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Design Challenges and Comprehensive Study on Cluster Based Routing Protocol in Wireless Sensor Network

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Abstract: Recent year's extensive research has been conducted on routing protocols for Wireless Sensor Network because of its numerous applications. A wireless sensor network is a collection of sensor nodes prearranged into a collective network to monitor the remote and physical environment. These sensors nodes are capable with limited processing and computing resources. The design of these routing protocols is to minimize the energy consumption in the network during transmission of information. During radio transmission and reception these sensor nodes consumes lot of power, hence forth to maintain uninterrupted transmission energy efficiency should be analysed and it is considered as one of the critical parameter in wireless sensor network is the inherent limited battery power within the sensor nodes. In this paper, the focus is mainly driven towards the review of energy efficient routing protocol and its design issues. Different routing protocols pros and cons were analysed. Some standard cluster–based available routing protocols were compared with respect to their clustering attributes for wireless sensor network. This document gives formatting instructions for authors preparing papers for publication in the Proceedings of an International Journal. The authors must follow the instructions given in the document for the papers to be published. You can use this document as both an instruction set and as a template into which you can type your own text.

Keywords: Wireless sensor network, network life span, cluster-based routing, distributed clustering, energy efficiency.

I. INTRODUCTION

Wireless sensor network can be defined a collection of movable or stationary nodes which are able to communicate with each other for transferring data more efficiently and autonomously [1]. Wireless sensor networks (WSNs) are becoming progressively attractive for plentiful application in the area for military exploration, security surveillance, habitat monitoring, disaster management, medical and health, industrial automation, *etc*. A WSN is a set of hundreds or thousands of sensor nodes working together to monitor a region to obtain data about the environment [2]. These sensor nodes have capabilities of sensing, establishing wireless communication between each other and doing computational and processing operations .The potential applications of WSNs shown in the "Fig. 1"are exceedingly varied, such as ecological monitoring tracking and military surveillance. When placed in unpleasant physical environment it becomes impossible to charge or replace the sensor nodes. Therefore it is desirable to design a communication network protocol such that energy source is used efficiently to maximize the lifetime of the network.

One of the crucial issues is the data delivery time by sensor nodes, in battle field, medical applications and border security applications, where minimum delay is desirable. Sensors in such networks are equipped with sensing, and processing the information with power which is highly inadequate [3]. Due to the sensors' limited power, advanced system that improves energy competence to extend the network lifetime is highly mandatory. Thus energy-awake policy has been a hot research area at all layers of the networking protocol stack. Sensor nodes are usually scattered in a sensor field and each sensor node comprises of sensing, processing, transmission, mobilize, position finding system and power units. Sensor nodes coordinate among themselves to process the sensed information about the physical environment. Each sensor node based on the radio connectivity and deployment nature the information is passed to the other level .Each of these dispersed sensor nodes has the ability to collect and route data either to other sensors or to the base station (BS). A BS may be a stable node or a transportable node capable of connecting the sensor network to a current communication organization or to the internet where the user can have access to the reported data [6]. However, sensor nodes are constrained in energy supply and bandwidth.

WSNs consists of a large number of tiny sensor nodes distributed over a large area try to establish the connection between the physical world, and the computing world with one or more powerful base stations (BSs) collecting information from these sensor nodes[4]. The sensor nodes, deployed in the remote environment or in the closed environment with the limited power supply sent the information to BS through wireless communication.

Routing is more challenging in WSN due to their inherent characteristics [8].

- Great constrained in terms of power supply
- Processing capability
- Transmission bandwidth.

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- Difficult to design a global addressing scheme,
- Dynamic WSN can result in heavy overhead.
- Due to the limited resources, it is hard for routing
- To cope with unpredictable and frequent topology changes
- Data collection by many sensor nodes usually results in a High probability of data redundancy,
- Most applications of WSNs require the only Communication scheme of many-to-one
- Time-constrained applications of WSNs, Data transmissions should be accomplished within Certain period of time.

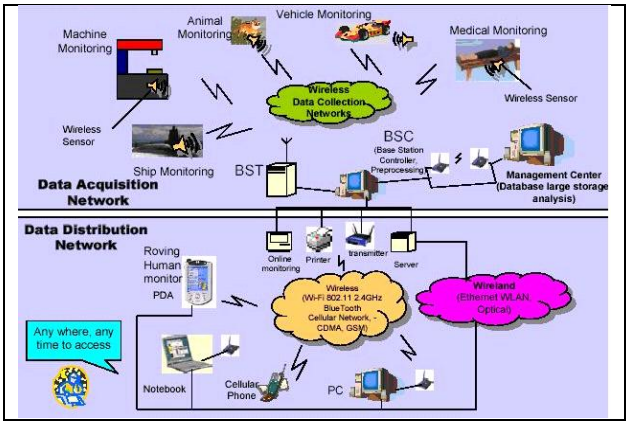

Fig.1. Articulation in Wireless Sensor Network

Thus, bounded latency for data transmissions must be taken into consideration in this kind of applications. Nevertheless, energy conservation is more important than quality of service (QoS) in most applications in that all sensor nodes are constrained with energy which is directly related to network lifetime [9].In this paper the focus is mainly driven towards to extend the life time of the sensors present WSN to enhance the performance. Section II of the paper discusses the related survey of routing protocols in WSN based on network characteristics and design objectives. In Sections III, describes the classification of routing protocols. Section IV states the design challenges and routing issues to be examined. In Section V and VI, review of various cluster based routing protocols are discussed and compared. Finally, Section VII concludes the survey.

II. RELATED WORK

This section reveals the some of the existing works on survey of clustering routing protocols and cluster based routing technique. In WSN the ultimate objective behind the routing protocol design is to extend the network lifetime by keeping the sensors operating for as long as possible. More over the energy consumption of the sensors is dominated by data transmission and reception. Therefore, optimized routing protocols designing is needed for WSNs to prolong the lifetime of individual sensors, and hence the network lifetime [9]. According to Xuxun Liu *et.al* on survey of cluster based routing protocols the cluster characteristics and its attributes must be defined for the comprehensive application of the WSN [14]. The operation of some basic routing protocol is discussed in the survey presented by Braginsky [8].A survey of clustering algorithm presented by Boyinbode*et.al* [15]. DipakGhosal*et.al* presented a survey paper on wireless sensor network .To make a comprehensive survey of design issues and challenges in routing techniques for sensor networks , the physical constraints on sensor nodes and the energy efficient routing protocols is considered as the main goal . Some of the routing challenges and design issues that have an effect on routing process in WSNs is discussed .Classification of WSN routing based on processes and network structure is done by considering the articulation factors like Proactive, reactive, hybrid. flat ,hierarchal location based and Qos. This will be useful for the researchers to select the appropriate routing process for their application in WSN

III. CLASSIFICATION OF ROUTING PROTOCOL

There are many routing protocols for WSN mainly for static networks and there are little protocols for networks with dynamicity. All major protocols may be categorized into four categories as shown in the "Fig .2"

A. Routing Protocols - Proactive, Reactive and Hybrid

This type of protocol is used in time critical applications. e.g. The Threshold sensitive Energy Efficient sensor Network (TEEN) is an example of a reactive protocol Hybrid protocols incorporate both proactive and reactive concepts. They first compute all routes and then improve the routes at the time of routing [10]. e.g. Adaptive Periodic TEEN(APTEEN) is an example of a reactive protocol. according to the participation style of the Nodes.:

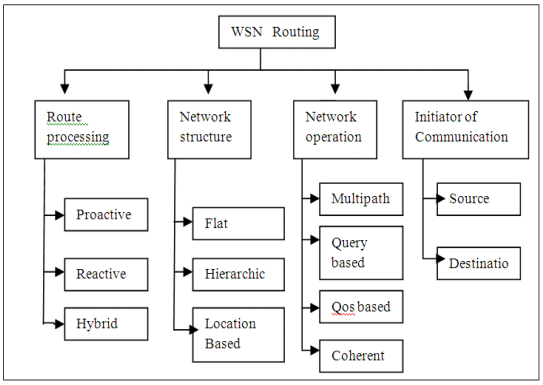

Fig. 2. Classification of routing protocols

B. Routing Protocols - Direct Communication, Flat and Clustering Protocols

Routing protocols can be classified as Direct Communication, Flat and Clustering Protocols, according to the Participation style of the Nodes. In this Direct Communication type of protocols, any node can send information to the Base Station (BS) directly [12]. When this is applied in a very large network, the energy of sensor nodes may be drained quickly. Its scalability is very small. e.g. SPIN is an example of this type of protocol. In the case of flat protocols, if any node needs to transmit data, it first searches for a valid route to the BS and then transmits the data. Nodes around the base station may

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drain their energy quickly. Its scalability is average. e.g. Rumor Routing is an example of this type of protocol In Clustering Protocols ,the total area is divided into numbers of clusters. Each and every cluster has a cluster head (CH) and this cluster head directly communicates with the BS. All nodes in a cluster send their data to their corresponding CH. e.g. TEEN is an example of this type of protocol.

C. Routing Protocols - Hierarchical routing and Location Based Routing Protocols

Routing Protocols can be classified as, depending on the Network Structure. Based on Mode of Functioning and type of target Applications Hierarchical routing is used to perform energy efficient routing, i.e., higher energy nodes can be used to process and send the information; low energy nodes are used to perform the sensing in the area of interest. examples: LEACH, TEEN, APTEEN . Location based routing protocols need some location information of the sensor nodes. Location information can be obtained from GPS (Global Positioning System) signals, received radio signal strength, etc. Using location information, an optimal path can be formed without using flooding techniques. e.g. Geographic and Energy-Aware Routing(GEAR) .

D. Routing Protocols – Query based- Data centric, Data Dissemination and Data diffusion.

Data centric protocols are query based and they depend on the naming of the desired data, thus it eliminates much redundant transmissions. The BS sends queries to a certain area for information and waits for reply from the nodes of that particular region. Since data is requested through queries, attribute based naming is required to specify the properties of the data. Depending on the query, sensors collect a particular data from the area of interest and this particular information is only required to transmit to the BS and thus reducing the number of transmissions. e.g. SPIN was the first data centric protocol. Data Dissemination Protocols Data dissemination is the process by which queries or data are routed in the sensor network. The data collected by sensor nodes has to be communicated to the BS or to any other node interested in the data. The node that generates data is called a source and the information to be reported is called an event. Anode which is interested in an event and seeks information about it is called a sink. Traffic Models have been developed for sensor networks such as the data collection and data dissemination (diffusion) models. In the data collection model, the source sends the data it collects to a collection entity such as the BS. This.could be periodic or on demand. The data is processed in the central collection entity. Data diffusion, on the other hand, consists of a two-step process of interest propagation and data propagation. an interested is a descriptor for a particular, intrusion or presence of bio-agents. For every event that a sink is interested in, it broadcasts its interest to its neighbors and periodically refreshes its interest. The interest is propagated across the network and every node maintains an interest cache of all events to be reported

IV. Routing Challenges and Design Issues in WSNs

The design of routing protocols for WSN is inclined by many challenging factors. In order to achieve efficient communication, these factors must be considered to an extent. Some of the routing challenges and design issues that have an effect on routing process in WSNs are elaborated as follows.

- Node deployment in WSN is application purely application dependent and affects the performance of the routing protocol.
- Sensor nodes can use up their limited supply of energy to perform computations and transmitting information in a wireless environment.
- Some sensor nodes may fail or be blocked due to lack of power, physical damage or environmental interference.
- Since sensor nodes may create significant unwanted data, similar packets from multiple nodes can be aggregated to reduce the number of transmissions.
- As the energy gets depleted, the network may be in need to reduce the quality of the output in order to reduce the energy dissipation of the nodes and hence lengthens the overall network lifetime.
- A given sensor's view of the environment is limited both in range and accuracy, that it can only cover a limited physical environmental.

V. Literature Review of Energy Efficient Cluster Based Routing Protocols

Clustering is a sample of layered protocols in which a network is composed of several clumps of sensors [11]. As depicted in “Fig. 3” each cluster is managed by a special node or leader, called cluster head, which is responsible for coordinating the data transmission activities of all the sensors in its cluster.All sensors in a cluster communicate with a CH that acts as a local coordinator or sink for performing intra-transmission arrangement and data aggregation. Cluster heads transmits the sensed data to the universal sink. The communication distance over which the sensors send their data to their CH is smaller compared to their particular distances to the universal sink [14]. Since a network is characterized by its limited wireless channel bandwidth, it would be useful if the amount of data transmitted to the sink is minimized.

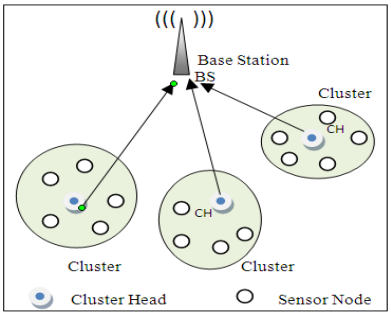

Fig.3. Clustering Mechanism

To achieve this goal, a local collaboration between the sensors in a cluster is required in order to reduce the bandwidth demands. As pictured in Fig. 3 clustering

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usually localize the routing setup within the cluster and therefore it reduces the routing overhead by each node and the topology maintenance overhead. Using clustering, the network appears smaller and more stable [28,29]. The information generated from neighbouring sensor nodes, is often redundant and correlated, thereby data aggregation by each CH conserves communication bandwidth as well. Moreover, the ability to use different power levels in inter-cluster and intra cluster communication reduces the interferences and collisions in the network resulting in a better throughput. Clustering is a challenging task and CHs often lose more energy compared to regular nodes[14]. It is necessary to perform re clustering periodically in order to select energy-abundant nodes to serve as CHs.

A. LEACH

LEACH is one of the traditional clustering protocols [17]for WSN, developed by Heinzelman*et al* .The main objective of LEACH is to select the cluster head by rotation. The operation of LEACH consists of many rounds ,each round is divided into two phase 1) the set up phase 2)steady state phase .During the setup phase the cluster head is selected for the current round .the decision is based on the Threshold value. The sensor nodes chooses a random number between 0 and 1 if the number is less than the threshold value the node becomes a CH.

$$\mathbf{T(i)} = \begin{cases} \mathbf{p/(1 - p * r \bmod \left(\frac{1}{p}\right), i \in G} \\ \mathbf{0 \qquad\qquad else} \end{cases} \qquad (1)$$

where pis the desired percentage of CHs, is the current round, and 1/p is the probability of node becoming CH in the next round .After receiving the broadcast message from the CH the remaining nodes send membership message to its CH to form cluster. During setup phase the sensor node transmits the sensed data to CH ,cluster head compresses the data arriving from sensor nodes and transmit to the base station BS using TDMA/CDMA technique to avoid inter cluster and intra cluster collision .Network goes back in to setup phase for selecting CH for the next round. LEACH performs load balancing by rotation of CH .However there are some disadvantages occurs ,LEACH performs single hop which is not suitable for large area network and more over LEACH cannot ensure real load balancing since each sensor nodes are with different amounts of initial energy. Extra overhead occurs for dynamic clustering, when node die prematurely energy hoe and coverage problem occurs. Gain in energy consumption is diminished when some nodes does not have CH in their vicinity.

B. HEED

Hybrid Energy Efficient Distributed clustering introduced by Younis and Fahmy*et.al* is an energy efficient multi hop routing algorithm[15] to get an even distributed energy. Unlike LEACH it does not select nodes as CHs randomly. Cluster formation is based on hybrid combination of nodes residual energy and intra cluster communication costs. In HEED each node is mapped to one cluster to communicate CH. In HEED CH are periodically elected there by energy consumption is minimized .The algorithm is decided into three phases as follows:

1)Initialization phase: The algorithm set an initial percentage of CH among all sensor nodes.$\mathrm{CH}_{\mathrm{prob}}$a percentage of CH among all nodes is to set to optimal percentage .The probability that a node becomes a CH is given in the equation (2).

$$\mathbf{CH_{prob}} = \mathbf{C_{prob}} \frac{\mathbf{E_{residual}}}{\mathbf{E_{max}}} \qquad (2)$$

2) Repetition phase: After several iterations the sensor nodes finds the CH to transmit the data at least cost. If it does not receive information about CH the node elects itself to be a CH and sends the announcement message to neighbours finally each sensor node doubles its $\mathrm{CH}_{\mathrm{prob}}$value and goes into next iteration and stop when CH reaches 1.If $\mathrm{CH}_{\mathrm{prob}}$< 1 the node becomes tentative CH ,when $\mathrm{CH}_{\mathrm{prob}}$ reaches 1 the sensor node becomes permanently CH.

3) Finalization phase: Final decision is made to pick up the least cost CH or pronounces itself as CH. The advantage of HEED is fully distributed clustering method and provides uniform CH distribution across the network and hence load balanced .However there are some limitation with HEED because of tentative CH. Cluster formation in each round improves a significant overhead in the network that causes energy dissipation which results in decreasing the network life time .The CH that are close to the sink die earlier when the network load is high.

C. DWEHC

Distributed weight based energy efficient hierarchal clustering protocol proposed by Ding *et.al* is distributed clustering algorithm [16]. Unlike HEED, DWECH achieve balanced cluster size, to optimize the intra cluster topology. DWECH proceeds with time complexity *O(1*). After locating the neighbour nodes each sensor calculates its weight.

$$\mathbf{W_{weights(s)}} = \frac{\mathbf{E_{residual(s)}}}{\mathbf{E_{intial(s)}}} \mathbf{X} \sum_{\mathbf{u}} \frac{\mathbf{R-d}}{\mathbf{6R}} \qquad (3)$$

Weight(sensor's energy; proximity to the neighbours) $E_{residual}$ and E_{intial} are residual and initial energy respectively R is the coverage range and d is the distance between node s and the neighbouring node with large weight would be elected as CH and the remaining nodes become members since they have direct link to the CH they are considered as first level members. After running DWECH algorithm a node either becomes CH or becomes a child in a cluster .The member node adjust such membership in order to reach a CH using the least amount of energy. DWECH and HEED are similar in many ways by considering energy reserves in CH selection. DWECH generates well balanced CHs and significantly lower energy consumption in intra cluster and inter cluster than HEED. Clustering process by DWECH terminates with little iteration. Another advantage network does not depend on topology or size of the network. However DWECH like LEACH protocol not suitable for large range of network. The iterative nature in both DWEHC and HEED during cluster formation produces a relatively high control message overhead compared to other protocols.

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D. EECS

An Energy Efficient Clustering Scheme (EECS) was proposed by Ye *et al* for periodical data gathering applications in WSNs [21,23]. EECS is a LEACH-like scheme, based on energy and distance, EECS constructs balancing point between intra-cluster energy consumption and inter-cluster communication load. Here the network is partitioned into several clusters and single-hop communication between the CH and the BS is performed. In the *cluster head election* phase, the cluster head is elected by localized competition which is unlike LEACH, and with no iteration which differs from HEED. The optimal value of competition range produces a good distribution of cluster heads. Further in the *cluster formation* phase, plain nodes join clusters not only taking into account its intra-cluster communication cost, but also considering cluster heads' cost of communication to the BS. EECS is autonomous and more energy efficient, that it prolongs the network lifetime much more significantly than the other clustering protocols.In EECS, a node chooses the CH by considering not only saving its own energy but also balancing the workload of CHs ,*i.e.* ,two distance factors: $d(p_j, CH_i)$and $d(CH_i, BS)$.A weighted function $C(j,i)$costis introduced in EECS for the ordinary node p_j*j* to make a decision, which is:

$$C(j,i) = \left(\left(1 - w(F_j)\right) WXf(p_j, CH_i) + W(p_j) Xg(CH_i)\right) \quad (4)$$

and node p_j, chooses cluster head $CH_i$with the minimal {cost}to join. In equation (4) f and g are two normalized functions for the distance $d(p_j, CH_i)$and $d(CH_i, BS)$ respectively:

$$f(p_j CH_i) = \frac{d(p_j, CH_i)}{d(d_{f-max})} \quad (5)$$

$$g(CH_i) = \frac{d(CH_i, BS) - d_{g_{min}}}{d_{g-max} - d_{g-min}} \quad (6)$$

$$d_{f-max} = \exp(\max\{d(p_j, CH_i)\}) \quad (7)$$

$$d_{g-max} = \max\{d(CH_i, BS)\} \quad (8)$$

$$d_{g-min} = \min\{d(CH_i, BS)\} \quad (9)$$

w the function of p_j is as follows:

$$w(p_j) = c + (1 - c)\sqrt{\frac{d(p_i, BS)}{d_{g-max} - d_{g-min}}} \quad (10)$$

In order to minimize the intra-cluster communication cost, the nodes choose the closest CH, while function *g* makes the nodes join the CH with small $d(CH_i, BS)$to alleviate the workload of the CHs farther from the BS. The optimal value of weighted factor *c* in the function *w* depends on the specific network scale. Unlike LEACH in EECS with uniform distribution of CH the problem that clusters with a larger distance to the BS require more energy for transmission than those with a shorter distance has overcome by dynamic sizing. Account of single-hop communications in EECS it is not suitable for large-range networks and global data aggregation adds overhead to all sensor nodes. EECS produces much more control overhead complexity because all nodes must compete for becoming CHs.

E. EEUC

Energy-Efficient Uneven Clustering (EEUC) proposed by Li *et al* is an unequal clustering approach [23] for the purpose of balancing energy consumption among CHs and for solving the hot spots problem. EEUC algorithm, proposed by Li *et al.* is a clustering and distributed competitive algorithm, where CHs are elected by localized competition, which is unlike LEACH. Every node has a pre-assigned competitive range, which is smaller as it gets close to the BS. Like LEACH during the process of CH election in EEUC, each node generates a random number, and only the node whose number is greater than a threshold will be activated for CH election by broadcasting compete message within a competition radius which is determined by its distance to the BS. The competition radius of node S_i is given by:

$$S_i \cdot R_{comp} = \left[1 - C\frac{d_{max} - d(s_i, BS)}{d_{max} - d_{min}}\right] R^0_{comp} \quad (11)$$

Where R^0_{comp} is the maximum competition radius which is predefined, the maximum and minimum distance between sensor nodes and the BS is denoted by d_{max} and d_{min} .The distance between node S_i and the BSis $d(s_i, BS)$, Cis a constant coefficient between 0 and 1. The nodes competition range decreases as its distance to the BS decreasing according to equation (8). Henceforth clusters closer to the BS have smaller cluster sizes, thus they will consume lower energy during the intra-cluster data processing. The tentative CHs in local regions compete in order to become a real CH. In EEUC, multi-hop routing is used for inter-cluster communication. For data transmission the CHs choose relay nodes according to the nodes' residual energy and distance to the BS. EEUC improves the network lifetime over LEACH and HEED by an unequal clustering mechanism to balance the energy consumption among CHs. This protocol can save more energy through inter-cluster multi-hop routing mechanism in the steady state phase based on communication cost. Communication overhead results after the cluster formation because each node must broadcast and receive a large amount of competition message for CH election. The extra global data aggregation can result in much overhead for all nodes and deteriorate the network performance. In EEUC the routing scheme can result in new hot spots, in that the neighbour CHs can be relay nodes, when communication costs are the least and both of them have little residual energy.

VI. COMPARISON OF DIFFERENT CLUSTERING ROUTING PROTOCOLS IN WSN

The following sections provide comparisons of the previously described cluster based routing algorithms. Furthermore we summarize different clustering routing approaches in WSN based on some performance metrics in Table I Furthermore we review the categories and difference of the energy efficient cluster based routing

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protocol based on various cluster attributes as shown in Table II and Table III. The study of routing techniques shows LEACH and HEED [18] differ from cluster characteristics for intra cluster routing. The simulation results prove the execution time of HEED is reduced with respect to LEACH. Compared with HEED the number of iteration is reduced in DWECH hence the execution time is reduced and moreover the network clustering process does not depend on topology or size of the network. However DWECH like LEACH protocol not suitable for large range of network. From the comparison Table I DWECH has high energy efficiency with scalability and load balancing is good when compared with LEACH, HEED,EECS and EECS. Further in EECS the cluster stability is good since the nodes join clusters not only taking into account its intra-cluster communication cost, but also considering cluster heads' cost of communication to the BS[22].

VII. CONCLUSION AND OPEN ISSUES IN WSN

Routing in wireless sensor networks has attracted significant attention in the area of research over past years. To design an effective, robust, and scalable routing protocols for WSNs is a challenging task. In this paper the main objective for reducing the energy consumption of sensor nodes , we have presented different routing protocol and its routing challenges and issues in WSN To overcome this constraint, the substantial efforts have been made in analysing the clustering techniques to design an energy efficient cluster based routing protocol s for WSN.

A novel taxonomy of clustering routing methods for WSNs based on clustering attributes has been developed. Finally, few performance metrics for different cluster based routing protocol have been discussed. Many of these routing techniques look promising; but still there many challenges that need to be solved in sensor networks. For future work the design trade-offs between energy and communication overhead can be considered to prolong the network life time there by avoiding the energy hole in the WSN.

For Qos application, the length of life time, data reliable, energy efficient, and location awareness, collaborative-processing. These factors will affect the selection of routing protocols.

TABLE I: COMPARISON OF DIFFERENT CLUSTERING ROUTING PROTOCOLS IN WSN

Protocol Name	Energy Efficiency	Cluster Stability	Scalability	Delivery Delay	Load Balancing	Algorithm Complexity
LEACH	very low	moderate	very low	very small	moderate	low
HEED	moderate	high	moderate	moderate	moderate	moderate
DWEHC	very high	high	moderate	moderate	very good	moderate
EECS	moderate	high	low	small	moderate	very high
EEUC	high	high	high	moderate	good	high

TABLE II: CLASSIFICATION OF VARIOUS ENERGY EFFICIENT CLUSTER BASED ROUTING PROTOCOL

Clustering Routing Protocols		LEACH	HEED	DWEHC
Cluster characteristics	Variability of cluster count	variable	variable	variable
	Uniformity of cluster sizes	even	even	even
	Intra-cluster routing	single-hop	single-hop	multiple-hop
	Inter-cluster routing	single-hop	single-hop multiple-hop	single-hop
Cluster-head characteristic	Existence	cluster-head based	cluster-head based	cluster-head based
	Difference of capabilities	homogeneous	homogeneous	homogeneous
	Mobility	stationary	stationary	stationary
	Role	relay aggregation	relay aggregation	relay aggregation
Clustering process	Control manners	distributed	distributed	distributed
	Execution nature	probabilistic	iterative	iterative
	Convergence time	constant	constant	constant
	Parameters for CH election	adaptive	adaptive	adaptive
	Proactivity	proactive	proactive	proactive
	Objectives	load balancing	load balancing	load balancing
Entire proceeding of the algorithm	Algorithm stages	cluster construction	cluster construction	cluster construction

TABLE III: CLASSIFICATION OF VARIOUS ENERGY EFFICIENTCLUSTER BASED ROUTING PROTOCOL

Clustering Routing Protocols		EECS	EEUC
Cluster characteristics	Variability of cluster count	variable	variable
	Uniformity of cluster sizes	uneven	uneven
	Intra-cluster routing	single-hop	single-hop
	Inter-cluster routing	single-hop	multiple-hop
Cluster-head characteristics	Existence	cluster-head based	cluster-head based
	Difference of capabilities	homogeneous	homogeneous
	Mobility	stationary	stationary
	Role	relay aggregation	relay aggregation
Clustering process	Control manners	distributed	distributed
	Execution nature	probabilistic	probabilistic
	Convergence time	constant	constant
	Parameters for CH election	adaptive	adaptive
	Proactivity	proactive	proactive
	Objectives	load balancing periodical data communications	load balancing
Entire proceeding of the algorithm	Algorithm stages	cluster construction	cluster construction

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