A Grid Clustering Algorithm For Underwater Wireless Sensor Network Using Control Information

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Abstract

Underwater wireless sensor network (UWSN) is an important emerging research area in wide range of application, unlike the terrestrial network it uses the acoustic signal which has a unique characteristics like limited bandwidth, high and variable propagation delay, transmit energy, minimum network lifetime and so on. This paper proposes an efficient clustering algorithm having 3D-GRID network architecture and it uses limited control information for data gathering to improve the energy efficiency of the network. The GRID clustering method supports 3D deployment based on geographical location of the sensors which has cluster heads (CH) and non cluster heads (NCH). All the cluster heads are present in the center of the network and all the non-cluster head nodes are in minimum distance to the cluster head. This network structure helps to avoid the control packets for intra communication. For inter communication the CH data packet contains the control packet for route establishment and data transmission. Thus this technique reduce the usage of energy while communication and improve the lifetime of the network.

Keywords: UWSN, Acoustic Signal, clustering algorithm, GRID network architecture.

1. Introduction

Recent research on both academic and industry is based on underwater systems for monitoring the underwater environment and gathering information. Underwater wireless sensor network is created by collaboration of several nodes and acoustic modem that establish and maintain a network using bidirectional acoustic links. Every node has the capability to send/receive the messages from/to any other nodes in the network. Each node contains more sensors for monitoring process.

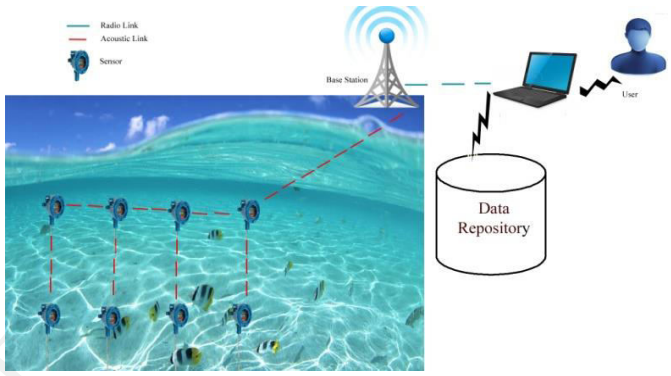

Fig 1: Underwater Wireless Sensor Network

Unlike the terrestrial network, UWSN uses the acoustic waves for communication. The terrestrial network uses the radio frequency which is not suitable for conductive seawater because the RF provide low frequencies about 30-300Hz and it is attenuate within few meters. It needs large antenna and high transmission power. The acoustic signals offers longer ranges and it operates below 30 KHz.

For using the acoustic signals in UWSNs, it is essential to have a description about the main aspects involved in the propagation including: (a) the propagation speed of underwater is about 1,500 m/s and thus the communication links will be suffer from large and variable propagation delays and quite large motion-induced Doppler effects; (b) phase and magnitude fluctuations escort to higher bit error rates compared with radio channels' behavior; (c) as frequency increases, the attenuation pragmatic in the acoustic channel also increases, leads to serious bandwidth constraint; (d) multipath interference is severe due to surface waves, being a serious problem to attain good bandwidth efficiency.

Major challenges in UWSN system designs:

- Load character of node in network: A sensor node contain sensor probe, an acoustic modem, a controller, storage, battery, and an interface with the controller. Since underwater environment has unique character the design of node is different.
- Resource management: Limited energy resources on node. The power will be consumed more compared to RF channel. Because of dynamic nature of environment the energy will be drained soon.
- Design of node: The battery capacity and density of node will be estimated while manufacturing.

Major challenges to design a protocol for UWSN are:

1. Narrow bandwidth: The bandwidth for UWSN is severely limited
2. Network lifetime: It is based on energy provided to the node and usage of the energy in the network.
3. Deployment: The sensors are deployed sparsely and it may be 2D or 3D.
4. Often failures: Loss of connectivity in the shadow region, node failure because of corrosion and energy, high bit error rate.
5. Propagation delay: It is high since the Propagation delay for Underwater=5 x Radio Frequency (RF) ground.

Node clustering is an effective technique for prolonging the network lifetime. This paper proposes GRID clustering method in 3D deployment based on geographical location of the sensors which has centralized cluster head (CH). All the non-cluster head (NCH) nodes are in minimum distance to the CH hence control packets are not necessary intra cluster communication. For inter cluster communication the CH data packet contains the control packet for route establishment. Thus this technique reduce the usage of energy while communication and improve the lifetime of the network.

2.Related Work

There be a full of thorough cram about the terrestrial network routing protocol LEACH [3], HEED [4] which do not equip for underwater environment since there is an impediment in the underwater like movement of animals, water current etc. Consequently Geographical routing protocol [1] is suited for underwater environment. In [3], It is protocol architecture for micro sensor network which utilizes the randomized alternation of local cluster base stations using prior knowledge of uniform node distribution.

In [4], it periodically selects CH according to a hybrid of the node residual energy and a secondary parameter, such as node proximity. It terminates in O (1) iterations, occur low message overhead, and achieve unvarying CH distribution across the network.

Some recent paper proposes routing protocol for underwater wireless sensor network. In [5], a protocol based on cost metric, a set of non-overlapping cluster is select by minimizing the overall cost of the cluster. It adapts the geographical cluster head distribution in the network and accordingly avoids the creation of hot spots in the region of the uw-sink. It preserves the balance of traffic load between cluster heads and cluster members through periodical re-clustering the sensor nodes in the network.

In [6], a clustering algorithm is proposed based on the geographical location of the sensor nodes for 3-D Hierarchical network architecture. It forms a cluster which has Cluster head at the center and it transmits the data within the cluster and to the above tiers. In [7], it is non geographical routing protocol, it use the control packet of establishing path is carried by the data packet. In [8], it selects primary and backup cluster head so that if the cluster head fails the cluster member can switch over to the backup cluster head. It use minimum total cost for select a set of cluster and thus it improve network lifetime.

3.Information Based Grid Clustering Algorithm

In this section, we introduce an algorithm Information Based Grid Clustering algorithm, 3D-GRID network architecture and it uses the control information for data gathering. It is based on Geographical based routing method. The entire network is divided into three-dimensional grids having 4-tier with the size of 30m*40m*500m. Each grid is considered as cluster. Each cluster contains more than one cluster head (CH). The CH is present in the center of the cluster, so that NCH which is present at last can send the data effectively. At a time only one CH is selected based on Sleep wake pattern. The cluster head will be elected and all other nodes send data to the CH.

The cluster head collect, process and transmits data to other CH and finally to the base station. The CH uses control information for sending the data to another CH and to the base station. The entire

communication process is completed in three phases: (i) Set up Phase, where the cluster head is selected. (ii) Data Gathering Phase, where data are sent to the cluster head by the nodes in the same cluster. (iii) Transmission Phase, where data gathered by the cluster heads are delivered to the base station using control information.

3.1 Network Structure

The entire network is divided into three-dimensional grids having 4-tier with the size of 30m*40m*500m. It is a heterogeneous network. Each grid is considered as cluster. Each cluster contains more than one cluster head (CH). The CH is present in the center of the cluster, so that NCH which is present last can send the data effectively. The horizontal acoustic link is used for intra communication (50m) and the vertical link is used for inter communication (500m).

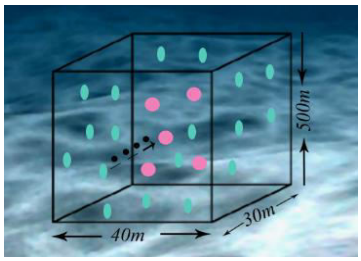

Fig 1: Single Cluster

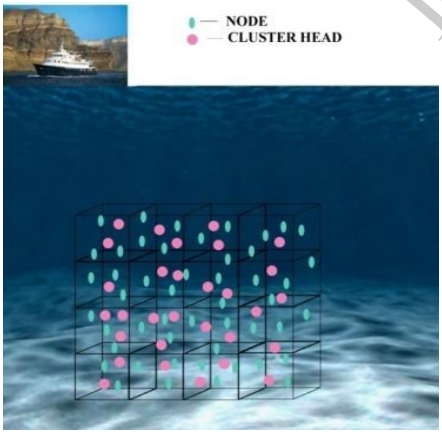

Fig 2: 4-tier network structure

3.2 Cluster Head Formation

Among that multiple CH, the present CH is selected using Sleep Wake pattern. The awake CH send CHADV message contain Node Id and an Integer Count. The NCH waits for some times ADV-WT for receiving all CHADV from all the potential CH. Then the NCH choose their corresponding CH which is having minimum Integer Count. If more than a CH having minimum Integer Count then it chosen the minimum Id. After that the CH waits for CH-JOIN for a period of JOIN-WT. After CH selection the data transfer will be done within the cluster.

3.3 Information Carrying Based Steering

The NCH send the data to CH and CH send it to base station. For intra cluster communication, no need for any control information. For inter communication the route is discovered using the control information.

a) Route Discover

The route discovering packet is carried by the first data packet from source to destination node due to energy constraints. The source check the existing route for destination, if there is not existing route then the packet will send to destination. After getting the data packet the destination send the acknowledgement along with reverse path to the source.

b) Route Maintenance

Each path from source to destination has time property called ROUTE LIFETIME. When the lifetime exceeds the threshold denotes TIMEOUT and inform that the route is invalid. Node uses the same path before threshold the lifetime is reset to “0”.

c) Route Retraction

Route lifetime in routing table exceeds the threshold value the route is discarded. If there is data to send the route rediscovery will be done.

d) Periodic Sleeping

The nodes shut down the transceiver till the next sampling or receiving will be done.

3.4 ROUTING METHOD

The routing packet is defined and the control packet has the size of 13 bytes. The routing table maintains the routing path which is distributed.

a) Packet Format

The destaddr and souraddr are respectively the address of destination node and source node, their length is 2 Byte. The type denotes packet type used to judge the validity of packet and to carry control message, its length is 1 Byte. The length denotes length of packet and occupies 1 Byte. The thisaddr

and nextaddr are respectively the address of medial source node and next-hop node, their length is 2 Byte. The seqNo denotes the sequence number of packet from the same source node and occupies 2 Byte. The hopcount is used to record the hop count passing of node and is 1 Byte.

b) Routing Table Management

Each node of path executes route maintenance and routing table management. A corresponding routing table item of destination address is stored in routing table to implement transmit hop by hop. The routing table is cleared while node initialization. When a new destination node is found, a new table item is added. The routing table stores the address of destination and next-hop node, the hop count from source node to destination node and the route lifetime. The route lifetime is used to clear the routing items unused for a certain time.

c) Transmission of Messages

The criteria for sending and discarding the received packets is determines as follows.

1. Packet type: The type of received packet is predefined. If the type of received packet does not match with the predefined, the packet is discarded.
2. Validation of the final: If the final destination address is valid, then transmit the packet.
3. Reduplicate packet: If the local address is same as the medial source address, the packet is reduplicate and discarded.

This algorithm support one-time transmission for intra communication and continuous transmission for inter communication.

In the onetime transmission manner, the node shuts down the power and waits for the next receiving after node receives a packet no matter whether it transmits.

In the continuous transmission manner, the receiving node judge whether this time of receiving is end according to packet sequence number. The packet sequence number is generated by the source node. The sequence number 0 denotes the transmission is end. The transmission does not start until the receiving is end. Node shuts down the power after transmission.

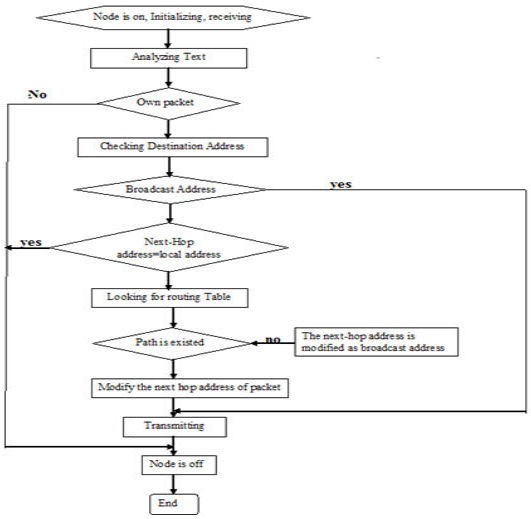

Fig 3: Program flow chart for one time transmission

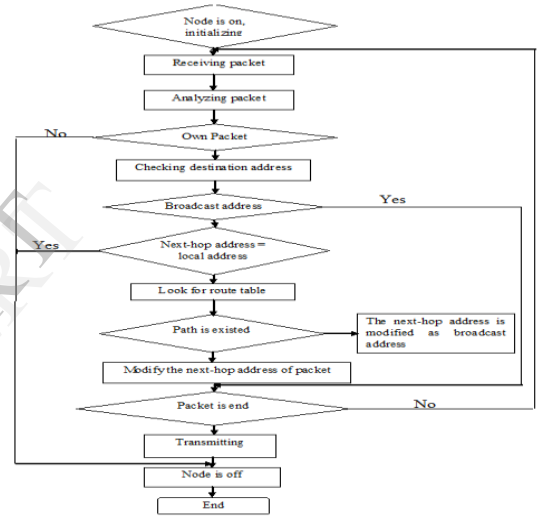

Fig 4: Program flow chart for continuous transmission

4.CONCLUSION

Underwater wireless sensor network (UWSN) uses the acoustic signal which has a unique characteristics like limited bandwidth, high and variable propagation delay, transmit energy, minimum network lifetime and so on. This paper proposes a clustering algorithm having 3D-GRID network architecture and it uses the control information for data gathering to improve the lifetime of the network.

5. References

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