Enhanced Energy Efficient LEACH Protocol using Adaptive Filter in WSN

Baljinder Kaur[1], Balraj Singh[2]
[1]Department of Computer Science & Engineering, Lovely Professional University, Phagwara, PUNJAB
[2] Lovely Professional University, Phagwara, PUNJAB
Contact: baljinderkaur.may@gmail.com, balraj.13075@lpu.co.in

***Abstract*— Wireless sensor network is most used network of today's world. Sensor node is the basic component of sensor network and having resources constrained like less memory, processing and battery power. These sensors are battery operated which means have limited battery capacity. It is important to efficiently use this battery so that network lifetime should be increased. Hierarchical routing protocols are energy efficient routing protocols which allows the sensor nodes to communicate with an energy efficient way. LEACH (Low Energy Adaptive Clustering hierarchical protocol) is clustering based hierarchical routing protocol which helps to reduce the power consumption by distributing the load among each sensor node and putting these sensor nodes into sleep mode when not in use. We use appropriate adaptive filter which is also energy efficient and helps to reduce the effect of noise and noise free data is received to sink. So, this leads to save the energy consumption and accurate data for making accurate decision by the base station for better utilization of the sensor network and fulfil the goal of implementation of the sensor network.**

Keywords- ***Wireless sensor network, sensor nodes, energy efficiency, LEACH, cluster head, adaptive filter,***

I. INTRODUCTION

A wireless sensor network having sensor nodes and these nodes are deployed over a geographical area also known as sensor area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events etc. from the environment [1].

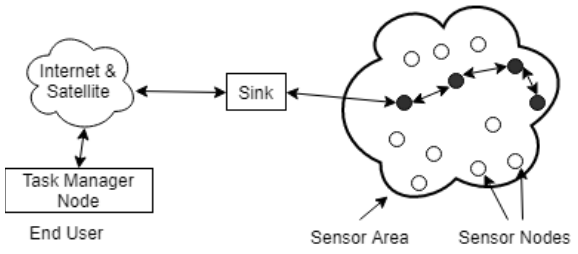

Fig. 1 Working of WSN

Sensor network is used for monitoring environment, military, health, home etc. which are very helpful to people. WSN having sensor nodes, sink or base station and end user. Sensor nodes sense the environment and Sink node is data collector which receive all sensor data. This data then pass to task manager node which is operated by user. These sensor nodes are deployed densely inside the real world phenomena or near to it and in hostile environment and required no human intervention [3].

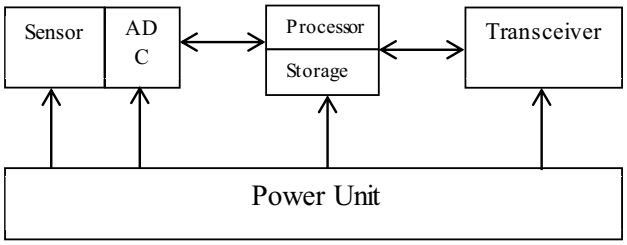

Fig. 2 Basic components of a sensor node

The basic components of sensor node include sensing subsystem for sensing the environment and for data gathering, processor for data processing and communication system for transmitting or receive data [22]. Sensor node may contain application dependent components like location finding system which is responsible for identifying the node location, mobilizer for moving sensor nodes within the sensing area and power generator for power backup. Each sensor node having battery and it is difficult to replace or recharge this battery in hostile environment [5]. This is main reason, to save the power of sensors to maximize the lifetime of the network.

Energy in transmission and receiving of k bit data in d distance is represent using following equations:

$$E_{Tx} = k*E_{elec} + k\,(E_{amp})\,d^2 \quad (1)$$

$$E_{Rx} = k*E_{elec} \quad (2)[2]$$

Where, E_{Tx} is transmission energy, E_{Rx} is receiving energy, E_{elec} is electronics energy and E_{amp} is amplifier energy [2].

Mostly power of SN is much wasted while transmitting data to sink, secondly in receiving time or idle listening time and less power is consumed when a node is in sleep mode. An efficient technique is used to manage the sensor node

978-1-5386-8025-4/18/$31.00 ©2018 IEEE
DOI 10.1109/ICCS.2018.00008

sleep/wakeup mode. LEACH protocol is cluster based routing protocol which is used for saving the energy of sensor nodes.

There are two main ways of energy consumption that are useful reasons and wasteful reasons [4]. Useful reasons of power wastage include transmitting and receiving data, query processing and forwarding query to neighbours nodes. Wasteful reason of energy waste include idle listening (in which sensor nodes listen to an idle channel), collision (any node who receive more than one packet at same time is considered as collision occurred at that node), overhearing (in this a sensor node received those packet whose receiver is another node but get packets that is not destined for that node), control packet overhead (some control packets are used for initial data transmission) and over emitting (means destination node at that moment of time is not ready for receiving data packets but sender start sending).

Sensor network lifetime should as much as it satisfied the application requirement. Life of the network is basically for few months to year. If there is no energy efficiency techniques used then, a node would stop working within a couple of days because of battery drain. So, need of energy efficient protocol is here to increase the lifetime and improve throughput with less delay.

A. WSN Architecture

Sensor nodes in WSN are the basic component of sensor network, sink node or base station is data collector which receives data from all sensor nodes. Sensor nodes are deployed using three different ways:

1. Layered based Architecture
2. Cluster based Architecture
3. Sensor nodes with mobile Sink node based Architecture

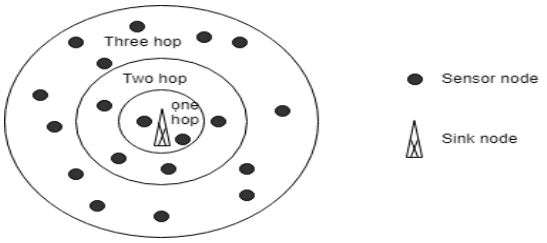

Fig. 3 Layered based Architecture

In Layered based architecture different layers are formed. There is one sink node who receives all sensor nodes information. Sensor nodes send data to sink node using one hop, two hops etc. In this way data is transmitted to the base station using layers.

In cluster based architecture, different clusters are created and one CH is elected in each clusters. All nodes present in the network, send its data to this CH and then CH transmit this data to sink node.

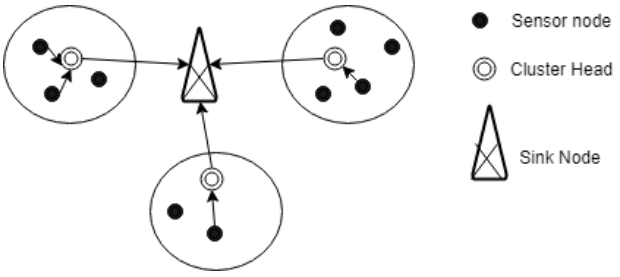

Fig. 4 Cluster based architecture

In sensor node with mobile sink node architecture, sink node is moveable and travel in sensing area and collecting the data from the sensor nodes. Sometimes data collectors are installed within the sensing area for collecting the data.

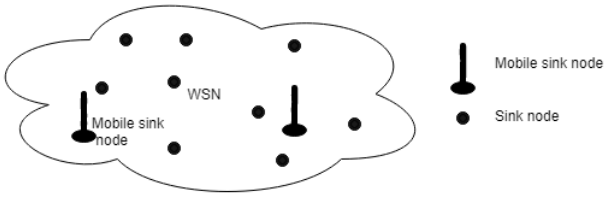

Fig. 5 SN with Mobile sink node

Wireless sensor network having many applications and used in different areas. Sensor nodes are resource constrained like limited memory, power and processing. It is important to save the power of sensor nodes by using energy efficient approach.

B. Application of Sensor Network

WSN is used in many application areas for giving the best results to the users where it is difficult to approach by human being. Sensors are deployed in hostile environment and to reach that place by human is dangerous and risky. For sensing the ground motion the device which is used is called seismic sensors. These sensors convert the ground motion to the electronic signal and this signal is analogue. After that, analogue to digital converter is used to change this analogue signal to digital signal. Following are the main applications of WSN [1]:

1. Military Applications: In this, sensors are deployed in the battlefield and monitor the activities done around them.
    - Sensor nodes perform the battlefield observation and identified how much damage of human or machine is happened.
    - Monitor the opposite forces, the equipment's other force having and ammunition.

- Different attacks like nuclear, chemical etc. are also detected.

2. Environment Applications: in this type of application, sensor nodes are deployed in the real environment.
   - Temperature, humidity, air pollution and monitor the environment condition.
   - Detect the fire in the forest, flood detection by COUGAR system.
   - Also monitor the bird movement and track them.
3. Health Application: these applications are very helpful to human being.
   - Small sensor node is attached with doctor or patient for monitoring the location of doctor in hospital.
   - Tele-monitor the physiological data of patient.
   - Which drug is given to patient and when monitor all these activities.
4. Home Applications include vacuum cleaners, washing machine etc. and smart environment in home.
5. Many other applications like vehicle tracking, inventory control, monitor the product quality etc. [22].

C. LEACH (Low Energy Adaptive Clustering Hierarchy Protocol)

W.R.Heinzelman projected LEACH protocol which is energy efficient hierarchical routing protocol and is good for load balance among the sensor nodes. In LEACH protocol whole sensor network is partitioned into different clusters. One head node is randomly chosen from all sensor nodes present in that cluster. Working of LEACH is done in different rounds and each round having two states: (1) Cluster setup state (2) Steady state.

In first state clusters are created and among each cluster one head is elected based on the threshold value. Each node in sensor network selects one value between 0 and 1 and that value is then compared with threshold value and if the selected value is less than this threshold value then the node become the CH for the current round [5].

Threshold is mostly given as in Equation (1):

$$T(n)=\begin{cases}\dfrac{p}{1-p*(r \bmod 1/p)} & \text{if } n \in G \\ 0 & \text{otherwise}\end{cases} \qquad (3)$$

Where

n represent each node from the set G,

p is percentage of node to become CH,

r is used for current round,

G represents set of nodes that haven't been CH within the last 1/p rounds.

After selecting the CH, cluster head node broadcast the advertisement message with CDMA code. The sensor nodes which received this message with higher frequency reply to that cluster head as joining message. Numbers of node join this cluster according to that number cluster head node decides the TDMA slots for the member sensor nodes.

In second state i.e. steady state, SN sends the processed data to the head node in their allocated TDMA slot. In the meantime these nodes are in sleep state which helps to save the power. After receiving all data from sensor nodes, CH done data aggregation periodically and redundancy present in the data is eliminated [6].

Advantages of the LEACH protocol are [7]:

i. Most useful hierarchical routing protocol in sensor networks which save the energy of nodes.

ii. Sensing area is divided into many cluster and cluster head among all sensor node collect data and send it to sink which helps to maintain the battery of sensor nodes.

iii. The node which is CH in current round is not become the CH in next 1/p round. In this way load which cluster head node handle is equally distributed among other nodes.

iv. The head node is chosen randomly among other nodes and probability for every node to become the CH is equal.

Wireless sensor network have many applications and used in different areas. Sensor nodes are resource constrained like limited memory, power and processing. It is important to save the power of sensor nodes by using energy efficient approach.

II Literature Review

In this paper, basic research area of wireless sensor network is covered as shown in the figure 6. In Power management, power of sensor nodes is maintained by system level power-awareness. Deepti Goyal and Sonal categorize power saving into two techniques: first is power control which save the energy by transmission range of sensor nodes and second is power management in which radio of those sensor nodes are off which are not active. SPCPM algorithm is used for simultaneously power control and power management [8].

In Node localization, sensor nodes location is determined by using different algorithm. GPS is not attached with every sensor nodes due to its cost. Some nodes called Seed have location information all times. When other nodes want to know its location then they exchange information with seeds and get to know its current location. Nasser Aghaie and Mohammad Ali Tinati solve the problem of non-line of sight nodes. In that the nodes which are not directly connecting through a straight path are not able to share the correct information regarding distance between these nodes. Author used the AOA i.e. Angle of Arrival method to identify that non-line of sight nodes, and then not considered these nodes for localization process. The nodes who don't know its location can contact to anchor node, if some obstacle is in between them [9].

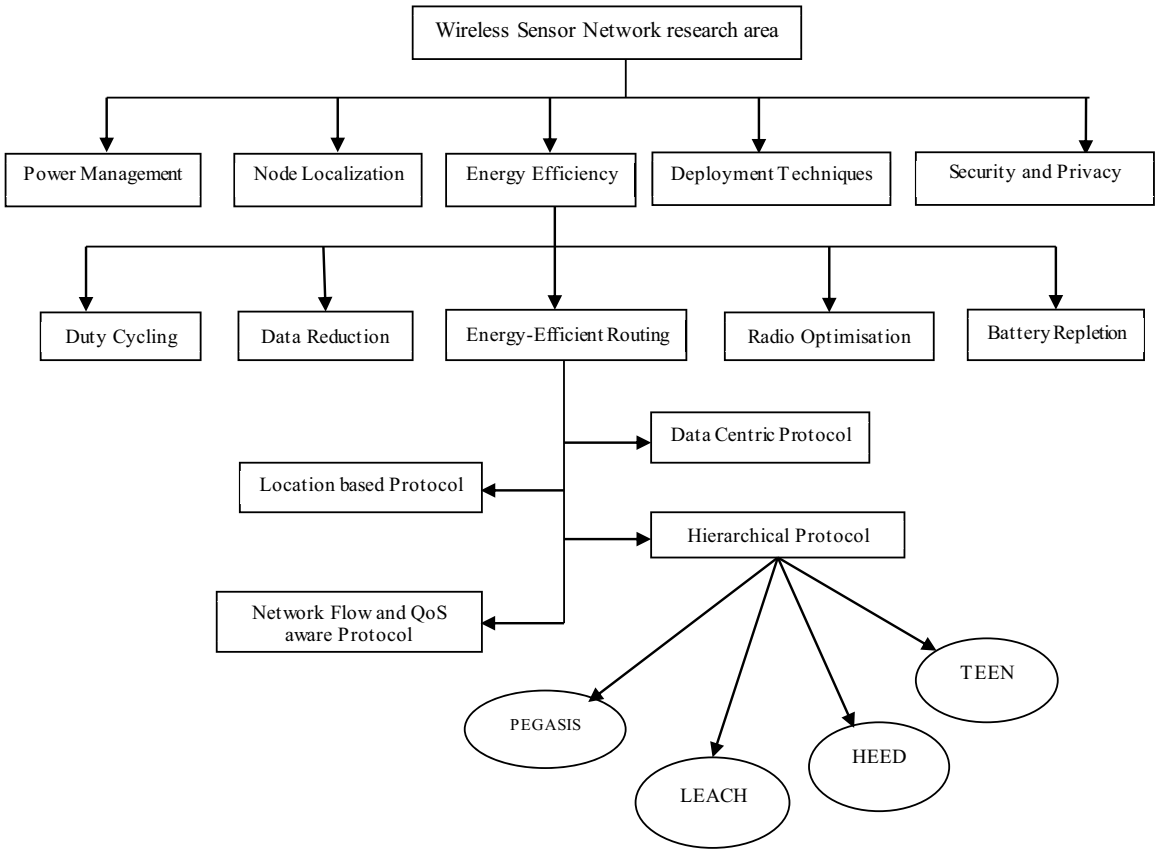

Fig. 6 Classification of Research areas of WSN

In deployment techniques, different ways are used to decide how each sensor node in real world environment is deployed. In [1], author defined pre deployment, post deployment and re-deployment mechanism for each node present in the network.

II CLASSIFICATION of ENERGY EFFICIENCY TECHNIQUE

A. Duty Cycling*:* duty cycling is that time of a node in which node is active. Putting the sensor node in sleep mode when not in use. Topology control and power management techniques are used in duty cycling for saving energy. Sensor radio has four modes that are transmission mode, receiving mode, idle listening and sleep mode. More energy is consumed in transmission mode and approximately same energy is consumed in receiving and idle listening mode, very less power is consumed in sleep mode. Duty Cycling include two methods for saving energy: topology control and power management [3].

1) *Topology control*: In this, the sensor node which is not currently needed can go to sleep mode and save energy. Sensor nodes switch OFF its radio when not in use and go to sleep mode. Topology control mechanism further classified into two categories.

- Location Driven Protocol: Taking decision about which node is turn ON and when. This decision is taken from their location. GAF (Geographic Adaptive Fidelity) and GeRaF (Geographic Random Forwarding) is used for location specific data transmission.
- Connection-driven: In connection-driven two channels data channel and wakeup channel are used. Data channel is used for data communication and wakeup channel is used for awaking node when needed. A node is wake up when its neighbor wants to communicate with it.

2) *Power Management:* Power management includes sleep/wakeup protocol and MAC protocol using low duty cycle.

- Sleep/wakeup Protocol: Sleep/wakeup is further divided into on-demand, scheduled rendezvous, asynchronous
- MAC Protocol: It includes TDMA, contention based, and hybrid approach.

B. Data Reduction*:* in this technique, data which is in the system is reduced to minimize its size. Redundancy in sensor nodes data can consume more energy which reduced the network lifetime. Data reduction technique reduced the amount of data which is delivering to the sink. Data reduction technique includes data aggregation and data compression [11].

1) *Data Aggregation:* In this sensor data is aggregated (using LEACH, Directed diffusion, or by centralized approach) and this aggregated data is send to the sink. Centralized approach, In-Network Aggregation, Tree-Based approach and cluster based approach are some type of data aggregation technique [10]. By removing redundancy in data, data become useful and also save the energy of sensor nodes.

2) *Data Compression:* Sensor node sense the data and though data compression technique size of data is reduced by using encoding and energy for transmitting these small packet is less as compared to before compression. Wireless sensor network is resource constrained network so different compression algorithms are designed for WSN. In [12], author defines some algorithms which are used for compression.

C. Energy Efficient Routing: routing protocols are able to maximizing the lifetime of the network by reducing the energy used while end to end transmission of data is going on and avoid those nodes which have less energy [13]. The main goal of routing protocol is to make and maintain the route between the nodes and sink. Data to the base station is received successfully.

1) *Data centric protocols* are spin, direct diffusion in which sensor node or sink broadcast the advertisement about interested data.

2) *Hierarchical protocols* include LEACH, PEGASIS and TEEN which is data centric and hierarchical.

3) Geographical protocols are GEAR, consisting of two phases. In this one node is turned on in each cell and rest all nodes are in sleep mode.

4) *Opportunistic protocols* are to exploit the broadcast nature and space diversity and node mobility.

D. Radio Optimization: in this technique, radio of sensor node managed in such a way that when a node is not in used, then put this node radio into sleep mode. In this way energy of the sensor node is save and improve the network lifetime.

E. Battery Repletion: Sensor nodes are deployed in hazardous area so to replace the battery of sensor nodes is difficult task. This technique is used for charging the batteries of sensor nodes without any human intervention. Energy harvesting and wireless charging are two techniques used for charging the battery of sensor node.

1) *Energy Harvesting*: In this sensor nodes are able to gaining energy from the surrounding environment like solar, wind or kinetic energy [14]. Nodes which have less energy put these nodes to sleep mode and lower transmission range on the other hand nodes which are rechargeable can use mostly prefer for data transmission routing.

2) *Wireless Charging*: transmitting energy between sensor nodes through electromagnetic (EM) radiation and magnetic resonant coupling. Placing the energy relay node in accurate position so that, sensor nodes easily gain energy without and disturbance. Author use multi-hop RF energy transfer which can save energy of the source and time [15].

III. PROBLEM STATEMENT

The sensor nodes in WSN having some resource constraints like minimum battery capacity and less memory. Protocols installed in sensor nodes consume memory and energy of sensor nodes and very soon the power level of sensor node decreases and lifetime of sensor network reduced soon. So, the protocol which is designed for the sensor network should be designed in such a way that it is not too much power consuming and not consume more memory capacity. Energy efficient routing protocols are used in sensor network for saving the power of sensor nodes and which result in increasing lifetime of overall sensor network [13]. LEACH protocol is energy efficient hierarchical routing protocol which is mostly used in WSN. Adaptive filter like LMS filter used to reduce the noise from the sensed data and done data aggregation by using beam form method and generate one single signal. This aggregated data is then sends to the sink node.

LEACH protocol till now is not implemented with the adaptive filter for the purpose of noise reduction from the sensed data. When noise is reduced from the sensed data the signal received by base station is noise free, which provides accurate information and also enhanced the efficiency of the WSN. Main objective of our work is to hybrid the LEACH protocol with adaptive filter, to reduce the noise signal from the sensed data and enhance the lifetime of sensor network and gave comparatively better results.

IV RESEARCH METHODOLOGY

We are used MATLAB Simulink for designing the network setup and deploying the sensor nodes in the simulation environment. MATLAB provides built-in graphics for visualizing data and tools for creating custom plots [19].

MATLAB Simulator tool is used for constructing the network of sensor nodes and have following criteria for each sensor node: Sensor nodes are uniform, all sensor deployed with same energy (i.e. 0.5J) and battery on each sensor. Sensor nodes know its location and energy level. Base station is located centre of the sensing area. Number of sensor nodes are 100 in our simulation, which cover the 100*100m area. Sensor nodes take 50nj/bit energy for data transfer and receive and 5nj/bit energy for data aggregation.

Adaptive filters are used for many purposes like system identification, noise cancellation, prediction etc. Most commonly used adaptive filter is LMS (Least Mean Square) adaptive filter and RLS (Recursive Least Square) adaptive filter.

RLS adaptive filter require more computation and having stability problem.

Table 1 Simulation Parameter

Parameter	Value
Network Size	100m*100m
Initial Energy	0.5j
P(CH probability)	0.1
Number of Nodes	100
Packet size of sensor node to CH	6400
Packet size of CH to BS	200
Energy for Transmitter	50nj/bit
Energy for receiver	50nj/bit
Transmit Amplifier	100pj/bit/m2
Aggregation Energy	5nj/bit

We calculated the results after its proper execution on network simulator MATLAB. After that we check the energy utilization and compute its efficiency against previous implemented protocol by graphically comparison. We recorded the improvement in our implemented protocol; which is effective and energy efficient.

Adaptive filter are basically used in changing environment and these filters easily adapt to the changes. Adaptive filters are mainly used as system identification, noise cancellation and data priction etc. [18]. Finite impulse response or infinite impulse response are types of linear filter [21]. The least mean square is one adaptive algorithm which is mostly used for adjusting the coefficients of finite impulse response [20]. LMS filter uses the concept of MSE (Mean Square Error), if this MSE is greater than zero then weight is reduced and vice versa.

DATA= True signal+ Noise [16].

So, it is required to reduce or cancel the noise signal from data for energy efficiency of the sensor node because sensor node having limited resources and we have to proper utilize these resources by using appropriate methods.

Adaptive filter are mainly of categorised as stochastic gradient approach and least square estimation. First type include LMS filter which basically used weight factor. Second one include RLS filter. We use LMS filter for reducing the effect of noise from the sensed signal and noise free signal is send to the base station.

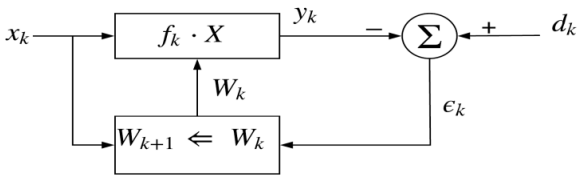

Fig. 7 Adaptive Filter Block Diagram

Where

k is current sample number or round
x is the input signal to the filter
X is all set of recent value of x,
f is finite impulse response of filter
W is set of parameters which are vary
∑ is basic summation operation
y is linear filter output
d is desired input to the summation [17].

V. RESULTS & DISCUSSION

By implement the LEACH protocol with adaptive filter improves the energy efficiency of sensor network. The sensor nodes are deployed in real world may contain noise in the environment. Adaptive filters reduce the effect of noise present in sense signal of sensor nodes. Valuable data is transfer which is noise free and resulted in accurate decision. LEACH protocol save the battery of sensor nodes by distributing the load among each sensor. We attempted to compare our LEACH using Adaptive LMS filter protocol with previous LEACH protocol. In LEACH protocol sensor area is divided into different cluster and one CH is selected from each cluster. That node becomes CH which having more energy and not become the CH for last 1/p round. In this way load is equally distributed among every sensor node in the network.

One random number is given to sensor node and on the basis of the threshold value calculated by the node, decision is made regarding choosing that node as a CH or not. At CH we use LMS filter to reduce the effect of noise from the data signal and aggregate the data by using beam-form method to make it single signal. This single signal is then transferred to the sink node in their respective time slot. The data present in the sink node is sent to task manager node through using the internet and this node is operated by the end user.

In this section we attempted to compare our algorithm with the LEACH algorithm. There are some limitations of LEACH like some nodes are far from the cluster and directly send data to sink consume more energy, random selection of cluster head, leads to dead that node fast if head having less energy. We designed the algorithm which is actually reducing the noise from the sensed data and send data to the sink node.

A. Comparison analysis on the basis of number of packet send:

In this section we compare the results of our algorithm i.e. LEACH using adaptive filter and LEACH using different number of rounds with number of packet send in respective round. In starting the variation is significantly low and with the increase in number of rounds the number of packet send is more in LEACH using adaptive filter. This is because of, we reduce the effect of noise from the sensed data, as the noise signal is reduced the number of packet send is more.

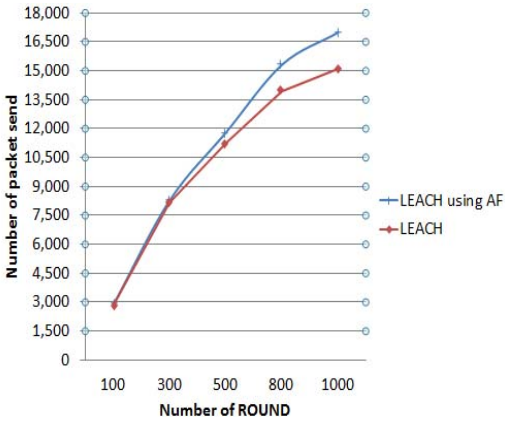

Fig. 11 Comparison on the Basis of number of Packet Send

Our algorithm shows improvement on the basis of less number of node dead as compared to previous one. In starting, like in round 100 numbers of dead nodes are zero. After reaching round 150, nodes start die. When we reach round 1000, only 88 nodes are dead with our designed protocol where in LEACH 91 nodes are dead. This difference is not too much bigger, but this affects the network performance.

B. Comparison analysis on the basis of number of dead nodes:

This section compares two protocols on the basis of number of dead node in different round. In starting rounds, there is no difference shown but when the number of round increases the dead node in basic LEACH protocol is also more as compared with the LEACH using adaptive filter.

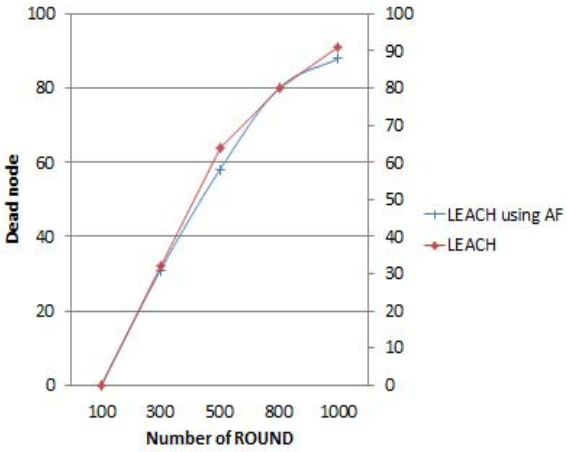

Fig. 12 Comparison on the Basis of Number of Dead Nodes

C. Comparison analysis on the basis of sum of energy:

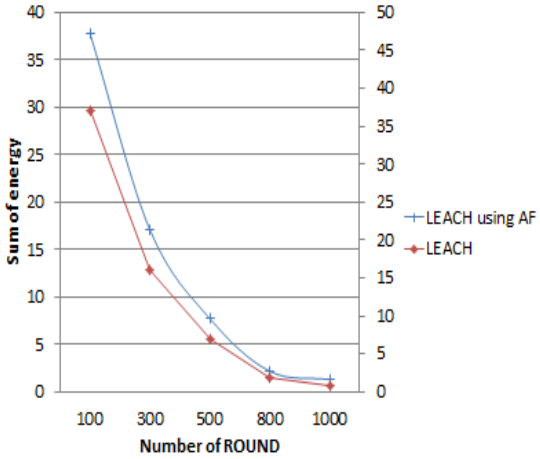

Fig. 13 Comparison on the Basis of Sum of Energy

This section describes the comparison on the basis of sum of energy for these two protocols. In different round such as 100,300,500,800 and 1000, our observation shows significant results of LEACH with adaptive filter. Our algorithm contains more energy than LEACH protocol and save energy in the network; hence network lifetime is improved due to more energy present in the network.

In Table 2 it is clearly shown that the algorithm sends more number of packets as compared with the previous LEACH and identifies the improvement in the implemented algorithm. Throughput of the network is more and network is operational for longer time duration. Signal to noise ratio measured in our protocol also shows that our work removes the effect of noise from the sensed signal and noise free data is send to the base station.

Table 2 comparison between LEACH using AF and LEACH

No. of Rounds	LEACH using AF	LEACH	Improvement with proposed algorithm
300	8209	8182	1.00 times
500	11797	11236	1.04 times
800	15312	13967	1.09 times
1000	16985	15103	1.12 times

VI. CONCLUSION & FUTURE SCOPE

In today's world, sensor network is most used network in many application areas like military, environment, health, home etc. Sometime sensor network are deployed in hostile environment and to recharge or replacing the battery of these sensor nodes are difficult. So, it is necessary to efficiently use the power of these sensor nodes so that each node actively participates in the network for longer duration.

In our work, there is an improvement in the network lifetime of sensor network and energy efficiency under certain control conditions. By combining LEACH with adaptive filter, simulation result shows better improvements. LEACH protocol with adaptive filter algorithm also shows improvement in throughput and used for energy efficiency. Signal to noise ratio measured in our protocol also shows that our work removes the effect of noise from the sensed signal and noise free data is send to the base station.

The work we done is further improved in the sense of using these filter for more purposes in different application areas depending upon the requirements. Hybrid LEACH with other variations of filters and can also integrate the adaptive filter with other protocols to see the behaviour of the protocol.

REFERENCES

[1] I. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "Wireless sensor networks: a survey", *Computer Networks*, vol. 38, no. 4, pp. 393-422, 2002.

[2] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "Energy -Efficient Communication Protocol for Wireless Microsensor Networks". *Proceedings of the 33rd Hawaii International Conference on System Sciences*.

[3] G. Anastasi, M. Conti, M. Di Francesco and A. Passarella, "Energy conservation in wireless sensor networks: A survey", *Ad Hoc Networks*, vol. 7, no. 3, pp. 537-568, 2009.

[4] Z. Rezaei, Shima Mobininejad "Energy Saving in Wireless Sensor Networks", *International Journal of Computer Science & Engineering Survey*, vol. 3, no. 1, pp. 23-37, 2012.

[5] S. Fakher and M. Moawad, "The main effective parameters on wireless sensor network performance", *International Journal of Scientific and Research Publications*, vol. 5, no. 6, 2015.

[6] S. Yadav and R. Yadav, "A review on energy efficient protocols in wireless sensor networks", *Wireless Networks*, vol. 22, no. 1, pp. 335-350, 2015.

[7] S. Singh, P. Kumar and J. Singh, "A Survey on Successors of LEACH Protocol", *IEEE Access*, vol. 5, pp. 4298-4328, 2017.

[8] D. Goyal, "Power Management in Wireless Sensor Network", *InternationalConference on Computing for SustainableGlobal Development*, pp. 598-601, 2016.

[9] N. Aghaie and M. Tinati, "Localization of WSN nodes based on NLOS identification using AOAs statistical information", *2016 24th Iranian Conference on Electrical Engineering (ICEE)*, 2016.

[10] N. Patil, P. R. Patil "Data Aggregation in Wireless Sensor Network", *IEEE International Conference on Computational Intelligence and computing Research*, 2010.

[11] T. Rault, A. Bouabdallah and Y. Challal, "Energy efficiency in wireless sensor networks: A top-down survey", *Computer Networks*, vol. 67, pp. 104-122, 2014.

[12] N. Kimura, S. Latifi, A survey on data compression in wireless sensor networks, in: Int. Conf. on Information Technology: Coding and Computing, Las Vegas, NV, 8–13, 2005.

[13] R. Soua and P. Minet, "A survey on energy efficient techniques in wireless sensor networks", 2011 4th Joint IFIP Wireless and Mobile Networking Conference (WMNC 2011), 2011.

[14] S. Sudevalayam, P. Kulkarni, Energy Harvesting Sensor Nodes: Survey and Implications, IEEE Com munications Surveys & Tutorials 13 (3) (2011) 443–461.

[15] K. Kaushik, D. Mishra, S. De, S. Basagni, W. Heinzelman, K. Chowdhury, S. Jana, Experimental demonstration of multihop RF energy transfer, in: IEEE 24th Int. Symp. on Personal Indoor and Mobile Radio Communications, London, UK, 538– 542, 2013.

[16] "Noisy data", En.wikipedia.org, 2017. [Online]. Available: https://en.wikipedia.org/wiki/Noisy_data. [Accessed: 02- jan- 2018].

[17] "Adaptive filter", *En.wikipedia.org*, 2018. [Online]. Available: https://en.wikipedia.org/wiki/Adaptive_filter. [Accessed: 07- jan- 2018].

[18] "Overview of Adaptive Filters and Applications- MATLAB & Simulink- MathWorks India", *In.mathworks.com*, 2018.[Online].Available:https://in.mathworks.com/help/dsp/ug/overview-of-adaptive-filters-and-applications.html. [Accessed: 26- Jan- 2018].

[19] "MATLAB", *En.wikipedia.org*, 2018. [Online]. Available: https://en.wikipedia.org/wiki/MATLAB. [Accessed: 28- Jan- 2018].

[20] "Adaptive Filter Concepts (Adaptive Filter Toolkit) - LabVIEW Adaptive Filter Toolkit 1.0 Help", *Zone.ni.com*, 2017. [Online]. Available: http://zone.ni.com/reference/en-XX/help/372357A-01/lvaftconcepts/aft_concepts_intro/. [Accessed: 17- Nov- 2017].

[21] C.Support, "FIR vs IIR filtering", *Minidsp.com*, 2017. [Online]. Available: https://www.minidsp.com/applications/dsp-basics/fir-vs-iir-filtering. [Accessed: 15- Nov- 2017].

[22] "Wireless sensor network", *En.wikipedia.org*, 2017. [Online].Available:https://en.wikipedia.org/wiki/Wireless_sensor network. [Accessed: 11- Nov- 2017].

Baljinder kaur is Master's student in the department of computer science and engineering at lovely professional university. Her research interest includes computer networks and wireless sensor network.

Balraj Singh is an Assistant Professor at LPU. His research interest includes distributed computing, networks and software engineering.