

## **Performance Comparison of Various Energy Aware Protocols for WSN Applications**

**S. Abarna**

PG Scholar, Department of ECE  
National Engineering College  
Kovilpatti, Tamil Nadu, India  
lsabarna2008@gmail.com

**N. Arumugam**

Associate Professor, Department of ECE  
National Engineering College  
Kovilpatti, Tamil Nadu, India  
armsece@gmail.com

---

**Abstract:** *Energy consumption remains as a major obstacle for full deployment and exploitation of sensor networks. Sensor nodes are generally battery powered devices and the critical aspect is to reduce the energy consumed by the node. There are so many techniques to reduce the energy consumed by the nodes. In this paper, the energy consumed by the sensor nodes are reduced by applying various energy aware protocols in the clustered sensor network. Three protocols namely, LEACH, PEGASIS and HEED are used to evaluate the network performance and can be concluded that which one is efficient. In this phase, the reduction in energy consumption is achieved by analyzing the network performance using the Network Simulator.*

**Keywords:** *Wireless sensor network, Cluster, LEACH, PEGASIS, HEED.*

---

### **1. INTRODUCTION**

Wireless communication endowed with numerous advantages over traditional wired network and enables to develop small, low-cost, low power and multi-functional sensing devices. These small sensing devices have the capabilities of sensing, computation, self organizing and communication. Sensor is a tiny device used to sense the ambient condition of its surroundings, gather data, and process it to draw some meaningful information which can be used to recognize the phenomena around its environment. These sensors can be grouped together to form a network communicating wirelessly using radio frequency channel. The collection of these homogenous or heterogeneous sensor nodes called wireless sensor network (WSN).

The ability of low cost, small size and easy deployment of the sensor nodes make it possible to deploy them in a large number in an area to be investigated. Interestingly, unlike other networks that performs poor with growth in their networks size, WSN get stronger and performs better as much as number of nodes exceeds. Owing all these considerable advantages, application domain of WSNs varies from environmental monitoring, to health care applications, military operation, to transportation, to security applications, to weather forecasting, to real time tracking.

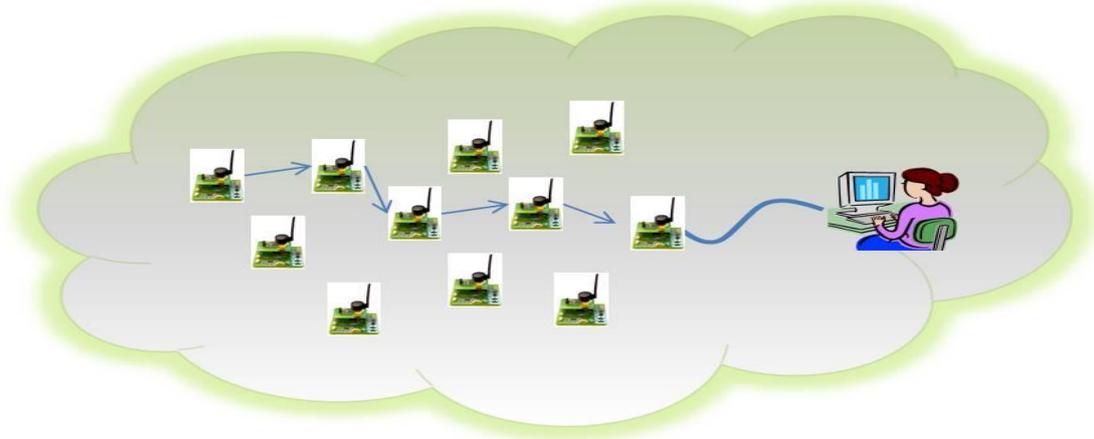
WSN is the collection of hundreds or thousands of tiny sensor nodes having the abilities of sensing, computations and communication among each other or with the base station. These tiny sensor nodes are scattered throughout the investigation area to acquire information from the environment, process it and then transfers it to the base station. By considering WSNs application domain, one can presume it like a traditional wired or wireless network. But the reality is very different because traditional wired or wireless networks have enough resources like unlimited power, memory, fixed network topologies, enough communication range and computational capabilities. But on the other side, WSNs have a resource constrained nature with respect to energy, computational capabilities and memory resources.

### **2. CHALLENGES AND APPLICATIONS OF WIRELESS SENSOR NETWORKS**

#### **2.1. Wireless Sensor Networks**

Wireless sensor network (WSN) is the collection of homogenous, self-organized nodes called sensor nodes. These nodes have the capabilities of sensing, processing and communication of data with each other wirelessly using radio frequency channel. The basic task of sensor networks is to

sense the events, collect data and send it to their requested destination. Many features of these networks make them different from the traditional wired and wireless distributed systems.



**Fig1.** *Wireless sensor network*

Traditional wired or wireless networks have enough resources like unlimited power, memory, fixed network topologies, enough communication range and computational capabilities. These features make the traditional networks able to meet the communication demands. On the other hand, WSNs are resource constrained distributed systems with low energy, low bandwidth and short communication range. The basic features which make WSNs different from the traditional networks are; self-organizing capabilities, short range communication, multi-hop routing, dense deployment, limitation in energy and memory. The constrained resource nature and unpredictable network structure (sensor nodes are scattered densely in an environment) poses numerous design and communication challenges for WSNs.

## **2.2. Challenges in WSNs**

Despite the innumerable applications of WSNs, these networks have several restrictions, such as limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing aggressive energy management techniques. The design of routing protocols in WSNs is influenced by many challenging factors. These factors must be overcome before efficient communication can be achieved in WSNs. In the following, we summarize some of the challenges that affect the routing process in WSNs.

- Node Deployment
- Infrastructure less
- Coverage
- Energy constraints
- Network lifetime
- Cost
- Exposure
- Fault tolerance
- Scalability
- Data Aggregation
- Quality of Service
- Security

### 3. CLASSIFICATION AND COMPARISON OF ENERGY AWARE PROTOCOLS

#### 3.1. Based on Network Structure Routing Protocols are Classified as Follows

- Flat routing protocol
- Hierarchical routing protocol
- Location based routing protocol

##### 3.1.1. Hierarchical Routing Protocol

Hierarchical routing is a method of routing in networks that is based on hierarchical addressing. Hierarchical routing is the procedure of arranging routers in a hierarchical manner. There are three protocols namely,

- LEACH Protocol
- PEGASIS Protocol
- HEED Protocol

#### 3.2. LEACH Protocol

LEACH is a routing algorithm designed to collect and deliver data to the sink (base station). LEACH protocol has two phases,

- Set up phase
- Steady state phase

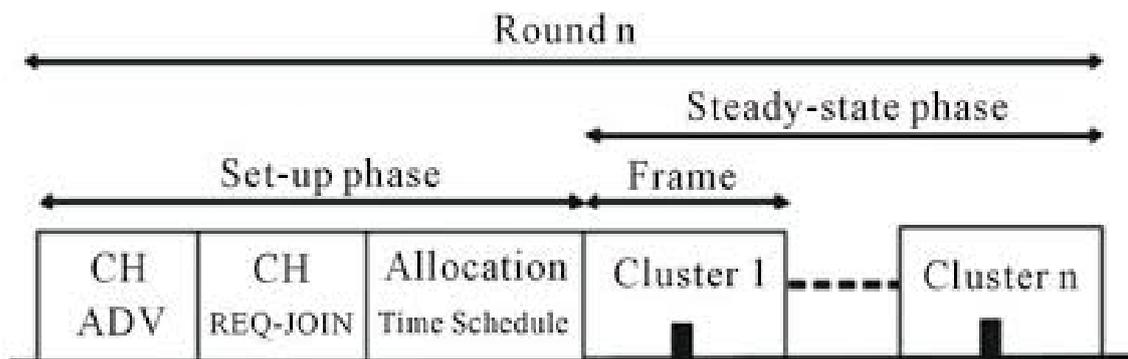


Fig2. LEACH phases

##### 3.2.1. Set Up Phase

This phase consist of two steps namely,

- Cluster head selection
- Cluster formation

##### Cluster Head Selection

- Consider set of nodes.
- Each node selects a number (n) between 0 and 1.
- If the number  $n < T(n)$  then the node will become cluster head .

Where,

$$T(n) = \begin{cases} \frac{P}{1 - p * (r \bmod 1/p)} & \text{if } n \in G, \\ 0 & \text{otherwise,} \end{cases} \quad (1)$$

T (n)-cluster head selection threshold

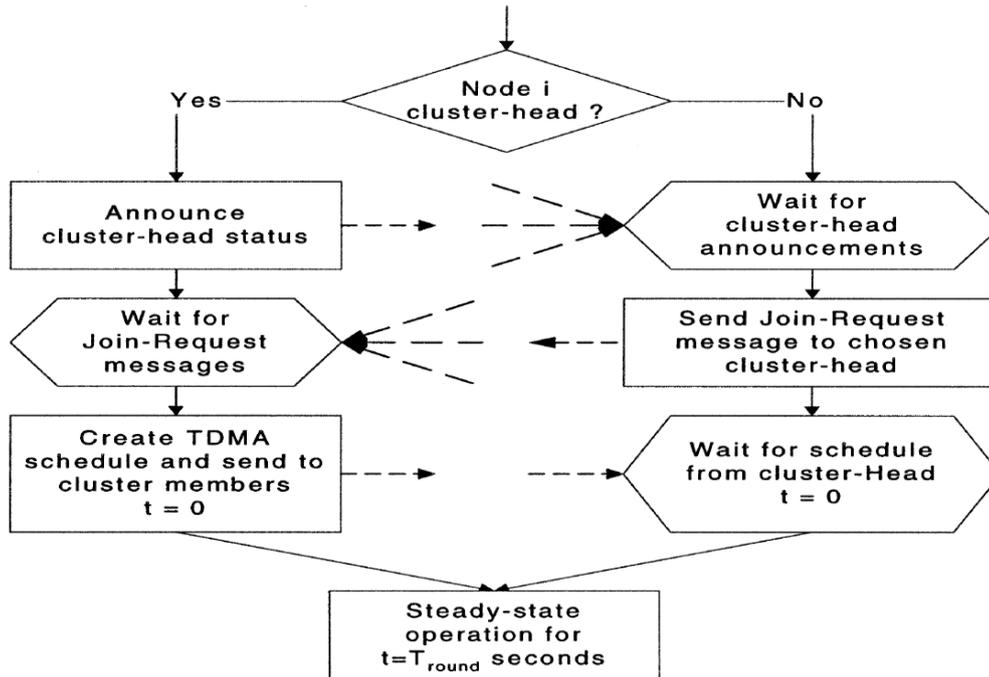
P-predetermined fraction of node elected as cluster head.

r-denotes current round.

G-set of nodes not elected as cluster head.

- Then the cluster head sends messages to immediate nodes that it becomes cluster head.

*Cluster Formation*



**Fig3.** Set up phase

*3.2.2. Steady State Phase*

Cluster head first collects and aggregates the collected data. Then it sends the aggregated data to the BS using single hop without repetition. That is there are three steps namely,

- Data collection
- Aggregation
- Delivery to the base station (BS)

Duration of the setup phase must be shorter than that of the steady-state phase to minimize the protocol overhead.

**3.3. PEGASIS Protocol**

It's a family of routing and information gathering protocol. PEGASIS uses a chain structure. The objective of this protocol is to extend the network lifetime. This protocol forms a chain among the sensor nodes, so that each node will receive and transmit data to the nearest neighboring node. Only one node is chosen as head node to transmit the aggregated data to the base station.

PEGASIS protocol has two phases,

- Chain construction
- Data gathering.

*3.3.1. Chain Construction*

Greedy algorithm is used to construct the chain. Whereas greedy algorithm provides solution to simple as well as complex problems. i.e., here the chain is formed by connecting the neighboring nodes based on the signal strength of the node.

*3.3.2. Data Gathering*

A node within the chain is selected as the leader node. Steps involved in this process is given by,

- Leader node issue token to the other nodes present in the network.
- Upon receiving the token, all other node transmit their data to their neighbouring node towards the leader.

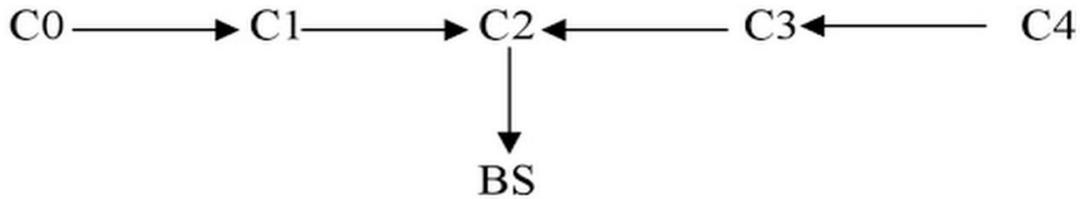


Fig4. Data gathering in PEGASIS

- The neighbouring nodes aggregate the data and transmit to the leader node.
- The leader node, then transmit the aggregated data to the base station.

### 3.4. HEED Protocol

It is designed to select different cluster heads in a field according to the amount of energy distributed among the node. HEED was proposed with four primary goals namely,

- Prolonging network lifetime by distributing energy consumption,
- Terminating the clustering process within a constant number of iterations,
- Minimizing control overhead and
- Producing well-distributed CHs and compact clusters.

There are three phases in this protocol,

- Initialization phase
- Repetition phase
- Finalization phase

#### 3.4.1. Initialization Phase

In this phase the cluster head is elected based on the following parameters,

- Residual energy.
- Communication cost.

Formula for probability of a node becoming cluster head,

$$CH_{prop} = C_{prop} * (E_r / E_{max}) \quad (2)$$

Where,

$C_{prop}$  – initial probability of cluster heads

$E_r$  – residual energy of the node

$E_{max}$  – max., energy identical for all nodes

#### 3.4.2. Repetition Phase

In this phase its stops execution when  $CH_{prob}$  reaches 1. There are two status in this phase,

- *Tentative Status:* The sensor becomes a tentative CH if its  $CH_{prob}$  is less than 1. It can change its status to a regular node at a later iteration if it finds a lower cost CH.
- *Final Status:* The sensor permanently becomes a CH if its  $CH_{prob}$  has reached 1.

#### 3.4.3. Finalization Phase

During this phase, each sensor makes a final decision on its status. It either picks the least cost CH or pronounces itself as CH.

#### 4. RESULTS AND DISCUSSIONS

The reduction in energy consumption is achieved by analyzing the network performance using the Network Simulator.

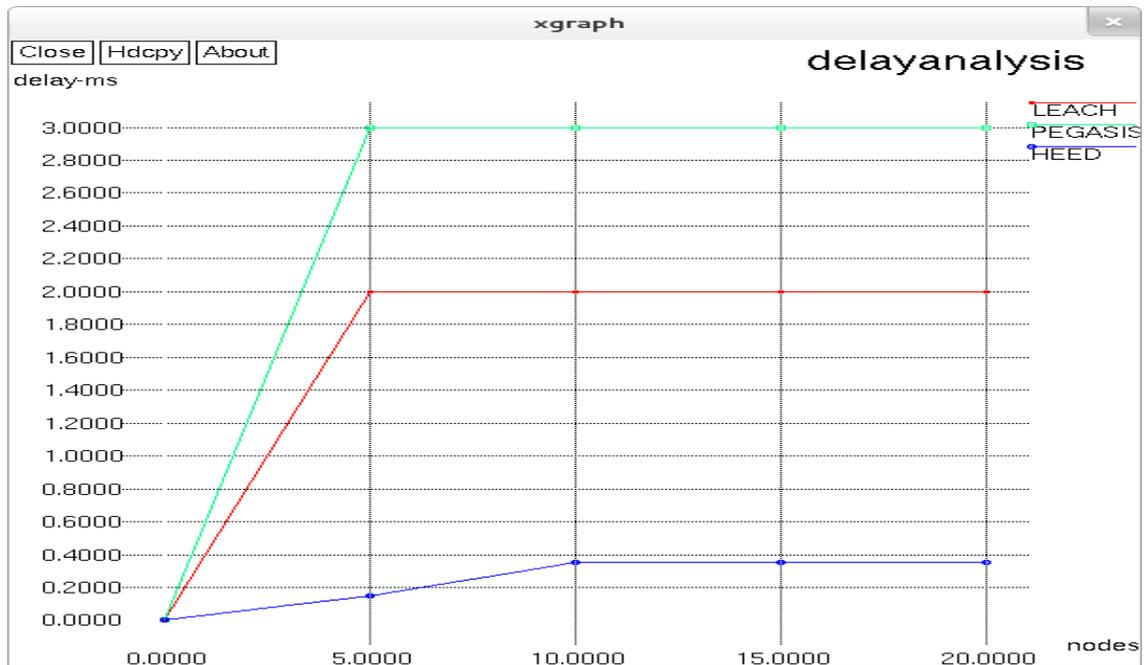


Fig5. Delay analysis

The above figure shows the x-graph for delay analysis. Red color indicates the delay in LEACH protocol. Green color indicates the delay in PEGASIS protocol. Blue color indicates the delay in HEED protocol. In the above graph, when compared with the other two protocols, there is a minimal delay in HEED protocol.

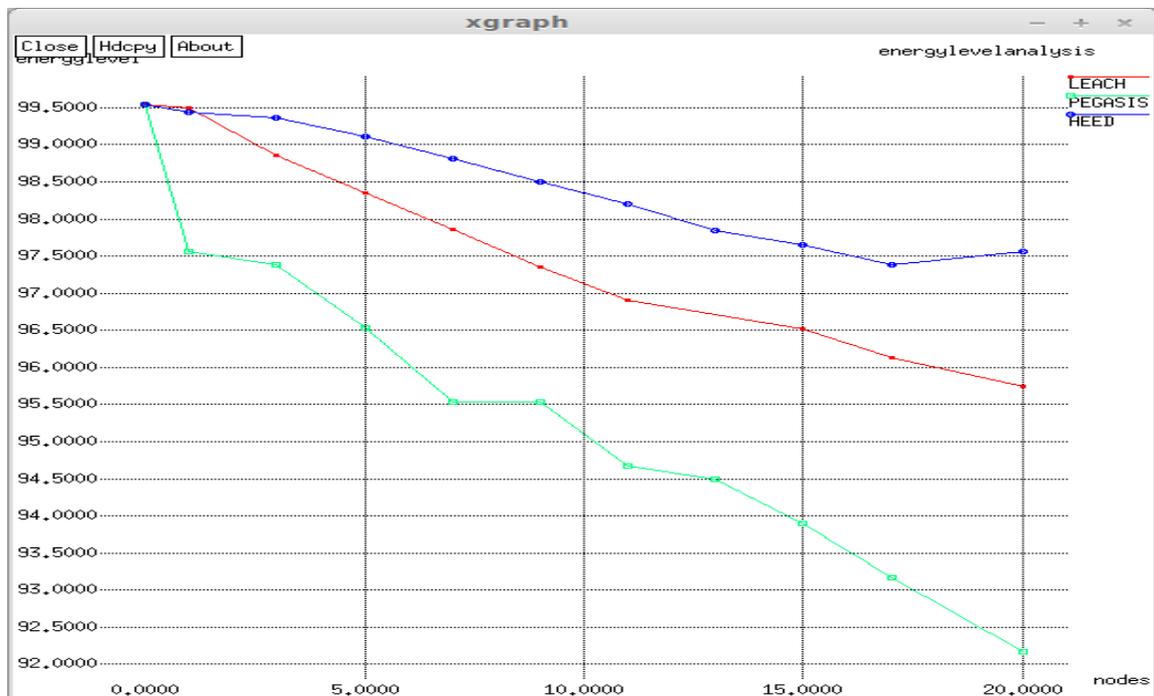
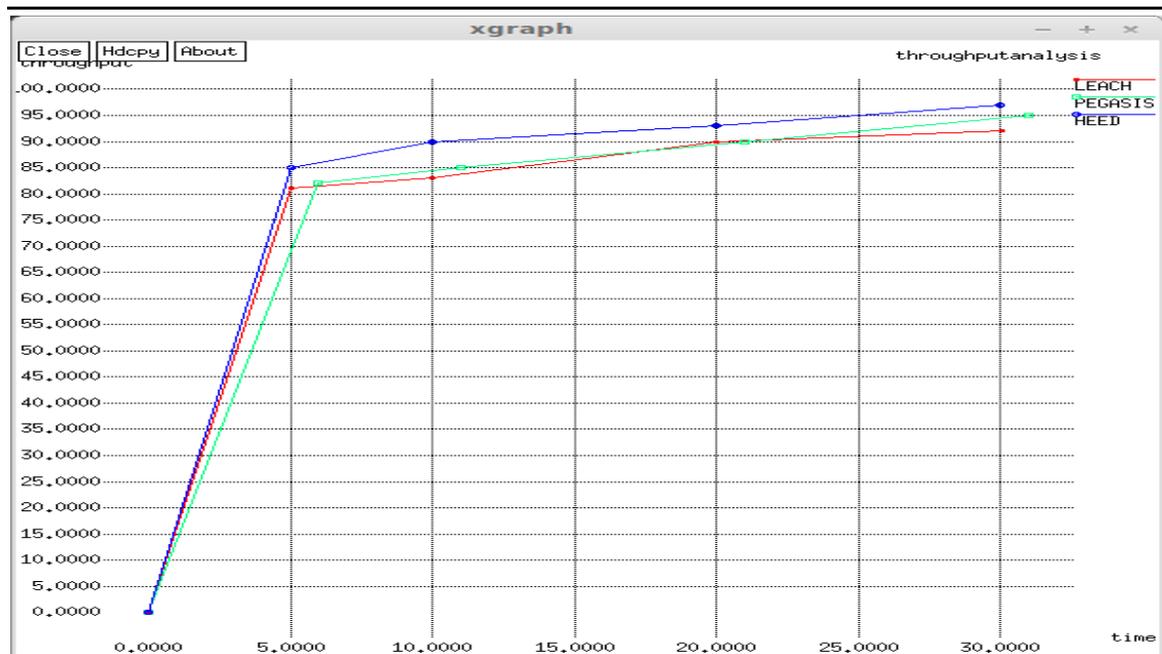


Fig6. Energy level analysis

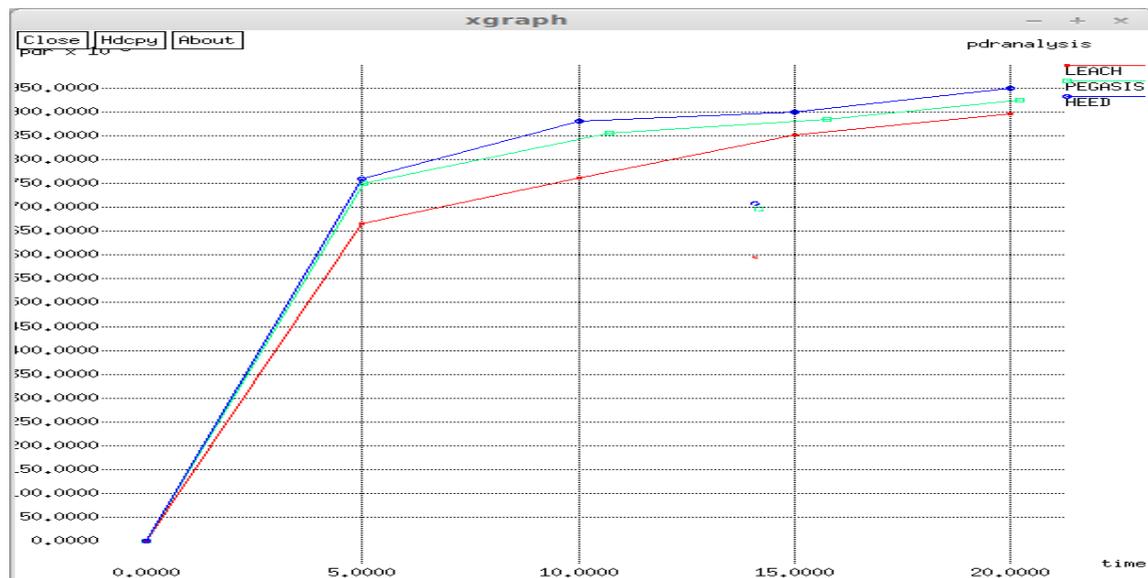
The above figure shows the x-graph for delay analysis. Red color indicates the energy level in LEACH protocol. Green color indicates the energy level in PEGASIS protocol. Blue color indicates the energy level in HEED protocol. In the above graph, the energy level in HEED protocol is high when compared with the other two protocols at the end of the simulation time.

## Performance Comparison of Various Energy Aware Protocols for WSN Applications



**Fig7. Throughput analysis**

The above figure shows the x-graph for delay analysis. Red color indicates the throughput in LEACH protocol. Green color indicates the throughput in PEGASIS protocol. Blue color indicates the throughput in HEED protocol. In the above graph, the throughput in HEED protocol is efficient when compared with the other two protocols.



**Fig8. Packet Delivery Ratio**

The above figure shows the x-graph for delay analysis. Red color indicates the packet delivery ratio in LEACH protocol. Green color indicates the packet delivery ratio in PEGASIS protocol. Blue color indicates the packet delivery ratio in HEED protocol. In the above graph, the packet delivery ratio in HEED protocol is high when compared with the other two protocols.

## 5. TABLE

**Table1. Performance Analysis**

TYPES OF PROTOCOL	DELAY (ms)	ENERGY LEVEL (%)	THROUGHPUT (%)	PDR (%)
LEACH	2.0	95	92	89
PEGASIS	3.0	92	94	91
HEED	0.3	97	97	95

## 6. CONCLUSION

The simulation result shows the performance analysis of network in three different energy aware protocols namely LEACH, PEGASIS and HEED. Among these energy aware protocols HEED protocol is the efficient one by analyzing the network performances such as delay, energy level, throughput and packet delivery ratio. When compared with other two protocols, in HEED protocol, the delay is minimum whereas the energy level, throughput and packet delivery ratio are high. So finally conclude that HEED protocol is efficient than the other two protocols respectively.

## REFERENCES

- [1] Giuseppe.A, Marco.C, and Mario.D.F, “Energy conservation in wireless sensor networks: A survey,” *Ad Hoc Netw.*, vol. 7, no. 3, pp. 537–568, 2009.
- [2] Krishnaveni.P, Sutha.J, “ Analysis of routing protocols in wireless sensor networks,” *International Journal of Emerging Technology and Advanced Engineering* Vol.2, issue 11, 2012.
- [3] Lakshmi Priya.M and Ankita Joshi, “A Survey of Hierarchical Routing Protocols in Wireless Sensor Network,” *MES Journal of Technology and Management*, 2011.
- [4] Mohamed Younis and Ameer Ahmed Abbasi, “ A survey on clustering algorithms for wireless sensor networks,” Published by Elsevier, 2007.
- [5] Monica R Mundada, Savan Kiran, “ A study on energy efficient routing protocols in wireless sensor networks,” *International Journal of Distributed and Parallel Systems (IJDPS)* Vol.3, No.3, 2012.
- [6] Shio Kumar Singh 1, M P Singh, “ Routing protocols in wireless sensor networks – A survey,” *International Journal of Computer Science & Engineering Survey (IJCSES)* Vol.1, No.2, 2010.

## AUTHORS' BIOGRAPHY



**S. Abarna** received the B.E. degree from the Department of ECE, PSR Engineering College, Anna University, Chennai, India, in 2013. She is currently working toward the Master degree in the Department of ECE. National Engineering College, An autonomous institution, Kovilpatti, India. Her current research includes energy conservation, optimization in sensor networks.



**N. Arumugam** received B.E (ECE) from Government College of Engineering affiliated to M.K University in 1986. M.E (Communication Systems) from Jadovpur University, Kolkata in the year 1994. He is pursuing as Associate Professor in National Engineering College, India. He has more than 25 years of teaching experience. His area of interest includes Communication, processors and controllers and sensor networks.