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Wireless Sensor Networks Protocol: WCWSN

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Abstract
In this work the two layered clustering is maintained to increase the energy efficiency of the sensor network. At layer one the clustering is done by the base station after getting the initial information from the active sensors. The base station finds out the redundant nodes by analyzing the data sent by the sensor nodes (their id, positions, energy level etc.) and put the redundant nodes in separate cluster so as to create the disjoint cluster sets in such a way that each cluster is able to cover the area under surveillance. In other words we can say that the clusters can be selected iteratively to sense the entire area. Only one disjoint cluster need to be active at a time and other clusters should go into sleep mode (energy conserving mode). Every disjoint cluster has a cluster head that is responsible to get information from the base station about their turn to transmit data or to go into sleep mode. The disjoint clusters themselves are also the collection of clusters. This is called second layer of clustering. Like other WSN protocols small clusters are maintained with in the upper layer cluster to reduce the transmission energy. Each cluster has a cluster head that aggregate the data from other nodes within the cluster and send it to the sink. We can select the cluster heads dynamically depending upon the energy left with them so that they can be prevented from losing their life much earlier.

Keywords: *WSN; WiseMAC; Clustering; Disjoint Clusters; Leach; Energy Efficiency.*

I. Introduction

Computers, communication, and sensing technologies are converging to change the way we live, interact, and conduct business. Wireless sensor networks [1], [2] reflect such convergence. These networks are based on collaborative efforts of a large number of sensor nodes. They should be low-cost, low-power, and multifunction. These nodes have the capabilities of sensing, data processing, and communicating [3]-[8].

Sensor networks have a wide range of applications, from monitoring sensors in industrial facilities to control and management of energy applications to military and security fields [9]. Because of the special features of these networks, new network technologies are needed for cost effective, low power, and reliable communication. These network protocols and architectures should take into consideration the special features of sensor networks such as: the large number of nodes, their failure rate, limited power, high density, etc [10]. Recently, wireless sensor networks have attracted great attention and are used in many fields such as hazardous environments, military fields of operations, exhibition halls, traffic monitoring, etc. [2]

Sensor nodes have constraints like limited power resources and bandwidth. Thus different innovative techniques which overcome the inefficiencies are required so that the lifetime of the network can be functional for a longer time and the life time of the network can be extended. Thus, the main aim is to evenly distribute the consumption of energy load among the sensor nodes in order to overcome the problem of overly utilized sensor nodes that will run out of energy as compared to other sensor nodes.

In order to minimize the energy consumption, some of the previous research works focused on the low energy hardware design of the digital circuits which include micro sensor, low power transceivers etc. But this only reduced the energy consumption up to certain level. However, the energy consumption is mainly due to the communication over the network. Thus the primary focus should be more on design and architecture of the Wireless Sensor Network. For this several research works have proposed energy efficient protocols on Clustering, Routing, Data aggregation etc. These protocols work on the evenly distribution of the energy consumption among the sensor nodes of the Wireless Sensor Network. The communication protocols can be classified into three domains [1]. These domains are: (i) Direct, (ii) Multi-Hop, (iii) Clustering [11].

Clustering is one of the efficient methods to reduce the energy consumption in the Wireless Sensor Network. In Direct communication, each sensor nodes transmits the sensed data directly to the Base Station or Sink. In this type of communication, huge amount of energy is consumed if the distance between the Base Station and the Sensor Node is large. In Multi-Hop architecture, data is transmitted from one sensor node to another (Hop by Hop) so as to reach the Base Station. In this, the energy consumption is reduced but the sensor nodes nearer to the Base Station die prematurely due to the over burden of transmitting the data to the Base Station. In the Clustering scheme, every sensor node actively participates in the communication. Thus, the energy dissipation is even which leads to extension of the lifetime of the network.

A. *Wireless Sensor Node Architecture*

The basic block diagram of a wireless sensor node is presented in Figure 1. It is made up four basic components: a sensing unit, a processing unit, a transceiver unit and a power unit. There can be application dependent additional components such as a location finding system, a power generator and a mobilizer. As example of a wireless sensor node is MICAz mote as shown in Figure 2

Various parts and their working is explained as below:

1. *Sensing Units*: Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs). Sensor is a device which is used to translate physical phenomena to electrical signals. Sensors can be classified as either analog or digital.

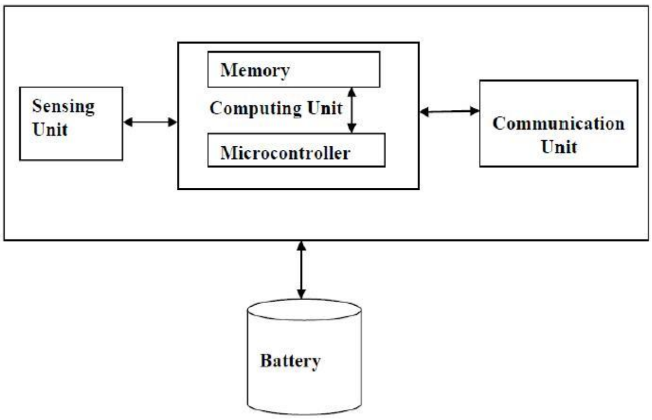

Fig. 1. Architecture of a wireless sensor node.

Fig. 2. MICAz mote.

There exists a variety of sensors that measure environmental parameters such as temperature, light intensity, sound, magnetic fields, image, etc. The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC and then fed into the processing unit.

2. *Processing Unit*: The processing unit mainly provides intelligence to the sensor node. The processing unit consists of a microprocessor, which is responsible for control of the sensors, execution of communication protocols and signal processing algorithms on the gathered sensor data. Commonly used microprocessors are Intel"s strong ARM microprocessor, Atmel„s AVR microcontroller and Texas Instruments' MP430 microprocessor. TinyOS operating system is used on this processor, which has 3500 bytes OS code space and 4500 bytes available code space.
3. *Transceiver Unit:* The radio enables wireless communication with neighbouring nodes and the outside world. It consists of a short range radio which usually has single channel at low data rate and operates at unlicensed bands of 868-870 MHz (Europe), 902-928 MHz (USA) or near 2.4 GHz (global ISM band). There are several factors that affect the power consumption characteristics of a radio, which includes the type of modulation scheme used, data rate, transmit power and the operational duty cycle.
4. *Battery*: The battery supplies power to the complete sensor node. It plays a vital role in determining sensor node lifetime. The amount of power drawn from a battery should be carefully monitored. Sensor nodes are generally small, light and cheap, the size of the battery is limited. Sensors must have a lifetime of months to years, since battery replacement is not an option for networks with thousands of physically embedded nodes. This causes energy consumption to be the most important factor in determining sensor node lifetime.

B. *Applications of Wireless Sensor Networks*

Wireless Sensor Networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, and acoustic and radar. They are able to monitor a wide variety of ambient conditions that include temperature, humidity, vehicular movement, lightning condition, pressure, soil makeup, noise levels, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects, and the current characteristics such as speed, direction and size of an object. WSN applications can be classified into three categories [2]:

1. Monitoring
2. Tracking
3. controlling

Monitoring applications include indoor/outdoor environmental monitoring, health and wellness monitoring, power monitoring, inventory location monitoring, factory and process automation, and seismic and structural monitoring.

Tracking applications include tracking objects, animals, and vehicles and categorize the applications into military, environment, health, home and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing and disaster relief.

Controlling application involve nuclear controlling.

C. Challenges and Constraints in Wireless Sensor Networks

Sensor networks are subject to a variety of unique challenges and constraints. These constraints impact the design of a WSN, leading to protocols and algorithms. The most important design constraints [3] of a WSN are:

1. *Energy:* Wireless Sensor Networks (WSNs) consist of battery-operated sensor nodes with limited processing capability. Such resource constrained characteristics distinguished WSNs from other data networks. Power is a precious resource in wireless sensor networks due to the limited battery capability. Once deployed, it is often difficult to charge or replace the batteries for these nodes. Prolonging the lifetime for nodes and the total network is a critical issue.
2. *Self-Management:* Sensor nodes must be self-managing in that they configure themselves, operate and collaborate with other nodes, and adapt to failures, changes in the environment, and changes in the environmental stimuli without human intervention.

   Wireless Networking: The reliance on wireless networks and communications poses a number of challenges to a sensor network designer. For example, attenuation limits the range of radio signals, that is, a radio frequency signal fades while it propagates through a medium and while it passes through obstacles.
3. *Decentralized Management:* The large scale and the energy constraints of many wireless sensor networks make it infeasible to rely on centralized algorithms to implement network management solutions such as topology management or routing. Instead, sensor nodes must collaborate with their neighbours to make localized decisions, that is, without global knowledge.
4. *Design Constraints:* While the capabilities of traditional computing systems continue to increase rapidly, the primary goal of wireless sensor design is to create smaller, cheaper, and more efficient devices.
5. *Security:* Many wireless sensor networks collect sensitive information. The remote and unattended operation of sensor nodes increases their exposure to malicious intrusions and attacks. Further, wireless communications make it easy for an adversary to eavesdrop on sensor transmissions. For example, one of the most challenging security threats is a denial -of-service attack, whose goal is to disrupt the correct operation of a sensor network. This can be achieved using a variety of attacks, including a congestion attack, where high-powered wireless signals are used to prevent successful sensor communications. The consequences can be severe.

D. Node Energy Utilization Protocols

There are various research papers on "Node-Energy Utilization in Wireless Sensor Network (WSN)". They provide various approaches for energy utilization like non cluster base and cluster base [12]. A brief introduction about these protocols is given here [2].

1. Non Cluster Based: There have been several network routing protocols proposed for wireless networks that can be examined in the context of wireless sensor networks. We examine three such protocols, namely:

a) Direct communication.
b) Minimum Transmission Energy (MTE) routing protocol.
c) WiseMAC Protocol [12],[13].

a) *Direct Communication:* Using a direct communication protocol, each sensor sends its data directly to the base station. If the base station is far away from the nodes, direct communication will require a large amount of transmit power from each node. This will quickly drain the battery of the nodes and reduce the system lifetime. However, the only receptions in this protocol occur at the base station, so if either the base station is close to the nodes, or the energy required to receive data is large, this may be an acceptable (and possibly optimal) method of communication.

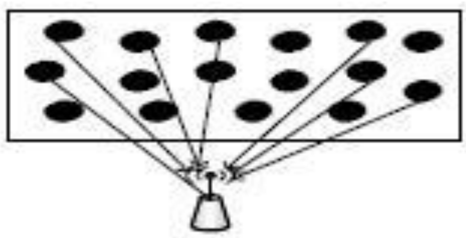

Fig. 3. Direct communication.

b) *Minimum Transmission Energy (MTE) routing protocol:* The second conventional approaches we consider is a "minimum-energy" routing protocol. In this protocol, nodes route data destined ultimately for the base station through intermediate nodes. Thus nodes act as routers for other nodes" data in addition to sensing the environment. These protocols differ in the way the routes are chosen.

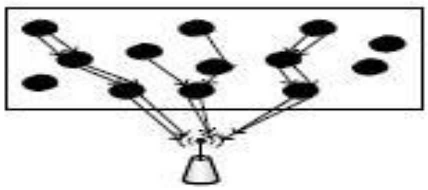

Fig. 4. Minimum Transmission Energy (MTE) communication

c) *WiseMAC Protocol:* WiseMAC uses the preamble sampling technique to minimize the energy wasted during idle listening [14]. Preamble sampling consists in regularly sampling the medium to check for activity. By sampling the medium, it is meant listening to the radio channel for a short duration, e.g. the duration of a modulation symbol. In a network, all nodes sample the medium with the same constant period *TW*, independently of the actual traffic. Their relative sampling schedule offsets are independent. If the medium is found busy, the receiver continues to listen until a data packet is received or until the medium becomes idle again. At the transmitter, a wake-up preamble is transmitted in front of every message to ensure that the receiver will be awake when the data portion of the message will arrive. The wake-up preamble introduces the power consumption overhead both in transmission and in reception. To minimize this overhead, sensor nodes learn the offset between the sampling schedule of their direct neighbours and their own one. Knowing the sampling schedule of the destination, sensor nodes send messages just at the right time with a wake-up preamble of minimized length *TP* (see Fig. 5). As nodes have independent sampling schedule offsets, this scheme naturally mitigates overhearing, since such short transmissions are likely to fall in between sampling instants of potential over hearers. Every node keeps an up-to-date table with the sampling schedule offset of its direct neighbours. The sampling schedule offset information is gained through the inclusion in every acknowledgement packet of the remaining duration until the next scheduled preamble sampling.

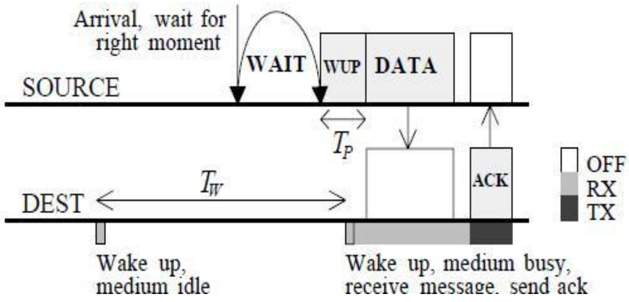

Fig. 5. WiseMAC protocol.

Because the clocks running on the sender and the destination can be inaccurate, a drift will accumulate in between two transmissions. To compensate this drift, it can be shown that the wakeup preamble must have a duration of $4\theta L$, if both quartz have an accuracy within $\pm\theta$ parts per million. L is the time elapsed since the last acknowledgement message was received from the destination. WiseMAC is hence adaptive to the traffic load, in the sense that the higher the traffic (the smaller L), the smaller the wake-up overhead ($4\theta L$). With this scheme, it is not necessary to regularly exchange data frames to keep the synchronization. If the interval between two communications is so large that $4\theta L > TW$, a wake-up preamble of length *TW* will be used. This also applies to the first communication between two nodes. In those cases where the wake-up preamble is longer than the data frame, it is composed of a repetition of the data frame. This permits to reduce the frame error rate, mitigate overhearing and detect interferences.

To mitigate collisions, WiseMAC uses non-persistent carrier sensing, with a back off chosen as a random integer multiplied by the turn-around time of the transceiver. To prevent collisions between two or more nodes that want to send a data frame to the same relay and at the same target sampling instant, a medium reservation preamble of randomized duration is added in front of the wake-up preamble. After the wake-up preamble, the WiseMAC data frame includes a bit synchronization preamble and a start frame delimiter (see Fig. 6).

Collisions caused by the hidden node effect can represent an important source of energy waste through the required retransmissions. The hidden node effect is mitigated by extending the carrier sense range beyond the interference range, at the cost of the capacity. The receive threshold has been chosen well above the noise threshold to mitigate useless wake-ups caused by interferences or weak signals. The receiver is hence waked up only when this is really worth it. Here, the lower power consumption is traded against a potential transmission range extension. The efficient transport of data bursts is made possible through the use of the "more" bit in the header of data packets, indicating to the receiver to continue to listen for the following packet.

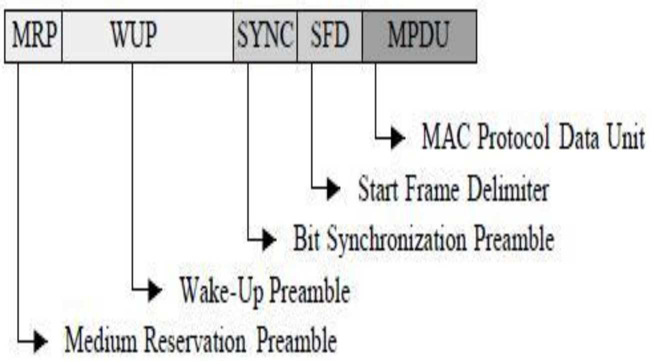

Fig. 6. WiseMAC data frame.

Cluster Based: In a cluster based routing protocol, sensor nodes are partitioned into many groups (clusters), which integrates information data collected from sensor nodes and transmits them to the sink node of the network. In each of the many clusters in this network resides a cluster head which collects data from sensor nodes within its group, completes Data aggregation, and sends them to the sink node of the network. Such data aggregation can reduce the consumption of node energy and the transmission delay as compared to multi-hop routing protocols.

There have been many studies presented for configuration and operation algorithms of a cluster based network topology in ad hoc networks. Advantages to a clustering network are the reduction of an overhead of routing establishment, minimization of the size of the routing table, and stabilization of the network topology. The clustering network can make resource management and bandwidth allocation more efficient and make node positioning management and transmitting power management possible. In addition, the clustering scheme in a wireless sensor network enables an aggregate data of cluster member nodes at the cluster head and can easily provide the network scalability due to node increase.

Consequently, in a huge sensor network that is several hundred - hundred thousand times bigger than adhoc networks; the clustering based routing algorithm is a possible approach to maintain network configuration management and to make data aggregation. In the clustering algorithm, all nodes in a sensor network can become a cluster head but must belong to only one cluster. The algorithm should minimize the overhead of clustering setup messages and establishing times. Additionally, the algorithm must maintain a stable network configuration, routing, network efficiency, with a minimization of energy consumption.

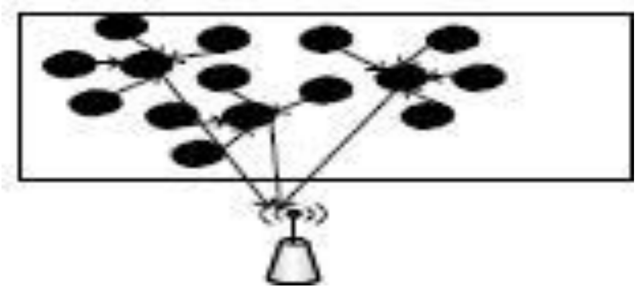

Fig. 7. Cluster base network.

Many clustering algorithms have been proposed, most of which are based upon node identifier, node connectivity, and node weights. Some of better-known cluster based hierarchical routing protocols are LEACH [15], LEACH-Centralized [16], and DEEAC.

a) *Low Energy Adaptive Clustering Hierarchy (LEACH):* LEACH is a clustering routing protocol in which a cluster head collects data from sensor nodes belonging to the cluster and sends the data to the sink node after data aggregation process. To make all sensor nodes in this network consume their node energy equally and extend the life time of the network, this algorithm randomly changes the cluster head, which in turn uses more energy than any other node belong to the cluster, every time period. To reduce overall communication costs, the cluster head performs data aggregation and then send the data to the sink node. The cluster head is determined by the following function:

$$T(n) = \begin{cases} \dfrac{P_t}{1 - P_t \cdot (r \cdot \mathrm{mod} \dfrac{1}{P_t})}, & \text{if } n \in G \\ 0, & \text{otherwise} \end{cases} \qquad (1)$$

Where Pt is the desired percentage of cluster heads, r is the current round number; G is the set of nodes that have not been cluster-heads in the last $1/P_t$ rounds. A round consists of two phases; a set-up phase and a steady state phase. The former is a stage for configuration of a cluster head and a cluster, and the latter is a stage for data transfer by the TDMA schedule. When a new round starts, each sensor node generates a random number in the range of 0 and 1, computes a threshold value by using equation (1), and compares the two numbers. If the generated number is smaller than the threshold value, the node is nominated as a cluster head; otherwise it neglects the number and remains a plain node. The nominated cluster head broadcasts advertisement messages over neighbour nodes. The neighbour node that receives the advertisement messages selects one of broadcasting nodes that transmits the strongest broadcasting signal as its head cluster node, and sends a "Join-REQ" message to the head cluster. After receiving the "Join-REQ" message, the head cluster registers the node onto its own member node table. The cluster head makes a TDMA schedule for data transfer within the cluster network and broadcasts the schedule to its member nodes. It is at this point that the setup has to select a cluster head has completed.

a) **LEACH-C (LEACH – Centralized)**: As previously mentioned, the disadvantage to LEACH is that the number of cluster head nodes is little ambiguous to count. LEACH-C, has been proposed to clarify this problem. LEACH-C provides an efficient clustering configuration algorithm, in which an optimum cluster head is selected with minimization of data transmission energy between a cluster head and other nodes in a cluster.

In LEACH-C, the base station receives information about residual node energy and node positions at the set up phase of each round. The received data can compute an average residual energy for all nodes. The nodes with less than average energy are excluded in selection of cluster heads.

Among the nodes that have more than average energy, cluster heads are selected with use of the simulated annealing algorithm. The base station sends all nodes a message of the optimum cluster head IDs (Identifiers). The node, the ID of which is the same as the optimum cluster head ID, is nominated as a cluster head and prepares a TDMA schedule for data transfer. Other nodes wait for the TDMA schedule from their cluster heads.

b) *Distributive Energy Efficient Adaptive Clustering (DEEAC):* LEACH‟s stochastic cluster-head selection is prone to producing unbalanced energy level reserves in nodes and thus increase the total energy dissipated in network. To ensure an even energy load distribution over the whole network, additional parameters including the residual energy level of candidates relative to the network and their hotness value should be considered to optimize the process of cluster-head selection.

II. WCWSN(Wisely Clustered WISEMIC)

WCWSN is a protocol proposed by us for the Wireless Sensor Networks to increase their energy efficiency and hence a remarkable increase in the sensor network lifetime.

A. *Proposed Work*

In this work the two layered clustering is maintained to increase the energy efficiency of the sensor network.

At layer one the clustering is done by the base station after getting the initial information from the active sensors. The base station finds out the redundant nodes by analyzing the data sent by the sensor nodes (their id, positions, energy level etc.) and put the redundant nodes in separate cluster so as to create the disjoint cluster sets [17] in such a way that each cluster is able to cover the area under surveillance. In other words we can say that the clusters can be selected iteratively to sense the entire area. Only one disjoint cluster need to be active at a time and other clusters should go into sleep mode (energy conserving mode). Every disjoint cluster has a cluster head that is responsible to get information from the base station about their turn to transmit data or to go into sleep mode.

The disjoint clusters themselves are also the collection of clusters. This is called second layer of clustering. Like other WSN protocols small clusters are maintained with in the upper layer cluster to reduce the transmission energy. Each cluster has a cluster head that aggregate the data from other nodes within the cluster and send it to the sink. We can select the cluster heads dynamically depending upon the energy left with them so that they can be prevented from losing their life much earlier.

III. Creating Disjoint Clusters

We consider that a large number of sensors are dispersed randomly in close proximity to a set of objectives and send the monitored information to a central processing node. Every target must be monitored at all times by at least one sensor and every sensor is able to monitor all targets within its operational range. One method for extending the sensor network lifetime is to divide the set of sensors into disjoint sets such that every set completely covers all targets [17]. We consider that a target is covered if it is within an active sensor‟s operational range. These disjoint sets are activated successively, such that at any moment in time only one set is active. The sensors from the active set are into the *active* state and all other sensors are in a low-energy *sleep* state. As all targets are monitored by every sensor set, the goal of this approach is to determine a maximum number of disjoint sets, so that the time interval between two activations for any sensor is longer. By decreasing the fraction of time a sensor is active, the overall time until power runs out for all sensors is increased and the application lifetime is extended proportionally by a factor equal to the number of disjoint sets. As a consequence, the spatial density of active nodes is lowered, thus improving channel access for transmitting sensor data.

The disjoint sets in our approach are modelled as disjoint set covers, where every cover completely monitors all the target points. We assume that the targets have fixed locations, so the algorithm for computing the covers is executed only once by a central node after the location for all sensors has been determined. After the wireless sensors are deployed, they activate their positioning service and send their location information to the central node. Based on this information, the central node computes the disjoint set covers and sends membership information back to every sensor.

1. Defining Disjoint Set Covers: Assume that n

sensors s1, s2, ..., sn are deployed in territory to monitor m targets t1, t2, ..., tm. A target is said to be *covered* by a sensor if it lies within the sensing region of the sensor. We can prolong the sensor network lifetime by finding the maximum number of disjoint sensor covers. The problem can be solved via transformation to the DSC problem, which is defined as follows:

Definition *(Disjoint Set Covers Problem)* [17]

Given a collection S of subsets of a finite set T, find the maximum number of disjoint covers for T. Every cover Ci is a subset of S, Ci ⊂ S, such that every element of T belongs to at least one member of Ci, and for any two covers Ci and Cj , Ci ∩ Cj = φ.

That is, let T be the set of the targets, t1, t2, ..., tm, sensor si can be represented by a subset, denoted as Si, of T, where tj ⊂ Si if and only if tj lies within the sensing region of sensor si. Thus, S is a collection of subsets representing sensors and a cover Ci represents a sensor cover.

As depicted in Fig. 3.1, s1, s2, s3, s4, and s5 are five sensors, and t1, t2, t3, and t4 are four targets. It is obvious that each sensor network may be represented by a bipartite graph G(V,E), where V = S⊂T and eij ⊂ E if si covers tj . **Fig. 3.2** depicts the bipartite graph for Fig. 3.1. In this example, S1 = {t1}, S2 = {t1, t2}, S3 = {t2, t3, t4}, S4 = {t3}, and S5 = {t4}. We can find two disjoint covers, C1 = {S1, S3} and C2 = {S2, S4, S5}. Note that, in this example, optimum number of disjoint covers is 2.

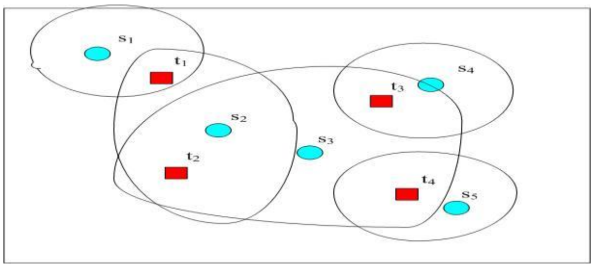

Fig. 8. Deployment of sensor networks.

(Note that in real-world applications, sensing region of a sensor can be an irregular shape [18]).

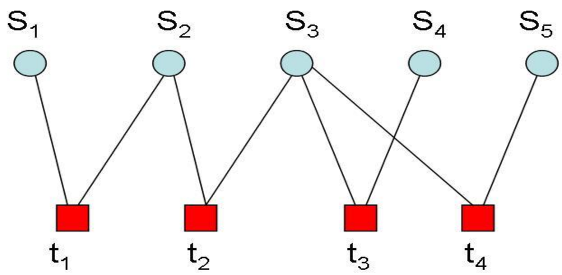

Fig. 9. An instance of the DSC problem.

Link between Si and ti means ti lies within the sensing region of Si Heuristics to solve DSC problem There are three heuristics available to solve DSC problem. These are:

1. MCMIP (*Maximum Covers using Mixed Integer Programming*) [17],
2. MCMCC (Most Constrained-Minimum Constraining Covers) [19], and
3. GAMDSC (*Genetic Algorithm for Maximum Disjoint Set Covers)* [20].

IV. Selecting the Active Cluster Set

One approach to select the active cluster head is by setting the timer for each cluster set and the nodes in the cluster sets get activated on their turn. But this approach is not a reliable one as it needs the time synchronization mechanism for its proper functioning. If not properly synchronized they start behaving unexpectedly.

Because of this limitation a new method of cluster synchronization is proposed here. We use WiseMAC protocol to select the cluster sets using preamble sampling technique. Every cluster set is represented by a cluster head which is responsible to send the preamble to BS. When BS gets the preamble it broadcast the awake signal to all the nodes concerned or linked to this cluster set. Now the nodes in the selected cluster set are in active mode.

Here at this level we can also apply some mechanisms to randomly select the cluster head that represent the cluster set so as to prevent the node selected as cluster head to die before all other nodes, due to more energy consumption. We can select the cluster head in following ways:

- Randomly selecting any node as cluster head (the approach used in LEACH protocol).
- Selecting the node with higher remaining energy as the cluster head.
- Rotating the cluster head so that all the nodes behave as cluster head at least once i.e. a node can"t be selected as a cluster head twice if there is a node that is never selected as a cluster head.

V. ESTABLISHING LAYER 2 CLUSTERING

To maintain the layer 2 clustering we apply the LEACH protocol. It creates the clusters within the disjoint cluster sets. This lower layer clustering is done

To minimize the energy consumed during communication by minimizing the distance of sending the information. Now the cluster sets themselves are divided into clusters and each cluster has a cluster head that is responsible to collect the data from the concerned nodes, fuse the data and send that data to the sink node. The communication process at layer 2 looks like as shown in fig. 10.

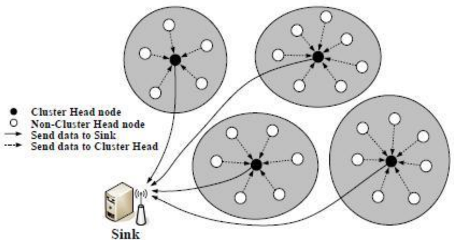

Fig. 10: View of layer 2 clustering

Simulator is the tool used to analyse a network protocol using a computer tailored numerical solution. This tool helps us to evaluate the performance of a given system. It takes a set of assumptions to model a system. So the very first thing while modelling a protocol or a system is to have a goal and decide the various assumptions and relationship between them and that determine mathematical model. Thus simulation is essential tool in the sense that it can often help to improve or validate protocols**.** All simulators provide a complete toolkit to developers that enable metrics collection and various wireless network diagnostics. Moreover in WSN there is no coordination or configuration before the set up of network, due to which it suffers from several challenges. The leading solution to these challenges is simulation. There are various simulators available for e.g. MATLAB, ns2, DIANEmu, GloMoSim, GTNet, J Sim, OMNET++, OPNET, QualNet, SWANS. We will use MATLAB simulator to simulate our proposed system because of its simplicity and GUI interface. Also some related codes are easily available on the Internet that can help in quick simulation.

Matlab is the software developed by the MathWorks, Inc., Natick, USA. In 1984, the first version appeared. Software was primarily used only for the mathematical computation enabling the computation of complicated matrix equations and their systems. All major functions can directly use the matrix as the input. From that year, the software is still under development enlarging the area of the users every year. Matlab became the standard in the area of simulation and modeling and it is used by the researchers and students at universities mainly in the areas of Control Engineering, Power Plant Systems, Aerospace, Bioinformatics, Economics and Statistics.

A. Implementing Protocol

We have proposed a two layered clustering protocol which make use of clustering at two levels in order to extend the life time of the Wireless Sensor Network. It includes two phases:

- Setup Phase (selection of disjoint Clusters at layer 1 and Cluster Head (CH) at layer 2, and the
- Steady Phase (transfer of sensed data from the environment to the Base Station or Sink).

B. Architecture

Radio Energy Dissipation Model [15]: We assumed a simple model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics as shown in fig. 11. Using this radio model, to transmit k - bit message at distance d the radio expends:

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$
$$E_{Tx}(k,d) = E_{elec} * (k) + E_{amp} * k * d^2$$

and to receive this message, the radio expends:

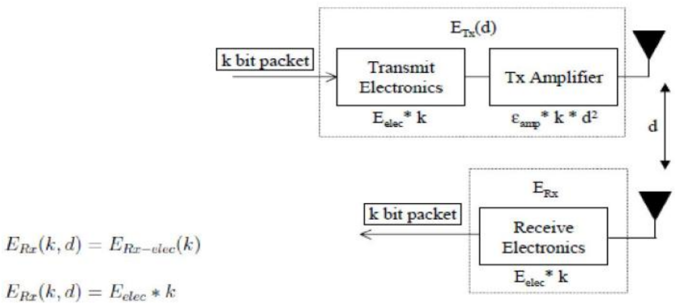

Fig. 11. Radio energy dissipation model.

1. *Network Model:* Assumptions: In our protocol architecture, we assume that N number of Sensor Nodes are scattered randomly over the network. A snapshot of the random network is shown in fig. 12. These nodes are static and homogeneous in nature and the Base station is in centre and is fixed and unlimited energy. Moreover, following assumptions are made for the underlying network model.

a) The energy of the Base Station is infinite.

b) Every sensor node is capable of communicating with every other sensor node and to the Base Station (sink) if needed.

Each sensor node has power control for communication i.e. range of the transmission can be controlled.

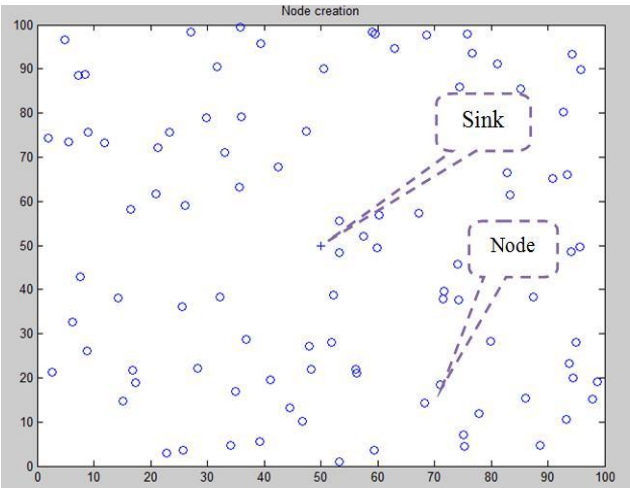

Fig. 12 A graph view of the nodes randomly generated inside the network with a range of 100 m X 100 m.

d) Each sensor node has a Unique Id for its identification and as well as region id.

e) The network is divided into region.

f) Each Node has same energy in starting of the network.

Nodes are setup randomly with id and region id.

VI. Proposed Protocol

In proposed protocol, there is 100 m x 100 m network area and there are 100 nodes which are randomly created in the network area with the id, energy, region id etc. there is two phases (1) setup phase and (2) steady phase.

1. *Setup Phase:* In the setup phase, nodes are created with id, energy, and region id etc. After this the maximum disjoint cluster sets are created by the base station and the information about the nodes under each cluster set is maintained at the cluster head of each cluster set. Now within the cluster sets we apply LEACH protocol to create clusters and cluster heads. A snapshot of the network is shown in fig. 12 and 13.

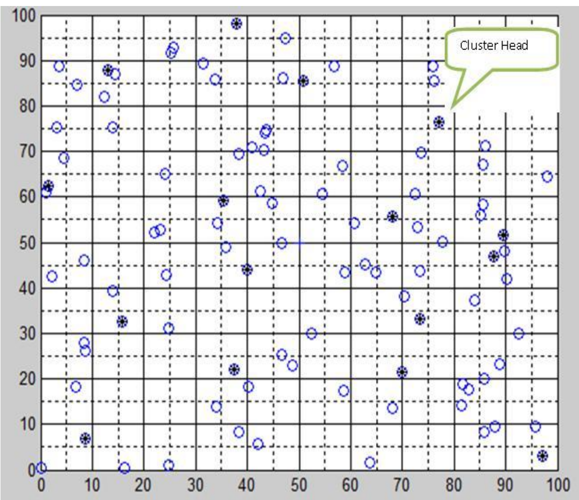

Fig. 13. Selecting the cluster head.

2. *Steady Phase:* In this phase nodes send their collected data to CH at once per frame allocated to them. This assumes that the node always has a data to transmit. The node goes to sleep mode after this transmission until next allocated transmission slot, to save the energy. The CH must keep its receiver on all the time to receive the data from cluster nodes. After reception of all the data, CH aggregates that data and transmits it to the base station. A snapshot of the network is shown in fig. 14.

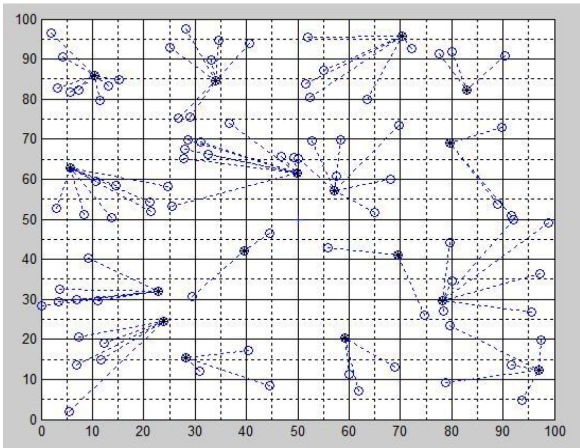

Fig. 14: CH aggregates data and transmits it to the base station (sink)

VII. Performance Evaluation

A wireless sensor network is densely deployed with a large number of sensor nodes, each of which operates with limited battery power, while working with the self organizing capability in the multi-hop environment. Since each node in the network plays both terminal node and routing node roles, a node cannot participate in the network once its battery power runs out. Increase in dead nodes generates network partitions and consequently, normal communication becomes impossible in a sensor network.

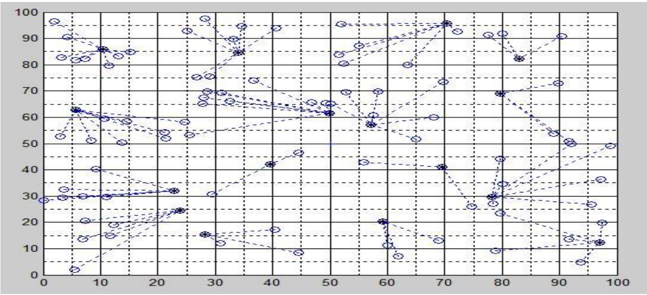

Fig. 15(a). Matlab simulation communicating nodes.

1. *Simulation Parameters:* Simulation is done in Matlab on Windows. Scenario conditions are stated in the Table 1.

Table 1. Simulation parameters

Parameters	
Network	100 x 100 m^2
Number of nodes	100
Base Station (Sink) Location	50,50 (center of network)
Initial Energy for all nodes	0.5 J
Energy dissipated for free space (Efs)	10 pJ/bit/m^2
Energy dissipated for multipath fading (Emp)	0.0013 pJ/bit/m^4
Data Aggregation Energy (EDA)	4 nJ/bit/signal
Data packet size	2000 and 4000 bits

2. Simulation results

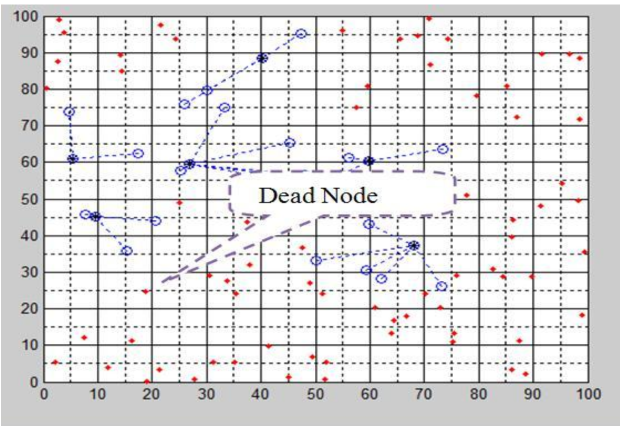

Fig. 15(b). Matlab simulation showing dead nodes

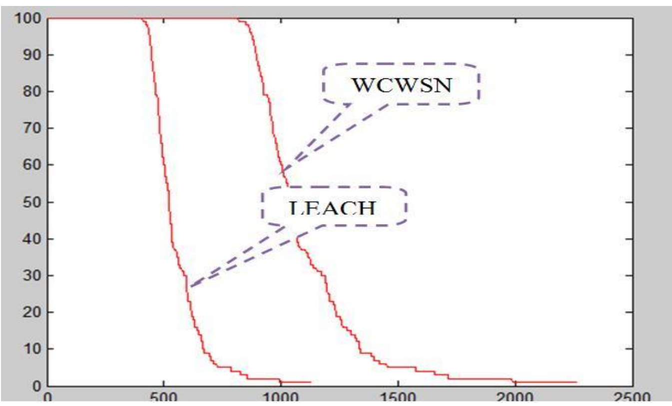

Fig. 15(c): Comparing LEACH and proposed WCWSN plotting no of communicating nodes against bits transmission

for redundancy factor (rf) = 2

3. Simulation Result Analysis:

Simulation and results of protocol LEACH is compared with proposed approach (WCWSN). A new algorithm shows its performance in comparison with existing and known algorithms. Results are derived from limited energy simulations where each node begins with 0.5 J/node of energy.

In the LEACH, first node is dead at 408 rounds when data size is 6400 bits with 0.5 J/node and for the same data first node in our proposed protocol is dead at near about 790 (this value depends upon rf and some constant c) rounds. This shows that almost double rounds without the node being dead can be obtained by our approach.

Where rf= no. of disjoint cluster sets at layer 1 and c= some constant that depend upon the energy consumed by the nodes while in sleep mode.

VIII. Conclusions

The result relevant to the proposed approach is that batteries discharging in short bursts with significant off-time have approximately twice as long a lifetime as compared to a continuous mode of operation. Therefore, a mode of operation that alternates active and inactive battery states extends network lifetime.

As the increase in redundancy can allow more time to nodes to remain in sleep node while using the proposed system, so we can say that the life time of the network is now directly proportional to the redundancy factor.

Using the proposed approach as the communicating nodes become less at a given time (as they are divided into disjoint clusters) so it also helps in managing/ tackling the congestion that may otherwise be there.

From the above discussion we can say that our proposed system provides a much more energy efficient protocol for wireless sensor network. Also we can increase the lifetime as much as we want by increasing the number of nodes i.e. the redundancy factor (rf). This may result in some increased cost but even though it may be reliable in certain cases where the risk of spreading the nodes is very high and we can‟t do this when we desire.

A. Future Scope

Routing in wireless sensor networks has attracted a lot of attention to the researchers in the recent years. This section summarized some of the research results on data routing in WSNs. There are mainly three routing categories, namely data-centric, hierarchical and location-based. Important considerations for these routing protocols are energy efficiency and traffic flows. Achieving a good trade-off between energy efficiency and QoS is one of the main issues in WSNs. The most effective way to reduce energy consumption is to have a low duty-cycle which in turn causes increase in delay. In order to improve network lifetime, suitable *cluster-based* approaches have been proposed in the literature.

The main *research issue* regarding such protocols is how to form the clusters so that the energy consumption and contemporary communication metrics such as latency is optimized. The factors affecting *cluster formation* and *cluster-head communication* are open issues for future research. Moreover, the process of data aggregation and fusion among clusters is also an interesting problem to explore. The problem of intelligent utilization of the location information in order to help energy efficient routing is the main research issue.

In applications where sensor nodes are *mobile*, new routing protocols are needed to handle frequent topology changes and reliable delivery. In the literature, most of the protocols assume that the sensor nodes and the sink are *stationary*. However, there might be situations such as battle environments where the sink and possibly the sensors need to be mobile. In such cases, the frequent update of the position of the command node and the sensor nodes and the propagation of that information through the network may excessively drain the energy of nodes. New routing algorithms are needed in order to handle the overhead of mobility and topology changes in such energy constrained environment.

B. Future Work

All of our contributions here are focused on the cluster setup stage with the region based. There is still much space to improve the performance of data transmission. In the large scale sensor networks, multi-hop communication is a mainstream technique for energy saving. We will remove the assumption of single-hop and design an energy efficient protocol for both intra-cluster and inter-cluster.

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