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Life Time Enhancement for Wireless Sensor Network using Fuzzy-ACO Combination along with an Enhanced Clustering Scheme

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Abstract - *The principle goal of this research is to build up an energy efficient routing technique which bears solid communication by considering routing challenges, and broaden the lifetime of WSNs. This paper has two primary commitments. That is it proposes an altered Energy Efficient Cluster Formation (EECF) technique in which the Cluster Heads (CHs) are chosen in light of parameters like up-keeping energy, distance to the neighbors, density, maximum distance and angle. And the center point of this system is to apportion overwhelming data traffic and high energy consumption load reliably in the network by offering unequal size of clusters in the network. In this, the K-means algorithm is used for the cluster member selection and the cluster head selection process. Then, a Super Cluster Head (SCH) is chosen among the CHs who can just send the information to the mobile BS by picking appropriate fuzzy descriptors. Along with an Ant Colony Optimization (ACO) is used for the optimal routing selection from the SCH to the Base Station (BS).*

Keywords: *Wireless Sensor Network (WSN), K-means clustering, Cluster head (CH) and Super Cluster Head (SCH), fuzzy descriptors, Ant Colony Optimization (ACO).*

1. Introduction

Wireless Technologies have shown an alternate dimension to the world of communication Methods. Actually it began with the utilization of radio receivers or transceivers for use in wireless telegraphy during an early stage, and now the term wireless is utilized to depict technologies, for example, the cellular networks and Wireless Broadband Internet etc. In spite of the fact that the wireless medium has restricted spectrum with different imperatives when compared with the guided medium. But wireless medium is the main channel for mobile communication. Remote AdHoc networking is an infrastructure technology which is utilized for random and quick arrangement of countless networks. Also this technology has utilizations in many fields. For example, tactical communications, disaster relief operations, health care and transitory networking in regions that are not thickly populated.

1.1 Wireless Sensor Networks (WSN)

Wireless Sensor Networks (WSN) are in some cases called Wireless Sensor and Actuator Networks (WSAN) [1]. WSN is spatially distributed autonomous sensors (NODES) inorder to screen the physical or natural conditions, and some normal parameters are temperature, sound, pressure, and so on. The improvement of wireless sensor networks was inspired by military and applications, such as, war zone Nuclear Reactor area respecively; today these networks are utilized as a part of numerous mechanical and technological applications, like, modern process checking and control, machine wellbeing observing etc.

The primary characteristics of a WSN include:

- Power consumption requirements for nodes utilizing batteries or energy harvesting
- Ability to adapt to node disappointments (resilience)
- Some mobility of nodes (for very mobile nodes see MWSNs)
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Easy utilization
- Adapting Cross-layer design

The principle use of WSN incorporates Healthcare monitoring, Area monitoring, Environmental/Earth sensing, Air contamination monitoring, Forest fire identification, Landslide recognition, Water quality monitoring, Natural fiasco avoidance, Industrial monitoring, Machine wellbeing monitoring, data logging, Water/Wastewater monitoring, Structural wellbeing monitoring and so on.

Conventional wireless communication networks like Mobile AdHoc Networks (MANET) varies from WSN [2] [3]. WSN has special attributes, for example, the denser level of node deployment, higher unreliability of sensor nodes and extreme energy requirements for computation and capacity requirements which introduce many difficulties in the improvement and utilization of WSN. Research has been done to investigate and discover answers for different plan engineering and application issues and noteworthy progress has been made in the advancement and the organization of WSNs. WSN regularly contains hundreds or thousands of sensor nodes which takes into consideration sensing over bigger geographical districts with more prominent accuracy [4]. As a rule, the sensor nodes are sent randomly finished the geographical area and these nodes speak with each other to shape a network. Every hub has three essential components: (1) sensing unit, (2) processing unit and (3) transmission unit.

1.2 Efficiency in WSN

Late improvements in low-control wireless integrated microsensor technologies have made these sensor nodes accessible in expansive numbers, requiring little to no effort, to be utilized in an extensive variety of uses in military and national security, ecological checking, and numerous different fields [5]. As opposed to traditional sensors, sensor networks offer an adaptable recommendation as far as the simplicity of deployment and various functionalities. In classical sensors, the position of the nodes and the network topology should be foreordained and painstakingly built [6]. Be that as it may, on account of modern wireless sensor nodes, their smaller physical dimensions allow a huge number of sensor nodes to be randomly sent in difficult to reach landscapes. Furthermore, the nodes in a wireless sensor network are additionally equipped for performing different operations similar to MANET which are data processing and routing. But in traditional sensor networks uncommon nodes with computational abilities must be introduced independently to accomplish such functionalities.

In the immediate transmission protocol, the base station fills in as the destination node to the various nodes in the network where the end user can get to the sensed data [7]. At the point when a sensor node transmits information specifically to the base station, the energy misfortune brought about can be very broad relying upon the area of the sensor nodes with respect to the base station. In such a situation, the nodes that are further far from the base station will have their power sources depleted significantly speedier than those nodes that are nearer to the base station [8]-[10]. Then again, using a conventional multihop routing plan, for example, the Minimum Transmission Energy (MTE) routing protocol will likewise bring about a similarly unwanted impact. In MTE, the Nodes nearest to the base station will quickly deplete their energy resources since these nodes take part in the routing of an extensive number of information messages (in the interest of different nodes) to the base station [1, 2]. Different routing protocols have been proposed for wireless sensor networks to ease such issues.

In this paper, at first a K-means clustering algorithm uses for the cluster member determination process, the CH among the cluster member is chosen in light of the Euclidean distance between the nodes. The SCH is chosen by using the fuzzy descriptors (Mamdani's rule). At last, the optimal way between the SCH and the base station is assessed by utilizing the ACO algorithm. Here, the lifetime of the WSN is improved in view of the packet delivery, throughput, and the energy consumption.

The rest of the segment of the work is delineated in the area underneath. Area 2 clarified the literature review, the proposed EECF is portrayed in segment 3, the results and the conclusion are delineated in segment 4 and 5.

2. Literature Review

A Stable and Energy-Efficient Clustering (SEEC) protocol for heterogeneous wsns is proposed by Farouk et al. [11]. What's more, the expansion to multi-level of SEEC is introduced. It relies upon the network structure that is partitioned into clusters. In the multi-level architectures, all the more effective super nodes are relegated to covering removed sensing territories. At each level of heterogeneity, the optimum number of capable nodes that accomplishes the base energy utilization of the network is acquired. Reenactment results demonstrate that the proposed protocol gives a more drawn out stability period, more energy productivity and higher normal throughput than the current protocols.

Chandet al. execution of HEED for a heterogeneous network [12]. Contingent on the kind of nodes, it characterizes one-level, two-level, and three-level heterogeneity and as needs be the usage of HEED is alluded to as hetHEED-1, hetHEED-2, and hetHEED-3, individually. One extra parameter is considered in this work, i.e., remove and apply fuzzy logic to decide the cluster heads and in like manner the hetHEED-1, hetHEED-2, and hetHEED-3 are named as HEEDFL, hetHEED-FL-2, hetHEED-FL-3, individually. The simulation results demonstrate that as the level of heterogeneity increments in the network, the nodes stay alive for longer time and the rate of energy scattering diminishes. And furthermore, expanding the heterogeneity level causes sending more packets to the base station and builds the network lifetime.

An Improved Harmony Search Based Energy Efficient Routing algorithm (IHSBEER) for WSNs is exhibited by Zeng and Dong [13], which depends on Harmony Search (HS) algorithm (a meta-heuristic). To address the WSNs routing issue with HS algorithm, a few key enhancements have been advanced: First of all, the encoding of harmony memory has been enhanced in light of the qualities of routing in WSNs. Furthermore; the ad lib of another harmony has likewise been making strides. A dynamic adjustment for the parameter HMCR is acquainted with stay away from the rashness in early ages and fortify its nearby pursuit capacity in later ages. In the interim, the change procedure of HS algorithm has been disposed of to make the proposed ROUTING algorithm containing less parameter. Thirdly, a successful local search strategy is proposed to upgrade the local search capacity, in order to enhance the merging pace and the ACCURACY of routing algorithm.

A powerful multi-level cluster algorithm utilizing link correlation is proposed for heterogeneous WSN was created by Javaid et al. [14]. The level-k hierarchy with single-hop communication between nodes inside a cluster is accomplished utilizing link correlation. The heterogeneous nodes are embraced as level-k cluster heads and actualizing network coding on those NODES builds network lifetime altogether. In the mean time, actualizing Time Division Multiple Access (TDMA) system inside a cluster makes a sorted out cluster design enhancing the energy productivity.

Rejina Parvin and Vasanthanayaki proposed E-OEERP [15] which lessens/takes out individual node formation and enhances the general network lifetime when contrasted with the current protocols. It can be accomplished by applying the ideas of Particle Swarm Optimization (PSO) and Gravitational Search Algorithm (GSA) for cluster formation and routing individually. For each cluster head, a strong node called cluster assistant (CA) node is chosen to lessen the overhead of the cluster head. With the assistance of PSO, clustering is performed until the point when every one of the nodes turns into a member of any of the cluster. This disposes of the individual node formation which brings about a similarly better network lifetime.

Zahedi et al.[16] proposed a Swarm Intelligence Based Fuzzy Routing Protocol (named SIF). In SIF, fuzzy C-means clustering algorithm has used to cluster all sensor nodes into adjusted clusters, and after that fitting cluster heads are chosen through Mamdani fuzzy inference system. This methodology not just certifications to produce adjusted clusters over the network, yet additionally can decide the exact number of clusters. Since tuning the fuzzy rules extremely influences on the execution of the fuzzy system, a half breed swarm intelligence algorithm in light of firefly algorithm is used and recreated toughening to advance the fuzzy rule base table of SIF.

An approach of choosing Super Cluster Head (SCH) the CHs was proposed by Nayak and Devulapalli [17]. The SCH can just send the data to the mobile BS by picking appropriate fuzzy descriptors, for example, remaining battery power (RBP), mobility of BS and centrality of the clusters. Fluffy inference engine (Mamdani's rule) is utilized to choose the opportunity to be the SCH. The outcomes have been gotten from NS-2 simulator and demonstrates that the proposed protocol performs superior to LEACH protocol regarding First node bites the dust, half node alive, better stability and better lifetime.

An energy efficient cluster formation algorithm called Active Node Cluster Formation (ANCF) was proposed by Faheem et al. [18]. The center expect to propose ANCF algorithm is to disseminate substantial data traffic and high energy consumption load equitably in the network by offering unequal size of clusters in the network. A lightweight sensing mechanism called active node sensing algorithm (ANSA) is additionally introduced. The key intend to propose the ANSA algorithm is to maintain a strategic distance from high sensing covering data repetition by selecting an arrangement of active nodes in each cluster with fulfill scope close to the occasion. An active node routing algorithm (ANRA) is additionally proposed to address complex inter and intra cluster routing issues in profoundly thick deployment in view of the node ruling values.

3. Proposed Methodology

The center point this system is to administer overwhelming data traffic and high energy consumption load reliably in the network by offering unequal size of clusters in the network. The created strategy settles each CH close to the sink and sensing occasion while the staying set of the CHs is designated amidst each cluster to accomplish the largest amount of ENERGY proficiency in dense deployment. Second, a super cluster head (SCH) is chosen among the CHs who can just send the information to the mobile BS by picking reasonable fuzzy descriptors, for example, remaining battery power, mobility of BS and the centrality of the clusters [18].We likewise think of one as more parameter, i.e., the energy dissipation ratio. Fluffy inference engine (Mamdani's rule) is utilized to choose the opportunity to be the SCH. We apply Ant Colony Optimization (ACO) for optimizing the routing in the proposed approach. By focusing on inalienable properties of routing, it will be reasonable to be settled by the ant colony algorithm. This determination of a path is viewed as optimal among the diverse paths. The possibility of energy efficient cluster formation alongside SCH logic builds the network lifetime significantly.

3.2. Cluster Member Selection based on K-Means Clustering

In the proposed conspire, the proficient clustering of nodes with minimum repetitive (un-clustered) node in the network is done in light of the k-means clustering algorithm. Here, the object's clusters are shaped by the Euclidean distance between the object. The K-means algorithm merges three stages to assess the cluster head.

(a) Initial Clustering

For cluster formation with the target WSN, the K-means algorithm is utilized. Presume, the number of nodes in the WSN is represented as n and the Euclidean distance between the nodes are assessed to isolate the k clusters. At first, the cluster heads (CHs) are randomly selected from the k out of n nodes. As per the Euclidean distance, the rest of the nodes in the network are considered as nearest cluster of CH.

(b) Reclustering

The CENTROID of the every CLUSTER is assessed, after the CLUSTER FORMATION for each NODE in the NETWORK. Consider the TWO DIMENSIONAL SPACE, every CLUSTER CENTROIDS of every NODE S are computed as takes after,

$$Centroid(U,V)=\left(\frac{1}{S}\sum_{i=1}^{n}u_i,\frac{1}{S}\sum_{i=1}^{n}v_i\right)$$

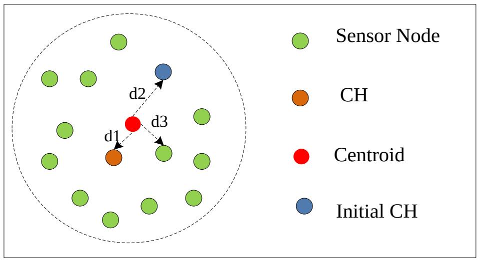

Figure.1: A cluster with the centroid

The center position of the cluster is meant as the centroid and it is known as a virtual node. The illustration, clustering process is portrayed in the Figure1, which has 15 nodes, here, the sensor node is distinguished by arbitrarily chosen CH before all else round. The nearest cluster of the centroid is considered as the new CH and the at first financed CH isn't a nearest to the centroid. The procedure is rehashed until there is no progressions may happen in the CH choice.

Input: Data $P=\{a_1,a_2,\cdots a_n\}\subset D^r$, assume the number of clusters $k\in N$

Subjectively pick k objects as the underlying cluster heads

Output: Set of k clusters

$$S_e=\sum_{j=1}^{k}\sum_{a_i=M_j}\left|a_i-m_j\right|^2$$

Figure.2: K-means Clustering Algorithm

3.3. Cluster Head Selection

After the cluster formation, an altered energy efficient CH determination system relies upon the parameter like residual energy, distance to the neighbor, density, maximum distance and angle. In the WSN network, the overwhelming data traffic and the and the high energy consumption are lessened by utilizing these strategies. According to the separation from the centroid, one ID number is doled out to every node in the cluster and which node has less ID number it is considered as the nearest one. In the CH node determination, the ID number assumes an imperative part. The CH are chosen in view of the accompanying advances,

- **Residual energy (RE_n)**
  To hold the availability of the network, the CH's lingering energy is checked each round. It is used for the packet transmission.
  $$CH_{RE_n}>Threshold$$
- **Maximum distance**
  In this progression, the greatest distance between the two nodes are estimated.
- **Angle**
  In this step, the angle between the two sensor nodes are estimated.

- **Density (ρ)**

  In the given locale,the NUMBER OF NODES is assessed by utilizing the DENSITY FUNCTION. In the thick district the value of ρ being one and the thin locale the value of ρ is 2.

- **Distance to the Neighbor**

Here, the distance to the neighbor node of the CH is computed as follows,

$$AN = \frac{RE_n}{\left(\sum_{i=1}^{n} d_{gh} / d_{gh(\max)}\right)^2 + \left(\rho - \left(\frac{d_i}{100}\right)\right)^2} \forall SN \quad (2)$$

In the above equation, AN is the active node, SN is the sensor node, RE_n is the residual energy and ρ is the density function.

3.4. Mamdani's fuzzy approach for SCH Selection

The SCH choice process is critical to expand the lifetime of the cluster and cluster head. So we have used a Mamdani's fuzzy approach for choosing super cluster head in the considered sensing region. By utilizing this procedure, the SCH are straightforwardly sent to the BS after the SCH are chosen among the already chose CH. There are four models incorporated into the fuzzy descriptors; they are (1) fuzzification (2) rule evaluation (3) aggregation of the rule outputs (4) defuzzification.

- **Fuzzification**

  In the fuzzification procedure, the crisp values are going about as the input and it is changed over into fuzzy set.

- **Rule Evaluation**

  In the rule evaluation process, the rashly changed over fuzzy input is given to the before the fuzzy rule and afterward it is sent to the ensuing membership function.

- **Aggregation of the administer yields**

  Each rule's combining yield is incorporated into this procedure.

- **Defuzzification**

  The defuzzification is the reverse of the fuzzification procedure. Here, the fuzzy sets are changed over into the crisp values. The Mamdani's fuzzy approach used the remaining battery power, the mobility of bs, the centrality of the cluster, and energy dissipation ratio for the SCH choice process. In the SCH choice process, the accompanying formula is used to infer the fuzzy rule,

$$SCH = RBP + Mobility + Centrality + EDR \quad (3)$$

In the above equation, the remaining battery power (RBP) of each node is computed by using the following equation,

$$RBP = (BP - 1) \quad (4)$$

In the above equation, RBP is the remaining battery power, EDR is the energy dissipation ratio and BP is the battery power. At the season of SCH choice, the energy and the RBP of every node is diminished by the information drive process. Here, the mobility and the centrality are going about as the additive factors, since the detachment of SCH from the BS augmentations or diminishes as the BS moves.

3.5. Ant Colony Optimization (ACO) approach for path selection

After the SCH determination process, the optimum path between the BS and the SCH nodes are chosen by using the ACO algorithm. Ant Colony Optimization [19] is a standard answer to finding optimal paths (from source to destination). ACO depends on the intellectual foundation that can without much of a stretch be portrayed in one sentence: ants select the best path among the current barriers and requirements in nature to accomplish food. This choice of a path is viewed as optimal among the distinctive paths. The possibility of energy efficient cluster formation alongside SCH rationale builds the network lifetime drastically.

In the ACO algorithm, the probability with which ant A in sensor S, selects to move to the sensor R is given viz,

$$R = \begin{cases} \arg\ \max_{v \in J_A(S)} \left\{ [\lambda(S,R)].[\beta(S,R]^{\mu} \right\} & if \quad p \le p_0 \\ r, & otherwise \end{cases} \quad (5)$$

In the above equation, the random number is represented as p which is distributed within the range $(0....1)$, the parameter is represented as p_0 which is ranges from 0 to 1 (i.e., $0 \le p_0 \le 1$) , the pheromone is represented as λ, the inverse of the distance $\chi(S,R)$ is represented as $\beta = 1/\chi$, the set of node is represented as $J_A(S)$ and it is visited by ant A. The relative importance of the pheromone versus distance ($\mu > 0$) is determined by the parameter μ and the positioned on the node S.

$$Q_A(S,R) = \begin{cases} \dfrac{[\lambda(S,R)].[\beta(S,R]^{\mu}]}{\sum_{v \in J_A(S)} \lambda(S,R)].[\beta(S,R]^{\mu}} & if \ R \in J_A(S) \\ 0 & otherwise \end{cases} \quad (6)$$

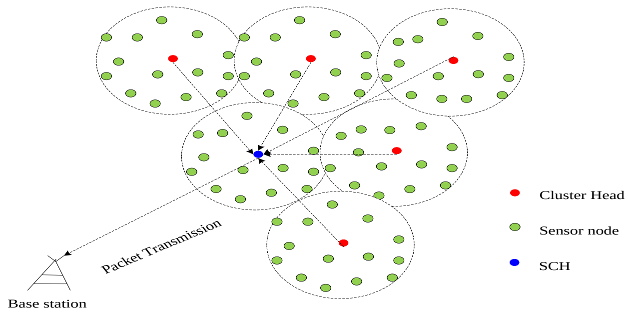

Figure.3: Packet Transmission Using EERRCUF Protocol

After every ant has completed its tour, the global updating is done. The pheromone was deposited by the every globally best ant. The global updating rule is given in the following equation,

$$\lambda(S,R) \leftarrow (1-\delta)\lambda(S,R) + \delta.\Delta\lambda(S,R) \quad (7)$$

In the above equation,

$$\Delta\lambda(S,R) = \begin{cases} (G_{\ln})^{-1}, & if (S,R) \in global - best - tour \\ 0, & otherwise \end{cases} \quad (8)$$

In the above equation,the length of the globally best tour from the beginning of the trail is represented as $G_{\ln}$ and the pheromone decay parameter is represented as δ.

In the process of finding the solution, when an ant visits a particular edge, the pheromone level changes according to the local updating rule, which given by

$$\lambda(S,R) \leftarrow (1-\vartheta)\lambda(S,R) + \vartheta.\Delta\lambda(S,R) \quad (9)$$

Where $0 < S < 1$ is a parameter and the initial pheromone level being represented as $\Delta\lambda$. Finally the best path is detected by using this ACO algorithm.

4. Simulation Results

The validity of the proposed protocol is checked by using the NS-2 simulator. The execution of the network in light of the lifetime improvement of the system. For expanding the lifetime of a WSN, the proposed energy efficient cluster formation (EECF) method joined by fuzzy logic utilizing 1EEE 802.11 MAC layer.

4.1. Performance Analysis

For the execution calculation, the proposed EECF strategy is contrasted and the current FLEACH (Fuzzy LEACH) and the LEACH strategies. The execution is evaluated in light of the packet delivery ratio, energy consumption, end to end delay, network lifetime and throughput.

(a) Packet Delivery Ratio

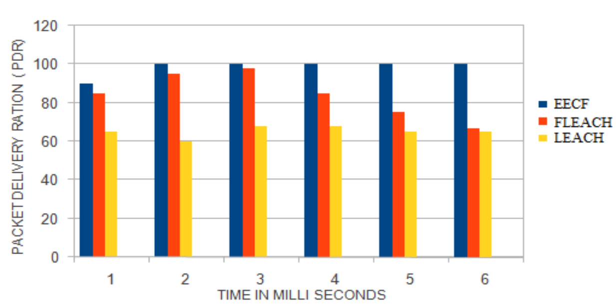

Figure.4 : Packet Delivery Ratio

Figure 4 demonstrates the packet delivery ratio of the proposed EECF technique and it contrasted and the FLEACH and LEACH strategies. The number of sending and got Packet's ratio is known as the packet delivery ratio. At the point when the packet delivery ratio was most extreme VALUE around then just the network plays a capable network. The reliability and trustworthiness of the WSN network are expanded, if the packet delivery is high. The proposed EECF procedure has better packet delivery ratio when contrasted and the other two methods.

(b) Energy Consumption

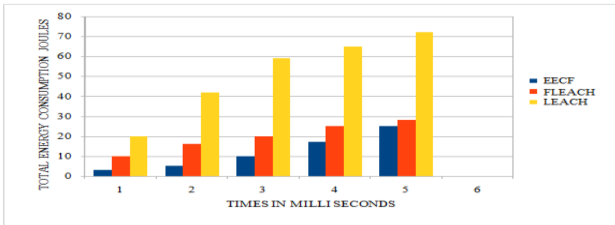

Figure.5 : Total Energy Consumption

Energy consumption is the total amount of energy required to transmit the data packet from the node to the base station. Here, the energy consumption of the proposed work estimated by the measurement of the various WSN time slots is compared with the existing techniques. The energy consumption of the proposed EERRCUF method is depicted in the Figure 5. When compared with the existing FLEACH and LEACH technique, the proposed EERRCUF technique required less energy to transmit the packet. Due to this reason, the lifetime of the proposed EERRCUF technique is enhanced.

(c) Network Lifetime

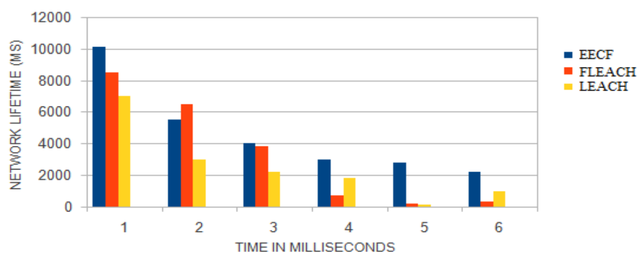

Figure.6: Network Lifetime

The network lifetime of the proposed EERRCUF technique is shown in the Figure 6 and it is compared with the existing techniques. Here, the lifetime of the WSN network is enhanced by utilizing the EERRCUF protocol. The proposed method enhances the WSN lifetime proficiently when compared with the other techniques.

(d) Throughput

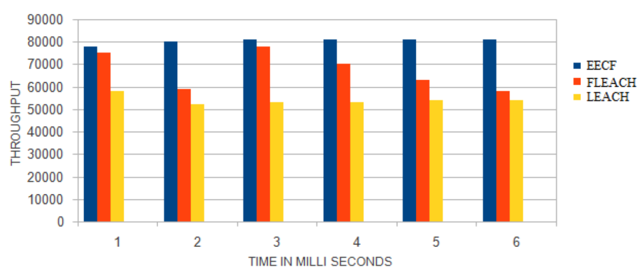

Figure.7: Throughput

The throughput of the proposed EERRCUF protocol is depicted in the Figure 7 and it is compared with the existing techniques. The efficiency of the data transmits from the node to the base station is known as the throughput. Here, the packet is delivered in bit per second and compared with the existing FLEACH and LEACH protocol the proposed EERRCUF protocol has high throughput.

5. Conclusion

This paper proposes an EECF protocol for upgrading the lifetime of the WSN. The proposed routing protocol executed utilizing an ACO algorithm and which assesses the optimum paths from the every accessible Path. The proposed protocol is contrasted and the current FLEACH and the LEACH protocol to assess the execution of the network. The trial result demonstrated that the proposed EECF protocol worked proficiently to upgrade the lifetime of the WSN in view of the packet delivery ratio, energy consumption, throughput.

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