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Design and Analysis of R-Leach Protocol for WSN

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ABSTRACT: As a new prerequisite for manhood, Wireless sensor networks (WSN) are gaining popularity. These networks are evolving very quickly, yet they are applicable to almost every part of life. There is a need for more research to be conducted in a standard way. These networks suffer from a shortage of energy. To consume energy efficiently by the network, we have amended one of the most well-known WSN routing protocols LEACH, and developed the REDACTION LEACH (R-LEACH) by initiating an effective cluster head substitution method and different transmission energy requirements. In comparison to the LEACH, the proposed R-LEACH performs better in terms of several parameters like cluster head setup, throughput, and permanence phase of the network. Subsequently, we have set a value of energy for cluster heads known as delta. We have also made a comparison of popular energy-efficient protocols for WSNs.

KEYWORDS: Wireless Sensor Network, LEACH, Clustering

I. INTRODUCTION

In simple terms, a Wireless Sensor Network (WSN) is a dispersed network made up of nodes. Sensor nodes or motes are the more prevalent names for these nodes. The sensor is consistently dispersed, restriction free devices that use energy from a finite supply [1-2]. The motes are scalable, power proficient entrenched devices that are part of a spatial network that retrieve, compute, and process data before it is eventually made available to consumers [3-4]. The tiny sensor devices known as motes come together to create a dense network. A mote's multi-functionality is its main advantage. Because of their numerous uses in the WSN, motes are regarded as important for this reason. In order to achieve their application goals, the motes work to gather precise information from the actual world without making any changes to it. A transceiver serves as the channel of communication amongst the motes. To achieve the best performance, the transceiver aids with establishing links amongst several motes in various contrasting configurations. The total nodes present in an unstructured network and a conventional WSN is what distinguishes them most from one another.

II. RELATED WORK

The WSN has achieved ample popularity, as it is being utilized in every other industry, because of the technical advancements in processors, low power consumption and cross-layer design. The varied applications of a WSN include area monitoring, health care monitoring, earth sensing, air pollution monitoring, water quality monitoring, machine health monitoring, data logging, threat prevention etc. Sensor nodes are employed for the measurement of ecological traits like temperature, compression, moisture, noise, vibration, placement etc. The sensor nodes are capable of performing numerous activities in real-time, including multiplexing, intelligent sensing, data collection, neighbour node discovery, quality assurance, location tracking, data incorporation, and proper pathing between the sensors and the BS (base station) [5-6]. The WSN is described in general in Fig. 1 and sensor/mote configuration is depicted in Fig 2.

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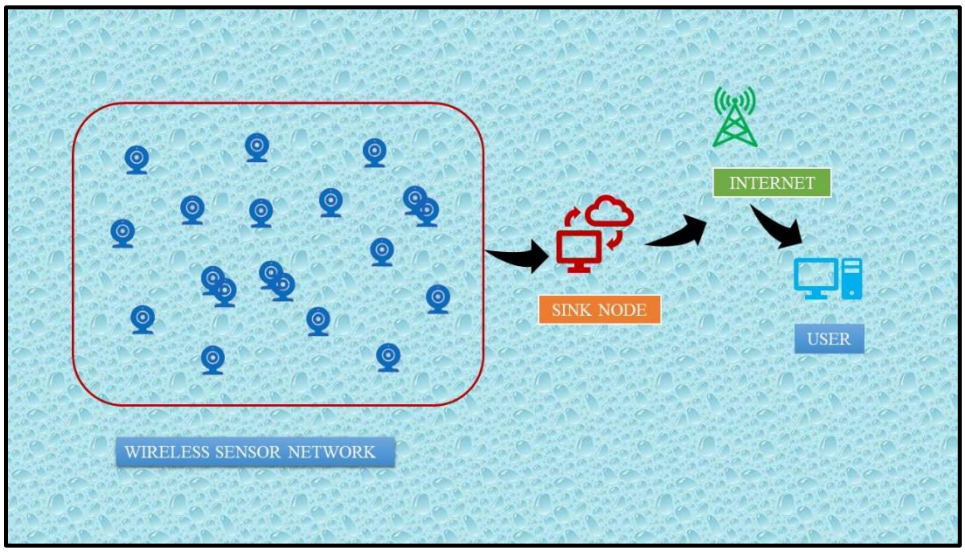

Fig 1: An instance of WSN

AN OVERVIEW OF LEACH PROTOCOL

The present attention to WSNs causes the occurrence of various applications centered protocols of which LEACH is the maximum ambitious and extensively employed method [8]. It may be defined as a mixture of a cluster-oriented design and multi-node transmitting. The expression cluster-oriented means sensors using the LEACH protocol work on the basis of CHs and members of clusters. This routing is employed for cluster transmission with CHs and BS. According to experiments, the multi-hop routing put away fewer powers when likened to straight communication.

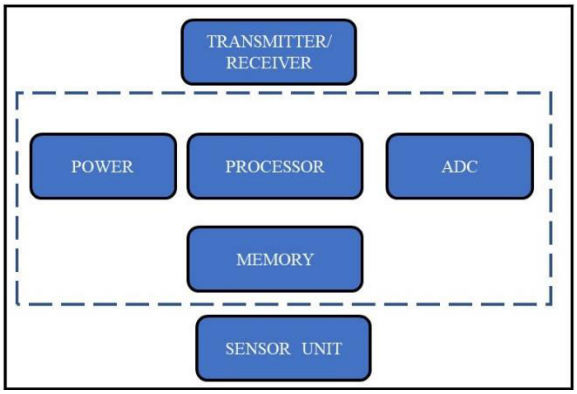

Fig 2: Components of a Sensor Node

The sensors detect data, combined them and transmit in the form of packets to the BS from a distant region through the radio broadcast method. Throughout this procedure, many challenging problems happen, like collision of data and the aggregation of data. LEACH is sufficient to lessen the data aggregation problems by means of a native data fusion which works by compressing the quantity of data which is composed by the CH afore it transmits it to the BS. Each sensor builds a self-maintained network by allocating the function of a CH at least one time. The CH is mainly liable for transmitting the data. It attempts to equilibrium the power depletion in the WSN and augments the lifespan of the network through improvement of the lifespan of the nodes. There are two stages of operations which take place in the LEACH (fig 3).

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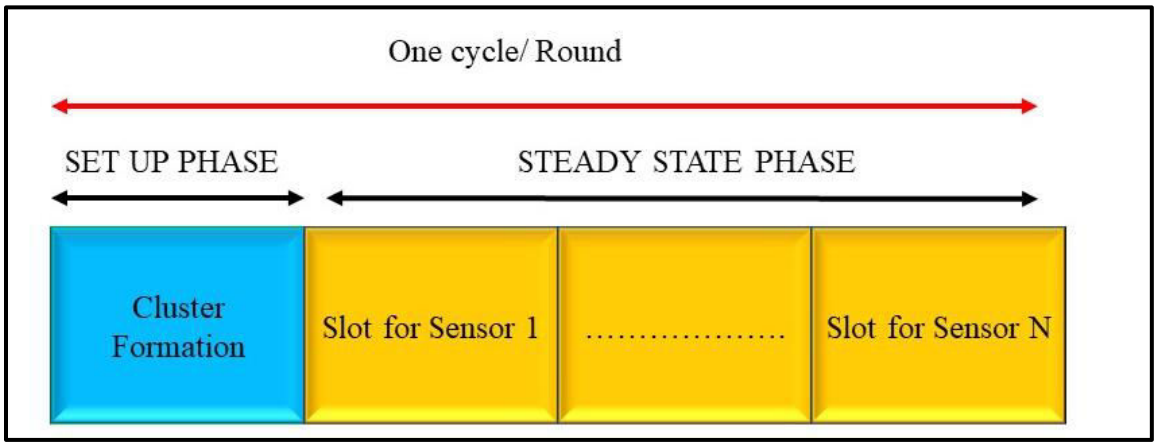

Fig 3: Phases of LEACH Protocol

Set-up Phase

Figure 3 shows parts of setup phase of LEACH protocol. In this stage, each node in a network cluster itself into a zone by transmitting with each other via MSG. In the framework, at an instance of time one sensor works as a CH and transmits short messages inside the network to all the other residual nodes. The nodes pick to connect those clusters or zones which are designed by the CHs, conditional to the power of the signal of the messages transmitted by the CHs. The nodes which are keen to join a specific CH or area reply to the CHs by communicating a return signal representing their approval to link. Therefore the set-up stage finishes in this manner. The CH can select the optimum number of cluster members which it is able to manage or entails. Prior entering in the steady-state stage, specific aspects are deliberated, like the topology of the network and the comparative costs of calculation vs. the transmission. A TDMA Program hasbeen applied to every cluster member of the group of cluster to convey packets to the head, and then to the CH to the sink.

Steady-State Stage

Once a CH is picked for a region, each member off that area transmits the accumulated or identified information in their allocated TDMA periods to the CH which transfer this composed data in a compacted form to the sink and finishes the second phase, known as Steady State Phase. As soon as this phase completes, the data transmits to the sink, the complete procedure finishes and a fresh hunt starts for the formation of CHs for a zone and fresh cluster-member arrangement starts. Concisely, we can say that a fresh set-up stage and steady setup stage begins with the completion of data communication towards the BS. This alternate assortment of CHs within the area, that is performed by the sensors in a self-regulating manner assists in decreasing or reducing the utilization of the battery.It is possible that each sensor is not very near to the CH; therefore, the quantity of power which is consumed by the remoter sensor is non-equivalent to the quantity of power consumed by the nearby mote. For the sake of minimizing it, the formation of CH or the role of CH is accomplished by a rotation among all the sensors in the cluster. At several intervals, LEACH reduces universal power consumption by allocating the burden of the network to each sensor or member of the cluster. All heads communicate the info to the sink in a compressed format. All the CHs cannot be nearby to the sink, they convey the compacted data to the adjacent CHs and in this manner, a multi-node routing WSN can be designed. LEACH performs the randomized alternation of the CH in the sake of saving the high battery which is wasted during the transmission of data to the BS. This alternation is performed for all the motes, as a result, there is no shortage of the energy or battery of the sensor.

III. PROPOSED METHOD

Our method is partially inspired by the LEACH protocol. In LEACH the CH changes in all rounds. But in the REDACTION LEACH Protocol for WSN (R-LEACH) the cluster head does not change at every round. We set a level of energy (delta) for each CH. If the battery of the CH is more than delta hence it remains as the CH else another node is set as a CH. This solution helps in less wastage of energy as a smaller number of routing packets will flow in the

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network.Moreover, there are three types of transmission: inter, intra, and cluster to sink node transmission. Inter-cluster transmission is performed within the cluster members. Intra cluster transmission is done between cluster heads. Finally, the collected data has been sent towards sink node by all the cluster heads. Our suggested protocol employs a hybrid technique, transferring data to the BS both directly and through CHs.The following are certain relations that are used in the suggested protocols:

- **Durability interval**: It is the timestamp between the starting of the framework and the expiration of the 1st sensor.
- **Impermanence interval:** It is the time between the 1st sensor's expiration and the last sensor's expiration.
- **Throughput**: The total data exchanged in the sensor-net throughout its operation, such as data transfer from sensors to head of cluster then towards base station, or sensors to directly to the BS.
- **Lifespan:** WSN's ability to function over an extended period of time.
- **Aggregation of Data**: Related types of data are combined and transported farther to reduce power consumption.

NETWORK CONFIGURATION

We take into account a system where N number of sensors and a BS are located in a physical zone. These sensor motes are installed arbitrarily in a given rectangular zone. Least amplification power is different for inter-cluster or intra-cluster or towards transmission to sink. For all kinds of transmissions, amplification energy is set same for LEACH. The low level energy for intra cluster communication with regard to CH towards BS transmission cause saving of energy. Furthermore, different energy levels also decrease the ratio of packet loss, crashes or intrusion for another signal. For this perspective, we adopt that, at maximum, a cluster can span into a zone of 10X10m^2 in a region of 100X100m^2. The energy which is sufficient to convey at maximum ends of a field of 100X100m^2 should be reduced much for intra-cluster communiqué. When a node becomes a CH, it uses excessive energy magnification and in subsequent cycle, if it becomes a member of the cluster, routing protocol shifts it to low energy level. Lastly, soft and hard threshold methods were also employed in R-LEACH and produce better outcomes.

POWER USAGE MODEL

We have taken into account the first order radio energy model or energy consumption estimation of the protocol. A node consumes radio electronic power (E_{elec}) to operate and amplification power (ε_{amp}) to transmit a packet [9]. The aggregate energy (E_{tx}) disbursed in the broadcast of a packet through a path of *s* transitional sensors, is expressed by:

$$E_t(|\dots|) = lb(E_{elec} + \varepsilon_{amp} * d^{\lambda}_{|\cdot|}) \quad (1)$$

Energy consumption in receiving a packet is given by:

$$E_r = lbE_{elec} \quad (2)$$

The distance factor is considered zero for receiving a packet. Let E_{DA} be the energy disbursed in data aggregation, then the energy disbursed in aggregating *M* messages is given by:

$$E_{Agg}(M, lb) = M \cdot lb \cdot E_{DA} \quad (3)$$

For the RF-based communication process, we postulate that all energy parameters are employed. The power usage by an RF unit to transmit a single bit of data can be stated as:

$$e_{RF}(d) = \begin{cases} \epsilon_{mp} d^4, & d_0 < d \\ \epsilon_{fs} d^2, & 1 < d \leq d_0 \\ \epsilon_{fs}, & d \leq 1 \end{cases} \quad (4)$$

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Where ϵ_{mp} and ϵ_{fs} denotes the energy (J) constants for multi-path and free-space channel model. Alternatively, During communication, the sensor node performs a variety of other duties including as modulation, channel coding, and spreading, among others and uses e_{elec} energy. Henceforth, the amount of energy expended by a cluster member to transport a packet can be calculated as follows

$$\mathbb{E}_n^{\overline{CH}} = P_L(e_{RF}(d_{mn}) + e_{elec}) \quad (5)$$

Let us consider that $E_n^r(i)$ and E_n^h denotes the residual energy and harvesting energy respectively of node n for the current i^{th} frame. Now, a cluster member sensor n can forward the data if it has adequate power of transmission and expressed as:

$$\mathbb{E}_n^r \geq \mathbb{E}_n^{\overline{CH}} \quad (6)$$

That means, If the cluster member node's remaining energy is equivalent to or greater than the packet's, the packet can be transmitted to other CHs. If there is insufficient energy, the sensor node waits until enough energy is gathered. The remaining energy of the node n can be expressed as:

$$\mathbb{E}_n^r(i+1) = \mathbb{E}_n^r(i) + \mathbb{E}_n^h(i) - \mathbb{E}_n^{\overline{CH}} I_A \quad (7)$$

Where $A = \mathbb{E}_n^r(i) \geq \mathbb{E}_n^{\overline{CH}}$ is an indicator function which is set to 1 if $\mathbb{E}_n^r(i) \geq \mathbb{E}_n^{\overline{CH}}$ otherwise $A = 0$.Generally, if a node does not have enough energy to transmit packets, it does not participate in communication and its energy consumption remains 0. Alternatively, if the node has sufficient energy, the CH node's energy consumption can be assessed as:

$$\mathbb{E}_m^{CH}(i) = I_{Tx_m}(i) \times \left(P_L \sum_{k=1}^{k_m-1} I_{Tx_k}(i)\,(e_{da} + e_{elec}) + P_L e_{da} I_{k_m>1} + e_n\right) \quad (8)$$

Where the first term symbolize the power required to forward the packets to the BS, the second term represents the energy required to receive data from its cluster member, and the 3rd term represents the energy required for data aggregation. k_m symbolizes number of nodes in the cluster, e_{da} symbolize the data aggregation power depletion and $e_n = P_L(e_{RF}(d_n) + e_{elec})$ is the least desired energy for node n to convey the packet straight to the BS. After the power criteria are met, the sensor conveys the MSG, which is received by the CH, which performs data aggregation and measures the CH node's energy level before passing the packet to the sink node. i.e. $\mathbb{E}_m^r(i) \geq E_m^{CH}(i)$ that means The CH node m can transport the MSg to the subsequent hop or BS since the residual energy is greater than the needed energy for transmission of packet. Conclusively, the residual energy can be stated as:

$$\mathbb{E}_m^r(i+1) = \mathbb{E}_m^r(i) + \mathbb{E}_m^h(i) - \mathbb{E}_n^{CH}(i) I_{E_m^r}(i) \geq E_n^{CH}(i) \quad (9)$$

MECHANISM FOR CH

We have used LEACH protocol [9] mechanism to choose CHs among the sensor motes. In the clustering setup phase, nodes within an area, choose themselves as the cluster heads in distinctive cycles. The number of CHs (k) in a round is given by:

$$\sum_{i=1}^{N} P_i = k \quad (10)$$

And the likelihood of a node $N_i$to be selected as a CH at round r is expressed as:

$$P(N_i) = \begin{cases} \frac{k}{N - k*(r \bmod N/k)} & : \ 1 \ if \ N_i \in S \\ 0 & : \ otherwise \end{cases} \quad (11)$$

The (r *mod* N/k) decides the total number of motes elected as the CHs in recent cycles. Whole number of sensors which are qualified to be a head at present round r is expressed as:

$$T(r) = N - k * (r \bmod N/k) \quad (12)$$

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This ensures the uniform energy depletion in complete set of sensors after every cycle. The selected CHs in each zone transmits an ADV control packet to their adjacent motes in their area. To evade collision, CH implements the TDMA [10] amongst its member motes for data communication.

IV. RESULTS AND DISCUSSION

We evaluated a WSN region of 100 X 100 m^2 that needs to be monitored. A total of 100 nodes have been distributed in the field. The investigations were conducted out in a MATLAB environment. The parameters utilised in Table 4.1. Fig. 4 exhibits a MATLAB figure of proposed network.

Table 4.1: Parameters and their Value

Parameters	Value
E_{init}	0.5 J
E_{elec}	5 nJ/bit
E_{fs}	10 pJ/bits m^2
E_{mp}	0.0013 pJ/bit/m^4
E_{DA}	5 pJ/bit
Initial energy of advanced nodes	E_{init} (1+β)

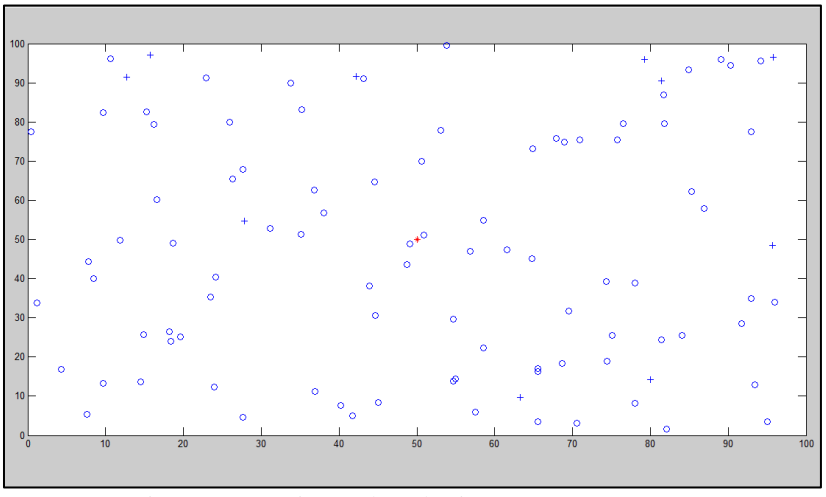

Fig 4: Base station and Nodes in a WSN (100 X100)

At each round, normal sensor nodes of each region forward data to their gateway node/ CH node and similarly nodes in the sink region convey their MSG to the destination. In the cluster regions, the cluster members convey data to their head and then it does aggregation of data. Next, all the cluster heads transmit MSG to the gateway of their area, the mote combined data received from all the cluster heads and from the normal nodes in its gateway zone. Moreover, if the distance of any CH is lesser to the sink than the gateway node in its region. The cluster head is substituted only if its power is less than a threshold value.The Permanence interval is depicted in Fig 5 alive nodes till the network's termination. The persistence phase increases as the number of alive sensors enhances. The network's Impermanence Phase is depicted in Fig 6. The WSN's throughput is depicted in Fig 6.

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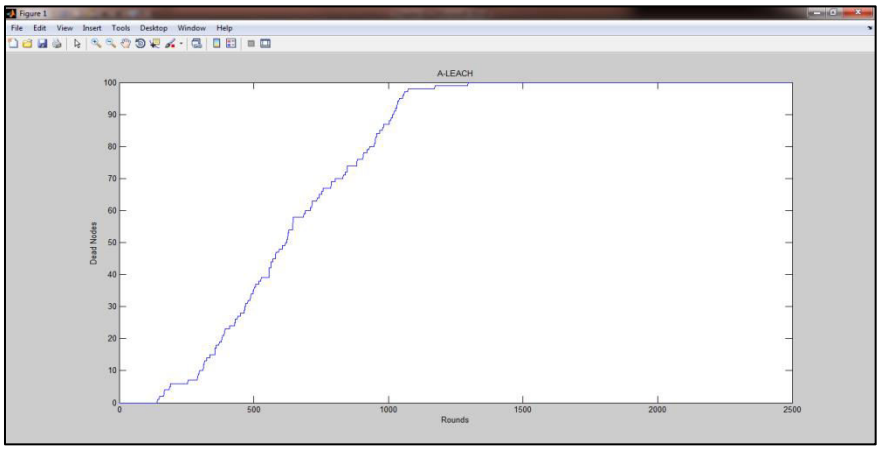

Fig 5: Permanence Phase

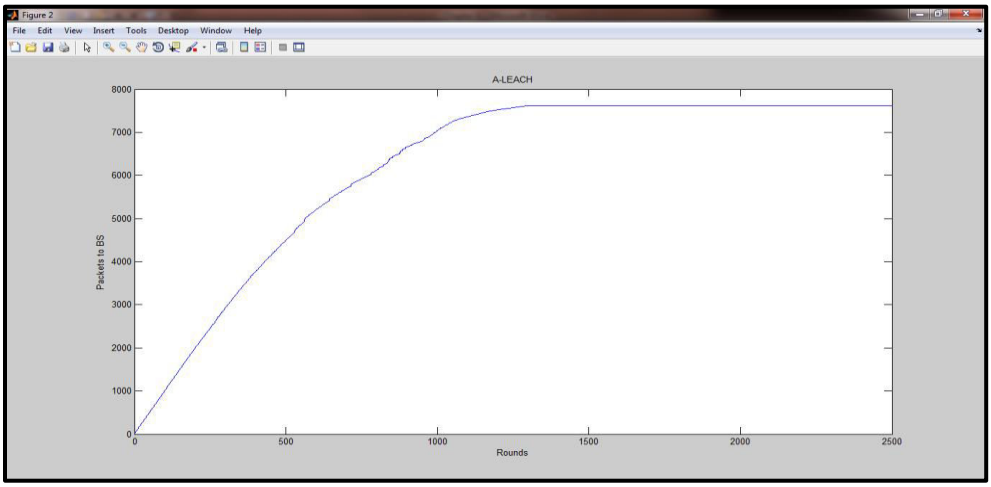

Fig 6: Throughput of WSN

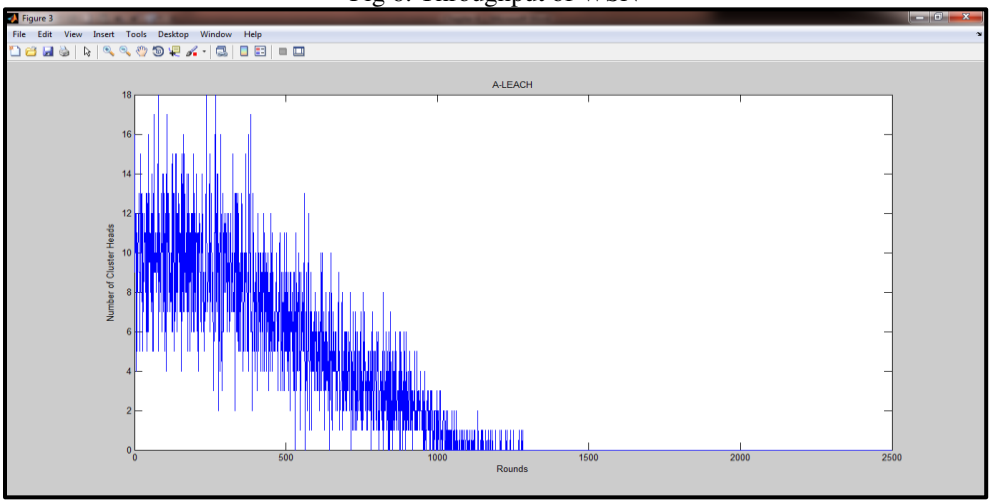

Fig 7: Number of Cluster Heads

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V. CONCLUSION

We have suggested R-LEACH, a fresh modification of LEACH which may be exploited in different cluster based routing protocols for energy proficiency. R-LEACH cause least energy consumption in network through effectual cluster head substitution after every cycle and double transmitting energy levels for intra-cluster and CH to sink transmission.In R-EACH, if the power of the head falls under a specific value, it can be replaced by another node to minimize the load of routing protocol. Henceforth, replacement procedure of CH includes residual energy of cluster head at the beginning of every cycle. Additionally, soft and hard thresholds have been applied on R-LEACH to provide a comparative analysis on enactments of these protocols taking into consideration throughput and energy consumption.

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