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Energy Efficient Hierarchical Routing in WSN: A SURVEY

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Abstract— Recently in the market of rapid growth of computers the processing power are increased unexpectedly but the price and size of computers have greatly reduced which encourages the use of computers very much. The latest technologies have made vast advancements in computers era and also enhance the use of computers in our daily activities. In recent years, due to cheapness in prices and reduction in size of computers, the use of computers with embedded sensors is becoming possible from economical point of view. Also 21st century has been termed as the "Sensor Decade" by researchers [3]. Large no. of sensor nodes are being deploying remotely in environments such as border protection, disaster areas, health-related areas, intelligent house control, agriculture and many more. Now, whether the WSNs are starting to become a reality in this world, but there are some limitations such as change in topology randomly, restrictions in power, limited computational resources like power, error-prone medium, energy-efficiency. Now-a-days, most of researchers are using their skills mostly on designing issue of energy awareness routing approaches. Thus, energy consumption is an important limitation of WSN which demands researcher's skills to get a way in reducing the energy consumptions by sensor nodes used in WSN. In this paper, survey is done on different routing protocols based on clustering used for wireless sensor networks along with comparison and advantages and disadvantages of them. The main focus in this survey paper is on clustering routing approaches.

Keywords— Wireless Sensor Network, Hierarchical, Cluster Head, Deployment, Energy.

I. INTRODUCTION

Today's in the market of rapid growth of computers the processing power are increased unexpectedly but the price and size of computers have greatly reduced which encourages the use of computers very much. The latest technologies have made vast advancements in computers era and also enhance the use of computers in our daily activities. In recent years, from the economic point of view, the single-purpose desktop computers having sensors embedded in them are highly used due to cheapness in prices and reduction in size of computers.

Wireless Sensor Network is a recently increasing in demand by all people involving in many applications because of their substantial applicability to improve our lives. They aid us by extending our ability to accurately monitor, study, and control objects and environments of various scales and conditions such as human bodies, geological surveys, habitats, and security surveillance. Large no. of sensor nodes in a sensor field are used to transmit information about events to satellite associated through Sink node as shown in below figure:

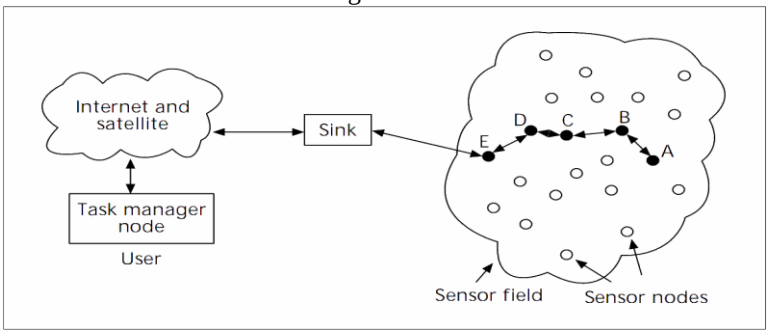

Fig 1 Sensor nodes scattered in a sensor field

This figure 1.1 shows sensed data is delivered to the user. Suppose data is sensed by the sensor node *A* inside the sensor field. As we all know that the range of transmission of radio is short for each sensor. *A*, at first, passes sensed data to the neighbor node *B*. In this example, this data may be routed by the path *A-B-C-D-E-Sink*. Since sink is already connected to the Internet, it can deliver sensed data to the user directly from sink. Sensor nodes in WSNs can also autonomously process and cooperatively analyze sensed data inside networks so that they can prune the redundant data observed inside a network and deliver only necessary data to the user through sinks. Furthermore, WSNs can dynamically adapt its topology. As soon as the deployment of sensor nodes gets completed, all the sensor nodes autonomously find the neighbour nodes and start communicating with each other in various ways, normally using multi-hop communications.

In wireless communication and embedded micro-sensing technologies, the advancements encourage the use of WSNs today in many environments to detect and monitoring sensitive information. In agriculture, WSN is used to detect and monitor the condition of crops which favours crop-harvesting very much by decreasing their cost value in cropping crops, also helps in improving crops quality. In military, WSN is used to detect and track the boundary areas for any kind of event. In forest, WSN is used to detect the rains and bad weather conditions. WSNs are here to detect and track the tanks on a battlefield, tracking the personnel in a building, measure the traffic percentage on a road, monitor environmental pollutants, detect fire and rain. Sensors contribute to electricity production, and also used in collecting the solar energy where WSN tracks the sun rays to detect the power.

All of these characteristics of WSNs are completely opposite from wired networks because in wired networks the energy consumption is not an issue. Moreover, the cost of transmission is very less, and the sensor nodes in WSN can do large processing. The energy is an important characteristic of WSN upon which the lifetime of network nodes depends and also the maintenance cost and performance depends. Distribution of energy throughout WSN is correctly dissipated so that the lifetime of the sensor node enhances and hence, the overall performance of system increase and maintenance cost decrease.

In WSN, protocols used for setting-up communication among network nodes incur some overhead for the process of synchronization. So, in this survey paper, we will study various energy-efficient routing algorithms and also give an eye on comparison part. Various authors have been introduced many clustering algorithms in [4-9]. These algorithms are heuristic by nature, aiming to generate the minimum number of clusters such that in a cluster any node is at most d hops away from CH. Time complexity of most protocols is O(n) , where n is the total no. of nodes. Time synchronization is also a factor upon which these protocols depend and these protocols are suitable for small network having small number of sensors. During the deployment of network, the frequency of activities of nodes is not distributed uniformly because of unspecified identification of definite observation points at deployment time. Transmission and reception consume almost 70 percent of total energy used for all node activities. Therefore, reducing energy for transmission and reception activities has significant impact for extending the lifetime of sensor nodes. The set of actively sensing nodes, as sources of data origination, consume extensive energy. Thus, their residual energy should be considered more precious than the residual energy of the node which does not perform sensing activities; however, no means are investigated to preserve actively sensing node in the literature. The scope of this comprehensive survey is briefing the clustering routing techniques in WSNs is done. Having section 2 explains the theoretical background of different routing protocols of WSN that could save energy consumption. Some of the energy efficient routing protocols based on clustering are LEACH, LEACH-C, LEACH SUB-CH, and so on. Section 3 explains in depth the proposed energy efficient routing.

II. APPLICATION AREAS OF WSN

With the new inventions in technologies that has enabled a sensor device to have higher cost performance and better capabilities like high resolution sensing, observations in vast fields that require a number of sensor devices has become possible. Networking of these intelligent yet low-cost sensor devices is expected to start sudden change in process of gathering and processing in many situations.

Countless applications in many different fields, including:

- **Agriculture:** In agriculture, WSN is used to detect and monitor the condition of crops which favours crop-harvesting very much by decreasing their cost value in cropping crops, also helps in improving crops quality.
- **Weather Monitoring:** In forest, WSN is used to detect the rains and bad weather conditions.
- **Monitoring and Controlling Traffic:** measure the traffic percentage on a road
- **Structural Health Monitoring**
- **Solar Energy:** Sensors contribute to electricity production, and also used in collecting the solar energy where WSN tracks the sun rays to detect the power.
- **Healthcare and medical research**
- **Homeland Security:** WSN are used in tracking the personnel in a building.
- **Military applications:** In military, WSN is used to detect and track the boundary areas for any kind of event. WSNs are here to detect and track the tanks on a battlefield.
- **Monitor environmental pollutants.**
- **Detection of chemical/biological agents**
- **Fire Detection in forest:** Using WSN to detect fires in a forest is another example where sensors are used to sense such events of fire occurring. Sensor nodes after sensing, reports to BS about the location where the fire event has occurred and BS then in response do some physical actions like dispatching fire trucks at that location are immediately.
- **New areas keep emerging.**
- **Intruders Detection**
- **Monitoring natural Disaster**

III. FEATURES OF WSN

- Sensing and data processing
- WSNs have many more nodes which are deployed
- Cheap hardware
- Nodes are more easily fail

- WSNs operate at strict energy constraints
- WSN nodes have static nature
- The communication scheme is many-to-one rather than peer-to-peer

All of these characteristics of WSNs are completely opposite from wired networks where energy is not an issue to worry. The energy is an important characteristic of WSN for increasing the lifetime of sensor nodes to reduce maintenance cost and increase the performance.

IV. LIMITATIONS OF WSN

Whether the WSNs are starting to become a reality in this world, but there are some limitations such as change in topology randomly, restrictions in power, limited computational resources like power, error-prone medium, energy-efficiency.

- Limited Energy (Energy consumption)
- Lifetime of Network
- Dynamic topology
- Application Dependency
- Power restrictions
- Limited computational resources
- Cluster formation and CH selection
- Security issues
- Synchronization
- Error-prone medium i.e. wireless
- Aggregation of data
- Repair Mechanisms
- Quality of Service (QoS)
- Complexity
- Lower speed as compared with wired network
- Surroundings can effect network
- Distracted easily with other technologies like Bluetooth
- Costly deployment of sensor nodes
- Fault occurrence

The energy consumption is an important limitation of WSN which demands researcher's skills to get a way in reducing the energy consumptions by sensor nodes used in WSN.

V. GENERAL SENSOR NETWORK ARCHITECTURE

The following figure shows the general sensor network architecture:

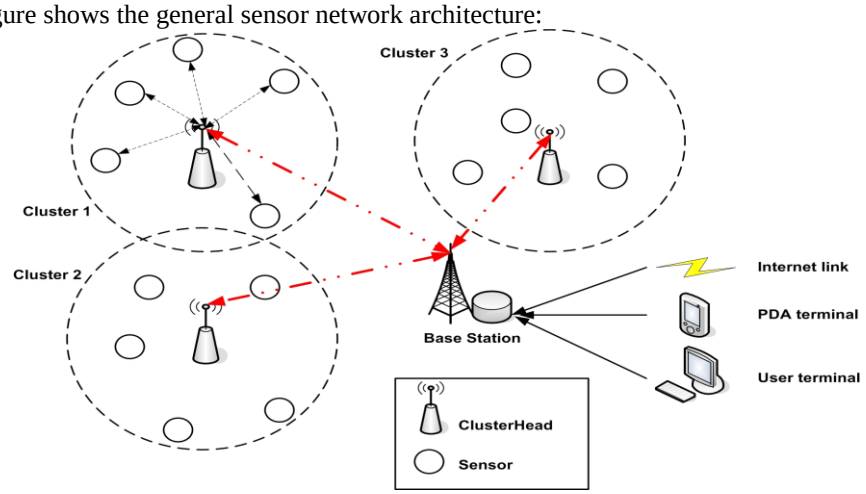

Fig 2: General Sensor Network Architecture

- **Sensor Node:** Sensor node is the important component of WSN because of its has multiple roles. It senses data, stores data, routes data and processes data.
- **Clusters:** Clusters are small manageable units which performs tasks such a simplifying the communication.
- **Clusterheads:** Clusterheads are special nodes who act as the leader and also organize cluster activities. It collects data from several sensor nodes and then aggregates those data and also organizes the schedule of a cluster for communication with BS.
- **Base Station:** Base station is a central component which collects data from several nodes distributed at different locations. The deployment of base station is also a critical issue of WSN. It acts as an intermediate between the network and end-user.
- **End User:** End User is a vital component if any network. It can be a computer or a PDA which generates a query to sensor network over the internet in a particular application.

VI. ROLE OF SENSOR NODES IN WSN

As we know WSNs are used to collect information about areas for event occurring. For this WSNs comprises various sensor nodes that are used for monitoring an area for events and after monitoring these nodes report to the BS (i.e. Base Station) about the location where the event has occurred. When BS receives the event occurring reports then it will response with a prompt physical message. In sense-response applications, nodes are deployed in the coverage field of area with overlapping sensing regions to avoid holes. Thus more than one sensor nodes (neighbours nodes) detects an event at same time and reports to BS and redundancy occurs. In such situation, the BS deals with this redundancy by replying to only those who are coming in the network area. In such a way, BS avoids any *false positives* i.e. event which has been reported was never occurred. Since problem has been solved but what about the energy which is used by every sensor node in large amount while transmission about detected event to the BS. An another solution would be that all the neighbour sensor nodes reports to one common node i.e. head which transmit an message to BS about an event detection and BS will get the information sensed by every node implicitly.

A. Components Of Sensor Node

The components of a typical sensor node as shown in Figure 3:

- **Sensing unit** – which consisting one or more sensor nodes for collecting data
- **Processing unit** – which consisting a memory unit and micro-controller for processing of local data collected by sensing unit
- **Power unit** – which supplies power to sensor nodes.

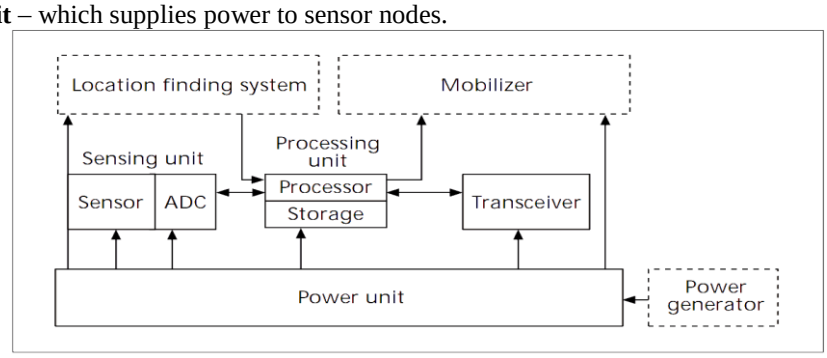

Fig3 Components of Sensor Node

Figure 1.6 shows the various components associated to form a sensor node includes *sensor, processor, storage and transceiver*. Once the sensing unit captures an event, it converts the analog signal in to digital signal and passes it to the processor for possible processing. The data can be stored in the storage and later transmitted to a downstream sensor node. In this figure, extra components are enclosed in dotted lines. For instance, a location finding system such as GPS is not always necessary, and centroid localization calculated from the location of sinks is used instead.

B. States Of Sensor Nodes

There can be three states of a sensor node such as: active, idle, or sleep state and any operational sensor node can be in any state among these states. Figure 4 shows a node state transition diagram. As soon as node is powered on, its state transits to the idle state. In the idle condition, node senses career and moves to the active state if some signal is received (JOB_READY). And if node doesn't sense any signal and timer is expired, then it goes to the sleep state (TIMEOUT). In the sleep condition, node turns off most of its process and keeps remaining inactive. Even when node is inactive, it still senses wake up signal to turn itself on when WAKE_UP signal is received. In the active state, they perform activities such as processing, transmission, and reception. Immediately after its job is done (JOB_DONE), it moves to the idle state and wait a signal.

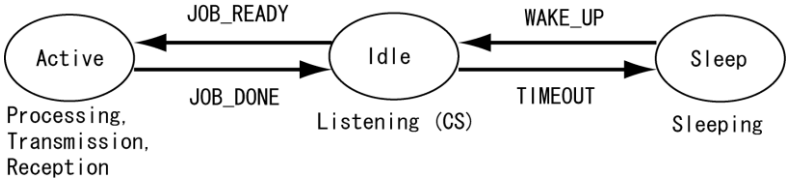

Fig 4 A State Diagram of Sensor Node

VII. ROUTING

Routing is the process used by data communication networks to deliver packets from a source device to a destination device. In Wireless Sensor Network, routing is a problem and time consuming task due to the different features of this network from other networks. In past years, many algorithms and protocols have been introduced by many researchers for solving these routing issues. As routing is very challenging task in WSN due to contemporary communication feature of this network, the routing protocols plays an very important role in WSN. These protocols are needed for transmitting data between sensor nodes and BS. Communication protocol is an important part of any network and has a strong impact on network performance. Also a protocol affect the factors such as energy dissipation, lifetime of a network, cost of system, latency and also sometimes security of the network.

(1) Routing Protocols

As routing is very challenging task in WSN due to contemporary communication feature of this network, the routing protocols plays a very important role in WSN. These protocols have very important role for transmitting data between sensor nodes which senses data and BS which that data sensed by sensor nodes.

Communication protocol is an important part of any network and is also a strong factor affecting the performance of network. Also a protocol affect the factors such as energy dissipation, cost of system, latency and also sometimes security of the network. If we choose any unsuitable communication protocol which can cause unbalanced energy division among nodes that will result in reduction of network lifetime. Cost involve in setting-up the communication process among sensor nodes will also increase if any wrong communication protocol is chosen.

(2) Phases Of Routing Protocols

- **Setting-up of communication:** this involves finding all routes and their energy costs
- **Communication phase:** this involves choosing of path for transmission
- **Route maintenance:** this involves flooding so that paths are available always, and also updating of cost of route.

(3) Categories of network based protocol

In WSN, routing can be categorized into three categories on the basis of network structure as shown in figure 5 below:

- ***Flat-based routing (Data* Centric)**: In this, all nodes have equal roles and perform equal functions.
- ***Location-based routing (Geographic):*** In this, all nodes have their roles to route data according to their locations.
- ***Hierarchical-based routing (Clustering):*** In this, all nodes have their own roles different from others.

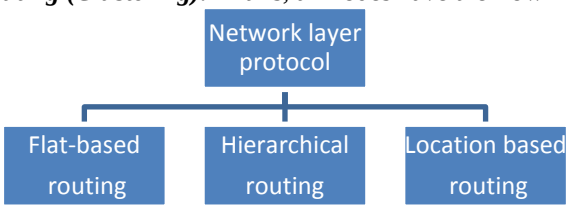

Fig 5 Categories of Network based routing

Therefore, in this paper focus is on the network layer protocols (responsible for route discovery and maintenance) that categorize different approaches for data routing. So in next section the brief introduction is given about Hierarchical based routing and its approaches.

VIII. HIERARCHICAL BASED ROUTING

Hierarchical routing consisting two layers:

- ***Choosing CH****:* In the first layer, CH is chosen
- ***Routing****:* In the second layer, routing is done.

IX. CLUSTERING

Clustering means dividing of large sensor network into small manageable units called 'clusters' which do data aggregation tasks so that WSN can become more scalable and energy efficiency also can improve. To achieve better scalability and to achieve the energy efficient routing of the network, the usage of the clustering scheme for routing is an important factor in WSN. Along these advantages, clustering scheme has more advantages like conserving bandwidth using while communication within the clusters, reduction of redundant transferring of messages between nodes in a network, and also setting-up local routes within the clusters. Following Fig 6 shows the traditional Clustering scheme:

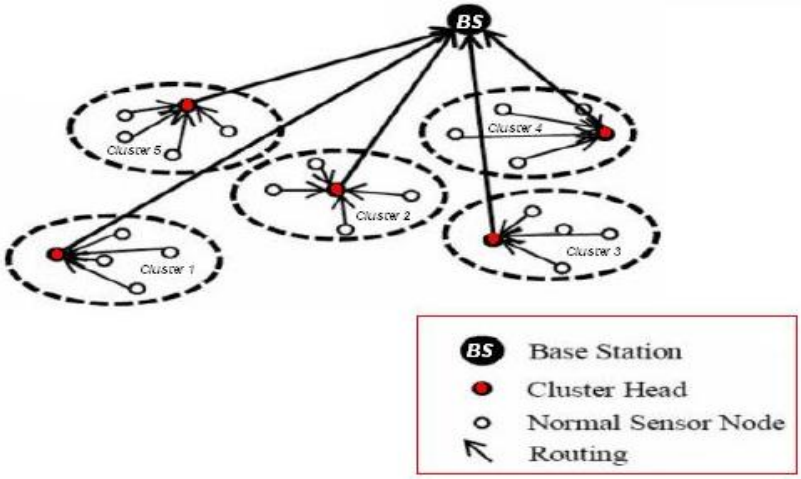

Fig 6 Traditional Clustering Scheme

Thus hierarchical routing protocols are having more advantages than other routing protocols. The existing research work shows some important hierarchical based protocols, which provides efficient energy consumption because of clustering architecture. Some of the energy efficient routing protocols based on clustering are LEACH, LEACH-C, LEACH SUB-CH, and so on. In this paper, the hierarchical routing protocols are discussed and comparison is done among them in next section.

X. RELATED WORK

Need of new routing schemes for WSN has encourage various researchers to do efforts in surveying the existing communication protocols along with their numerous characteristics and comparing themselves [1,2,3,8]. The goal of survey of different protocols along with their classification for sensor network routing is done in [1]. In [10], the author did survey on clustering routing protocols and analyse them with their classification based on some factors covering durability convergence rate of clusters, cluster overlapping, locate the situation of cluster and some other parameters.

The author has conducted a study in [11] on WSN routing protocols. In this paper they have analysed various energy efficient routing (EER) routing protocols. The authors proved that WSNs by nature, is extremely energy constrained thereby forcing the routing protocol designers to go for energy-efficient design. In this paper, a comprehensive list of the EER protocols for WSN has been studied. In this survey, EER protocols are left with many issues like QoS, bandwidth optimization, accurate and cost effective implementation, etc. Finally EER protocols lack standardization and they have to be standardized.

In [12,13], the author proposed routing protocol for an energy efficient based on hierarchical and cluster architecture. The author investigated the protocol in which the CH is selected by BS. There are two stages of selection procedure. First stage consisting tasks such as listing of all nodes which have to become CH. For listing nodes, this protocol evaluates the various parametric measures of nodes like relative distance between the candidate and BS. Also these parameters involve remaining energy level, how many sensor nodes (neighbors) the candidate node have, and how many times the candidate node has become the CH. In this, CH creates two schedules: SLEEP based transmit and TDMA based transmit.

A. LEACH

Heinzelman, et.al [16] introduced LEACH protocol which is a hierarchical based. It is a first hierarchical clustering algorithm for WSN. LEACH i.e. Low Energy Adaptive Cluster Hierarchy based protocol is a hierarchical clustering energy efficient routing protocol which reduces the energy consumption so that the network life can be increased of WSN. In LEACH, clusters are formed. And each cluster has its own CH which is selected randomly by selecting a random number either 0 or 1 by the node so that the energy dissipation among nodes can be balanced.

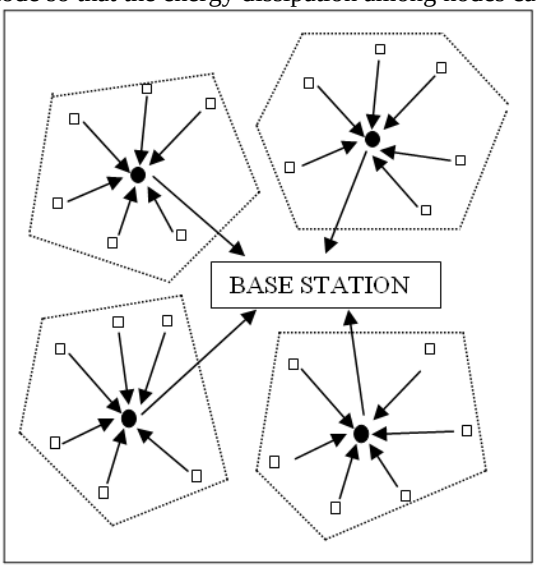

Fig 7. LEACH Protocol Architecture.

The following are the steps of each round of this protocol:

(1) Advertisement phase: In this initial step of LEACH protocol, all nodes in a range are issued a notification by the eligible CH so that they can become a cluster member in respective cluster. The nodes accepts the offer if they have adequate signal i.e RSS (Received Signal Strength).

(2) Set-up phase: In this step, the nodes respond to their respective CH.

(3) Schedule creation: At the time, the cluster head gets response from the nodes, and then the CH makes a TDMA scheme and sends this scheme via message to its cluster members to intimate them about the schedule when they have to transmit their information to CH.

Data transmission: *The individual sensor collects data during its time interval and then transmits to the CH.* After its fixed time period schedule, the cluster members off their radio signals to reduce its energy usage. CH fuses the data it collected and passes that data (fused data) to the Base Station.

In LEACH, there are different rounds having different in each round. Once a node is chosen as CH, then it cannot become CH for next '*p'* rounds. Thereafter, probability of each node for becoming CH in each round is '1/p'. At the end of each round, each non-CH node choose the closest CH and becomes a part of that cluster for the transmission of data.

B. LEACH-C

LEACH-C [17] is the modified LEACH protocol proposed earlier in [16], the author proposed a modified version of LEACH which uses a centralized control algorithm for the formation of clusters in a better way by spreading the CH throughout the network. Thus, LEACH-C is a algorithm based on centralized clustering , rest it is same as LEACH as its steady state phase is also same as LEACH [16].

The following are the steps of each round of this protocol:

(1) Set-up phase: In this stage, all nodes in the network sends their information about level of energy, current location to the base station and it ensures that all nodes energy is evenly distributed by calculating its average node energy level. So the nodes which are less than this level cannot become CH for the current round. It uses an annealing algorithm for the remaining nodes to find the K optimal clusters. LEACH-C decreases the energy consumption by non-cluster head nodes during data transmission to CH.

(2) Broadcast CH-ID: Finally when the CH is selected by the base station it broadcasts this CH–ID of the node to the network. If this ID matches to the particular node then that node will be denoted as a CH for particular round. The remaining non-CH nodes goes off to sleep when no transmission in a network.

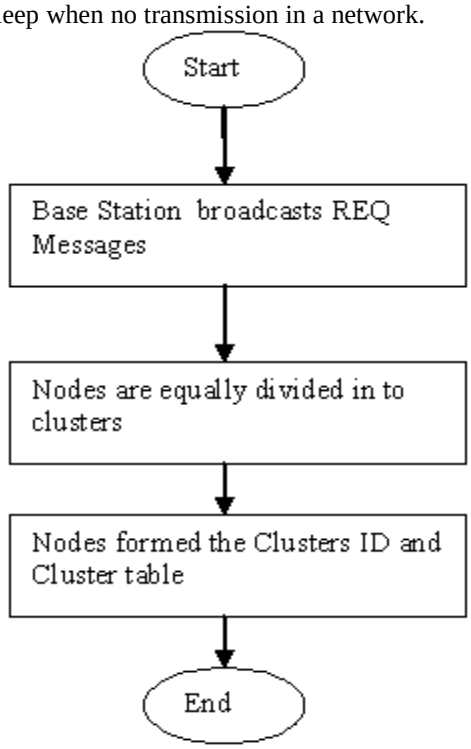

Fig 8. Initialization phase

The advantage of LEACH-C is that in this CH is selected according to the level of energy which reduces the chances of failure of CH and increases the network life time. The overload usage of energy in uneven clustering problem leads to energy consumption problem in sensing environment. Thus, some clusters are of maximum sized and some are of minimum sized. Since the minimum sized cluster transmits more number of frames to CH than maximum sized cluster since it has less member nodes so this makes the cluster head always busy in aggregation of data to BS. Thus it consumes more amount of energy and since in LEACH-C the round time is decided during initialization of network and it is kept as constant because at starting of round every node will have high energy. So the CH has minimum size spends more amount of energy, it will leads to death of CH and if it happens between the rounds the members nodes will transmit frames without knowing about the death of the cluster head this will leads to wastage of energy, it also leads to a network failure in which nodes die due to lack of energy.

C. LEACH sub-CH

In [21], the author proposed the improvement in the original LEACH. In LEACH, clusters are formed. And each cluster has its own CH which is selected randomly by choosing a random number either 0 or 1 by the node so that the energy dissipation among nodes can be balanced.

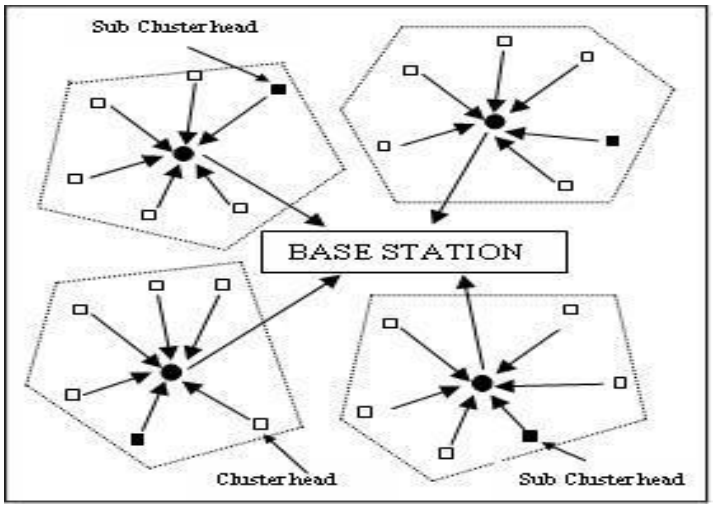

Fig 9 LEACH sub-CH Protocol Architecture.

The limitation of LEACH that CH will die before the other nodes in the cluster because of overhead tasks like receiving data, sending data to BS located at far distance from it. As CH is responsible for transmission in cluster, if it will die, the cluster will become useless and it will be a reason of energy wastage. Also, the cluster nodes have no way to send the gathered data to the base station. In LEACH sub-CH protocol, there is a sub Cluster-Head which will be responsible for whole operations of CH if the CH dies.

D. HEED

Whether LEACH is much more energy efficient protocol as compared with other previous protocols, but its limitation is the random selection of CH due to this all nodes are not properly distributed with CH nodes and it affects data gathering procedure. A new algorithm called HEED [14] was developed to avoid this limitation of LEACH. In this protocol, CH is selected according to level of residual energy and cost incurred during communication. The HEED protocol has following three subsequent phases:

(1) Initialization phase: During this phase, the percentage of initial CH nodes will be given to the nodes. Each sensor node calculate its probability to become CH by using following formula:

$$CHprob = Cprob * Eresidual/Emax$$

where CHprob is CH probability, Eresidual is node's residual energy level, Emax is node's maximum battery energy which may vary according to capacity of different nodes.

(2) Repetition phase: In this phase, node discovers the node with least transmission cost for CH selection. This phase is repeated until the CH node is selected. If the node cannot search the appropriate CH, then the concerned node selects itself as the CH.

(3) Finalization phase: Finally, the CH is selected. Now, the tentative CH becomes the CH node.

E. DECA

DECA is an improved **D**istributed **E**fficient **C**lustering **A**pproach [22]. The basic difference between the HEED and DECA is how the nodes take the decision and the score computation. The following are the phases of this DECA protocol:

(1) Start Clustering: In the initial phase all the nodes will compute its score with the help of the function score=w1E+w2C+w3I. E represents the residual energy, C represents node connectivity, and I represent node identifier. After some delay time the score value will be given to the neighbouring nodes with the node ID and cluster ID if the computed score is a higher value.

(2) Receive Clustering Message: CH is selected by the node if the value of score which it receives is higher than its own score value and it is not attached to any cluster yet.

(3) Actual announcement: After the completion of second phase, when new nodes and already exciting nodes from some other cluster forming a cluster with a new head, the CHs ID, cluster ID and score value should be broadcasted.

(4) Finalize Clustering: This is the same as HEED protocol that the new cluster with its head is finalized for all other nodes

TABLE 1. COMPARISON BETWEEN HEED AND DECA

	HEED	DECA
Selection criteria	Calculation of probability is done by using following formula: CHprob = prob*Eresidual / Emax	Calculation of score is done by using following function: Score=w1E+w2C+w3I.
Choosing CH	CH is selected according to level of residual energy and cost incurred during communication.	CH is selected by the node if the value of score which it receives is higher than its own score value and it is not attached to any cluster yet.

F. TEEN

In [18], the author proposed a protocol named as Threshold sensitive Energy Efficient sensor Network protocol (TEEN). TEEN is a cluster-based hierarchical routing protocol like LEACH i.e. the nodes form clusters and then form higher levels so that the sink node is reached. It merges hierarchical technique and data-centric approach. Transmission of data is done less frequently so to save energy efficiently, it usually works in reactive mode. In this scheme, the sudden changes in sensing features/attributes of sensors like temperature are monitored. Transmission of data is done less frequently so to save energy efficiently, it usually works in reactive mode.

Two Thresholds are used to monitor the sensing changes:

(1) Hard threshold: The value of sensing attribute which triggers the node to send data if value exceeding HT

(2) Soft threshold: The value of sensing attribute which triggers the node to send data if value have small change in value of threshold.

Nodes send the sensing data only if the value of attribute exceeds HT or the value's change is bigger than ST.

G. EECS

In [19], the author has proposed a protocol named as An Energy Efficient Clustering Scheme in Wireless Sensor Networks (EECS). EECS is modification in LEACH protocol which is based on clustering. It operates in single hop mode between CH and BS. In each round, nodes compete with each other to become CH and for this purpose all nodes advertises their residual level of energy to all neighboring candidates. Node becomes CH, if it does not find a node having more residual energy than its own. Difference between EECS and LEACH is because of EECS's dynamic sizing feature used in clustering. Dynamic sizing, distance between cluster and BS is calculated.

Usage: Mostly used in applications where data is gathered periodically.

H. DWEHC

DWEHC [15] is an extension of HEED protocol. In Distributed Weight-based Energy-efficient Hierarchical Clustering protocol, multi-level structure is build for communication purposes between nodes. Clusters are build in such a way that the sizes of all clusters are balanced and there is no assumptions on network density. This protocol uses location awareness among nodes for optimizing the inter-cluster topology. Each node is implemented individually and the algorithm ends after execution of some iteration in a distributed manner.

Each node computes its weight using following formula:

$$W_{weigh}(n) = \frac{E_{residual}(n)}{E_{initial}(n)} \times \sum \frac{R-d}{6R}$$

where Eresidual(n) represents residual energy, Einitial(n) represents initial energy of node n, R represents the cluster range. Cluster range is the distance of node from the cluster head inside a cluster, and d represents the distance between node n and the neighboring node say 'u'.

I. EEPSC

Amir Sepasi Zamati et. al. proposed [19] An Energy Efficient Protocol with Static Clustering for Wireless Sensor Networks enhancing LEACH. It is a dynamic clustering protocol based on the LEACH. In this, node is chosen as CH temporary first of all, and then it helps in choosing the best CH for network and hence increases lifetime of network. It has 3 phases:

(1) Setup Phase: In this scheme, the desired no. of clusters is set initially, say 'k'. BS sends k-1 messages to sensor nodes of network through different transmission channel. Now, nodes who hear message k=1 will take 1 as their cluster id and so on for all 'k' (k=1,2,3…. k-1). Nodes which do not join any cluster, they will set 'k' as their cluster ID and will inform to BS using CSMA for sending JOIN-REQUEST message. For sending data, nodes uses TDMA based schedule and they can only send data in their respective scheduled time slot. It reduces collision so that energy can be preserved which will enhance the network lifetime in return.

(2) Selection Phase: In this phase, all nodes sends their level of energy to temporary CH, then T-CH compares residual energy levels of all nodes and choose the node as CH for that particular cluster which has highest energy level and node as T-CH which has lowest energy level for next round.

(3) Steady State Phase: In this phase, all nodes sends their collected data to CH and CH receives data, aggregates data and computes data so that only the important data must be selected for transmission to BS directly.

J. EEEPSC

S. K. Chaurasiya et. al.[20] proposed a scheme named as An Enhanced Energy Efficient Protocol with Static Clustering (EEEPSC) based on EEPSC. In this scheme, the main motive is to minimize intra-cluster communication overhead of EEPSC. It enhances the EEPSC by focusing on the highest residual energy level and relative location (approx. centrally in cluster) of the node while selecting as CH. It has 3 phases:

(1) Setup Phase: In this scheme, BS calculates the mean location (L$mean_i$) of node of every cluster having unique id say 'i' and mean distance to every node (d$mean_{ij}$).

(2) Selection Phase: In this phase, node having highest residual energy, Eresidual(s) and smallest mean distance is selected as CH. The node which is having second highest residual energy is selected as T-CH for next round in each cluster.

(3) Steady State Phase: In this phase, all nodes sends their collected data to CH and CH receives data, aggregates data and computes data so that only the important data must be selected for transmission to BS directly. *This scheme improves the no. of messages received by BS as compared to EEPSC.*

XI. COMPARISION

There are many differences in discussed routing schemes whether on basis of choosing CH or choose hop mode for communication with BS. Let us focus on quick to see comparison of these schemes via following table:

TABLE II ***COMPARISON OF PROTOCOLS***

PROTOCOL	SINGLE/ MULTI HOP	STATIC/DYNAMIC ROUTING	MAC PROTOCOL	ENERGY EFFICIENCY
LEACH	Single hop	Dynamic	TDMA	Very low
LEACH-C	Single hop	Dynamic	TDMA	Low
HEED	Multi hop	Dynamic	NA	Moderate
TEEN	Multi hop	Dynamic	NA	High
EECS	Single hop	Dynamic	CSMA	Moderate
EEPSC	Single hop	Static	Csma/tdma	Moderate
EEEPSC	Single hop	Static	Csma/tdma	High

XII. ADVANTAGES/DISADVANTAGES

TABLE III ADVANTAGES AND DISADVANTAGES OF PROTOCOLS

Protocol	Advantages	Disadvantages
LEACH	• Low Energy • Adhoc	• Not applicable to large networks deployed • Due to single-hop routing in intra and inter-clustering communication • Cluster head selected randomly • Difficult to optimize random selection
LEACH-C	• Produces better clusters • Requires less energy for data transmission	• Overhead
LEACH SUB-CH	• Increase lifetime by using a supplement sub-CH for the situation when CH will be die.	• Extra efforts for selection of CH

HEED	• Overcomes dis of LEACH random selection of cluster head • Heterogeneous sensor nodes	• Leave some uncovered nodes. • Forcing nodes to make them CH • More chs are generated than the expected number • Unbalanced energy usage in the network • Cluster heads near the sink have more work load so die early • Overhead occurs
TEEN	• Controlled data transmission • Transmission of only the sensitive data • Reduces the energy transmission usage.	• Limited implementation area, may not be applicable to applications like periodic reporting since data may not be available at all because of threshold condition. • The data may lose if there will no communication range available for chs
EECS	• Mostly used in periodical data gathering applications	• Consume more energy and more overhead because of single hop networks if distance is longer between chs and BS. • More complexity overhead
EEPSC	• Reduce collision which in turn improves the network lifetime • Removes complexity overhead	• Consume more energy when node residing on the boundary with utmost energy is selected as CH than the node in that cluster. • Intra-communication overhead • Thus energy is more consumed will lead to early dead nodes.
EEEPSC	• Improves the lifetime due to dynamic nature • More messages received by BS as compared with EEPSC	

XIII. CONCLUSIONS

Sensor network routing has gained large attention in the recent years. In comparison to traditional data routing in wired networks it has introduced unique challenges. In this survey paper, the clustering routing protocols for WSNs from the work researched are discussed. Each routing protocol has its own positive and negative points, which are discussed in this paper in detail. As the energy is very important factor of routing in WSN for the lifetime of network, its efficiency, its connectivity with base station, and moreover to fulfil all requirements of application area of WSN, it is necessary to give a light on energy efficiency routing techniques more.

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