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Comparative Evaluation of Cluster-based Routing Protocols for WSN

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***Abstract**: The importance of WSN as a enabling technology for the future development of IOT has been widely accepted. IOT is a culmination of physical world with the cyber world. A lot of literature in the recent past have optimized the performance of WSN in terms of energy conservation, energy harvesting, path and latency optimization. The major work in the WSN related to MAC and network layer issues. In order to take the advantage of WSN, to create a robust IOT infrastructure routing protocols in the wsn need to be revisited. So in this paper, the cluster-based routing protocols that appear to be applicable for the IOT infrastructure have been identified. The performance of EDEEC, DEEC, SEP, LEACH protocols has been evaluated in terms of important performance metrices like throughput, dead nodes, energy consumption, packet transmitted to base station. In doing so, the performance of EDEEC was found to be better. After EDEEC, DEEC performed better than SEP and LEACH. .*

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I. Introduction

Today's world needs some technologies to fulfill their routine work. WSN is that technology which fulfills the routine work of the society. Wireless sensor network senses the physical world whether it is temperature, pressure, humidity and some other environment activities. WSN is used in an environment where the wires or cable are not possible to reach. It is easy to install compared with the other cables network. Now, these day's WSN are using mainly for the data transfer purpose. Sensor nodes in the wireless network transfer the data packets from source to destination. Wireless sensor network includes sensors nodes and a base station (sink) and there are so many sensors which create a network. All the sensor nodes in a network communicate with each other and transfer the data packet from source node to the sink. Sensor nodes can communicate directly with the base station. Sensor nodes consume a lot of energy while data transfer. On the other hand, sensor nodes also consume energy after transferring the data packets. Due to this consumption, the lifetime of the network also gets reduced. This is the major issue of the sensor network. There are more issues of the network but energy consumption and improve the lifetime of the network. Taking these issues in concern, there is one method which is very much useful to resolve these problems called clustering. Clustering, the technique in which large network region is divided into smaller one. With this technique, sensor nodes do not require direct communication with the base station. In every cluster, there is a cluster head which collects the data from all the network nodes and then transmits that data to the base station. The cluster head is elected on the basis of maximum energy of the node. The node which has highest energy is selected for cluster head. Basically only cluster head is responsible for the communication in the network. Cluster head needs more energy for the data aggregation and transmitting the data. So after transmission of the data, its energy reduces and the node which has second highest energy is selected for cluster head. There is so many clustering protocols which not only reduces the energy consumption but also enhance the network lifetime. These protocols are LEACH, HEED, DEEC, EDEEC, SEP etc. These protocols are cluster-based protocol and a lot of work have been done with these protocols. LEACH is the first protocol which came into the existence in the clustering protocol. DEEC is also a cluster-based protocol in which cluster head is selected based on the residual energy of the sensor nodes and the average energy of the network. EDEEC is the enhanced version of the DEEC protocol and requires a heterogeneous network. LEACH is the homogeneous network. In this paper, we have done a comparison between various clustering based routing protocols and evaluated their performance using extensive simulations. The important parameters like throughput, energy consumption, dead nodes etc have been evaluated. The results so obtained will prove to be ready reference for the IOT system designers. This paper is organized as follows. Section 2 given the related work which has been done on cluster-based routing protocols. Section 3 given the simulation methodology and environment. Section 4 shows the simulation results and discussion of the cluster-based routing protocols. The paper is finally concluded n section 5.

II. Related Work

The major contribution available in the open literature related to clustering protocols has been enumerated below. Davood Izadi et al in [1] proposed an alternative clustering scheme in WSN. Here the author tells that in clustering mechanism there is always a need of cluster head. However, there is a possibility that the cluster head fails at any condition. So cluster head is unable to receive the data packets, in that scenario data would be lost. To resolve this issue, the author presented an alternative clustering where a BCH(backup cluster head) always present in the absence of cluster head. In this paper, author purposed a self-configurable clustering (SCCH) to detect cluster head failure and replace a BCH in the place of failed cluster head. Ebin Deni Raj et al in [2] proposed a technique called EDRLEACH (energy distance relation low energy adaptive cluster hierarchy) which is made with the help of distance based cluster head, an energy efficient algorithm for cluster head selection, consumed energy by cluster head and relation of cluster head and non-cluster head nodes. These factors are considered in EDRLEACH. In this paper author tells few limitations of LEACH, compare the node density and distance between cluster head node, an energy efficient formula used to get the energetic node in a clustering groups that energetic node will be a cluster head node in a current round because the energetic node is needed to transfer the packets to base station and also discussed the consumed energy by the cluster head so that in a next round the max energetic round would be a cluster head node to transfer the data packet.

Simrandeep Kaur et al in [3] investigate the RLE data compression algorithm which is lossless in nature. Lossless in the sense of text compression technique where there is a dictionary based compression is happening. In the dictionary, a 5-bit code is generated for every character of Text instead of 7 bit ASCII code. For this technique, the storage and transfer spaces utilize less a compare with or without compressed data. The text data can easily compress and that compressed data is transferred on the network with the help of node to node and at last, it reaches the base station and then decompression algorithm is performed. In this paper, RLE the compression rate is 30.3% and the reduction of a physical space to 60.25%.

Ankit Tripathi et al in [4] they are showing the survey on data combination. Wireless device networks consist of sensor nodes. These networks have a lot of application in home monitoring, disaster management, security, and military etc. wireless device nodes have limited processing skills and are small in size as well as very low battery power. This limit of low battery power makes the device network prone to failure. Data collection is a very crucial method in wireless device networks. Data aggregation helps in the use of energy consumption by removing redundancy. This work focuses on various methods used for the purpose of data aggregation and its various energy-efficient uses.

G Nivetha et al in [5] state the energy optimization techniques in WSN. In this paper, the authors survey the different clustering protocols which are using for optimization in WSN. Some of the popular routing techniques which are discussed by the author in this paper, these are LEACH (low energy adaptive clustering hierarchy), PEGASIS (power-efficient gathering in sensor information), HEEP (Hybrid energy efficient protocol) and PEACH (Power efficient and adaptive clustering hierarchy). In this research, the paper author presents a survey on energy efficient clustering routing protocol and analysis that the PEACH has no overhead on cluster head selection. PEACH significantly improves the lifetime and energy consumption of the wireless sensor network compared with other clustering protocols.

Jamal N.Al-Karaki et al [6] state routing techniques in wireless sensor network: A survey in WSN. In this paper, the author surveys the different routing techniques of the network. Such as grid based, sensor aggregate and hierarchical power routine based etc. In this paper, the author points out various routing techniques which work in a kind of computer networks. Saini and K. Sharma in [7] proposed an energy efficient cluster head method for heterogeneous wireless sensor networks, called TDEEC (Threshold Distributed Energy Efficient Clustering) protocol. In TDEEC protocol, the value of the threshold has adjusted by the authors according to which a node decides to be a cluster head or not which is based on the ratio of the residual energy of the sensor nodes and the average energy of that round in respect to the optimum number of cluster heads. Simulation results show that TDEEC performs better than SEP and DEEC in a heterogeneous environment for wireless sensor network.

Parul Saini et al in [8] proposed EDEEC (enhanced distributed energy efficient clustering scheme for heterogeneous WSN). For three types of nodes, they proposed EDEEC in prolonging the lifetime and stability of the network. Hence this protocol increases the heterogeneity and energy level of the network. They have done the comparison between EDEEC and SEP. Simulation results show that EDEEC has greater stability and can send more effective messages and can perform better than SEP.

III. Simulation Methodology And Environment

The performance evaluation of the cluster-based routing protocols has been done based on the simulation methodology for each of the cluster-based routing protocols as described below.

DEEC

A distributed multilevel clustering algorithm for heterogeneous wireless sensor networks is considered with following characteristics

- The cluster head is elected by a probability based on the ratio between the amount residual energy present at each node and the average energy of the network.
- The lifetime of a cluster head is decided according to its initial energy and residual energy. So always the nodes with high initial and residual energy has a better chance to become a CH.
- DEEC is implemented based on the concepts of LEACH algorithm. The role of cluster head is rotated among all nodes of the network to uniformize the energy dissipation.
- Two levels of heterogeneous nodes are considered in this algorithm to achieve longer network lifetime and more effective messages than other classical clustering algorithms.
- It also works better for multilevel heterogeneous networks.

In DEEC, all the nodes must have the idea about total energy and lifetime of the network. Average energy of the network is used as the reference energy.

LEACH

Low-energy adaptive clustering hierarchy (LEACH) is a TDMA-based MAC convention which is coordinated with clustering and a basic directing convention in Wireless sensor systems (WSNs). The objective of LEACH is as follows

- To bring down the energy utilization required to make and keep up groups with a specific end goal to enhance the life time of a remote sensor arrange.
- Drain is a various leveled convention in which most hubs transmit to Cluster heads, and the bunch heads total and pack the information and forward it to the base station (sink).
- Every hub utilizes a stochastic calculation at each round to decide if it will end up being a bunch head in this round.
- Filter expect that every Cluster head has a radio sufficiently capable to specifically achieve the base station or the closest bunch head, however that utilizing this radio at full power all the time would squander energy.
- Nodes that have been cluster heads can't move toward becoming bunch sets out again toward P rounds, where P is the coveted rate of bunch heads. From that point, every hub has a 1/P likelihood of turning into a group head once more.
- Toward the finish of each round, every hub that is not a group head chooses the nearest bunch head and joins that bunch.
- The cluster head then makes a calendar for every hub in its group to transmit its information.

All hubs that are not group heads just speak with the bunch head in a TDMA mold, as indicated by the calendar made by the group head. They do as such utilizing the base energy expected to achieve the bunch head, and just need to keep their radios on amid their schedule opening.

SEP

SEP concentrate the effect of heterogeneity of Clusters, as far as their vitality, in remote sensor arranges that are progressively bunched. Following properties are considered

- In these systems a portion of the nodes progressed toward becoming bunch heads, total the information of their group individuals what's more, transmit it to the sink.
- It accept that a rate of the populace of sensor hubs is outfitted with extra vitality assets which is a wellspring of heterogeneity which may come about from the underlying setting or as the operation of the system advances.
- It additionally consider the sensors are arbitrarily (consistently) appropriated and are not versatile, the directions of the sink and the measurements of the sensor field are known.
- It is assumed in SEP that nodes cannot take full favorable position of the nearness of hub heterogeneity.
- SEP, a heterogeneous-mindful convention to draw out the time interim before the passing of the principal hub (we allude to as strength period), which is pivotal for some applications where the criticism from the sensor organize must be solid.
- SEP depends on weighted race probabilities of every hub to end up bunch go to the rest of the vitality in every hub.

It appear by reenactment that SEP dependably delays the steadiness period contrasted with (and that the normal throughput is more prominent than) the one got utilizing current grouping conventions.

EDEEC

Remote Sensor Networks (WSNs) comprises of across the board arbitrary sending of vitality obliged sensor hubs. Following properties exists of EDEEC.

- Sensor hubs have distinctive capacity to detect and send detected information to Base Station (BS) or Sink.
- Detecting and in addition transmitting information towards sink requires substantial measure of vitality.
- In WSNs, save vitality and delaying the lifetime of system are incredible difficulties. Many directing conventions have been proposed with a specific end goal to accomplish vitality productivity in heterogeneous condition.
- EDEEC for the most part comprises of three sorts of hubs in amplifying the lifetime and solidness of system.

Consequently, it expands the heterogeneity and vitality level of the system.

The performance has been evaluated in terms of following parameters

- A number of dead node is the number of dead nodes which gets dead after traveling some rounds.
- Lifetime/throughput is the total number of rounds for which network is active and producing output.
- Packet to base station is the number of packets which is received at the base station.
- Energy consumed is defined as the nodes in the network consumed energy per round

Simulation Environment

The simulation environment created in the Matlab has been explained below.

The simulation environment consists of 100*100 region having 100 sensor nodes placed randomly. The probability of advanced nodes is kept as 0.2, so the number of advanced nodes is 20. The packet size os considered to be 4000 bit.

Parameters	Values
Area	100*100
Rounds	5000
Cluster Head	Having maximum energy
Techniques	EDEEC,DEEC,LEACH,SEP
Packet Drop(initially)	0
Energy consumed (initially)	0
Eelec	50j
Efs	10j

Table 1: Simulation parameters

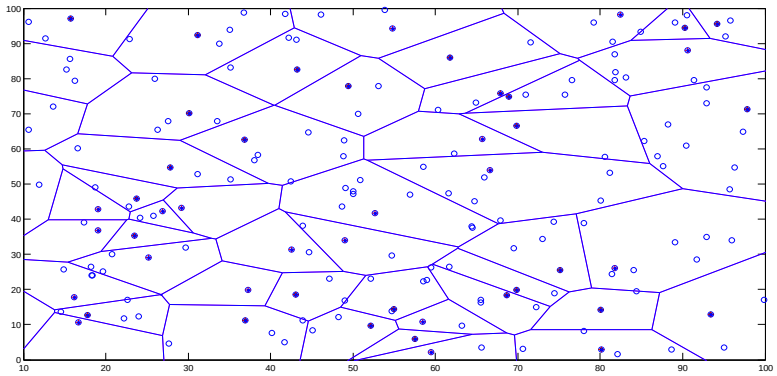

Fig 1: A clusted based network area with 100 nodes.

IV. Simulation Results And Discussion

Simulation is conducted in MATLAB. The simulation results are obtained up to round 5000. Number of dead nodes is evaluated at interval of 5 in rounds. Energy consumed is evaluated on an average and maintaining fixed area of 100*100. Packets are transferred towards cluster head and then cluster head transfer the data towards base station. The Parameters of evaluation are listed as under.

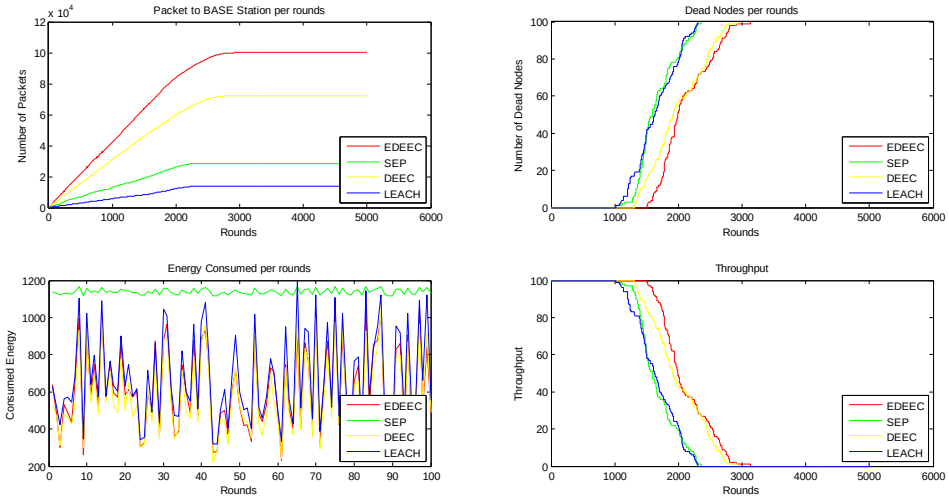

Fig 2: Performance evaluation of routing protocols

DEAD NODES

PROTOCOLS	DEAD NODES AT 1000 ROUNDS	DEAD NODES AT 5000 ROUNDS
LEACH	100	500
SEP	95	465
DEEC	80	400
EDEEC	50	250

Related bar graph

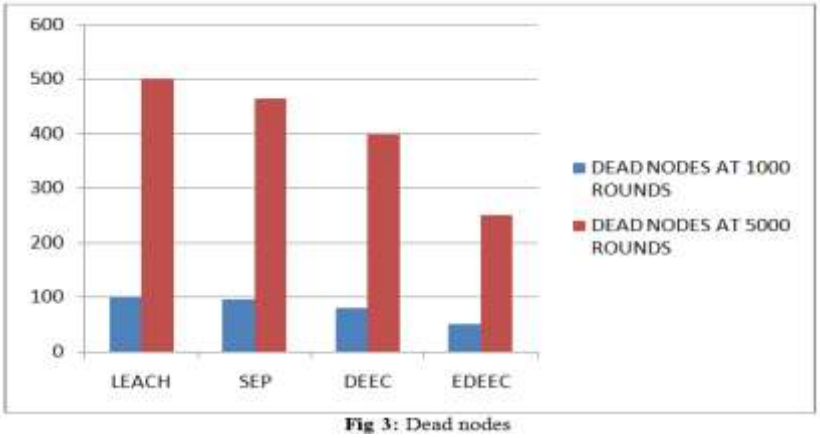

Fig 3: Dead nodes

PACKETS TO BASE STATION

PROTOCOLS	ROUNDS 1000 PACKET TO BASE STATION	ROUNDS 2000 PACKET TO BASE STATION
LEACH	1000	2000
SEP	2000	4000
DEEC	3000	6000
EDEEC	4000	8000

Related bar graph

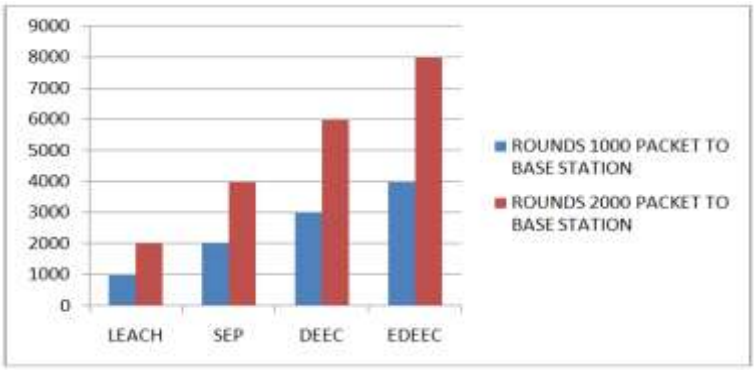

Fig 4: packet transmitted to base station

ENERGY CONSUMPTION

PROTOCOLS	ENERGY CONSUMPTION (JOULE) AT 1000 ROUNDS	ENERGY CONSUMPTION (JOULE) AT 3000 ROUNDS
LEACH	95	285
SEP	85	255
DEEC	78	234
EDEEC	65	195

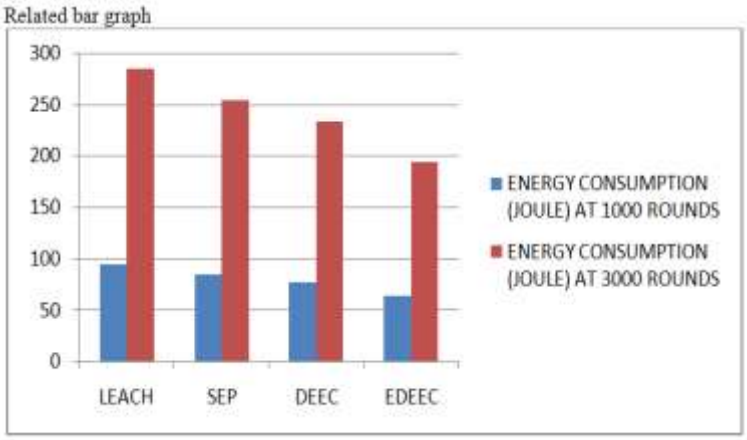

Fig 5: Energy consumed by nodes

THROUGHPUT

PROTOCOLS	THROUGHPUT AT 2000 ROUNDS	THROUGHPUT AT 4000 ROUNDS
LEACH	20	40
SEP	21	42
DEEC	65	130
EDEEC	76	152

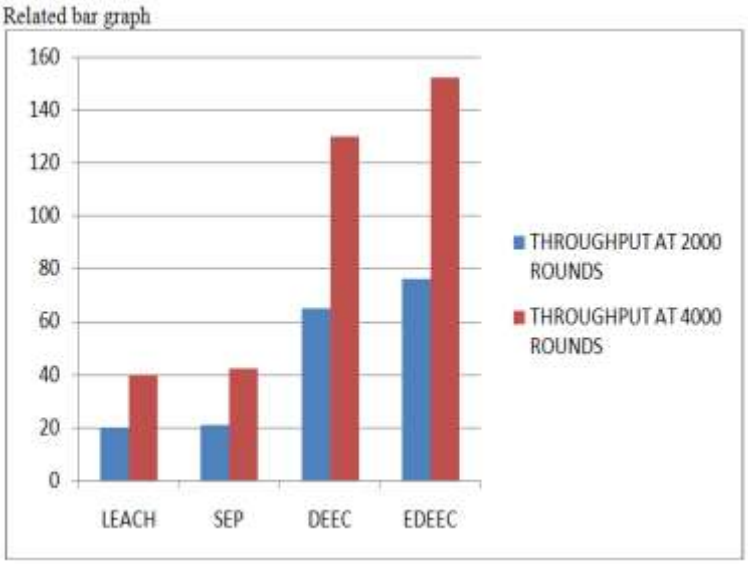

Fig 6: Throughput

In this segment, we examine the execution of DEEC, EDEEC, SEP and LEECH and contrast the execution of DEEC and that of different conventions. In our reenactments, we consider arbitrary organization of 100 sensor hubs in a square field of measurement 100 M x 100 M. The base station is situated at the middle and it can be at the most extreme separation of 70 roughly from any hub. The underlying vitality of a typical hub is set as E0 ¼ 0:5 J. In spite of the fact that this esteem is subjectively taken for reenactment reason, yet this does not influence the conduct of our simulation. Results indicate better performance of EDEEC in almost every aspect. The performance of LEECH is obtained to be least and can be improved using distance reduction mechanisms. Number of dead nodes, energy consumption , throughput and packets to base stations are

considered parameters. The DEEC protocol can also be enhanced by using dense network of nodes to reduce energy consumption and subsequently enhance throughput.

V. Conclusion And Future Work

The performance results obtained in this paper, will be useful for the wireless network designers in generate IOT applications developer in specific.We have done the comparison between EDEEC, DEEC, SEP and LEACH. EDEEC is the enhanced version of DEEC and it has better results than the other cluster-based routing protocols. After EDEEC, DEEC cluster-based protocol has better result than LEACH and SEP. After DEEC, SEP performs well whether it is throughput, packets transfer, dead nodes or energy consumed. It shows that LEACH performance is not well when we compared LEACH with the others protocols. . From the results, it can be concluded that DEEC variants performs better than its predessors like SEP AND LEACH. In order to take the advantage of WSN to create a robust protocols in the WSN need to be revisited.

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