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A Comparative Study of Clustering Routing Protocols in Underwater Wireless Sensor Networks

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Abstract
Underwater wireless sensor networks have acquired a lot of consideration of research. About two third part of our earth is occupied by water. Underwater wireless networks are used for exploration of resources, collection of data under the water, detection of flood, strategic surveillance systems, and unmanned underwater automobiles. In underwater wireless networks, nodes are there which are deployed under the water and on the surface. Limited energy of sensor nodes has an important consequence on underwater sensor network. Reliability and energy consumption are important issues in underwater sensor networks.
The main motive in underwater sensor networks is to activate the nodes having inadequate battery power for a long time. It has been a crucial issue to design an energy efficient technique for reduction of energy consumption of underwater sensor network. Clustering method is used to save energy in UWSN. In clustering technique whole network is divided into various subparts called clusters, where each cluster consists of one controller node called as cluster head node. LEACH (Low Energy Adaptive Clustering Hierarchy) is the basic hierarchical clustering routing protocol used for conservation of energy. LEACH protocol is self-organizing hierarchical clustering routing protocol that allots energy evenly on all sensor nodes in sensor network. Energy consumption is avoided using cluster head and data aggregation method.

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1. Introduction

With universal network technology's commercialization in the 21st era, people around the world accomplished network connection using optical or electric media on terrestrial, and a radio communication or cables in the air. People also achieved network connections in oceans since oceans occupy about two third part of global area. Underwater sensor network technology becomes a worldwide research focus nowadays. Underwater wireless sensor networks are used in underwater environment monitoring, disaster prediction in ocean, detection of targets, military defense, tactical surveillance and so on [1][2].

These sensor nodes have battery power which is limited and it is not possible to recharge batteries under water. How to balance node energy consumption is key of underwater wireless sensor networks [3].

In terrestrial sensor networks various type of routing protocols are used for communication. Due to some specific properties of medium under the water some terrestrial routing protocols are not used for underwater sensor networks.

Various challenges that occur in development of effective routing protocols for underwater sensor networks are [4][5][6]:

- High propagation delay
- Mobile nodes
- Error rate in underwater networks
- Limited energy
- Limited Memory
- Harsh deployment environment

1.1. Underwater Clustering Features

1.1.1. Attributes of Clustering

All clustering protocols have some unique architectural and topological properties. Best clustering protocol can be chosen by analyzing these attributes [7]:

- Number of clusters: In densed deployments, cluster head selection is dynamic in nature while numbers of clusters are predetermined in sparse deployment due to energy constraints in this environment.
- In-cluster link: In sparse environment multi-hop technique is used for data transmission while both single hop and multi hop methods are used in densed environment.
- Role of Cluster Head: If there is monitoring or surveillance in an application then cluster head initially fuse all data because in such type of application lot of data is processed and then transmits it to next phase.
- Goal of clustering: Energy conservation is main issue in sensor network, mostly clustering algorithm focus on to save energy. There are various secondary objectives of these clustering algorithm like to increase network lifetime, every clustering technique also has other objectives like, to increase network lifetime, to achieve high throughput by avoiding hotspots, packet collision reduction, balance of network traffic, enhancement of cluster heads and minimization of packet.

1.1.2. Performance Constraints

Efficiency of a clustering protocols can be measured on the basis of following constraints:

- Cluster reliability: This parameter states about connection status of a cluster node. A node is stable if it is connected to other nodes in cluster otherwise it is adaptive in nature.
- Delay efficiency: In multi hop architecture there is more delays as compared to single hop architecture because in multi hop every hop will create delay so the whole system will produce high aggregate delays.
- Load balancing: In heterogeneous networks, one special node is selected as controller head so there is need of load balancing. In acoustic sensor networks, energy is applied externally so there is no need of load balancing.
- Data reliability: Signals that are transmitted affect reliability of data. When radio frequency is chosen as communication media the water salinity will reduce data reliability. Line- of-sight signal propagation in under water free space optics communications affects data reliability.
- Energy efficiency: This is very important parameter in underwater sensor network, since it will decide the lifetime of network specially using acoustic method. Sensor node's topology

also affects energy consumption in network. Energy consumption is less in case of communication using magnetic induction; as attenuation is these signals is less.

Recently cluster-based routing protocols have attained much consideration in both global and underwater wireless sensor networks, since these protocols can reduce energy consumption, increase the capacity of sensor nodes and also help in enlarging network coverage [8].

Various protocols are there that are cluster based which are also energy efficient. Basic of all these protocols is LEACH protocol. Main motive of this protocol is to provide reliable and efficient communication between the sensor nodes in the network [9]. LEACH is single-hop adaptive clustering routing protocol which saves energy as compared to non- clustered protocols. This protocol falls under hierarchical routing protocol. This protocol randomly distributes energy load in the network [10] [11][12].

1.2. Objectives of Clustering Routing Protocols

A clustering routing protocol is intended to achieves various objectives simultaneously or a single objective [13]. Efficiency of network is measured by the objectives of technique. Various objectives are explained below:

1. Energy Consumption

This is most critical objective in sensor network, clustering protocols are mainly used for energy conservation and to increase life time of complete network. In sensor network most of the energy is used up when data is transmitted from various nodes to base station node. So, in clustering technique first of all data is aggregated at cluster head node and then this aggregated data is sent to base station. When there is direct transmission of data between various nodes and sink node then there is more energy consumption [13][14]. For optimization of energy consumption various techniques are used in clustering techniques which are listed as below:

a. Cluster head duty rotation
b. Hierarchical clustering
c. Balancing of clusters

2. Load Balancing

This is the another most significant objective of clustering technique. High load in network results in unbalanced energy consumption, loss of data, congested network etc. So, divide and conquer procedure is used for transmission of data from nodes in clusters to base station node. A balanced amount of data is transmitted to base station node to support load balancing [13][15].

Some methods are used to balance load in network, these are:

a. Balanced Clusters
b. Congestion Control
c. Balancing of energy consumption

3. Quality of Service

This factor depends on various other aspects, such as network throughput, delay, optimization of jitter etc. this factor has been a very challenging issue in underwater network [14]. There are various solutions which will help in increasing quality of service in network, three of them are listed below:

a. By increasing reliability
b. By minimizing delay
c. By preventing jitter

4. Connectivity

This is very challenging issue in underwater network that should be considered in improving lifetime of network. Reliability of network is directly proportional to connectivity, when node connectivity increases then reliability is increased automatically. When network is divided into various clusters then connectivity is improved since each node has at least one connection to other nodes. So, by improving coverage in network, connectivity is increased [13].

5. Fault Tolerance

Node's failure in sensor networks depends on various factors. By using clustering techniques, faulty nodes can be found out and stability is maintained in network.

Failure in nodes connection can happen due to battery depletion. There are various physical and environmental factors of connectivity failure. If connection to cluster head node is lost then transmitted data also get lost. Various fault tolerant techniques are used to avoid such situation in network in which faulty nodes are replaced by other new nodes [13][15].

6. Management of Mobile Nodes

This is very challenging issue in underwater environment as node can move under the water due to water current. This factor can cause various problems like connectivity loss, no reliability, no stability etc. Using clustering whole network is divide into various subnetworks to reduce localization overheads. In clustering techniques mobile sink nodes are used to improve efficiency in network [13].

This paper is organized as follows: In section 2 related works of routing protocol used in Underwater sensor networks is discussed. In section 3 various clustering routing protocol are discussed and their performance is compared. In section 4, conclusion and future work is discussed. References are discussed in last section.

2. Related Work

Many researches have been conducted by various researchers on underwater wireless sensor network on the subject of energy conservation. Dario pompilid et al. [16] designed a cross layer protocol for under-water wireless network, this protocol consists of following features: (i) inter communication of various components of underwater communication network, such as modulation, media access control, routing. (ii) network bandwidth is shared efficiently by sensor nodes. Experimental results shows that this protocol helps in improving energy efficiency.

Nadeem Javaid et al. [17] introduced an effective data collecting protocol for enhancing network life-time. This protocol uses an independent automobile for gathering of data and limits the figure of associated sensor nodes for conservationof energy.

Wan et al. [18] proposed an algorithm for inter cluster communication. They used Ns2 simulation tool to implement proposed AUCN algorithm. Comparison is performed between the proposed algorithm and two other protocols, ATP and DEBCR and conclude that the proposed protocol is better than these two in saving energy in the sensor network. Following points are included in this research:

a. Multi-level hierarchical network structure is used.
b. Residual energy is considered to select a cluster head node.

Zhang et al. [19] proposed a novel cluster-based protocol which is based on k- means algorithm. This protocol helps in avoiding unbalanced clustering. Authors have used depth of nodes and density to select a cluster head node. In this paper residual energy is also considered. Multi-hop method is used for transmission of information to the base station. After simulating the method, they concluded that CBKU (proposed protocol) can effectively balance the energy consumption thus improve the lifetime of sensor network.

Majid et al. [20] proposed an energy efficient protocol EBECRP. This protocol uses concept of mobile sinks to balance loads on all sensor nodes instead of depth-based routing technique. Global communication is replaced by locally compressed communication in this protocol. Using simulation method, it is concluded that this protocol achieves more stability.

Huang et al. [21] proposed a routing protocol of underwater network to tackle underwater problems such as low bandwidth, more propagation delay, mobile sensor nodes, more power consumption etc. Authors have used forward node selector and forward tree trimming method for prevention of excessive spread of forwarded packets. Fuzzy logic inference and decision tree methods are used to determine the receiver sensor node. Authors have concluded that proposed protocol is better than others protocols in terms of conservation of energy, high packet delivery ratio and also there is less end-to-end delay.

Guangzhong Liu, and Changye Wei [22] proposed an energy effective protocol termed as HMR- LEACH protocol. Authors have used multi-path and multi-hop method instead of one hop method to transmit the data. Authors also consider energy and distance factor for the selection of transmission path. Using simulation method, it is concluded that HMR- LEACH protocol is better than basic LEACH protocol in terms of energy conservation and in increasing network lifetime.

Goyal et al. [23] proposed a new technique, Intra and inter cluster communication (IICC) for information collection. Authors have used fuzzy logic technique for the selection of cluster-head. Authors also used smallest route clustering protocol for intra-cluster communication. Hierarchical multi-path routing scheme is used for inter-cluster communication. Using simulation methods authors have concluded that IICC method advances the performance of under-water network in case of end-to- end delay, utilization of energy and packet delivery proportion.

Mari Carmen [24] introduced a new energy efficient routing protocol DUCS **(**(Distributed Underwater Clustering Scheme). This protocol does not consider flooding method to minimize the exchange of proactive routing message. Author has used data aggregation method reduce the redundant information. Author consider random node mobility technique

to compensate the high propagation delay in underwater environment using a frequently adjusted timing united with guard time- values to diminish data loss. Using experimental technique effectiveness of proposed protocol is discussed.

Azam et al. [25] proposed a sparsity-aware new energy efficient routing protocol authors have divided whole network into various subregions of equal size. This protocol specially designed for sparse region. Authors used sparsity search engine and density search engine algorithms to divide the network into sparse and dense area. Authors have considered mobile sink in sparse area and clustering in dense area. This protocol achieves stability in network due to formation of optimal number of clusters in dense region. Routing hole problem is also removed in this protocol.

Climent et al. [26] presented a complete view of underwater wireless sensor network by analyzing physical, MAC and network layer. Various challenges are discussed in physical layer for the implementation of composite algorithms and modulating low energy and low-priced micro-controllers. T-Lohi protocol in MAC layer is discussed. This protocol implements new characteristics, like low energy wake-up mechanisms.

Authors also discussed various challenges in MAC layer, like localization and synchronization. In network layer various routing protocols are discussed, out of them some are energy efficient. Authors also summarized various security threats in these three layers of UWSN architecture.

Khan et al. [27] proposed Energy Efficient Routing for UWSNs- A Clustering Approach (EERU-CA) routing protocol. Idea of cluster head is used in sensor network. Initially head node is selected out of all sensor node based on some properties, if head node is not selected then neighbor method is used to transmit the data. CDMA method is used as an access protocol. Authors have concluded that this protocol is better in case of energy consumption and node dead ratio than other protocols.

Nam and Sunshin An [28] proposed an energy efficient and delay decreasing routing protocol. This protocol aggregates data on the basis of energy. Authors used dynamic clipping and grafting function to reconfigure the aggregation tree. A temporal path is built up from sources to sink node. Authors concluded that this protocol is better in case of reduction of energy consumption by minimizing the number of data transmission and decrease in delay due to automatic movement of aggregation point.

Wahid et al. [29] proposed EEDBR (energy efficient depth-based routing protocol) protocol. This protocol exploits the idea of depth of nodes to forward the information. Authors have used concept of residual energy to increase sensor network lifetime. NS2 simulator is used to evaluate the result of this protocol. Authors have concluded that this protocol helps in improvement of network lifetime, reduces energy consumption and also decrease end to end delay.

3. Clustering Routing Protocols

The hierarchical routing-based clustering protocol is very efficient technique usedto conserve energy in both terrestrial sensor networks and underwater wireless sensor networks. The main motive of clustering protocol is to extend the lifetime of sensor network. In this section initially LEACH protocol is discussed which is basic clustering protocol and after that its descendants are discussed in brief.

3.1. LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH protocol was introduced by Hienzelman in 2000 as the first clustering routing protocol. Both energy efficiency and media access control factor are introduced in this protocol to increase system lifetime and latency.to distribute energy evenly to all nodes in whole network, cluster head node is selected randomly [10][12][22].

Various mechanisms like fusion of data, sleep and wake up of nodes are used to improve network lifetime and reduce energy consumption. System lifetime is increased by 15% in LEACH protocol as compared to multi-hop and static clustering algorithm. LEACH is single-hop adaptive clustering routing protocol which saves energy as compared to non- clustered protocols. This protocol falls under hierarchical routing protocol. This protocol randomly distributes energy evenly on all sensor nodes in network [11][12][30][31]. Sensor nodes in sensor networks are grouped into clusters and each cluster has its coordinator node called as Cluster Head (CH). Energy consumption is more in cluster head node than other nodes in cluster. The node in monitoring area of sensor network will send data to controller node and then the head node will forward all the collective data to the Base station node [11].

3.1.1. Characteristics of Leach Protocol [11][12]

1. The organization and synchronization in the clusters is restricted in the set-up phase.
2. There is rotation in role of cluster head node and energy is distributed randomly among all nodes in the whole network.
3. Local compression mechanism is used in the head node of cluster to reduce the total sum of data transmission.
4. LEACH protocol is appropriate for homogeneous sensor networks.

3.1.2. Phases in LEACH Protocol [11]

LEACH protocol functioning is divided into various rounds and each round consist of two phases: (a) Set-up phase (b) Steady-state phase

To reduce energy utilization first stage is more time consuming than second stage [32].

a. Setup Phase

In this phase all sensor nodes are divided dynamically into various clusters and a head node called as Cluster- Head node is selected randomly among all sensor nodes in each cluster.

During clusters formation every node in network randomly choose a number between 0 and 1 and based on this selected value a threshold value is calculated. After that on the basis of threshold cluster head node is selected. The node whose selected value is less than threshold value is selected as cluster head node.

Threshold value is calculated by using the following formula:

$$T(n)=\begin{cases}\dfrac{P_t}{1-P_t\cdot(r\cdot \bmod \frac{1}{P_t})}, & if\ n\in G\\ 0, & otherwise\end{cases}$$

Whereas:

T (n) = Calculated threshold value Pt= Percentage value of cluster heads R= Round number

G= Number of sensor nodes that have not been elected as cluster head in previous 1/Pt rounds.

After cluster- head nodes selection in network, an advertisement message is broadcasted by each cluster-head node. These messages are perceived by all nearby nodes and they will connect to their respective cluster-head node in their respective cluster.

If there exist more than one cluster-head node in one cluster then in that case sensor nodes can select any one of them as their controller node based on received signal indication. Each sensor node in cluster sends a request to join in the cluster along with its ID to its respective cluster-head node using CSMA (carrier sense medium access) technique. After this phase each cluster head has information about all its member nodes and their respective ID no [33].

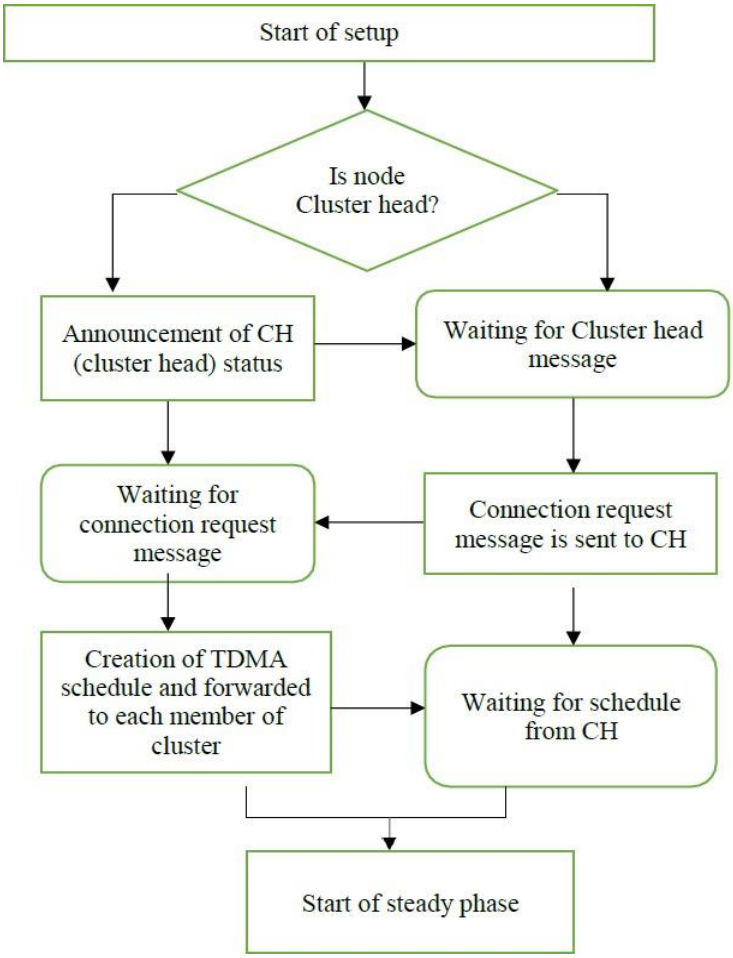

Figure 1: Set up phase in LEACH [33]

b. Steady State Phase

In this phase inter and intra data transmission is there. Each node in a cluster sends its data to its corresponding controller node or head node. After that head node will aggregate all data and then forward it to the base station more consumption of energy is at head node than other nodes in a cluster because aggregation of data and communication to base station is done by this node [33].

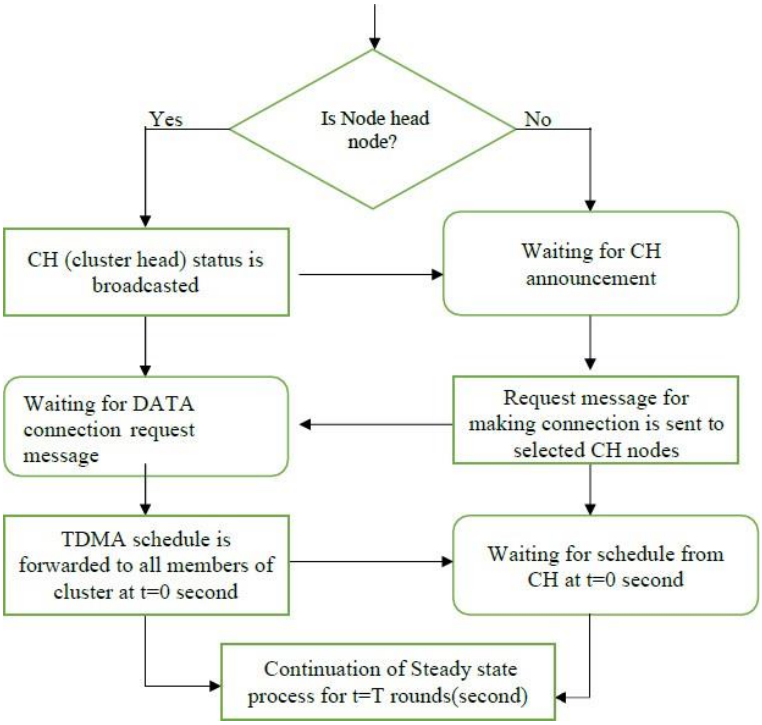

Figure 2: Steady State Phase in LEACH [33]

3.1.3. Advantages of LEACH [12][34]

- Energy distribution is even in this protocol.
- This is hierarchical routing protocol of network layer that use clustering technique to save energy.
- Every node in this gets a chance to be elected as head node since cluster head is selected randomly on the basis of probability.
- In each cluster, communication of nodes is with the corresponding head node so coordination and control maintenance are easy.
- Minimum data redundancy is there since data collection is only at cluster head node.

3.1.4. Disadvantages of LEACH [30][34]

- Every node in cluster has no information about other nodes location and how many numbers of cluster head are present in a cluster.
- Since cluster head location is not known so lots of energy is wasted to find out its location.
- Since cluster-head node has to do more tasks like receiving of data, sending the data to base station and overhearing so this node dies earlier than other nodes.
- Single hop routing scheme is used that result in more energy consumption.
- This protocol does not work when there are multiple base stations.
- Dynamic clustering result in extra overhead.
- This protocol works better in case of static nodes but in underwater environment all nodes are mobile.

3.2. Motivation behind Modification of LEACH Protocol [35]

1. There is requirement of a new cluster head node in each round of cluster development which

leads to redundant overhead and lots of energy is wasted. To remove this disadvantage of LEACH protocol there is need of some change in cluster head node in each round. This change can be done by using leftover energy of currently active cluster head node. In underwater wireless sensor network environment, more energy is consumed than terrestrial network so there is need of efficient cluster head replacement algorithm.

2. In LEACH protocol equivalent amplification energy is used to transfer the data without consideration of the gap between the sender and receiver. So, in order to decrease the energy consumption there should be some approach to specify required amplification energy for communicating with cluster head node or the base station node.
3. LEACH protocol uses a simple energy model and it is limited. It does not consider transmission error which results in unexpected analysis result.

3.3. Improvement of Leach

3.3.1. E LEACH:

This protocol is based on LEACH protocol to decrease the energy consumption in sensor networks. Energy is balanced evenly to all sensor nodes in this protocol. This protocol also uses clustering approach for conservation of energy. Number of head nodes in clusters is the main key factor that affects energy consumption in network. If we increase the number of cluster head then it will result in high consumption of energy since more energy is consumed when there is transmission of data from head node to sink node than transmission between nodes in cluster to cluster-head node. If we decrease cluster heads then each cluster head node has to cover large region this will also result in problem that some cluster members go far from head node and will consume more energy. So, this problem of selection of cluster head node is removed in E-LEACH protocol by using minimum spanning tree algorithm between cluster heads nodes [35].

3.3.2. M-LEACH (Multi-hop LEACH)

In basic LEACH protocol there is single hop communication between cluster heads nodes and sink node which will increase more time of communication and more energy is consumed. In M-LEACH protocol this disadvantage is removed using multi-hop technique. This protocol is efficient when there is large area of sensor network. In M-LEACH protocol, cluster head sends data to relay station and then this relay station aggregates all data from all cluster-head nodes and send it to the sink node. This protocol is distributed hierarchical clustered routing protocol [35][36].

3.3.3. C-LEACH (CELL-LEACH)

In this whole network is divided into various cells which are hexagonal in shape. Sensor nodes are present in every cell. Seven cells form a cluster and every cell has its own head node and remaining nodes are called cell members. Each cluster which is made from seven cells has its controller node called cluster head node. There is random change in cell head nodes and cluster head nodes in each round. A time schedule is allocated to all cell head using TDMA. Cell members can send data during this allocated time only. And during this transmission of data entire cell is turned off except the node which sends data to the head node. All cell head nodes aggregates data and send it to the respective cluster head node.

After that this aggregated data is transmitted to sink node. This protocol is useful in large network area. It is highly energy efficient as compared to LEACH protocol but due to two type of head nodes, complexity of this protocol also increases [35][36].

3.3.4. LEACH-M (Mobile LEACH)

In basic LEACH protocol there is mobility issue which is overcome in this protocol. In both phases of working of this protocol, mobility is provided to all nodes including head node in a cluster. Node position is calculated by using GPS process and all nodes are assumed homogeneous. Head node is chosen on the basis of mobility and attenuation, the node having minimum mobility and less attenuation is chosen as head node. After cluster head node selection, status of this is broadcasted to all nodes in cluster [36][37].

3.3.5. LEACH-L (Energy Balanced Low Energy Adaptive Clustering Hierarchy)

This protocol is also multihop routing protocol used in large network. When sensor nodes are near to sink node then in this case cluster head directly communicate to sink node. But when sink node is far from all sensor nodes then communication take place by using multi- hop technique. This protocol also works when all sensor nodes are having different frequencies and different frequency gap. In each round of communication there is reestablishment of clusters and so a new cluster head is chosen in each round. So, network load is distributed evenly among all sensor nodes and this balance will help in energy conservation [37][38][39].

3.3.6. I-LEACH (Improved LEACH)

In I-LEACH protocol two adaptation are done in basic LEACH protocol, these are:

i. Detection of twin nodes
ii. Assignment of sub cluster head nodes.

The nodes whose are located close to each other are named as twin nodes. These nodes will intellect the same information. So, if both are in active state then more energy consumption is there but if we put one node in sleep node then energy is saved. In this protocol there is uniform distribution of cluster head node so it will also conserve some energy for longer distance of transmission. Also, threshold value is maintained by every head node in each cluster [40] [41].

3.3.7. LEACH-F (Low Energy Adaptive Clustering Hierarchy- Fixed no of Cluster)

In this protocol clusters are created in the initial phase and these are fixed. All working except this is same as basic LEACH protocol. The main advantage of this protocol is that there is no set-up overhead in each round. Centralized cluster formation algorithm is used for cluster formation. Main drawback of this protocol is that it is not possible to add new nodes in the network and if any node dies then its behavior is not adjusted in this [42][43].

3.3.8. LEACH- C (Centralized LEACH)

In this protocol centralized clustering algorithm is used for achieving a better distribution of nodes and similar clusters size. In the initial phase each node in the network sends its location information and available energy to the base station node. Base station node then calculates

the average available energy of the network. The nodes whose residual energy is below than this average value cannot become cluster head node in next round [35][36].

Table 1: Performance Comparison between LEACH Protocol Descendants

Routing protocol	Year	Classification	Scalability	Mobility	Hop-count	Energy-efficiency	Homogenous	Requirement of location information
LEACH	2003	hierarchical	Limited	Fixed Base station	Single Hop	High	Yes	No
E-LEACH	2007	hierarchical	Good	Fixed base station	Single Hop	Very high	Yes	Yes
M-LEACH	2007	hierarchical	Very good	Fixed base station	Multi Hop	Very high	Yes	Yes
C-LEACH	2012	hierarchical	Excellent	Fixed base station	Single hop	Very high	Yes	No
LEACH - M	2008	hierarchical	Good	Mobile Base station and nodes	Single Hop	Very high	Yes	Yes
LEACH - L	2008	hierarchical	Good	Fixed base station	Single Hop	Very high	Yes	Yes
I-LEACH	2009	hierarchical	Very good	Fixed base station	Single Hop	Very high	Yes	Yes
LEACH - F	2002	hierarchical	Limited	Fixed base station	Single Hop	Very high	Yes	Yes
LEACH - C	2002	hierarchical	Limited	Fixed base station	Single Hop	high	Yes	Yes

Table 2: Comparative Analysis of Merits and Demerits of LEACH and its Descendants' Protocols

Reference	Protocol name	Merits	Demerits
[9-12] [22][30][31]	LEACH	No requirement of control information in cluster, Each node has equal probability to be cluster head	If cluster head node dies then cluster become useless, Cluster heads are unevenly distributed.
[35-36]	E-LEACH	Cluster head node is selected based on energy threshold value i.e. no random selection of cluster head	Uneven cluster size and load balance in the network.
[35][37]	M-LEACH	Multi-hop technique is used in clustering, Useful in large area of sensor network	Not suitable in heterogenous network.
[35,41]	C-LEACH	Useful in large network coverage area.	More complex in structure due to two types of head nodes
[36]	LEACH-M	No mobility issue	All nodes are considered homogenous,
[34]	LEACH-L	This protocol also works when all sensor nodes are having different frequencies and different frequency gap, Network load is distributed evenly among all sensor nodes	There is requirement of location information by each node in network which becomes very complex and costly.
[41]	I-LEACH	Useful in longer distance data transmission, Twin nodes detection	There is requirement of location information of each node by base station node which increases complexity in the network.
[42-43]	LEACH-F	No set-up overhead at beginning of each round.	Not possible to add new node in the network.
[35-36]	LEACH-C	In this protocol, the complete process is managed by base station node so it is very energy efficient.	Every node use GPS for location information which is very costly and also it consumes extra energy. It is less scalable protocol.

4. Future Challenges

In this section, numerous open research issues in designing energy efficient routing protocols have been deliberated which should be considered for the future work on under- water sensor network. If there is any failure then there must be self-configuration of routing in network. In underwater environment for time critical applications, routing protocols must afford strict or loose latency bounds.

In summary, future work in this area should think about insight procedures, QoS, node flexibility and security. In case of mobile nodes, new routing protocols are expected to deal with the recurrent network topology variations besides to certify consistent delivery.

5. Conclusion

In both underwater and terrestrial wireless sensor networks each sensor node is power driven by a limited energy source. Energy consumption is a significant issue that should be taken into account in order to build mechanisms that will help in increasing the lifetime of entire networks. Energy efficient routing protocols will help in balancing the energy load in sensor networks which will increase the lifetime of sensor network.

The main motive of this paper is to discuss various clustering routing protocols based on LEACH protocol. These routing protocols helps in balancing and managing the energy in underwater sensor networks. LEACH algorithm is basic energy efficient hierarchical clustering routing protocol which helps in reduction of energy consumption by controlling data transfer. This protocol is suitable in dealing with the energy requirement however some improvement is as yet required. There are various drawbacks of LEACH protocol and these drawbacks are overcome by its descendants.

Various versions of LEACH protocols have been discussed in brief and their performance are compared with classical LEACH protocol. From this study it is concluded that there is need to explore more robust, reliable and energy efficient protocols in future for underwater sensor networks.

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