A Survey of Energy Efficient Clustering Algorithms in Underwater Wireless Sensor Networks

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Abstract- Underwater wireless sensor networks (UWSNs) have been showed as a promising technology to monitor and explore the oceans in lieu of traditional undersea wire line instruments. Nevertheless, the data gathering of UWSNs is still severely limited because of the acoustic channel communication characteristics. One way to improve the data collection in UWSNs is through the design of routing protocols considering the unique characteristics of the underwater acoustic communication and the highly dynamic network topology. In this paper, we proposed and discussed different routing protocols for UWSNs. The types of UWSN systems namely, Dynamic programming approach (DPA), Asymmetric Multi-path Division Communications mechanism(AMDC), GEographic and opportunistic routing with Depth Adjustment based topology control for communication Recovery over void regions (GEDAR), and Quality of service Aware Evolutionary Cluster based Routing Protocol. This paper presents a Literature survey of the algorithms explaining the concepts of energy efficient with optimization routing and network operation.Various routing algorithms have been studied by authors to improve the network performance and minimize the energy consumption.

Keywords- Underwater sensor network, Energy allocation, Clustering, dynamic programming, AMDC, GEDAR, QERP.

I. INTRODUCTION

Wireless Sensor Networks have been associated in numerous respects including wellbeing observing, ecological checking, military applications, and numerous others as Internet of Things [1]-[5]. Energy effectiveness has turned into the most key issue for WSNs. Be that as it may, control supplies for sensor nodes are constrained and difficult to supplant. Additionally, differentiated and distinctive nodes, nodes near the base station (in like manner called the sink) exhaust more energy, since the nodes exchange the data assembled by sensor nodes a long way from the sink. From this time forward, when these sensors near the sink fall flat, the data assembled by various sensors can't be traded to the sink. By then, the entire framework winds up right on time, in spite of the fact that a vast part of the nodes can even now have an extensive proportion of energy. In this way, to extend the system lifetime, constraining the energy usage of sensor nodes is the key challenges for WSNs.

Presently a days, submerged remote sensor systems utilize distinctive loads of a grapple with the surface float settled at various profundities or are mounted on a self-governing submerged vehicle as the sensor carrier [6]. The sensor is sent at various areas inside the observing waters to perform dynamic checking of sea flows, marine contamination, catastrophe cautioning, asset investigation, logical research and different undertakings. UWSN can, in principle, be utilized in numerous fields; in any case, specialized issues limit the attainability of commonsense application. For instance, UWSN is presently just utilizing submerged acoustic correspondence on the grounds that a high recurrence remote flag is effortlessly consumed by the large data and an optical flag will bit by bit be lost in the ocean of refraction and reflection and isn't helpful for long-separate correspondence.

UWSN investigate incorporates UWSN arrange topology, issues of MAC and steering conventions. In China, UWSN inquire about began late, yet there are presently many research foundations and colleges occupied with research in the field, and some advancement has been made in research. In 2006, China's National Natural Science Foundation set up submerged sensor organizes as a noteworthy research venture. "Eleventh Five-Year" National High Technology Research and Development Program (863 Program), the national key essential research program (973 program) needed to give bolster for the key research undertaking of UWSN [7].

II. RELATED WORK

In [8], the author proposed an underwater energy harvesting system based on plucked-driven piezoelectric. Trial results demonstrate that the proposed energy collector accomplishes a most extreme power density Trial results demonstrate that the proposed vitality collector accomplishes a most extreme power thickness of 350μW/cm3. Trial results demonstrate that the proposed vitality collector accomplishes a most extreme power thickness of 350μW/cm3. of 350μW/cm3.

In [9–11], the authors studied the throughput maximization problem over a finite number of transmission blocks for energy harvesting systems. In [12, 13], the authors investigated optimal power allocation to minimize the average outage probability in block-fading channels under energy harvesting constraint.

The authors of [14] studied the problem of energy allocation for data acquisition and transmission in general wireless sensor networks. In [15], the authors extended the consideration to include a single source with finite battery and data buffer. In [16], the authors studied the energy allocation problem between sensing and transmission to maximize the total amount of data transmitted. In [17], the objective is to minimize the mean squared-error distortion between the Gaussian source samples and their reconstructions over a flat fading channel. However, the existing works typically do not consider the effect of ACK/NACK feedback and as well as the impact of delayed CSI.

III. DYNAMIC PROGRAMMING APPROACH

Jing L, He C, and Huang J [18] presents DP approach divides the sequential optimization problem into a series of single stage problems. According to the Bellman's Optimality Principle, DP approach is a well-known optimum mathematical method for solving the sequential decision making problems.

We optimize the allocation of limited energy capacity to maximize the number of expected successful packets within a finite time interval without data buffer overflow by modeling both energy harvesting and time-varying acoustic channel as Markov processes. We incorporate the practical impact of ACK/NACK feedback along with CSI availability. We considered cases of both delayed and non-delayed CSI feedbacks. Without feedback delay, the transmitter receives the feedback messages (CSI and ACK/NACK) at the end of each time slot and therefore knows the immediately previous CSI.

The DP approach can achieve optimal solution for this problem; however, its drawback is the high computational complexity. The DP method needs to first construct a look-up table containing the optimal solution for each system state. Once we obtain the table, we can easily find the optimal solution by table lookups. The computational complexity of DP method comes mainly from building the look-up table. A DP problem could be decomposed into multiple sub-problems and the computational complexity of DP problem has linear increase with the number of sub-problems. Due to the table contains all of system state at each time slot, the computational complexity of each sub problem is related to the number of system state.

Recall that in the optimal DP method, there are two parts. The first part is the current reward, and the second part is the expected reward from all future slots. It introduces high computational complexity which becomes a major problem in practical implementation. Instead of compute the expected reward from all future slots, we can consider a myopic solution by focusing only on the expected reward of the next P slots. Since we only compute optimal solution for P slots, this myopic goal can substantially reduce the complexity when N is large.

IV. ASYMMETRIC MULTI-PATH DIVISION COMMUNICATIONS MECHANISM

Junfeng Xu, Keqiu Li, and Geyong Min [19] presents a tree-based Asymmetric Multi-path Division Communication (AMDC) mechanism with the aim of obtaining both high reliability and energy efficiency in UANs. In AMDC, thinking about the noise attenuation, the correspondence space is separated into numerous layers to instate the tree-based multi-path. The cross nodes in the multipath are situated close to the border of layers. The source node transmits the first data packet along the different ways to the sink. At the point when the data packets are conveyed to the cross nodes, the right packets are sent by temperance of multicasting along the various ways. The packets with error headers are dropped in the event of header errors caused by the noise. Otherwise, they are relayed and forwarded straightforwardly. In the sink, the achieved data packets are consolidated to create the first packet. In addition, in every way, the middle of the nodes can control transmission power and data rate in order to manage energy consumption. Along these lines, AMDC empowers to accomplish high reliable quality and energy proficiency, and additionally decrease packet retransmissions for UANs. The fundamental commitments of this system include: 1) An Asymmetric Multiple Layer Division conspire is proposed to separate the submerged correspondence space and to introduce the tree-based multipath because of various commotion levels in the profound submerged area; 2) The issue of energy proficiency of AMDC is detailed as a disseminated enhancement issue and is settled to compute the ideal transmission power and data rate in order to accomplish a lot of achievable arrangements; and 3) Extensive simulation tests are led to assess the execution of the proposed AMDC. The outcomes uncover that AMDC altogether outflanks the current multi-way transmission plot in UANs regarding energy productivity and aggregate Packet Error Rate (PER).

The center part of the AMDC instrument is the multi-way division module in the halfway nodes situated close to the outskirt of layers in the submerged situation. We will take care of three key issues of AMDC in this segment:

1) How to course packets in the different ways;

2) How to separate the space into different layers; and

3) How to ensure the required Packet Error Rate (PER) and limit energy utilization.

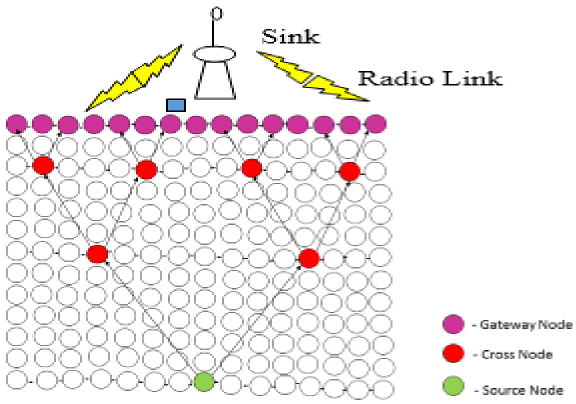

Fig.1: The Network scenario

As shown in Fig. 1, the network consists of source nodes, many intermediate nodes, multiple gateway nodes on the surface of the water and a sink located above the water. The operation of AMDC is described as follows:

1. Step 1: The communication plane is divided into multiple layers according to the strength of the acoustic signal in thefading channel.
2. Step 2: The source node initiates a multi-path division process to establish the tree-based path. Given the number oflayers in Step 1, we can obtain the location of all nodes which are located within the threshold distance from the borderof the layers. Here these nodes are named as border nodes. Set the coordinates of the source nodes as the origin, *(*0, 0*)*and let *X* denote the number of layers, *a* and*b*represent the width and height of the communication area, respectively. Initially, the source node transmits the multicast data packets to the two intersection nodes on the X-th border. Furthermore, when the data packets are sent to the following intersection nodes, the multi-way division process in the intersection nodes distinguishes whether the Cyclic Redundancy Check (CRC) in the packet header is right or not. On the off chance that indeed, the intersection nodes conveys data packet through two ways to the following two intersection nodes by ethicalness of multicasting. Something else, the intersection nodes advances the data packet to the following intersection nodes. Thus, the following intersection nodes will at that point distinguish the CRC and hand-off the data packet until the point that it is transmitted to the surface gateways. At last, the surface passages transfer the data packets and transmit them to the sink through the radio channel.

Stage 3: Since the various duplicates of the first data packet contain a similar arrangement ID1 in the packet header, the sink recognizes the data packets as indicated by their grouping ID. In particular, the sink right off the bat distinguishes the CRC of the got packets. On the off chance that it is right, this implies the sink has gotten the first data packet appropriately. Something else, the sink will gather all the ruined duplicates and join them to produce the first data packet.

V. GEOGRAPHIC AND OPPORTUNISTIC ROUTING WITH DEPTH ADJUSTMENT BASED TOPOLOGY CONTROL FOR COMMUNICATION RECOVERY OVER VOID REGIONS

Coutinho, R.W.L., Boukerche, A., Vieira, L.F.M [20] presents we propose the GEDAR routing rule. GEDAR uses the area data of the neighbor nodes and some known sonobuoys to choose a next-bounce forwarder arrangement of neighbors to keep sending the packet towards the goal. To dodge superfluous transmissions, low need nodes stifle their transmissions at whatever point they recognize that a similar packet was sent by a high need node. The most essential part of the GEDAR is its novel void node recuperation technique. Rather than the customary message-based void node recuperation system, we propose a void node recuperation profundity modification based topology control calculation. The thought is to move void hubs to new profundities to continue the geographic directing at whatever point it is conceivable. To the best of our insight, this work is the primary that considers profundity modification hub abilities to sort out the system topology of a versatile submerged sensor system to enhance directing errand. Recreation results demonstrated that GEDAR can lessen the measure of void nodes through the profundity modification based void node recuperation technique. Therefore, GEDAR enhances the packet conveyance proportion and diminishes the conclusion to end delay for the basic situations of low and high densities and assorted system traffic stack.

Intermittent beaconing assumes a energy job in GEDAR. It is through occasional beaconing that every node gets the area data of its neighbors and reachable sonobuoys. Calculation 1 is an upgraded occasional beaconing utilized by GEDAR to communicate intermittent signals and to deal with got guides. In the signal messages, each sonobuoys installs an arrangement number, its interesting ID, and it's X, Y location. We expect that each sonobuoy at the surface is furnished with GPS (Global Positioning System) and can decide its area. The grouping number of the guide message shouldn't be synchronized among all sonobuoys. It is utilized together with the ID to recognize the latest signal of each sonobuoy (line 24). The profundity data of sonobuoys is discarded from the signal message since the sonobuoys are sent at first glance and vertical development is immaterial as for the even development.

```
Procedure BroadcastPeriodicBeacon(node)
m: a new beacon message with the next seq_num
if beacon timeout expired then
m.coordinate ← location (node)
if node ∈ Nn then
for s ∈ Si(node) do
if Λ (s) = 0 then
m.addSon.(seq_num(s),ID(s),X(s),Y(s))
  Λ (s) ← 1
  end if
  end for
 end if
 Broadcast m
Set a new timeout
end if
end procedure

procedure ReceviedBeacon (node,m)
if m is from a sonobuoy then
 update (Si (node),m)
else
update_neighbour(m.seq_num,m.id,m.location)
for s ∈ m do
if seq_num(s,m)> seq_num (s,Si(node)) then
update (Si (node),s)
 end if
 end for
end if
end procedure
```

Algorithm1: Periodic beaconing

So also, every sensor node implants a grouping number, its unique ID and X, Y, and Z position data. Moreover, the reference point message of every sensor node is enlarged with the data of its known sonobuoys from its set Si(t).Each hub incorporates the grouping number, ID, and the X, Y location of the it's known sonobuoys. The objective is for the neighboring hubs to have the area data of the all reachable sonobuoys. GPS cannot be used by underwater sensor nodes to determine their locations given that the high frequency signal is rapidly absorbed and cannot reach nodes even localized at several meters below the surface.

VI. QUALITY OF SERVICE AWARE EVOLUTIONARY CLUSTER BASED ROUTING PROTOCOL

Muhammad Faheem, Gurkan Tuna, and VehbiCagri Gungor [21] presents an evolutionary clustering based routing protocol (QERP) for UWSNs to overcome the inefficiencies of the existing routing schemes. Second, the key performance requirements of UWSN applications, such as low delay, high packet delivery ratio (PDR) and low overall energy consumption, can be met by the proposed protocol. Third, the challenges caused by excessive noise, high interference, multipath effects, high bit error rate (BER), long propagation delay, and low bandwidth can be addressed if the proposed protocol is integrated into UWSN applications. Comparative performance evaluations demonstrate that QERP is successful in attaining the commonly used UWSN performance indicators.

A. Generic Representation of Scheme

In [21], we consider a chromosome (routingpath), which consists of sequences of non-negativity integers that denote the IDs of genes (CH nodes) through which a routingpath passes. In a routing path, the order of each CH is represented by the locus of chromosome in which the gene of the firstlocus is always reserved for the source CH nodes. The lengthof each constructed routing path is variable; however, it must not be greater than the total number of defined CH nodes toavoid data path loops in the network. Thus, a chromosome encodesthe problem from its origin CH node toward destinationby listing up the node IDs depending on topological informationobtained from the constructed routing table in underwateracoustic network. Physically, several alternative partial routesfrom the source CH node to the destination are generated bythe proposed scheme in a greedy manner. The one with betterfitness value based on high residual energy, SNR, least numberof member nodes, and minimum distance to the sink is acceptedas a final route. After the route selection, each CH node is responsiblefor maintaining history of the relay nodes in its routingtable. This phenomenon avoids the energy depletion of the sameCH nodes being selected twice in different routing paths.

B. Population Initialization

In population initialization phase of any clustering-based routing solution, initial population size and procedures to initializethe population are two main issues to be addressed. To enhance the underlying populace, heuristic or irregular initializations are favored. Because of its power in complex problematic search space, we consider irregular introduction to generate an introductory populace. After the sending, surface floats are responsible for running a developmental calculation to generate an introductory populace of people by utilizing an arbitrary number generator.

C. Selection of Parents

The selection process determines which of the chromosomesfrom the current population undergoes recombination to createoffspring to populate the next generation in order to survive.The selection weight defines the selection probability ratio of theelite chromosomes to that of average chromosomes in the population.Among various selection schemes, tournament selectionis found robust to preserve the selection noise at extremelylow as possible.

D. Crossover

The crossover process examines the current solutions for generating offspring from the chose guardians in a way that combines and keeps up the alluring highlights from the two guardians. Inthis study, we prefer basic crossover operators, including multipartand universal parent operators to exchange parent chromosomesinformation.

E. Mutation

The mutation process plays a significant role to enhancethe fitness of the solution. We use a non-uniform mutationoperator instead of uniform mutation operator.

F. Fitness Function

In each generation, a set of fittest individuals receives higherfitness values and thus has a higher chance of surviving in theresulting generation. Better fitness function leads to lower clusteringcost and more stable link quality for reliable data transmissionwith minimum energy consumption.

VII. COMPARISON OF ENERGY EFFICIENT ROUTING METHODS IN UNDERWATER SENSOR NETWORKS

S.NO.	Author	Title	Analysis
1.	Jing L, He C, and Huang J	Energy Management and power allocation for Underwater acoustic sensor network	Limited energy capacity, maximize number of successful packets and CSI accuracy
2.	Junfeng Xu, Keqiu Li, and Geyong Min	Asymmetric multi-path division communications in underwater acoustic networks with fading channels	Energy efficiency, Reducing Total packet error rate, and Avoiding packet retransmission
3.	Coutinho, R.W.L., Boukerche, A., Vieira, L.F.M	Geographic and Opportunistic Routing for Underwater sensor networks	Increases the network performance, Utilize the location information of neighbors, and improve the routing task
4.	Muhammad Faheem, Gurkan Tuna, and Vehbi Cagri Gungor	QERP: Quality-Of- Service (QoS) Aware Evolutionary Routing Protocol for Underwater Wireless sensor networks	Reduces the data path loops, network delay, and energy consumption

VIII. CONCLUSION

This paper presents a detailed literature of the latest state of the art routing techniques in UWSNs. The concept of sensor nodes and cluster head identification is described in detail. This process is followed by the routing techniques available for the secure transmission of the data. Energy efficient techniques have been used to optimize the network process and save the energy.

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