# The Energy Efficiency Clustering in Wireless Sensor Network

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**Abstract – Recently, the wireless sensor network is being applied in a lot of different applications. The Sensors in these applications are expected to be remotely deployed in large numbers and to operate autonomously in unattended environments. As per scalability, the nodes are often grouped into disjoint and mostly non-overlapping clusters. We propose an energy efficient clustering algorithm for wireless sensor network. The algorithm can divide a sensor network into a few clusters and select a cluster head base on weight value that leads to more uniform energy dissipation evenly among all sensor nodes.**

**Index Terms – Wireless Sensor Networks (WSNs), Sensor Node (SN), Microelectronic Mechanical Systems (MEMs). Mobile Ad-Hoc Networks (MANET), cluster head (CH).**

## 1. INTRODUCTION

The WSNs have been widely considered as one of the most important technologies for the twenty first century. Enabled by recent advances in MEMs and wireless communication technologies, tiny, cheap, and smart sensors deployed in a physical area and networked through wireless links and the Internet provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring, battle field surveillance, and industry process control. In fig.1, distinguished from traditional wireless communication networks, for example, cellular systems and mobile ad-hoc networks (MANET), WSNs have unique characteristics, for example, denser level of node deployment, higher unreliability of sensor nodes, and severe energy, computation, and storage constraints, which present many new challenges in the development and application of WSNs. In the past decade, WSNs have received tremendous attention from both academia and industry all over the world. A large amount of research activities have been carried out to explore and solve various design and application issues, and significant advances have been made in the development and deployment of WSNs. It is envisioned that in the near future WSNs will be widely used in various civilian and military fields, and revolutionize the way we live, work, and interact with the physical world.

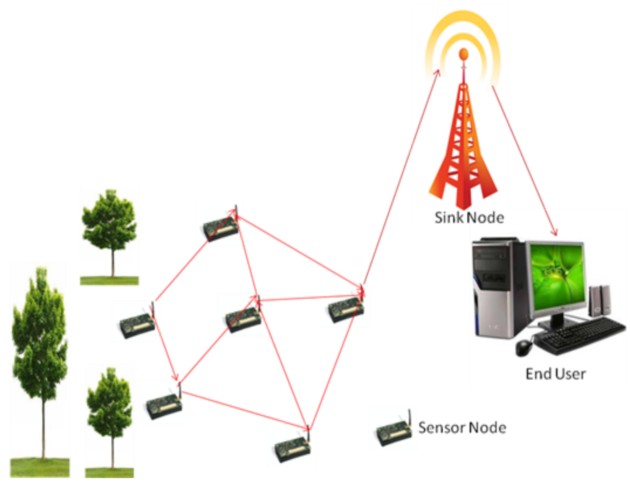



**Figure. 1:** The overall view of WSN.

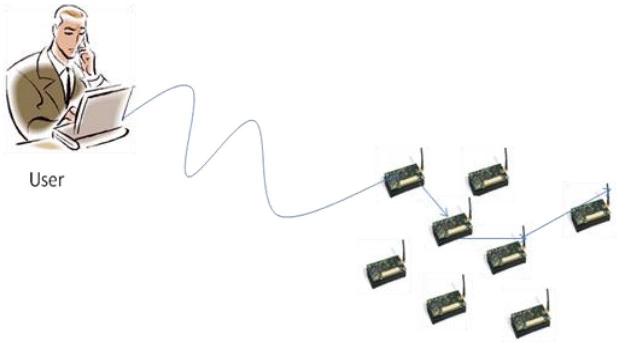
Typically, a WSN consists of a large number of low - cost, low-power, and multifunctional sensor nodes that are deployed in a region of interest. These sensor nodes are small in size, but are equipped with sensors, embedded microprocessors, and radio transceivers, and therefore have not only sensing capability, but also data processing and communicating capabilities. They communicate over a short distance via a wireless medium and collaborate to accomplish a common task, for example, environment monitoring, battlefield surveillance, and industrial process control. Compared with traditional wireless communication networks, for example, cellular systems and MANET, sensor networks have the following unique characteristics and constraints:

- Dense Node Deployment.
- Battery.

- Severe Energy, Computation, and Storage Constraints.
- Self -Configurable.
- Application Specific.
- Unreliable Sensor Nodes.
- Frequent Topology Change.
- No Global Identification.
- Data Redundancy.

The WSNs have gained worldwide attention in current years, particularly with the proliferation in MEMS technology which has facilitated the development of smart sensors. These sensors are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors[1-3].

These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user shown in figure 2.




### 1.1 Types of sensor networks

Current WSNs are deployed on land, underground, and underwater. Depending on the environment, a sensor network faces different challenges and constraints. There are five types of WSNs: terrestrial WSN, underground WSN, underwater WSN, multi-media WSN, and mobile WSN.

Terrestrial WSNs typically consist of hundreds to thousands of inexpensive wireless sensor nodes deployed in a given area, either in an ad hoc or in a pre-planned manner. In ad hoc deployment, sensor nodes can be dropped from a plane and randomly placed into the target area. In pre-planned deployment, there is grid placement, optimal placement, 2-d and 3-d placement models. In a terrestrial WSN, reliable communication in a dense environment is very important. Terrestrial sensor nodes must be able to effectively communicate data back to the base station in figure 3.

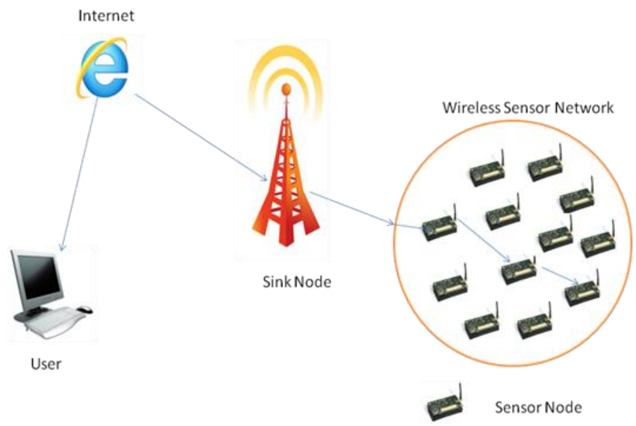



**Figure. 3 :** The deployment of sensor node in WSN.

### 1.2 Applications of Sensor Technology

In fig. 4, the broad classification of various issues in a WSN. QoS defines parameters such as end-to-end delay which must be guaranteed to an application/user be rechargeable, terrestrial sensor nodes however can be equipped with a secondary power source such as solar cells. In any case, it is important for sensor nodes to conserve energy. For a terrestrial WSN, energy can be conserved with multi-hop optimal routing, short transmission range, in-network data aggregation, eliminating data redundancy, minimizing delays, and using low duty-cycle operations [4-5].

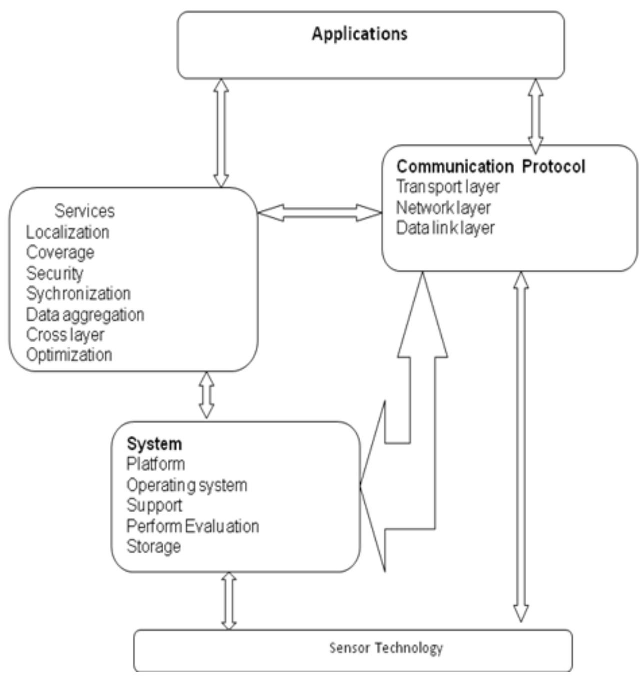



**Figure 4**: The application of sensor in WSN.

## 2. CLUSTERING

Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective. Every cluster would have a leader, often referred to as the CH. Although many clustering algorithms have been proposed in the literature for ad-hoc networks, the objective was mainly to generate stable clusters in environments with mobile nodes. Many of such techniques care mostly about node reach ability and route stability, without much concern about critical design goals of WSNs such as network longevity and coverage. Recently, a number of clustering algorithms have been specifically designed for WSNs. These proposed clustering techniques widely vary depending on the node deployment and bootstrapping schemes, the pursued network architecture, the characteristics of the CH nodes and the network operation model. A CH may be elected by the sensors in a cluster or pre-assigned by the network designer. A CH may also be just one of the sensors or a node that is richer in resources. The cluster membership may be fixed or variable. CHs may form a second tier network or may just ship the data to interested parties, e.g. a base-station or a command center. In addition to supporting network scalability, clustering has numerous advantages. It can localize the route set up within the cluster and thus reduce the size of the routing table stored at the individual node. Clustering can also conserve communication bandwidth since it limits the scope of inter-cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes. Moreover, clustering can stabilize the network topology at the level of sensors and thus cuts on topology maintenance overhead. Sensors would care only for connecting with their CHs and would not be affected by changes at the level of inter-CH tier. The CH can also implement optimized management strategies to further enhance the network operation and prolong the battery life of the individual sensors and the network lifetime. A CH can schedule activities in the cluster so that nodes can switch to the low-power sleep mode most of the time and reduce the rate of energy consumption. Sensors can be engaged in a round-robin order and the time for their transmission and reception can be determined so that the sensors reties are avoided, redundancy in coverage can be limited and medium access collision is prevented. Furthermore, A CH can aggregate the data collected by the sensors in its cluster and thus decrease the number of relayed packets.

### 2.1 Classification of clustering techniques

• Network model: Different architectures and design goals/constraints have been considered for various applications of WSNs. The following enlists some the relevant architectural parameters and highlight their implications on network clustering.

• Network dynamics: Basically WSNs consist of three main components: sensor nodes, base-station and monitored events. Aside from the few setups that utilize mobile sensors, most of the network architectures assume that sensor nodes are stationary. Sometimes it is deemed necessary to support the mobility of base-station or CHs. Node mobility would make clustering very challenging since the node membership will dynamically change, forcing clusters to evolve over time. On the other hand, the events monitored by a sensor can be either intermittent or continual depending on the application. For instance, in a target detection/tracking application, the event (phenomenon) is dynamic whereas forest monitoring for early fire prevention is an example of intermittent events. Monitoring intermittent events allows the network to work in a reactive mode, simply generating traffic when reporting. Continual events in most applications require periodic reporting and consequently generate significant traffic to be routed to the sink. Although continual events would mostly make the clusters stable, it may unevenly load CHs relative to the nodes in the cluster and a rotation of the CH role may be required if the CH is randomly picked from the sensor population. Intermittent events would favor adaptive clustering strategies if the number of events significantly fluctuates.

• In-network data processing: Since sensor nodes might generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions would be reduced. Data aggregation combines data from different sources by using functions such as suppression (eliminating duplicates), min, max and average. Some of these functions can be performed either partially or fully in each sensor node, by allowing sensor nodes to conduct in-network data reduction. Recognizing that computation would be less energy consuming than communication, substantial energy savings can be obtained through data aggregation. This technique has been used to achieve energy efficiency and traffic optimization in a number of routing protocols. In some network architectures, all aggregation functions are assigned to more powerful and specialized nodes. Data aggregation is also feasible through signal processing techniques. In that case, it is referred as data fusion where a node is capable of producing a more accurate signal by reducing the noise and using some techniques such as beam forming to combine the signals. It will be intuitive to expect CHs to perform such data aggregation/fusion which may restrict the choice of CH to only specialized node or require limiting the number of sensors per cluster in order to ensure that CHs are not overburdened. It is worth noting that sometimes it may be necessary to assign backup CHs for a cluster or rotate the role of being CH among the sensors in the cluster. Obviously, such design choices/constraints influence the clustering scheme.

• Node deployment and capabilities: Another consideration is the topological deployment of nodes. This is application dependent and affects the need and objective of the network clustering. The deployment is either deterministic or self-organizing. In deterministic situations, the sensors are manually placed and data is routed through pre-determined paths. Therefore, clustering is such setup is also preset or unnecessary. However in self-organizing systems, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner . In that infrastructure, the position of the base-station or the CH is also crucial in terms of energy efficiency and performance. When the distribution of nodes is not uniform, optimal clustering becomes a pressing issue to enable energy efficient network operation. In addition, in some setups different functionalities can be associated with the deployed nodes and the CH selection may be constrained. In networks of homogenous sensor nodes, i.e. all having equal capacity in terms of computation, communication and power, CHs are picked from the deployed sensors. Often in that case, CHs are carefully tasked, e.g. excluded from sensing duties, in order to avoid depleting their energy rather quickly. In addition, the communication range and the relative CH's proximity to the base-station may also be constraints/issues that have to be considered. Sensors' communication range is usually limited and a CH may not be able to reach the base-station. Even if a node can directly communicate with the base-station, it is still better to pursue multi-hop routes. Therefore, inter-CH connectivity becomes an important factor that affects the clustering scheme.

On the other hand, heterogeneous WSNs may impose more constraints on the clustering process since some nodes may be designated for special tasks or empowered with distinct capabilities. It may then be required to either avoid such specific nodes to conserve their resources or limit the selection of CHs to a subset of these nodes [6-7].

### 2.2 Clustering objectives

In figure.5, the clustering algorithms in the literature varies in their objectives. Often the clustering objective is set in order to facilitate meeting the applications requirements. For example if the application is sensitive to data latency, intra and inter-cluster connectivity and the length of the data routing paths are usually considered as criteria for CH selection and node grouping. The following important objectives for network clustering:

• Load balancing

• Fault-tolerance

• Increased connectivity and reduced delay

• Minimal cluster count

• Maximal network longevity

## 3. DISTANCE MESUREMENT

### 3.1 Euclidean distance

The Euclidean distance between points a and b is the length of the line segment connecting them. In Cartesian coordinates, if a = ($a_1$, $a_2$... $a_n$) and b = ($b_1$, $b_2$... $b_n$) are two sensor nodes in Euclidean n-space, then the distance from a to b, or from b to a is given by:

$$\text{Euclidian distance } d_2[1]=\sqrt{\sum_{i=1}^{d}(xi-yi)^2}$$

The position of a sensor node in a Euclidean *n*-space is an Euclidean vector. So, **a** and **b** are Euclidean vectors, starting from the origin of the space, and their tips indicate two nodes.The **Euclidean norm**,or **Euclidean length**,or **magnitude** of a vector measures the length of the vector. where the last equation involves the dot product.

A vector can be described as a directed line segment from the origin of the Euclidean space (vector tail), to a sensor node in that space (vector tip). If we consider that its length is actually the distance from its tail to its tip, it becomes clear that the Euclidean norm of a vector is just a special case of Euclidean distance: the Euclidean distance between its tail and its tip.

The distance between nodes **a** and **b** may have a direction (e.g. from **a**to **b**), so it may be represented by another vector, given by

$$a-b=a_1-b_1, a_2-b_2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots a_n-b_n$$

In a three-dimensional space ($n$ = 3), this is an arrow from **a to b**, which can be also regarded as the position of **b** relative to **a**. It may be also called a displacement vector if **a** and **b** represent two positions of the same node at two successive instants of time.

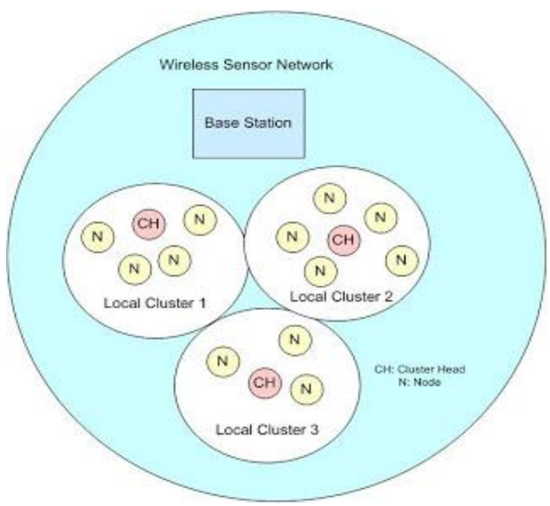



**Figure.5 :** The clustering with cluster-head.

### 3.2 Squared Euclidean distance

The standard Euclidean distance can be squared in order to place progressively greater weight on objects that are farther apart. In this case, the equation becomes Squared Euclidean

Distance is not a metric as it does not satisfy the triangle inequality, however it is frequently used in optimization problems in which distances only have to be compared. It is also referred to as quadrance within the field of rational trigonometry.

$$d^2(p,q) = (p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_i - q_i)^2 + \cdots + (p_n - q_n)^2.$$

Squared Euclidean Distance is not a metric as it does not satisfy the triangle inequality, however it is frequently used in optimization problems in which distances only have to be compared. It is also referred to as quadrance within the field of rational trigonometry.

### 3.3 Manhattan distance (city-block)

The distance between two vectors a and b in an n-dimensional real vector space with fixed Cartesian coordinate system, is the sum of the lengths of the projections of the line segment between the nodes onto the coordinate axes. More formally,

Manhattan (City-block) distance

$$d_2[3]=\sum_i^d |xi - yi|$$

Where (a , b) are vectors $a = x_1 + x_2 + \dots\dots\dots . x_n$ and

$b = y_1 + y_2 + \dots\dots . y_n.$

For example, in the plane, the taxicab distance between $(a_1, a_2)$ and $(b_1, b_2)$ is$|x_1 - y_1| + |x_2 - y_2|$.

### 3.3 Chebyshev distance

In mathematics, Chebyshev distance (or Tchebychev distance), maximum metric, or L∞ metric is a metric defined on a vector space where the distance between two vectors is the greatest of their differences along any coordinate dimension. It is named after Pafnuty Chebyshev.

It is also known as chessboard distance, since in the game of chess the minimum number of moves needed by a king to go from one square on a chessboard to another equals the Chebyshev distance between the centers of the squares, if the squares have side length one, as represented in 2-D spatial coordinates with axes aligned to the edges of the board. For example, the Chebyshev distance between f6 and e2 equals 4.

The Chebyshev distance between two vectors or points *p* and *q*, with standard coordinates $x_i$ and $y_i$,

respectively, is Chebyshev (maximum) distance

$$d_2[4]=Max|xi - yi|$$

Mathematically, the Chebyshev distance is a metric induced by the **supremum norm** or **uniform norm**. It is an example of an injective metric. In two dimensions, i.e. plane geometry, if the points *p* and *q* have Cartesian coordinates $(x_1, y_1)$ and $(x_2, y_2)$, their Chebyshev distance is

$$D_{\rm Chess} = \max\left(|x_2 - x_1|, |y_2 - y_1|\right).$$

Under this metric, a circle of radius *r*, which is the set of points with Chebyshev distance *r* from a center point, is a square whose sides have the length 2*r* and are parallel to the coordinate axes. On a chess board, where one is using a *discrete* Chebyshev distance, rather than a continuous one, the circle of radius *r* is a square of side lengths 2*r*, measuring from the centers of squares, and thus each side contains 2*r*+1 squares; for example, the circle of radius 1 on a chess board is a 3×3 square [8].

## 4. ENERGY CALCULATION

The energy spent on transmitting a frame for each cluster can be expressed as:

$$E_2[i] = bE_{tx} + b \in_1 d_2[i]$$

The cluster nodes transmit the sensed data messages to its cluster head where d2[i],is the distance between each member nodes and their cluster head.

$$E1 = bE_{tx}(N/M) + bE_{da}(N/M) + b \in_2 d_1^4$$

Where $d_1$, is the distance between cluster head and base station,

$$d1 = Min[d2] - Base\ stasion\ value$$

We assume that N nodes are distributed in the area of A*A randomly. If there are M clusters, then there are N no of nodes in each cluster on an average. Every cluster head receives the sensed data from its cluster nodes, aggregates all the data, and sends it to the base station [9].

## 5. SIMULATION

We assume that N nodes are distributed in the area of A*A randomly. If there are M clusters, then there are N/M nodes in each cluster on an average. Every cluster head receives the sensed data from its cluster nodes, aggregates all the data, and sends it to the base station. The total energy spent on transmitting a frame for every cluster head can be expressed in the table 1.

**TABLE 1 Summarizes meaning of each term and typical value**

| Term | Meaning | Value |
|---|---|---|
| $E_{da}$ | Consume energy for data aggregation | 5nj/bit |
| $E_{tx}$ | Radio electronics energy | 50nj/bit |
| $\varepsilon_1$ | Transmit amplifier for free-space | 10pJ/(bit *m$^2$) |
| $\varepsilon_2$ | Transmit amplifier for two-way model | 0.001 3pJ/(bit*m$^2$) |

- It generates the sensor nodes & each node code contain x-axis & y-axis coordinate system using the java program in figure 6.

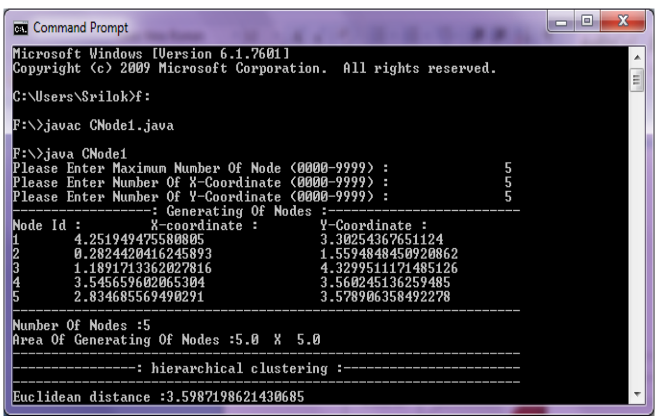



**Figure.6:** Generating sensor node for clustering.

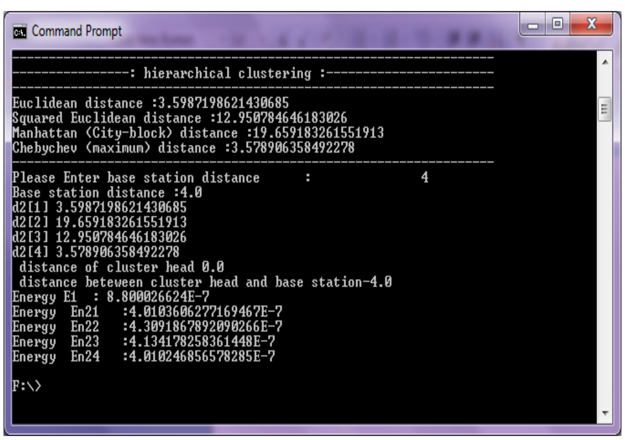



**Figure.7:** Calculating energy efficiency for clustering.

- It calculates the distance between the sensor nodes & energy efficient clustering in Wireless Sensor Network using java program in figure 7.

- Now we are generating the sensor nodes in Wireless Sensor Network & each sensor node contain x-axis & y-axis coordinate system in figure 8.

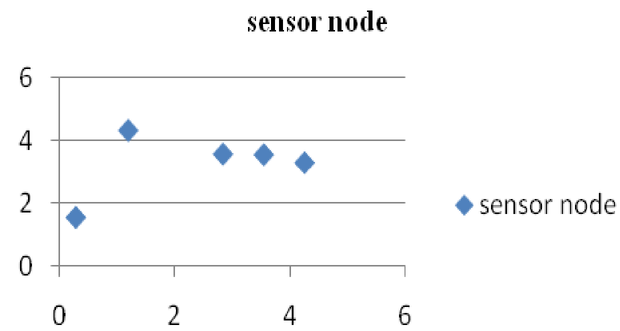



**Figure.8:** The graph of generating sensor node for clustering.

- We are calculating the different types of distance & it shows the following graph in figure 9.

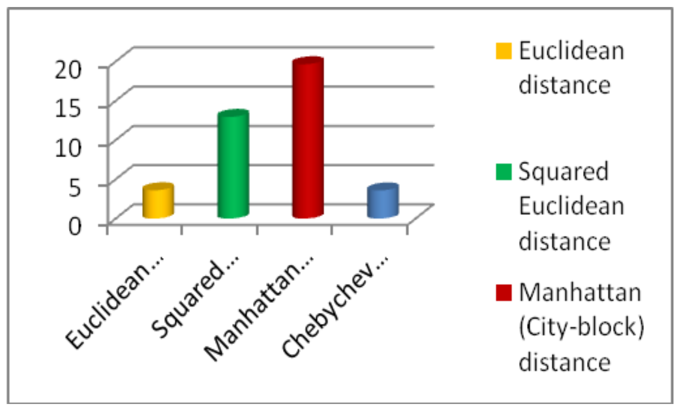



**Figure.9: The** graph major various distance for clustering.

- We are designing energy efficiency in WSN & it shows the following graph in figure 10.

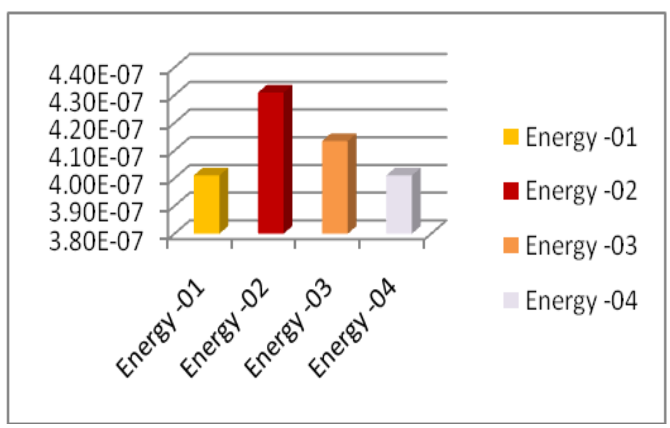



**Figure.10: The** graph calculates the energy efficiency for clustering.

## 6. CONCLUSION

We study the energy efficient clustering algorithm for wireless sensor network has been introduced. We have given the detailed simulations of wireless sensor network environment demonstrate that EEC (energy efficient clustering) can reduce energy consumption, improve evenness of dissipated network energy, and has the ability of extending the life span of the network. As for future work, considerable attentions have been paid to improve the algorithm performances and consider the different wireless sensor network.

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