}$$

Where p is the desired percentage of cluster heads (e.g. 0.1), r is the current round and Gis the set of nodes that have not been cluster heads in the last 1/p rounds.

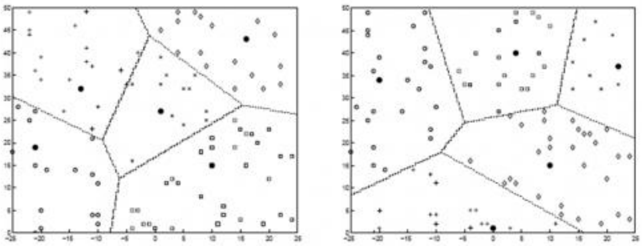


Fig – clustering in WSN

TEEN

In 2001, A. Manjeshwar and D. P. Agarwal proposed Threshold sensitive Energy Efficient sensor Network Protocol (TEEN) protocol

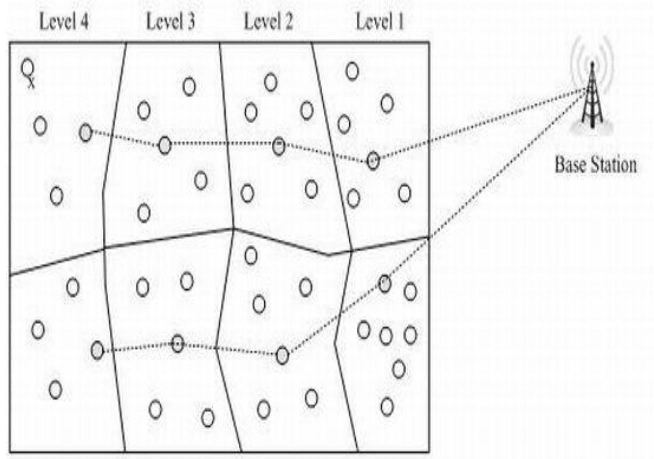


Fig : each cluster node is connected to BS

Advantages of TEEN

On the basis of two thresholds, data transmission can be easily controlled i.e. only the required data is transmitted. In this way it reduces the energy of transmission. Since TEEN is complementing for reacting to large changes in the sensed attributes, it is suitable for reactive scenes and time critical applications.

Disadvantages of TEEN

It is not suitable for periodic reports applications because if the values of the attributes are below threshold, the user may not get any data at all. There exist wasted time-slots and a possibility that the BS may not be able to distinguish dead nodes from alive ones, because only when the data arrive at the hard threshold and has a variant higher than the soft threshold did the sensors report the data to the BS. If CHs are not in the communication range of each other the data may be lost, because information propagation is accomplished only by cluster-heads.

APTEEN

A. Manjeshwar and D. P. Agarwal proposed Adaptive Threshold sensitive Energy Efficient sensor Network Protocol (APTEEN) protocol in 2002. The protocol is an extension of TEEN aiming to capture both time-critical events and periodic data collections. The network architecture is same as TEEN. After forming clusters the cluster heads broadcast attributes, the threshold values along with the transmission schedule to all nodes. According to energy dissipation and network lifetime, TEEN gives better performance than LEACH and APTEEN, because of the decreased number of transmissions. The main drawbacks of TEEN and APTEEN are overhead and complexity of forming clusters in multiple levels, implementing threshold-based functions and dealing with attribute based naming of queries.

SEP

In 2004, G. Smaragdakis, I. Matta and A. Bestavros proposed Stable Election Protocol (SEP) . This protocol is an extension of LEACH. It is a heterogeneous aware protocol, based on weighted election probabilities of each node to become cluster head according to their respective energy. This approach ensures that the cluster head elections randomly selected and distribution is based upon the fraction of energy of each node, which assures a uniform use of the energy. In this protocol, two types of nodes (two tierin-clustering) and two level hierarchies were considered. CHs selecting probability for normal nodes is pnrm=popt/(1+m.α) and for advanced nodes padv=popt.(1+α)/(1+m.α),where popt is the optimal probability of each node to become CH. The idea is that the advance nodes have to become the CHs more often than normal nodes. SEP gives better result as the value of α and m will increase.SEP maintains the constraints ofwell-balanced energy consumption. As initially, advanced nodes have to become the CHs more often than normal nodes. Thus, SEP yields longer stability region by utilizing the extra energy of more powerful nodes. But the main drawback of SEP method is that the election of the cluster heads among the two type of nodes is not dynamic, which results that the nodes that are far away from the powerful nodes will die first. SEP sets two probabilities based on only nodes initial energy. But the possibility in SEP is that after certain rounds an advanced node might become normal node due to more energy consumption. In such conditions, SEP selects low energy node as a maximum probability of being cluster head as SEP is only aware of nodes initial energy.

E-SEP

The extension of SEP, Femi A. Aderohunmu and Jeremiah D. Deng proposed E-SEP in the year of 2009.E-SEP considers three types of nodes, normal nodes, intermediate nodes and advance nodes. Where, advance nodes are in a fraction of total nodes with an additional energy as in SEP and a fraction of nodes with some extra energy greater than normal nodes and less than advance nodes, called intermediate nodes, while rest of the nodes are normal nodes. As in SEP, the initial energy for normal nodes is Eo, and for advanced nodes is (1+α).Eo. E-SEP added another set of initial energy nodes i.e. Eint as (1+ α).Eo, where α = α /2. Like SEP, in E-SEP CHs are selected depending on probability of each type of node. However, energy dissipation is controlled to some extent due to three levels of heterogeneity.

DEEC

In 2006, Q. Li, Z. Qingxin and W. Mingwen proposed Distributed Energy Efficient Clustering Protocol (DEEC) protocol. This protocol is a cluster based scheme for multilevel and two level energy heterogeneous wireless sensor networks. In this scheme, the cluster heads are selected using the probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster- heads for nodes are different according to their initial and residual energy. The nodes with high initial and residual energy have more chances to become the cluster heads as compared to nodes having low energy. The main disadvantage of DEEC is advanced nodes are always penalized, particularly when their residual energy reduced and become in the range of the normal nodes. In this position, the advanced nodes die rapidly than the others.

HEED

In 2004,OYounis, S Fahmy proposed HEED: A hybrid, energy-efficient, distributed clustering approach. HEED is a multi-hop clustering algorithm for wireless sensor networks, with a focus on efficient clustering by proper selection of cluster-heads based on the physical distance between nodes. Cluster construction in HEED Reference 2is performed based on two parameters- the node's residual energy, and intra-cluster communication cost. In HEED, elected CHs have relatively high average residual energy.

EEUC

In 2005, C. Li, M. Ye, G. Chen and J. Wu proposed An energy-efficient unequal clustering mechanism for wireless sensor networks. EEUC is designed for periodic data gathering applications in WSN. According to this scheme the nodes in one region compete to become CH in such a way that the node's competition range decreases as its distance to the base station decreasing. Thus the nodes closer to the BS consume less energy for intra cluster routing and can utilize it for inter-cluster routing. Energy consumed by cluster heads per round in EEUC much lower than that of LEACH standard but similar to HEED protocol.

M-GEAR

In Gateway-Based Energy-Aware Multi-Hop Routing Protocol for WSNs: M-GEAR proposed in 2013, sensor nodes are divided into four regions based on nodes location. Base Station is situated out of sensing area and a special node termed as Gateway is placed at the Centre position. Nodes which are near to BS or Gateway use direct communication to send packets directly to BS or Gateway. Rest nodes are divided into two equal regions, and only this regions are taking part of CHs formation exactly the same way as of LEACH. M-GEAR performs better than LEACH but it has certain limitations. M-GEAR is a region based protocol where node has to decide whether to take part in clustering or in direct communication which increase overheads. Secondly implement of gateway which is not energy restricted leads to more cost.

III. THEORETICAL DEVELOPMENT

Motivation

The design of the clustering technique in Wireless sensor network is influenced by the limited power of the battery that mandate to design the energy efficient clustering protocol. Much researches has been done in the recent past investigating different aspects like low power protocol, network establishment, coverage problems and the establishment of reliable wireless sensor networks. But, even after many efforts, there are still design options open for improvement. This leads to motivate me to devise a new protocol which enables more efficient use of scare resources at individual sensor nodes for an application.

Routing Challenges and Design Issues

Depending on the application, different architectures and design goals have been designed for sensor networks since the performance of a routing protocol is closely related to the architectural model-

Network dynamics- Most of the network architectures assume that sensor nodes are stationary, because there are very few setups that utilize mobile sensors. It is sometimes necessary to support the mobility of sinks or cluster-heads. Route stability becomes an important optimization factor, in addition to energy, bandwidth etc. The routing messages from or to moving nodes is more challenging. So, the sensed event can be either dynamic or
Static depending on the application.

Node deployment- It is application dependant that affects the performance of the routing protocol. The deployment is either deterministic or self-organizing. In deterministic deployments, the sensors are placed manually and data is routed through a fixed-determined paths. On otherhand, in self-organizing systems, the sensor nodes are scattered randomly creating an infrastructure in and adhoc manner.

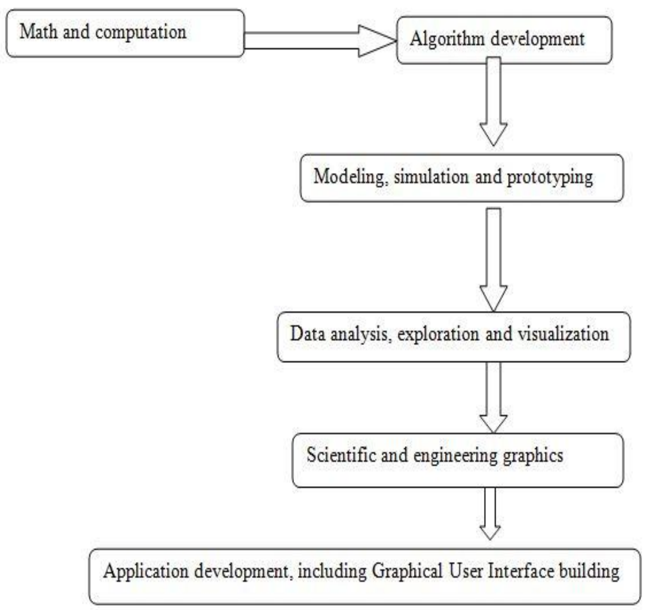
Energy Considerations- During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. As thetransmission power of a wireless radio is directly proportional to the distancesquaked or even higher order in the presence of obstacles, multi-hop routingwill consume less energy than direct transmission.

Proposal:
I will use multi-hop and multi-path for increasing the network life and decreasing the consumption of power. The power consumption will be less due to load balancing on cluster heads of every cluster. Then Compared to traditional networks, sensor networks have rather different characteristics and quality measurements. Because of the high collaboration of sensor nodes and very specific application goals, there is no "one size fits all" solution to routing, so the specific characteristics decide what routing mechanism to use. In this thesis we have made simulations that show that asymmetric communication with multi hop extends the lifetime of large cluster based sensor networks. We have also investigated the usefulness of enforcing a minimum separation distance between cluster heads in a cluster based sensor network to prolong network lifetime. For Above requirements we are implementing as below.

Implementation of Multi hop Communication
A large number of sensor nodes have to work together and techniques such as sending information directly from each sensor node to a base station need in many cases to be avoided. When a sensor node sends data directly to a base station, the amount of energy used by the sensor node can be quite high, depending on the location of the sensor node relative to the base station. In such a scenario, the nodes that are furthest away from the base station will run out of power much faster than those nodes that are closer to the base station, and parts of the network area will no longer be covered by functional sensor nodes. When communicating in a sensor network the amount of energy used by a sensor node depends on e.g. the size of the packet and the communication distance. The amount of energy used when communicating can be proportional to up to d4 (d = distance between the two communicating nodes), for long distance communication. To avoid problems with long distance communication, so called multi hop communication is used. In multi hop, information is sent from sensor node to sensor node to finally reach the base station, thus routing mechanisms/techniques are needed. We have, in paper A, made simulations that show that multi hop communication together with asymmetric communication between the base station and the sensor nodes are less energy consuming than not using asymmetric communication. The simulations are made in the AROS architecture where the base station acts as a master for the sensor nodes and is able to reach all its sensor nodes in one hop. However, all sensor nodes might not reach the base station in one hop, hence other nodes might need to forward information towards the base station, i.e. multi hop. In the AROS architecture we use cluster heads to forward information.

Insertion of Cluster Heads
Clustering is one way of making routing less complex, and for some sensor networks, more energy efficient. To decrease routing complexity and increase energy efficiency it is important to decide how many cluster heads that are most suitable, and which of the sensor nodes are going to act as cluster heads. Another important issue is the geographical placement of the cluster heads. If the cluster heads are grouped together or located too close to each other, the adherent cluster nodes need to communicate very long distances and thereby draining their energy. The size of the clusters are also likely to vary, some clusters may be very small and others very large (many nodes belong to one cluster head). To be able to know that the cluster heads are not too close to each other, we have in paper B made simulations to investigate the usefulness of enforcing a minimum separation distance between cluster heads in a cluster based sensor network. The simulations, made in the AROS architecture, indicates that enforcing a minimum separation distance increases network lifetime and that the number of clusters used also influences the lifetime of the network. Implementation of extended Heuristic Routing Algorithms The most power-consuming activity of a sensor node is communication. Hence, communication cost must be as small as possible in order to save power. One approach to minimize energy consumption is to always use the route that is least energy expensive to reach the base station. But if all traffic is routed through the minimum energy path (the least energy expensive way), the sensor nodes in this path will drain their energy and the network lifetime will be affected. To avoid this problem, routing paths will have to be changed several times during the lifetime of the network, and the energy consumption need to be balanced among the senor nodes to maximize the network lifetime. In paper C, an initial study of maximum lifetime routing in sparse sensor networks has been made to be able to see how different heuristic routing algorithms influence the energy consumption for individual sensor nodes, and thus the lifetime of a sparse sensor network. The maximum lifetime of the heuristic algorithms is also compared to the maximum lifetime of an optimal routing solution.

Process Flow



IV. RESULT AND DISCUSSION

Simulation

To evaluate the performance of our protocol, we have implemented it on the MATLAB simulator with the integrated model of Advance teen protocol. Our goals in conducting the simulation are as follows:

Compare the performance of the TEEN and LEACH protocols on the basis of energy dissipation and the longevity of the network. Study the effect of the soft threshold ST on TEEN. The simulation has been performed on a network of 20 nodes and a fixed base station. The nodes are placed randomly in the network. All the nodes start with a some initial energy. Cluster formation is done as in the leach protocol. However, their radio model is modified to include idle time power dissipation (set equal to the radio electronics energy) and sensing power dissipation (set the radio electronics energy). The idle time power is the same for all the networks and hence, does not affect the performance Comparison of the protocols.

Simulated Environment

For our experiments, we simulated an environment with varying temperature in different regions. The sensor network nodes are first placed randomly in a bounding area of 100x100 units. The actual area covered by the network is then divided into four quadrants. Each quadrant is later assigned a random temperature between 0_F and 200_F every 5 seconds during the simulations. It is observed that most of the clusters have been well distributed over the four quadrants.

Experiments

We use two metrics to analyze and compare the performance of the protocols. They are:

Average energy dissipated: This metric shows the average dissipation of energy per node over time in the network as it performs various functions such as transmitting, receiving, sensing, aggregation of data etc.

Total number of nodes alive: This metric indicates the overall lifetime of the network. More importantly, it gives an idea of the area coverage of the network over time. We now look at the various parameters used in the implementation of these protocols. A common parameter for both the protocols is the attribute to be sensed, which is the temperature. The performance of TEEN is studied in two modes, one with only the hard threshold (hard mode) and the other with both the hard threshold and the soft threshold (soft mode). The hard threshold is set at the average value of the lowest and the highest possible temperatures. The soft threshold is set at for our experiments.

MATLAB Simulation Environment

Overview

In this Chapter we are going to discuss about the MATLAB simulation environment. MATLAB is a numerical computing environment and 4th generation programming language. Initially MATLAB was developed for numerical computing but after adding some additional toolbox and packages now MATLAB is a programming environment for algorithm development, data analysis, visualization, and numerical computation. Typical uses of MATLAB high-performance language for technical computing include

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The name MATLAB stands for Matrix Laboratory. It can solve technical computing problems especially problems with matrix and vector formulations very efficiently. Educational institutes used it as standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis. Toolboxes can be added on to MATLAB and they allow learning and applying specialized technology. Toolboxes are collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Here toolboxes are available for signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many other areas.

The MATLAB System

The MATLAB system consists of these main parts :

Desktop Tools and Development Environment

This part of MATLAB is the set of tools and facilities that help to use and MATLABfunctions and _les. Many of these tools are graphical user interfaces. It includes theMATLAB desktop and Command Window, an editor and debugger, a code analyzer, browsers for viewing help, the workspace, and files, and other tools.

Mathematical Function Library

This library is a vast collection of computational algorithms ranging from elementary functions, like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix Eigen values, Bessel functions, and fast Fourier transforms.

The Language

The MATLAB language is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features.

Graphics

MATLAB has extensive facilities for displaying vectors and matrices as graphs, as well as annotating and printing these graphs. It includes high-level functions for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level functions that allow to fully customize the appearance of graphics as well as to build complete graphical user interfaces for MATLAB applications.

External Interfaces
Programs written in C and FORTRAN can interact with MATLAB by using external interfaces library.

Motivation of Using MATLAB
The rich function library of MATLAB enables easy implement of different types of algorithms for WSN. Especially topology control, routing, network partitioning and sink placement algorithms can be viewed lively using MATLAB. The graphical functions help to visualize the WSN very efficiently. Random deployment of nodes can be shown in MATLAB figure very interestingly. Uses of different colors make representation of nodes and sink very striking. Also data transmission from one node to another can be shown graphically using MATLAB. MATLAB has built in mathematical functions for array, matrices, computational geometry, polynomials, linear algebra and numerical methodsetc. Which are very useful for implementing algorithms discussed throughout this thesis. Use of these functions makes the implementation of graph partitioning, sink placement and fault tolerance algorithms very easy. Furthermore MATLAB allows user to write their own functions and scripts using the built in functions and data types and data structures. Therefore MATLAB ischosen as simulation environment for implementation of algorithms of this thesis.

Used MATLAB Functions
Several graphical and mathematical MATLAB functions are used for implementing algorithms of this thesis. Prominent among these functions are as follows.

Graphical Functions
Figure ()
Figure () function creates a new figure window and returns its handle. figure (h) makes h the current figure, makes it visible, and raises it above all other figures on the screen.
If figure h does not exist, and h is an integer, a new figure is created with handle h. In this thesis function figure(1) is used to create figure shown in Figure .
Hold
Hold function holds the current graph hold on holds the current plot and all axis properties so that subsequent graphing commands add to the existing graph.
Hold on returns to the default mode whereby plot commands erase the previous plots and reset all axis properties before drawing new plots. In this work the hold function is represented.
Plot ()
Plot(x, y): If x and y are real number, plot(x, y) produce a point on the figure with coordinate x and y. It is possible to specify color, line styles, and markers when data are plotted using the plot command.
In this thesis plot () function is used for showing random node deployment graphically. Also the plot function used to show sink location. In this work the plot function is represented
The plot () function used in figure below plots all nodes of a WSN. Figure below shows the random deployment of nodes using plot function.

Line ()
Line(X,Y) : adds the line defined in vectors X and Y to the current axes. User can use properties like line style and color to show the line in desired style and color.

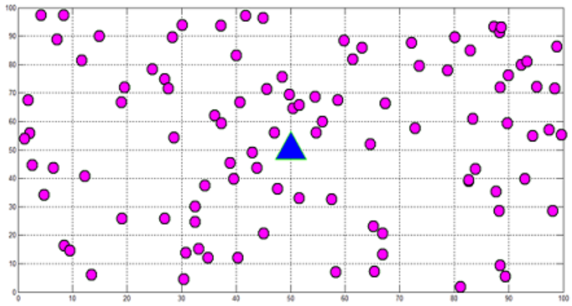


Figure : A WSN with random node deployment
In this thesis line function is used for showing the data transmission path from source to sink. Figure shows data transmission paths following which event information reached to sink.

Grid
Grid on adds major grid lines to the current axes.grid off removes all grid lines from the current axes.In this work the grid function is represented like Figure below

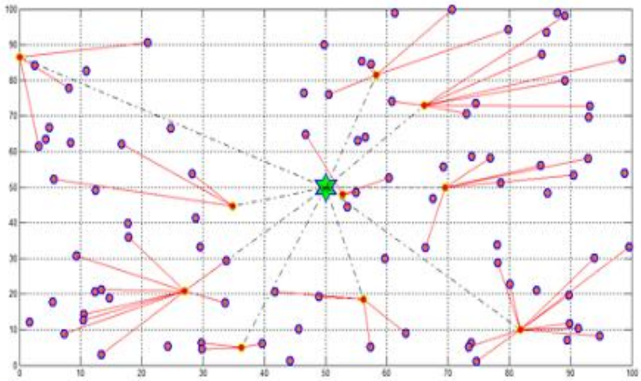


Fig: Mathematical Functions
Rand ()
Rand (): generates uniformly distributed pseudo random numbers. This function hasvarious forms. In this work rand (1, n) is used. It generate a one dimensional array ofn random numbers, where n is the number of nodes. This function is used to generate coordinates of n nodes.X collects the x coordinates of n nodes whereas Y collects ycoordinate of n nodes. xm and ym is the length of the network field along with the xand y coordinate in which the nodes will be deployed.

Convhull ()
Convhull(x,y): returns indices into x, y vectors of the points

on the convex hull. In the algorithms discussed in subsequent chapters convhull is used in conjunction with plot function to roughly define the area under each cluster .A partitioned WSN via clustering. Here each clustering area is bounded using convhull and plot functions.

MATLAB Code Segments

MATLAB is a high level programming language and it include matrix based data structures. The data types, built in functions enables the user to write their own functions,

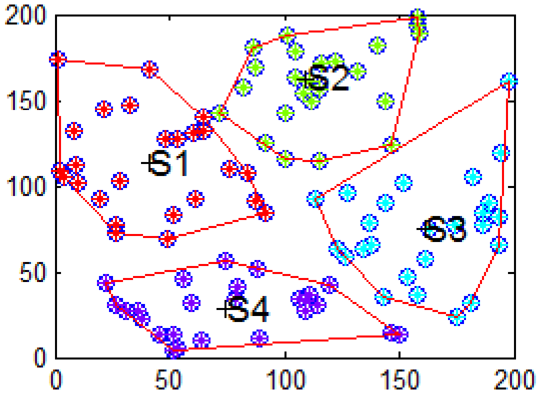


Figure: Partitioned WSN using clustering

Scripts etc. It also provides object oriented programming capabilities, error handling etc. Some of the MATLAB code segments used in the implementation of algorithms in this thesis is presented in these section. All algorithms of this thesis consider random deployment of sensor node. These random deployments are done in MATLAB by generating the x and y coordinate of a node randomly. Figure shows a code segment for random deployment of 100 sensor nodes ina 100 m*100 m area and also calculate the location of sink. In WSN data packet delivered to the sink using multi-hop path. Therefore each intermediate node transmits and receives the data packet. After transmitting and receiving each data packet every node lost some of its energy. The energy calculation using MATLAB programming is depicted in Figure .First order radio model is adopted here for measuring energy consumption by sensor nodes while communicating. Figure is a code segment which calculates energy consumption for transmitting and receiving a packet.

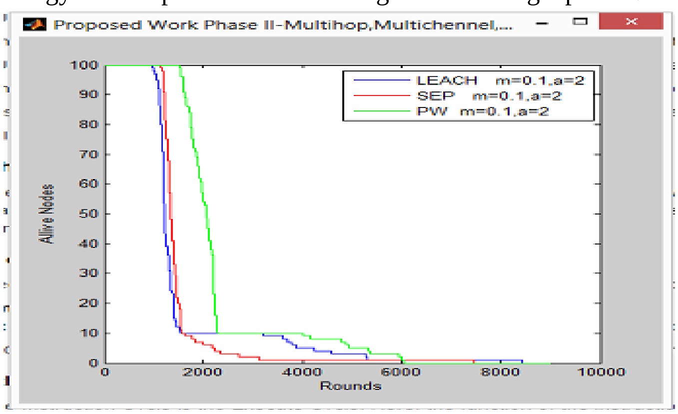


Figure : -Comparison to Leach, SEP, Proposed Work (Adv. Teen) for Alive Nodes

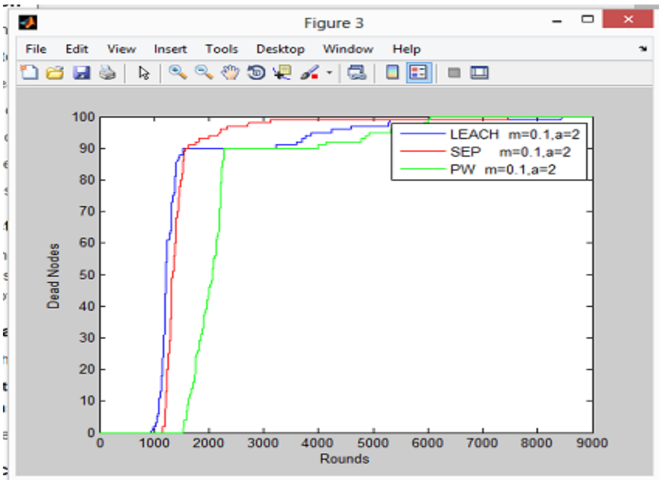


Figure :-Comparison to Leach, SEP, Proposed Work (Adv.Teen) for Dead Nodes

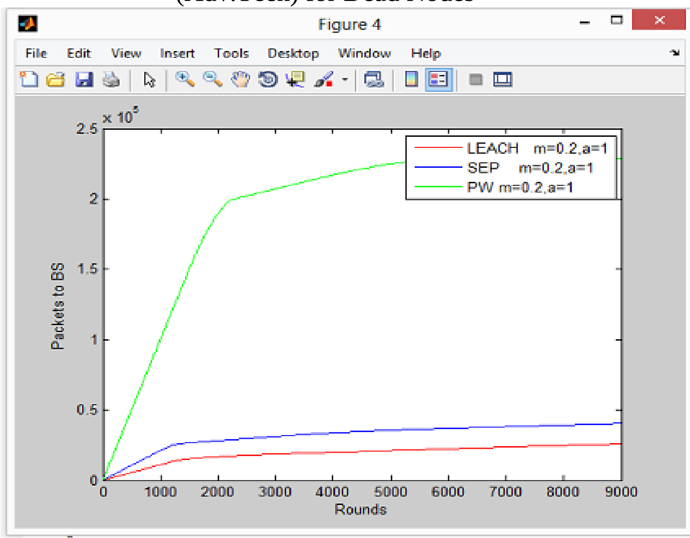


Figure : -Comparison to Leach,SEP,Proposed Work(Adv.Teen) for Throughput

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