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ENHANCED ENERGY BASED LEACH-MODRA AND LEACH-THRA PROTOCOLS IN WSN

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***Abstract*— Wireless Sensor Network (WSN) is a collection of tiny, energy constrained self-organized sensors used for sensing the environment. Applications with the lack of human interaction involve random placement of sensors. The main concern is to prevent an additional energy consumption. LEACH is the first cluster based protocol introduced in WSN for improving the lifetime of the network. LEACH-RA provides an optimal way of excluding the extra sensors to retain the energy. MODLEACH is an energy efficient protocol with an efficient cluster head replacement scheme and dual transmitting power levels. In this paper, an improved version of LEACH-RA such as LEACH-MODRA and LEACH-THRA are introduced. LEACH-MODRA is designed with an additional capability of dual transmitting power levels. The main aim of LEACH-THRA protocol is to conserve the energy consumption by avoiding the transmission of redundant data based on the soft and hard threshold mentioned in the TEEN protocol. The simulation is conducted for testing the efficiency of these protocols. The proposed system provides comparatively better results in terms of residual energy.**

***Keywords*— LEACH, LEACH-RA, MODLEACH, LEACH-MODRA, TEEN, LEACH-THRA, Soft threshold, Hard threshold**

I. INTRODUCTION

Wireless Sensor Network is a collection of self-configured and infrastructure less network to monitor the physical environmental conditions such as temperature, sound vibration etc. WSN is widely used in many applications like Environmental Monitoring, Battlefield Awareness, Industrial Sensing and Diagnostics etc. The topology of the network varies with the following assumptions based on the underlying applications. The network constitutes either static sensors or mobile sensors or both. All the sensed information are forwarded to the destination node called sink or Base Station (BS). The network allows either single or multiple sinks. The position of the sink is at the center or distributed. The sensor may be placed regularly or distributed randomly. The communication may be through a single hop or multiple hops to reach the destination. Anchor nodes are the sensors with the enhanced capabilities at the same time they are expensive. The main functionality of the anchor nodes is to determine the position of the other sensors. The anchor nodes are either static or mobile in nature. The location of the anchor nodes is predetermined and they are selected in an optimal way so that the selected one can reach every sensor. The sensor node by itself has severe resource constraints, such as low battery power, limited signal processing, limited computation and communication capabilities, and a small amount of memory [12]. The main concern about the sensor is to minimize its energy consumption. Most of the energy is exhausted in sensor during data communication in comparison with the sensing. Each and every activity of the network is governed by various protocols. Among these, the routing protocol takes the responsibility of transferring the received information to the BS in an optimal manner. The main functions of routing protocols are selecting the neighbours for framing the routing path and the format for the data to be transmitted, pre-processing the data before transmission and the delivery of acknowledgement etc. Based on the underlying application, the protocol is used selectively. The broad classification of the existing protocol is represented in Fig.1 [10]. The most commonly used protocol is flat or hierarchical. The organization of the sensors will be different in all the protocols. In the flat routing protocols, all the nodes are treated as a standalone node. Every node will take its own responsibility for sensing and transmitting the sensed information to the sink. The node will transmit the data directly towards the sink using a single hop or multihop communication. In the wide area network, the number of intermediate nodes will be increased,

which will add an additional workload for the sensor to transmit the sensed information. Also, the remaining energy will be exhausted and it affects the normal functioning of the network.

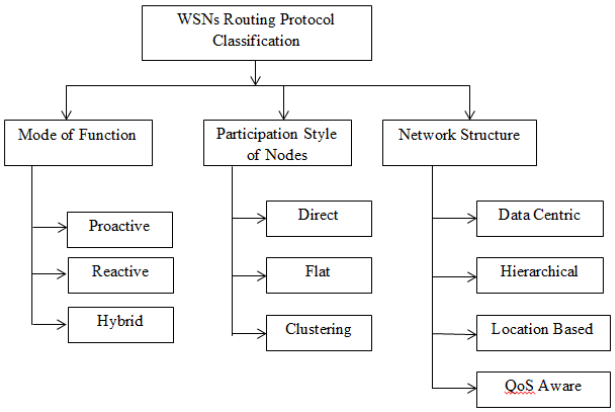

Fig. 1 Classification of Wireless Sensor Network Routing Protocols

To overcome these limitations, the hierarchical routing protocols are introduced. In these protocols, the sensors are grouped together to form clusters. One sensor is elected as the cluster head (CH) within a cluster and the remaining sensors act as their cluster members (CMs). The CMs will forward the sensed information to their respective CH. The CH will take the responsibility of collecting the data from its CMs and process the received information to avoid the data duplication, insertion of extra bits, wrong data etc. Unlike the flat routing protocol, the workload is evenly distributed to minimize the energy consumption which will enhance the lifetime of the network in the hierarchical routing protocol. The hierarchical routing protocols may include sensors with homogeneous or heterogeneous sensing profile. The homogeneous sensors will have same sensing capabilities whereas the heterogeneous sensors will have different sensing capabilities. The distribution of energy dissipations will be optimal if the heterogeneous sensors are involved. The sensors with high energy may be fixed as CHs that will carry out both data aggregation and data communication to BS, whereas the sensors with low energy level may be fixed as CMs which will carry out sensing the Area of Interest (AOI) only. The functionality of sensors such as sensing and the communication are highly depending on the location of the sensors in the AOI. Various techniques are available for estimating the position of the sensors. Some of the commonly known techniques are lateration, angulation trilateration, multilateration and triangulation. The process of distribution of sensors in the AOI is called deployment. The deployment may be either fixed or random. In the fixed deployment, the position of the sensors are predetermined and fixed. In the random deployment, the sensors are scattered in a random manner using airdrop method. The fixed deployment is the best suited methodology for the applications in which the AOI is accessible such as border surveillance, intrusion detection, and healthcare. Random deployment is useful for the applications which are inaccessible like disaster areas, active war zones etc. The deployment strategy influences some of the Quality of Service (QOS) parameters such as coverage, connectivity, energy consumption, throughput etc. To overcome the practical difficulties, extra sensors are placed or mobile sensors are included. The inclusion of extra sensors will lead to redundancy. The redundant sensors will be replaced in case of emergency of link failure, node failure etc. to avoid the data loss. The required level of redundancy varies based on the various factors such as the orientation of sensors, mobility, sensing profile, unexpected changes in the environment etc. The redundancy is both an ally and enemy. It is highly a desirable one to provide the required amount of redundancy to reduce unnecessary energy consumption considerably. Another form of redundancy that prevails in WSN is data redundancy. If the density of the nodes is high then the sensors are found to be closer to each other. CH will receive the same data as duplicate. So, the data loss will be less as well as the reliability of the data will be more. The reliability is an important aspect in the sensitive applications like key distribution, medical diagnosis etc. In other words, the redundant data will introduce extra workload for the sink or CH because more data are to be processed for removing the redundant data in data aggregation process. The sensing and processing of the redundant data will drain the residual energy of all the active sensors in the network. Once the energy of the sensor is drained

then the functioning of the network will be affected which in turn decrease the lifetime of the network. There is a trade-off between the reliable data and the energy conservation of the network. For a wide area network, static sensors are less preferred than the mobile sensors for enhancing the coverage. If the frequency of the changes in the position of the sensors increases, then the serious effects will occur such as link failure, data loss, coverage hole and security issues. The energy conservation may be carried out either by reducing physical redundancy or temporal redundancy. To eliminate the physical redundancy, extra sensors which produce redundant effect must be excluded for the normal functioning of the network. Also, the redundant data to be communicated is reduced to eliminate the temporal redundancy. In this paper, hierarchical based protocols LEACH-MODRA and LEACH-THRA are proposed. They are framed by combining LEACH-RA protocol with MODLEACH[7] protocol, and LEACH-RA protocol with TEEN[9] protocol in the aspect of energy conservation.

The rest of the paper is organized as follows. Section 2 describes the recent research works carried out in WSN. Section 3 explains the preliminaries of hierarchical protocols LEACH-RA, MODLEACH, and TEEN. Section 4 gives the working principle of LEACH-MODRA and LEACH-THRA. Section 5 explains in detail the simulation works carried out and the results obtained. Section 6 includes the conclusion of the proposed work.

II. RELATED WORK

In WSN applications, the underlying protocols and the nature of sensing the environment differs based on their requirements. The sensor has to sense the environment either continuously or in an event driven manner. In this session, some of the works which support the proposed works are discussed in detail. For large area of applications, the distance between the CH and the BS is increased and it leads to energy loss. To overcome this problem, Multi-hop LEACH protocol is proposed [1]. In this protocol, the clusters are formed and cluster heads are selected in a similar way of LEACH. In the steady phase, it allows two types of communication. The data from the cluster members are forwarded to the respective cluster heads through a single hop. If the cluster head is at the farthest distance then it forwards all of its aggregated data to the BS either in a single hop or multihop. In Multi-hop, inter-cluster communication is performed. When the distance between CH and BS is large, then CH use intermediate CH to communicate to the BS.

An improved version of LEACH, namely, I-LEACH was developed [2] and it considers three factors such as Residual Energy in the nodes, Distance from the BS and the number of neighbouring nodes for cluster selection. A node has been considered as the head node if it has more residual energy as compared to the average energy of the network, more neighbours than average neighbours for a node calculated in the network and node which has less distance from the BS as a comparison to node's average distance from BS in the network. In addition to the residual energy, the network parameters such as density and the distance of separation to the BS shows some positive impact in the network performance. There is a lack of maintenance in case of emergency when LEACH protocol is used. The V-LEACH [3] an extension of LEACH protocol was developed to provide a solution for this issue. The vice-CH is introduced within every cluster in addition to the CH and CM. When the assigned CH dies, its responsibilities are taken over by vice-CH. By doing this, cluster nodes data will reach the BS and there is no need to elect a new CH each time. This will extend the overall network lifetime.

APTEEN [4] is a hybrid protocol which includes both proactive and reactive nature of sensing the environment. APTEEN is based on a query system which allows three types of queries: historical, on-time, and persistent, which can be used in a hybrid network. In APTEEN, CHs broadcast the following four parameters: (i) Attributes (A) - this is a set of physical parameters from which the user is interested in obtaining data particulars. (ii) Thresholds-this parameter consists of the hard threshold (HT) and soft threshold (ST). HT is a particular value of an attribute beyond which a node can be triggered to transmit data. ST

is a small change in the value of an attribute which can trigger a node to transmit data again. (iii) Schedule-this is a Time Division Multiple Access (TDMA) schedule that assigns a slot to each node. (iv)Count time (CT)-it is the maximum time period between two successive reports sent by a node. It can be a multiple of the TDMA schedule length and it accounts for the proactive component. All the nodes sense the environment continuously, but only those nodes which sense a data value at or beyond the hard threshold permit transmitting. If a node does not send data for a time period equal to the count time, it must sense and transmit the data again.

In APTEEN, each CH aggregates the data from the Member Nodes (MNs) within its cluster and transmits the aggregated data to the BS. During the process of data aggregation, it is assumed that the data received from the corresponding CMs are sufficiently correlated, thus it reduces a large amount of redundancy of the data to be transmitted to the BS. Moreover, a modified TDMA schedule is used to implement the hybrid network by assigning each node a transmission slot within a cluster.

Redundancy is one of the crucial factors which affect the network. It is very difficult to determine an enough amount of redundancy required for the specific application. Three types of redundancy are considered; which are physical, spatial and temporal. The temporal redundancy refers to the transmission of unnecessary data which consumes the available energy. The main drawback of the well-known reactive protocol TEEN is that if the thresholds are not reached, the nodes will never communicate and the user will not get any data from the network at all and the user will not come to know even if all the nodes die. To avoid these limitations, two thresholds are introduced [5]. They are critical threshold and base threshold.

The Critical Threshold is a critical value above which it has to be assumed as an emergency and processed quickly to reach the sink. Base Threshold is the minimum value desired to be sensed and reported to the sink node. A value below the base threshold will be ignored. The values between these thresholds are compressed by the CHs before forwarding to the BS which will reduce the redundant data

III. PRELIMINARIES

A. CLASSIFICATION OF NETWORKS

The components of a wireless sensor network enable wireless connectivity within the network, connecting an application platform at one end of the network with one or more sensor or actuator devices in any part of the network [11]. The main functionality of the sensor is sensing the environment. The nature of sensing the environment leads to the variety of sensors. Based on the underlying application, the type of the sensors is opted. The nature of sensing of the sensor may be periodic sampling, Event driven, Store and Forward. Periodic sampling sensors are required for the applications which require constant monitoring the environmental conditions or the behaviour of processes. The common examples are monitoring the changes in the temperature, pressure in the area, and industrial application. Event driven sensors are useful for the applications which involve the monitoring of crucial conditions like natural disaster monitoring, pressure alarms, fire alarms, indoor monitoring etc. The Stored and Forwarded sensors are involved in the applications for which the sensed data are forwarded immediately after aggregating and processing the sensed information. Based on the type of sensors involved in the network and they are classified as proactive or reactive networks. The common difference between these two networks is given in the Table 1.

1) Proactive Networks:

The sensors and transmitters are always in an ON state so that the environment is monitored continuously and the sensed information is communicated to the BS at regular intervals. The main aim of this approach is to deliver the recently sensed information to the outside world through BS. When a sensor receives the same information it will never fail to transmit it to BS. All the nodes are involved in gathering the data. The information given by each and every sensor will play a vital role in obtaining the recent values. Most of the energy will get exhausted in processing the redundant data.

2) Reactive Networks:

In the reactive protocols, every node has the ability to respond immediately to the changes in the underlying environment. The node will respond only to the drastic change that occurs in the received information. The transmitter will be triggered to transmit the information. The nodes with high transmitting power will take part in the activities such as data aggregation and data transmission. Both the networks are combined to form the hybrid network.

TABLE I
PROACTIVE VS REACTIVE

Description	**Proactive Networks**	**Reactive Networks**
Type of Applications	Periodic monitoring	Critical monitoring /event detection
Mode of Sensing Circuitry	Periodically switch on	Always on
Mode of Communication Device	Periodically switch on	Always on
Data Delivery	Periodic/continuous	Event driven / On demand

IV EXISTING PROTOCOLS

A. LEACH (LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY PROTOCOL)

In this paper, a popularly known hierarchical protocol LEACH[6] is considered. All the nodes are grouped in clusters. It is implemented in rounds. There are two phases called steady state phase and set up phase. In the steady state phase, the cluster formation is carried out. The CH is selected in a random manner. A sensor node chooses a random number, r, between 0 and 1. Let a threshold value be T(n)[19] :

$$T(n)=\begin{cases}\dfrac{p}{1-p\times\left(r\times \bmod \dfrac{1}{p}\right)} & \text{if } n\in G\\ 0 & \text{otherwise}\end{cases} \qquad (1)$$

If the random number is less than a threshold value T(n) then the node becomes a CH for the current round. The threshold value is calculated based on the above equation (1) that incorporates the desired percentage to become a CH in the current round, and the set of nodes that have not been selected as a CH in the last (1/p) rounds is represented by G, p is the CH probability. The selected CH node will broadcast the control message to all non-CH nodes. On receiving the control message, the node will decide the CH node to become its CM based on the received signal strength. The steady state phase is initiated to carry out the data communication from the CMs to CHs and from the CHs to the BS. The CHs in LEACH act as a local control centre to coordinate the data transmissions in their cluster [18]. The CH node sets up a TDMA schedule and transmits this schedule to the nodes in the cluster. This ensures that there is no collision between data messages and it also allows the radio components of each non-CH node to be turned off at all times except during their transmit time, thus minimizing the energy dissipated by the individual. The notable characteristics of LEACH are its scalability, less load, less energy and more robustness. Since LEACH follows a compact cluster structure, it easily manages the node or link failure. The bandwidth utilization is efficient because Code Division Multiple Access (CDMA) based scheme is used for communication. LEACH reduces the communication energy by 8 times as compared to direct transmission and minimum transmission energy routing [13]**.** The well-known drawbacks of LEACH are that when the nodes with different sensing profile are included, the chances of becoming the CH are same for all the nodes which will introduce the uneven distribution of remaining energy. This tendency of the network will reduce the network lifetime. Also, the CH at the distance farthest away from the sink will increase the energy consumption. When the number of CMs for the CH is not fixed, then it leads to the uneven distribution of the sensors. There is no well-established recovery or preventive mechanism for both link and node failure.

B. MODLEACH PROTOCOL (MODIFIED LEACH PROTOCOL)

MODLEACH [7] is a modified version of LEACH protocol. All the nodes use the same

amplification energy for the communication irrespective of the distance of separation in LEACH protocol. The distance of separation is less within the cluster because the CMs select their CH with minimal distance. But the distance between the CH and the BS varies based on its location because CHs are selected in a random manner without considering their location. The amplification energy required for the long distance transmission will be more when compared to the short distance transmission. In order to avoid the extra energy consumption, the MODLEACH introduces a dual transmitting power level. In the heterogeneous network, it is not always necessary that CHs have to be selected for every round. The selection of CHs for the next round is decided based on the residual energy of the CHs in the current round. If the energy resides more than the fixed threshold, then the same CH will act as the CH for the next round. By doing so, the even distribution of energy consumption is achieved to prolong the network lifetime. Also, this protocol avoids the energy consumed during cluster formation. In the hierarchical structure, the possible data transmissions are within the clusters, CH to CH and CH to the BS. The data transmission within the cluster is called intra cluster transmission. The communication between the different CH is termed as inter cluster communication. The energy requirement varies for these types of transmissions. The low energy level is used for intra cluster communication in comparison with the other form of transmission. By doing so, one can reduce the collisions, inferences and the packet drop which will enhance the throughput of the network. According to MODLEACH protocol, the amplification energy of intra cluster transmission can be reduced to 1/10 of the total energy required for inter cluster and for the transmission from CH to BS. The role of the node will change for every round. The amplification energy of the node is switched to the higher level when it acts as a CH and the energy is reduced to 1/10 when it acts as a CM.

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C. TEEN PROTOCOL (THRESHOLD SENSITIVE ENERGY EFFICIENT SENSOR NETWORK PROTOCOL)

It is a well suited protocol for reactive protocols. The main aim of this protocol is to minimize the energy consumption by avoiding the continuous transmission of data. The data will be transmitted whenever the environment under monitoring had a drastic change. To overcome the practical difficulties in wireless communication, some applications like monitoring the airplane, hospital, industries etc. are opted for the wired sensor network. Since sensors are resource constraints, the main objective for designing the protocol is to minimize its energy dissipation to prolong its lifetime. Unlike proactive protocols, the attributes of the information to be sensed show both positive and negative impact in the working of the protocol. This leads to the necessity of fault tolerant protocol. The organization of the cluster in the TEEN [9] protocol slightly differs from the LEACH protocol. The architecture of the TEEN is given in Fig. 2. It introduces different levels of CHs based on their distance of separation from the BS. The CHs will collect the information from its CMs. The CH will forward it to BS directly if it is an upper level CH. Otherwise, the information is directed from the lower level CH to the upper level CH which in turn forwarded to the BS. To minimize the energy consumption in data transmission, TEEN protocol introduces two thresholds, namely, hard and soft thresholds. The hard threshold will determine whether to turn on the transmitter or not. It is the value beyond which the data are transmitted. Similarly, soft threshold will fix the deviation between the current sensed value and the previously sensed value. On receiving the data, the protocol will check whether the received data is greater than the fixed hard threshold. If it is so, then the data is allowed to transmit. Also, the difference between the successive sensed values of the sensor is observed. The criteria for transmitting the information are that the difference in the attributes value must be equal to or greater than the soft threshold value. For every change in the cluster formation, the CH will report the details regarding the desired attributes of the sensed data and the time

at which the sensor has to transmit the sensed data to all its cluster members.

1). *Highlights:*

- Most of the energy is exhausted during communication when compared to sensing. TEEN protocol minimizes the energy consumption by restricting the transmission of the information based on the reporting time. The frequency of the transmission is fixed by the Reporting time. It is the time interval for transmitting the data.
- It provides the flexibility in deciding the sensitivity of the data by fixing the soft threshold. If it is fixed as a smaller value then the accuracy and the energy consumption will be more. Otherwise, one can conserve the energy with the minimum accuracy. There is a trade-off between the accuracy and the energy.

2). Drawbacks:

- Since the reporting time is fixed by the user, there may be a possibility of delayed transmission of critical data.
- The data loss may occur if the sensed information does not reach the threshold.

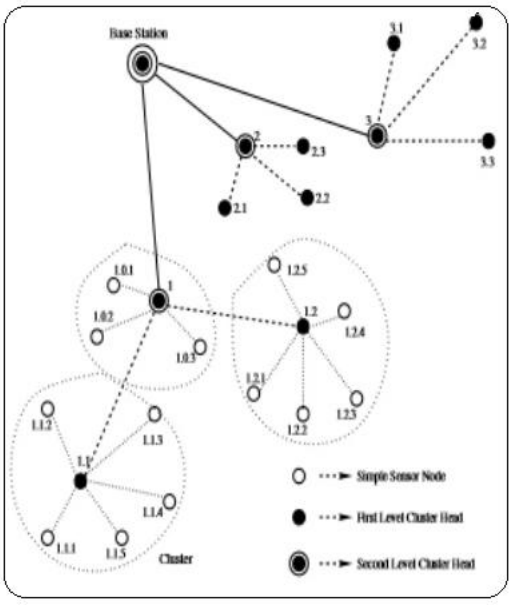

Fig. 2 The Architecture of TEEN Protocol.

TEEN is not suitable for time critical data sensing applications.

D. LEACH-RA (LEACH –REDUNDANCY AWARE)

It is an extension of LEACH protocol. The main objective of this protocol is to conserve the energy by reducing the number of active sensors which maximize the energy consumption. LEACH-RA[8] consists of three phases, namely, Setup Phase, Redundancy Check Phase and Steady State Phase. Both Setup phase and Steady State Phase are same as LEACH. It is a centralized process in which all the nodes should undergo all the three phases in each round. In the setup phase, the network is grouped as clusters. CHs are selected based on the probability similar to LEACH. The CMs select their CH based on the minimum distance. The control messages regarding the selection of CHs are broadcast to its individual CMs. The TDMA schedule is initiated for the beginning of the transmission. After the formation of the setup phase, Redundancy check phase is initiated. The sensors which produce redundancy effects are turned off. The redundant sensors are identified based on the following assumptions:

- The CHs with cluster size less than the Cthres was selected for redundancy check. The selected CHs are marked as redundant if their distance to the sink is more than 2*RC [14] and the number of neighbouring CMs are more than Tneigh [15].
- The CM is considered as redundant if its distance to the sink is less than RC and its number of neighbouring CMs are more than Tneigh.($0.074 \log n < Tneigh < 5.1774 \log n$).
- The identified redundant sensors are turned OFF and are not allowed to participate in that round. They will be revoked again to ON state for the next forthcoming round.

- *Steady State Phase:*
  - The process of data aggregation is performed within the different clusters of the network.
  - Compression of the sensed information is sensed by the sensor node into its different CH within the cluster only.
  - Transmission of the compressed data is done to the sink via different CHs [16].

- The duration of the setup is assumed to be relatively shorter than the steady-state phase to minimize the protocol overhead. [17]

1). Highlights:

- The residual energy of the node can be increased by turning the extra sensors to ON and OFF mode.
- Extra sensors are identified based on the threshold which will guarantee better coverage and connectivity [15].

E. PROBLEM DESCRIPTION

Most of the research activities aim at providing the optimal way for enhancing the network functionality with improved QOS providing factors such as energy, coverage connectivity, throughput etc. In order to achieve the objective, the parameters with same and contradictory effects are considered. In this paper, some of the contradictory metrics are considered to avoid the drain of energy.

- To remove the extra sensors based on their density and their distance towards the BS without affecting the coverage.
- To introduce the dual transmitting power levels as in MODLEACH protocol to conserve energy.
- To include hard and soft threshold as in TEEN protocol to avoid the transmission of similar data so as to improve the residual energy of the network.

V. THE PROPOSED WORKS

A. LEACH – MODRA PROTOCOL(LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY- MODIFIED REDUNDANCY AWARE PROTOCOL)

Several research activities are carried out for enhancing the LEACH protocol with a slight variation. LEACH-RA[8] outperforms LEACH in the aspect of conserving the remaining energy and reducing the number of CHs for each round. The CH is responsible for aggregating and transmitting the data after processing the data. The property dual transmitting power level of MODLEACH [7] is introduced to further enhance the LEACH-RA. The functionality of LEACH-MODRA in each round is represented in Fig. 3. There are four stages, namely, Setup phase, Redundancy Check Phase, Assignment of Power levels and Steady Phase. After deploying the sensors in the AOI, the sensors are grouped as CHs and CMs. The setup phase is initiated. In this phase clusters are formed. In the Redundancy Check phase additional sensors are turned to off. The TDMA is initiated for transmission of data. The amplification energy levels are assigned and two different amplification levels are used, namely, high power amplification and low power amplification. The Steady Phase is initiated to perform data transmission. . Most of the energy is spent by the CH as compared to CMs. By reducing the number of CHs, the energy is conserved to some extent. The energy consumption is reduced in two ways. One way is to reduce the number of active sensors which produce redundant effects. Another way is the inclusion of dual transmitting power level.

B. LEACH–THRA PROTOCOL (LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY – THRESHOLD REDUNDANCY AWARE PROTOCOL)

The nature of the application decides the mode of transmission of data. Either the transmission may be continuously monitored data or event driven data.

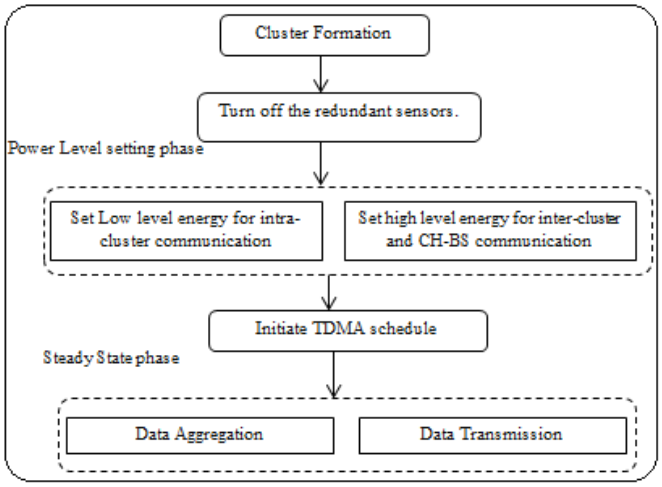

Fig. 3. Functional Diagram of LEACH-MODRA

For both data transmissions, the nature of deployment introduces both physical and temporal

redundancy. Physical redundancy refers to the redundant effects due to the placement of sensors.

Simulation Parameter	Value
Area	100 m * 100 m
Number of Nodes	200
Number of Rounds	100
Position of BS	50, 50
Packet Size	4000 bits
Hard Threshold (HT)	100
Soft Threshold (ST)	2
Initial Energy	0.5 J
Data Aggregation/ Fusion Energy Consumption	5 nJ/bit/report
Transceiver Idle State Energy Consumption	50 nJ/bit
Amplification Energy used for communication between the CH and BS when $d \leq d_o$ (d_o = sqrt(Efs/Emp),d = Distance between the CH and BS.)	Efs = 10pJ/bit/m^2
Amplification Energy used for communication between the CH and BS when $d \geq d_o$	Emp = 0.0013pJ/bit/m^2
Amplification Energy used for communication between the cluster members when $d \leq d_1$. (d_1= sqrt(Efs1/Emp1),d=Distance between the CM to CH)	Efs1 = Efs/10
Amplification Energy used for communication between the cluster members when $d > d_1$	Emp1 = Emp/10

TABLE. II LIST OF PARAMETERS USED FOR SIMULATION

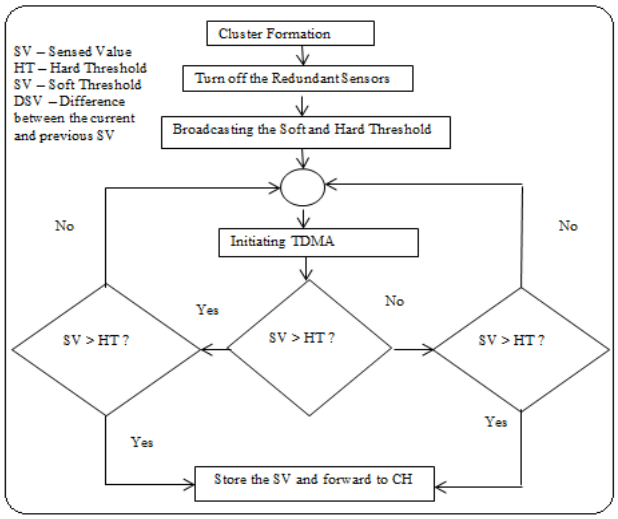

Fig. 4. Functional Diagram of LEACH-THRA

If the same area is monitored by more than one sensor, it may lead to physical redundancy. Temporal redundancy refers to the same value transmitted by different sensors. Redundancy is unavoidable in most of the applications. LEACH-RA minimizes the physical redundancy to some extent by excluding the redundant sensors. In addition to that, the temporal redundancy must be reduced to enhance the lifetime of the network. TEEN [9] is a well-known Threshold sensitive Energy Efficient sensor Network protocol, used to avoid the temporal redundancy. The concept of fixing soft and hard threshold is included in the existing LEACH-RA protocol with the concern of minimizing the energy consumption. The proposed protocol LEACH-THRA will reduce both physical and temporal redundancy to some extent. After initiating the TDMA in LEACH-THRA, the received data is transmitted based on two conditions. The received data must be higher than the hard threshold and the received data may differ by the soft threshold. In doing so, the average energy of the node will be minimized. The functionality diagram of LEACH-THRA is given in the Fig. 4.

VI. SIMULATION AND RESULTS

The proposed work LEACH-MODRA and LEACH-THRA are implemented in MATLAB – 2013. The results are compared with their variants. The parameters used for simulation are listed in Table 2. The performance of the proposed model is evaluated in terms of average energy of the node. It is a measure of the average of residual energy of individual nodes in every round. The protocols like TEEN, MODLEACH, LEACH-RA, LEACH-THRA, and LEACH-MODRA are implemented and the results are shown in Fig. 5, Fig. 6, Fig. 7, Fig. 8 and Fig. 9 respectively.

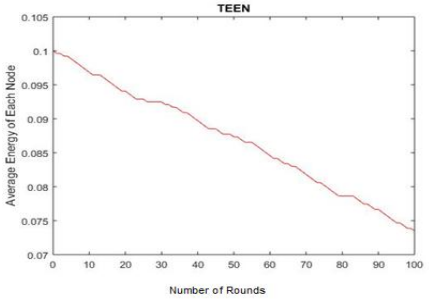

Fig. 5. Average Energy of Each Node in TEEN Protocol.

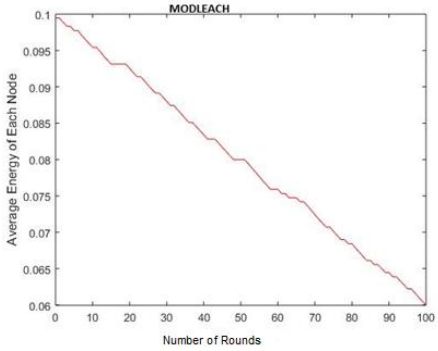

Fig. 6. Average Energy of Each Node in MODLEACH protocol

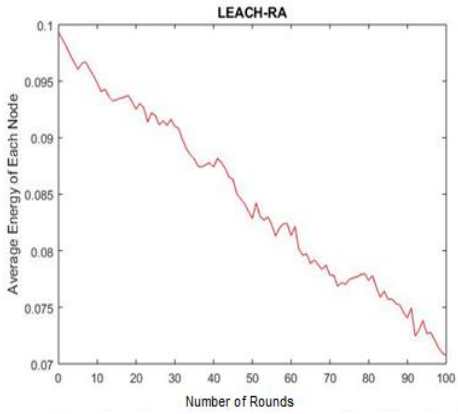

Fig. 7. Average Energy of each node in LEACH- RA

Among these protocols, LEACH-MODRA gives highest residual energy when compared to others. On increasing the residual energy of the network, the lifetime of the network can be increased. The above mentioned protocols are simulated on considering the same environment. The Fig. 5 and Fig. 6 conclude that the TEEN protocol shows better results when compared to the MODLEACH protocol. The average energy of the node remains in the network for every round on applying redundancy aware protocol, LEACH-RA is graphically represented in Fig. 7.

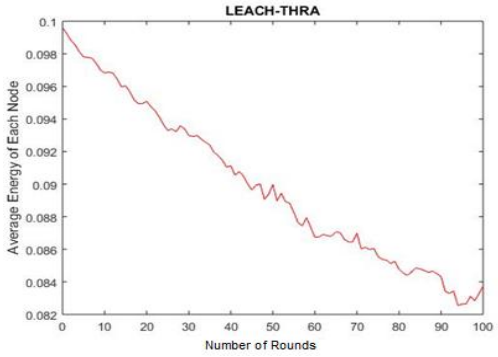

Fig. 8. Average Energy of each node in LEACH- THRA

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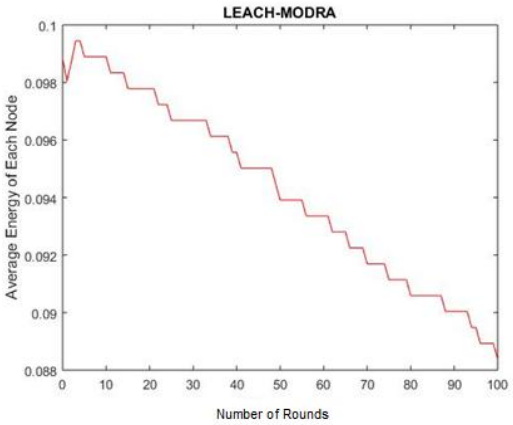

Fig. 9 Average Energy of Each Node in LEACH-MODRA

The LEACH-RA produces comparatively higher results than TEEN and MODLEACH protocol. The redundant sensors are identified based on the C_{thresh} and the value 10 is assigned for 200 nodes. The threshold value Cthresh varies on increasing the number of nodes. The cluster head which has cluster size less than C_{thresh} was adopted for redundancy check. Based on the above mentioned constraints, the redundant sensors are turned off.

Extensive care has been taken for fixing the threshold value. If the value is too large then the number of cluster heads for the redundant check will increase. It may lead to coverage hole, link failures, data loss etc. Similarly, if the C_{thresh} value is too small, then the redundancies will exist and these will consume network resources unnecessarily.

The simulation results of the proposed protocol LEACH-THRA which combines the features of both LEACH-RA and TEEN are represented in Fig. 8. The LEACH- THRA produces comparatively more energy conservation than TEEN, MODLEACH and LEACH-RA. It removes both physical and temporal redundancy to some extent. It may be suitable for the applications which support both proactive and reactive protocols. The LEACH-MODRA is designed by incorporating the dual power levels in LEACH-RA. The results are represented in Fig. 9. It outperforms other protocols in terms of average residual energy of the network.

A. CONCLUSION AND SCOPE FOR FUTURE RESEARCH

In WSN, several works are carried out in different directions in the aspect of conserving the energy. The main objective of the proposed system is to remove the redundant effects to conserve energy. The performance of the proposed systems LEACH-RA, LEACH-THRA and LEACH-MODRA are analysed and compared with the existing protocol TEEN and MODLEACH using the parameter average energy of the network. It is the sum and average of the residual energy of all the nodes participating in the network. The increased residual energy will increase the lifetime of the nodes and in turn extend the lifetime of the network. The LEACH-THRA produces comparatively better results due to the inclusion of soft and hard threshold of TEEN protocol in LEACH_RA. The dual power levels included in LEACH-RA further improve its performance. There is a trade-off between the energy and other factors like coverage, data loss, and the accuracy. As a future work, the protocol can be improved further by concentrating on other network parameters like coverage, accuracy throughput, mobility etc. Instead of fixing the probabilities for selecting the cluster heads, an optimal way of cluster selection can be included in the future research.

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