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Autonomous Underwater Vehicle: 5G Network Design and Simulation Based on Mimetic Technique Control System

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Abstract

The Internet of Underwater Things (IoUT) exhibits promising advancement with underwater acoustic wireless network communication (UWSN). Conventionally, IoUT has been utilized for the offshore monitoring and exploration of the environment within the underwater region. The data exchange between the IoUT has been performed with the 5G enabled-communication to establish the connection with the futuristic underwater monitoring. However, the acoustic waves in underwater communication are subjected to longer propagation delay and higher transmission energy. To overcome those issues autonomous underwater vehicle (AUV) is implemented for the data collection and routing based on cluster formation. This paper developed a memetic algorithm-based AUV monitoring system for the underwater environment. The proposed Autonomous 5G Memetic (A5GMEMETIC) model performs the data collection and transmission to increase the USAN performance. The A5GMEMETIC model data collection through the dynamic unaware clustering model minimizes energy consumption. The A5GMemetic optimizes the location of the nodes in the underwater environment for the optimal data path estimation for the data transmission in the network. Simulation analysis is performed comparatively with the proposed A5Gmemetic with the conventional AEDG, DGS, and

CC License CC-BY-NC-SA 4.0	HAMA models. The comparative analysis expressed that the proposed A5GMeMEMETIC model exhibits the ~12% increased packet delivery ratio (PDR), ~9% reduced delay and ~8% improved network lifetime. ***Keywords: Autonomous Underwater Vehicle (AUV), Memetic Algorithm, Clustering, Trajectory Estimation, 5G communication***

1. Introduction

UWSN is a networking technique to monitor and explore oceans. UWSN supports aquatic applications ranging from environmental monitoring to disturbance detection. It is extensively used in industrial, environmental and military domains for navigation, surveillance, monitoring, tracking, etc. Because of its wide range of applications, underwater research needs more attention [1]. UWSN model exhibits the difficulties with the equivalent underwater model for the inclusive range of applications such as pollution monitoring, maritime through water based exploration and exploitation. It provides the promising technology to provide on-demand service access to the users. UWSN comprises of the sensor node those deployed within the water bodies for the environment sensing to collect information in the ocean data for the transfer of surface sinks [2]. The data is accelerated based on the handling of the onshore data composed of appropriate surface sink in the complex underwater environment. To perform underwater Wireless Fidelity (Wi-Fi) perform obligation with the data sensor build up [3].

Its network characteristics are different from terrestrial ones. Wireless data communication through the ocean is one of the enabling technologies for the growth of upcoming ocean-observation structures and sensor networks. The water-related properties are sensed by the UWSN network of independent sensor nodes which are spatially scattered underwater to sense the parameters such as temperature, pressure and quality. It provides benefits for humans and the sensed data can be used by a variety of applications [4]. The sensor nodes are connected wirelessly via communication modules to handover various events of interest, the sensor nodes are either stationary or mobile. By the structures of sound, Electro-Magnetic (EM), or optical waves, the transmission of data is processed. All the above strategies have focal points and drawbacks. Electromagnetic signals carry a very meagre execution submerged; the common Radio Frequency (RF) sensor gives transmission for a couple of meters. Submerged sensor systems use light waves by optical correspondence [5]. The technique for optical provides the high power exactness for the examination of sensor hubs expensive value. The acoustic audio signal system drives the sound wave to obtain the perfect choice in water. The acoustic system demand for the minimal power RF and optical waves for the self-governing and individual hub sensor those are submerged with the accelerative information collection through the UW sink. With the computational power the challenges for the power transmission is evaluated with the correspondence range based on memory with the constraint battery resources [6].

A gathering of sensor hubs is connected to the lower part of the sea with profound sea telecasters. In the remote acoustic connections, submerged sensor hubs are interconnected to at least one submerged sinks, which are network gadgets in the care of communicating information from the sea base organization to a surface station. By a vertical and a flat handset, submerged sinks are outfitted with two acoustic handsets [7]. To discuss the sink with the sensor hubs, the flat handset is utilized for the accompanying purposes (I) send orders and arrangement information to the sensors (ii) gather checked information to sink. By the utilization of an upward connect, the information is communicated to a surface station from the sink. The scope of the upward handsets for profound water applications in the sea can be essentially as profound as 10 km [8]. To deal with different equal communications with the sent sinks, the surface station is furnished with an acoustic handset. Either through direct connections or multi-bounce ways, the sensors can be associated with sinks. For this situation, every sensor straightforwardly drives the gathered information to a specific sink. This is the least complex method for systems administration sensors, yet it may not be the most energy proficient, since the sink might be a long way from the hub [9].Network area issues are worried about tracking down the right areas to put at least one office in an organization of interest focuses, i.e., clients addressed by hubs in the organization, that improve a specific goal capability connected with the distance between the offices and the interest focuses [10]. Generally, the offices to be found are alluring, i.e., clients like to have the offices situated as near them as could be expected. For instance administrations, for example, police, fire stations, emergency clinics, schools, and retail plazas are commonplace advantageous offices.

In this paper proposed A5G Memetic algorithm for the optimal data transmission in the underwater environment. The A5GMemetic model uses the energy-aware clustering in the underwater environment for the estimation of the path in the network for the data transmission. The simulation analysis expressed that proposed model exhibits the ~12% increased packet delivery ratio (PDR), ~9% reduced delay and ~8% improved network lifetime compared with the AEDG, DGS and HAMA.

The paper is organized as: Section 2 provides the related works conducted in the clustering and underwater environment. The overview of A5GMemetic is presented in section 3 and process involved in A5GMemetic algorithm is presented in Section 4. The simulation results are presented in Section 5 and overall conclusion is presented in Section 6.

2. Related Works

In [10] explored the issue that the CH load is unequal and the organization life cycle is short and proposed a simple and viable bunching technique in regards to the PSO calculation in this work. The CH energy, bunch range and CH load are extensively explored in this work. Simultaneously, the multifaceted nature of the calculation is low and it has a similar to handling capacity without a doubt. This calculation can satisfy the ideal number of CHs, the CH load adjusting and the area of the bunch is pragmatic and consequently the organization life expectancy is expanded productively.

In [11] projected two new disseminated bunching directing calculations named Energy Proficient sensible Cubical layered Way Arranging Calculation (EECPPA) and Various Sink Energy Effective coherent Cubical layered Way Arranging Calculation (MSEECPPA) for UWSNs. In EECPPA, the CHs straightforwardly record to BS while MSEECPPA utilizes various sinks as temporary hubs between chose CHs and BS.

In [12] planned the bunching convention and the unique CH determination and they projected a jellyfish breathing cycle for CH choice and a programmed change calculation for sensor hubs. To start with, all sensors have an equivalent registering ability, detecting span and battery limit. Second, proposing to do a practical reproduction of genuine applications, they pick the Poisson probabilistic model for sensor hub dispersion in 3D space. As a matter of fact, in a huge scope UWSN, the expected number of nearest neighbours of a transmitter should extend logarithmically with the region as an area could comprise of an enormous number of hubs. Likewise, the organization should run a re-sending as certain hubs in the organization might become shaky under the climate, to keep the organization network and inclusion.

In [13] analysed the exhibition of an Ideal Visiting Visit Planning for Versatile Information Social occasion in UWSN. Essentially, the bunch development and it is finished to pick the CH determination. Afterward, the totalled information from the CH is assembled by conveying the messenger hubs into bunches. As to Decisional Welzl's calculation, the meeting visit through every messenger hub is arranged. This strategy diminishes energy utilization, cradle flood and postponement.

In [14] recommended a versatile information gathering plan for UWSNs by using a compromise among energy and information gathering idleness. This plan, called Bunch based AUV helped Information Assortment plot (CADC) is a gathering of sensors, chose as CHs to accumulate information locally from their individuals. A close ideal visit is then arranged by AUV to visit every one of those CHs to collect information parcels and convey them to a static sink on a superficial level. CADC is profoundly expandable and furthermore material in both associated and detached networks.

In [15] gave the Energy Degree (EG) and Profundity Change (DA) plans to keep away from the directing opening in the correspondence stage. These steering conventions are influential for forestall the directing opening and repetitive transmission. The EG conspire communicates information in view of the energy correlation, in the event that the energy of a forwarder hub is more prominent, the forwarder hub advances information straightforwardly to the sink. Alternately, in the event that the energy is less, the hub sends information by means of the regressive transmission to recognize the higher energy hub. Similarly, the possibility of the DA geography of a void hub moves to the new profundity and it begins the information transmission.

In [16] recommended a Circulated Energy-Productive and Adjusted (DEEB) steering calculation for Submerged Remote Optical Sensor Organization (UWOSN). The DEEB is able of (1) limiting directing utilization of energy to expand the life expectancy of hubs; (2) levelling energy utilization among sensor hubs; (3) working in static as well as a unique organization. An energy-utilization of broadcasting motioning for a geography revelation can be forestalled as each sensor hub just has to know its situation and areas of sink hubs which prompts saving the energy of sensor hubs.

In [17] concentrated on UW-WSN plan in both the physical and network layer simultaneously. Appropriately, the mix of steering and the helpful transmission incorporates picking Directing Transfer (RR) for sending information on directing ways and Agreeable Hand-off (CR) for one-bounce agreeable correspondences simultaneously. In this work, in light of their connection quality pointers, i.e., Season of Appearance (ToA), SNR and their actual distances addressed by Bounce Count (HC) to the objective, sources with information to advance exclusively pick their transfers (i.e., both RR and CR) among their neighbours.

3. Memetic Algorithm

Memetic Algorithm (MA) exhibits the evolutionary computation process for the population computation approach to increase the performance. Memetic algorithm belongs to the class of the heuristic based global search operation integrated with the Evolutionary Algorithm. MEMETIC algorithm uses the 6 metaheuristics algorithm performance computed with the local search operation with the optimization, continuous optimization, dynamic optimization and multi-objective optimization model. The proposed A5G MEMETIC model uses the genetic based model for control system design in underwater system. The developed model comprises of the different phases such as initialization of population, selection, crossover and solution. The process of Memetic algorithm is based on metaheuristic population with the natural evolution of analogy.

3.1 Selection

The proposed A5GMEMETIC belongs to the class of evolutionary algorithm computed between exploration and exploitation process. The selection of parent is performed with the chance of individual reproductive characteristics. The model elects the optimal selection from the available population through the estimation of fitness function. The operators considered for the analysis are roulette-wheel, rank selection, tournament and elitist model.

3.2 Crossover

The crossover model uses the recombination of the biological mimics those are essential components of the genetic algorithm. The search space of the algorithm is classified based on the cross over operator based genetic algorithm model. The computations of features are based on the chromosomes features with cross over operation in single-point, double-point, uniform and several factors.

3.3 Mutation

The operation of mutation comprises of the predefined probability value for the operator. The entries in the mutation process are independent strings those are user-defined probability values.

3.4 Local Search

The local search features are evaluated with the heuristics-based solution for the small changes to derive the improved solution values. The structure of neighbourhood values are estimated based on local search value for the solution S with the improvement in the local optimum scan neighbourhood, predefined improvement order to derive the solution s0 with $f(s0) < f(s)$ with the random set solution to for the condition $f(s0) < f(s)$.

3.5 Solution Constraints

The location probability is estimated based on the maximum and location probability for the solution set in locations. The cardinality probability is computed for the solution set of p through constructed phenome for the location in search space. The estimation of probability is computed using the equation (1)

$$p_{ij} = \frac{[\tau_i][\gamma_{ij}]}{\sum_{l \in N_i}[\tau_i][\gamma_{ij}]} \tag{1}$$

Where
p_{ij}: Probability of i^{th} location with respect to j^{th} client.
τ_i: Pheromone on i^{th} location
η_{ij}: Reciprocal of distance between i^{th} location and j^{th} client
N_i: Neighbourhood of i^{th} location

3.6 Update of Pheromone

The solution set for the updated pheromone value is calculated using the equation (2)

$$\tau_i = (1-\rho)\tau_i + \sum_{i=1}^{\rho} \Delta\tau_i \tag{2}$$

Where
ρ: rate of pheromone evaporation, $\rho \in (0,1)$
p: Number of locations present in the solution set
τi: 1/fitness(Pi)
After initialization step, selection, crossover, and improvement are applied for the improvement of solution. The process involved in memetic algorithm is illustrated in figure 1.

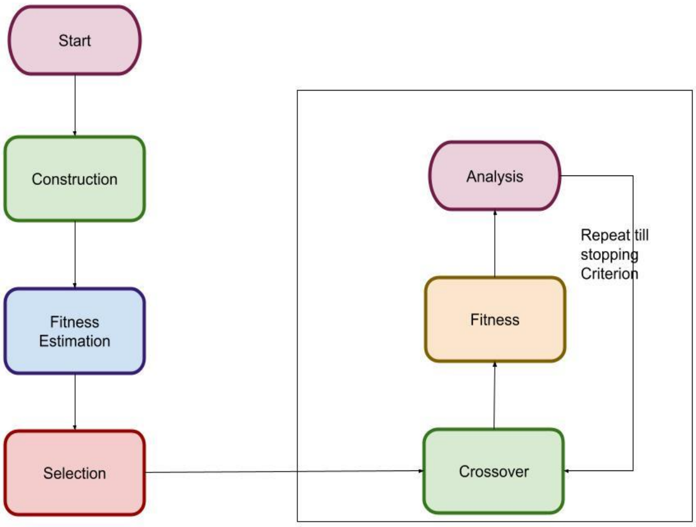

Figure 1. Process in Mimetic Algorithm

The A5GMemetic computes the size of the population for the location number for the generated population. Every population member is computed with the selection of initial population count based on iteration process.

Algorithm 1: Pseudocode for A5GMemetic
Initialize t:=0; Perform node construction; Compute Fitness Function; Select the population size as Pop_size; Perform binary search

```
while (condition)
t:=t+1;
Perform Crossover operation
Perform the Local Search;
Estimate the probability values pm;
update Gbest;
end //
```

4. Trajectory Estimation with A5GMemetic

In A5GMEMETIC, multiple AUVs are used, but for consideration, only two AUVs are taken and that dual AUVs can move simultaneously to collect the data. For this purpose, AUVs can move in the opposite direction, with similar speed and Possess a diverse communication range. By these factors, the proposed system does not contain any bottleneck on the dual trajectory overlap. Therefore there is no clash between the movements of dual AUVs. They can continuously move with their trajectories. Due to the dual AUV, high data transfer can be achieved by transferring data from the sensor nodes and the BS. It increases the overall delivery rate of the network. The delivery rate is the ratio of the packets received by the BS and the packet generated by the nodes. Here the system uses dual AUVs; therefore the delivery ratio of the network will increase. Figure 5.1 shows the motion structure of the proposed trajectory. The vehicle can move along the trajectory for data collection. One of the main constraints while setting the trajectory is the radius of the communication circle of each node. The sensor nodes have a particular region of communication radius. While the AUV can move, it may repeatedly cover the same communication coverage of a particular node. So, if the communication radius increases, an AUV can cover the same node twice or thrice.

The trajectory is estimated for the receiver antenna for the sensor node communication in the range of $0 < X \leq R/3$.The distance comprises of the successive segments in the vertical diameter within the communication circle of 2R. The AUV compute the circles those are higher than three times for the increased value of X for the redundant beacon points. Conversely, the value of X provides the chord length below the threshold value.

4.1 Determine the Localization

The location of nodes is determined with the estimation of sensor node physical coordination based on localization or position. To perform the communication GPS uses the information about node location under different environment. The configuration is achieved with the each sensor reference in the dense network.

4.2 Hot-Region Avoidance

The avoidance of hot-region is achieved with the transmission protocol, aggregation and network lifetime.

4.2.1 Trajectory Adjustment

Trajectory adjustment is moving the trajectory concerning the X and Y-axis. The proposed A5GMEMETIC method provides a technique for adjusting the trajectory and avoids the Hot-Region problem. Here the trajectory is adjusted by the horizontal translation method.

The horizontal translation is a transformation method, which can shift the coordinates horizontally either left or right corresponds to the unit of value mentioned. The trajectory of the AUV shifted corresponding to the time. That means the lifetime of the node is taken into account. Based on that time, the trajectory will be shifted. The proposed work defines the horizontal translation which will be made on the trajectory of AUV at every period. This can be programmable with the AUV for the trajectory adjustment. With the base function $f(x)$ the constant is computed for k based on the defined function $g(x) = f(x - k)$, where the values are classified in to segments horizontally $f(x)$. The point value of the constant k is computed based on the equal distance in the vertical segments based on trajectory as measured using equation (3)

Here the point of value which will be added is equal to the distance between the two successive vertical segments. Therefore to adjust the trajectory, Equation (3) is used,

$$(x, y) \rightarrow \left(x + \frac{R-X}{2}, y\right) \tag{3}$$

This applies to the initialization process. After the new trajectory is set up, it could follow the R-X for the breadth of S1 and E1 and so on. The trajectory adjustment has shown in Figure 5.4. Now, the normal sensor nodes which are located on the new trajectory will be responsible for the transmission of data with the AUV. These nodes are now called as GNs. In the proposed work, the Hot-Region was cured by the adjustment of trajectory. This will significantly help in the network's lifetime because the network lifetime depends on the lifetime of the nodes presented in the network. The Hot-Region problem affects the node's aliveness (it causes the earlier death of nodes due to heavy load). This is significantly addressed by the proposed work.

By doing the adjustment in the trajectory, the GNs which are continuously affected by the overwork will be released from that zone and the normal nodes are promoted as GNs. Now the new GNs are responsible for the transmission of collected data from other nodes and also the transmission of its own sensed data with the AUV. Therefore in this method, all the nodes in the network are working equally; the energy was equally used by all nodes in the network instead of utilizing the same node's energy again and again. So it could avoid the same node's energy depletion largely. The main reason for the Hot-Region problem is overcome by this approach. And also the nodes and the network lifetime were ensured.

4.2.2 Velocity Adjustment

Velocity is known as the speed of the object in a particular direction. When the discussion is made on velocity, the other two parameters are also defined. They are speed and acceleration. As the speed is stated the rate of change in position defined in moved distance (d) per unit time (t). As the speed is stated in scalar dimension defined in equation (4)

$$Speed = \frac{Distance}{Time} \tag{4}$$

Velocity is states the object displacement with respect to time calculated using equation (5). The magnitude of standard velocity is measured in meter per second (m/s)

$$Velocity = \frac{Speed}{TIme} \tag{5}$$

Acceleration

Acceleration is the rate of change of velocity of an object with respect to the time that is defined by Equation (5.4). Acceleration, also a vector quantity, is the rate at which an object changes its velocity.

$$Acceleration = \frac{Velocity}{Time}$$

4.2.2.1 Phases in Velocity Adjustment

To solve this problem, A5GMEMETIC proposes a scheme called velocity adjustment. Velocity adjustment means the speed of the vehicle will change based on the status of the nodes. If the node (GN) holds the data, then labelled its status as "Holding-data" else it sets its label as "No-data". Based on the label, the AUV can control its speed. There are three phases followed to achieve this,

Deceleration phase

When the AUV senses the GN as the "Holding-data" state, then it speeds down to the minimum speed and gathers the data from those nodes. By doing this, the AUV does not leave any node and data. The driving speed is calculated through Equation (7).

$$v = \frac{-b}{2}\tanh\big(k(t-p)\big) - \frac{b}{2} + v_0 (7)$$

where, v represented as driving speed, $v_\circ$ as the initial speed, t is stated as time, p stated as the model mobility, the hyperbolic tangent function is represented as tanh and the absolute difference velocity is stated as b.

Acceleration Phase

After collecting data from one node, AUV senses the nearby GN"s state. If it is the "No-data" state, then it accelerates the speed to the particular level. And also AUV follows this phase while it moves towards the BS after collecting the data. Equation (5.6) denotes this operation,

$$a = -bk/2(1-(\tanh(k(t-p)))^2$$

4.2.2.2 Uniform Speed Phase

This phase is a speed maintaining phase. Whether AUV moves with high or low speed, this phase helps to maintain that speed. For example, if the AUV senses more number of nearby GNs with "Holding-data" state, then it follows the low speed until it collects the data from those nodes. Maintaining the same speed for some time is denoted as the Uniform speed phase. The figure 2 illustrated the velocity adjustment with the A5GMemetic algorithm.

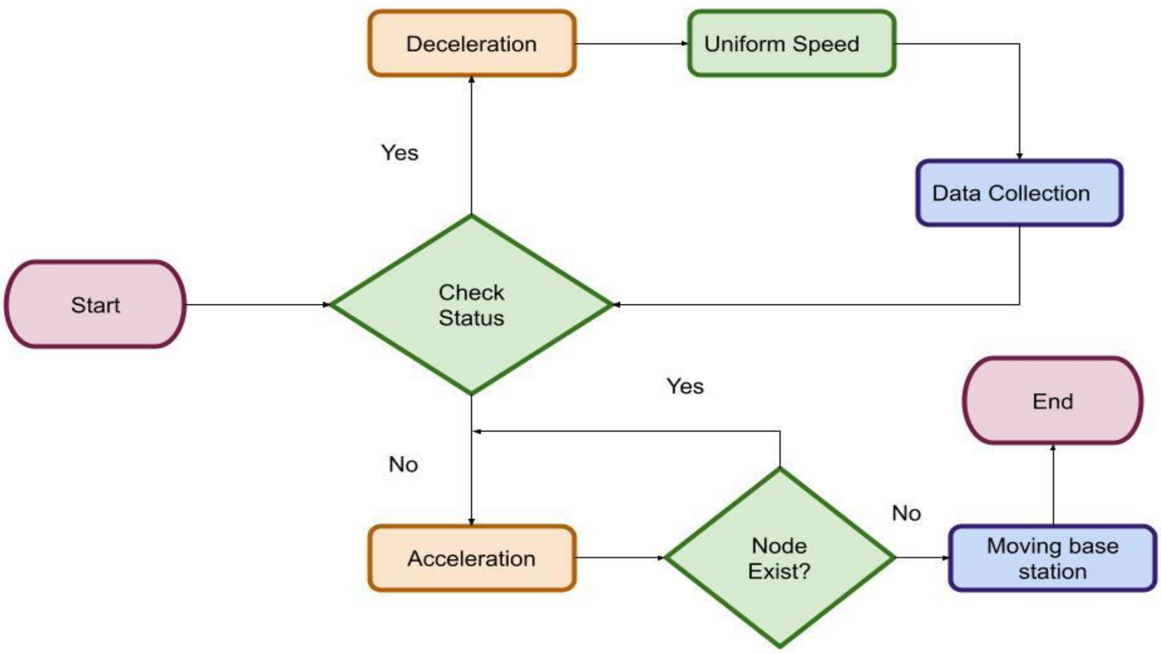

Figure 2. Velocity Adjustment with A5G MEMETIC

5. Simulation Results

The proposed A5GMemetic algorithm is comparatively examined with the conventional algorithm those are evaluated in this section as follows:

5.1 Network Lifetime(s)

In table 1 contains network lifetime for AEDG, DGS, HAMA and A5G MEMETIC. Table 1 shows the effect of several nodes and the network lifetime. Proposed work provided the scheme to avoid the

Hot-Region problem so that the energy loss of the same node will be avoided. So energy consumption of every node should be balanced. This significantly has an impact on the lifetime of the network. And also, the proposed work uses dual AUV. Most of the time, the transmission is carried out by source-GN-AUV, some nodes only need the next-hop forwarding node. Therefore the energy consumption of the node was reduced and balanced through the trajectory adjustment scheme. Because of the reduced energy consumption, the lifetime of the network is stable illustrated in figure 3.

Table 1. Comparison of Network Lifetime

No. of nodes	Network's Lifetime (s)			
	AEDG	DGS	HAMA	A5GMEMETIC
20	11200	11198	11143	11500
40	11198	11167	11132	11470
60	11078	11067	11163	11321
80	11123	11039	10094	11278
100	10034	10098	11021	11224
120	10021	10067	10083	11186
140	984	10043	10056	11134
160	973	10021	10029	11123
180	967	980	989	11067
200	950	954	974	11047

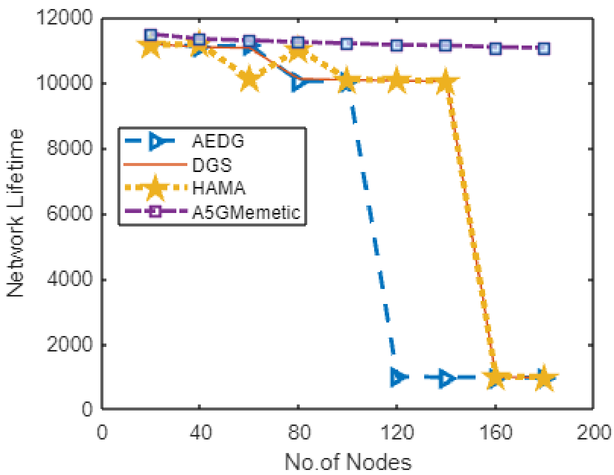

Figure 3. Comparison of Network Lifetime

5.2 Average Residual Energy

Average residual energy is defined as the energy left over after doing all the routing process. It is the average energy of all active or alive nodes in the network. Energy is one of the important factors for the wireless network. The measured residual energy of nodes is presented comparatively in table 2.

Table 2. Comparison of Average Residual Energy

Time(s)	Average Residual Energy (J)			
	AEDG	DGS	HAMA	A5GMEMETIC
2000	90	96	99	120
4000	75	91	94	118
6000	60	87	89	115
8000	30	85	86	114
10000	10	79	80	114

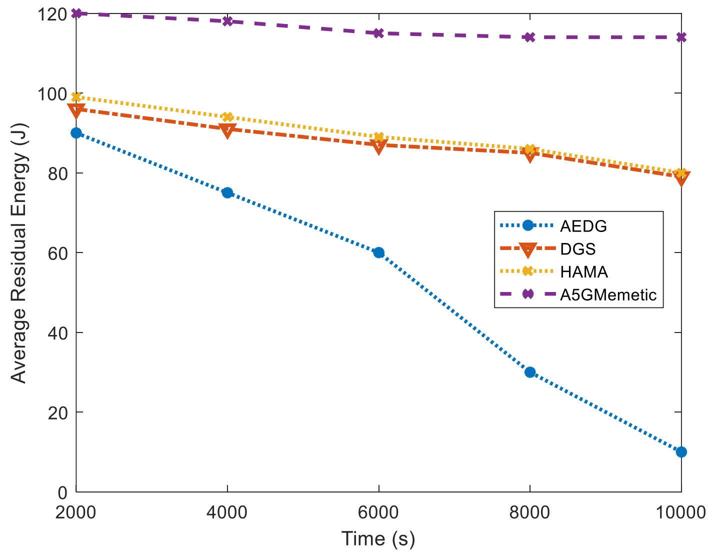

Figure 4. Comparison of Residual Energy

Table 2 contains the average residual energy for AEDG, DGS, HAMA and A5GMEMETIC. A comparison of average residual energy for AEDG, DGS, HAMA and A5GMEMETIC has shown in Figure 4. The relationship between the average residual energy and the time shows the energy utilization rate of the network. Here compared to other protocols, the average residual energy is larger for A5G MEMETIC since the proposed system uses dual AUV. There the node consumes less energy and also the node's energy was balanced due to the trajectory adjustment. Therefore, until the residual energy persists, the node will be stable. The existing schemes may be affected by the energy consumption problem. AEDG and DGS were affected by the Hot-Region problem. The energy consumption of nodes was large in that method. This was reduced in the A5G MEMETIC method.

5.3 Packet Delivery Ratio

It defines the ratio of the number of packets sent by the source node and the number of packets received by the destination node. Table 3 contains the packet delivery ratio for AEDG, DGS, HAMA and A5GMEMETIC. In UWSN, the sensor nodes generate the data and forward it to the GNs. GNs also generate data. These data are forwarded to the BS through the AUV. Therefore packet delivery ratio is the ratio of several packets generated by the sensor node and several packets received by the BS. Figure 5 shows the comparison of delivery ratio for AEDG, DGS, HAMA and A5G MEMETIC.

Table 3. Comparison of Packet Delivery Rate

Size of deployment region(m)	**Packet Delivery Ratio**			
	AEDG	**DGS**	**HAMA**	**A5GMEMETIC**
200	0.9	0.7	0.9	1
300	0.8	0.6	0.9	1
400	0.7	0.6	0.8	0.9
500	0.7	0.7	0.7	1
600	0.8	0.8	0.7	0.9
700	0.7	0.8	0.6	1
800	0.6	0.7	0.6	1
900	0.6	0.9	0.7	1
1000	0.8	0.8	0.8	0.9

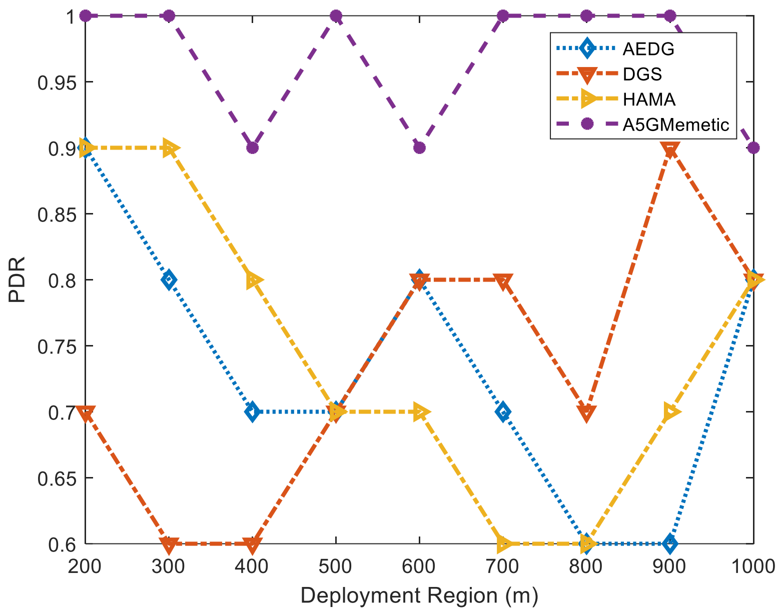

Figure 5. Comparison of PDR

Data transferring is crucial in UWSN. So the GNs should not wait for a longer time. Whenever the AUVs come closer to it, the GNs can forward the data in A5GMEMETIC. Therefore, the data, either it is important or normal can be forwarded to the BS without any delay or loss. With the increasing size of the deployment region, the packet delivery ratio is decreased. This is due to the large size of the deployment region. But the ratio was high for A5GMEMETIC as it uses dual AUVs.

5.4 Average Delay(s)

The average delay is the average time required by a data packet to reach the BS from the source node. Table 4 contains the average delay for AEDG, DGS, HAMA and A5GMEMETIC.

Table 4. Comparison of Average Delay

Size of deployment region(m)	**Average Delay(Sec)**			
	AEDG	**DGS**	**HAMA**	**A5GMEMETIC**
200	150	140	180	120
300	167	159	221	128
400	189	186	276	138
500	197	203	294	147
600	208	218	329	153
700	228	249	349	159
800	246	274	398	162
900	273	293	439	169
1000	280	310	468	179

The average delay may depend on various factors such as the speed of the acoustic signal, the transmission distance, speed of the AUV and the length of the trajectory. Based on figure 6, the HAMA method has the highest delay rate compared to the other three. One of the major issues in that was the slow speed of AUV. The speed of the vehicle has a major impact on the delay factor.

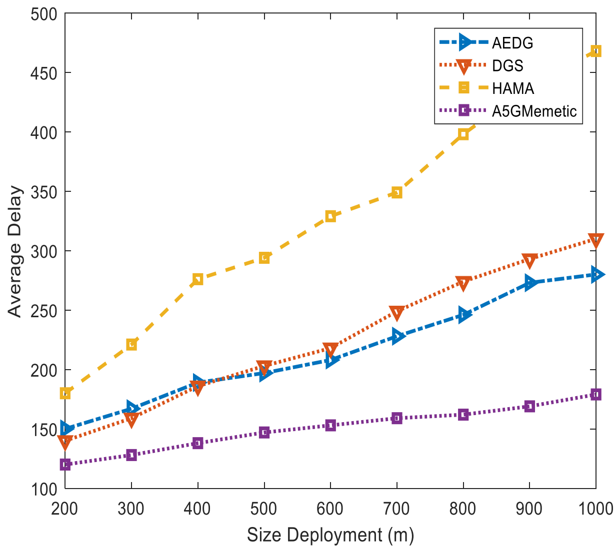

Figure 6. Comparison of Average Delay

One of the key issues in UWSNs is the hot-Region problem i.e. the nodes closer to the Trajectory of AUV tend to drain their energy at a faster rate when compared to other nodes as they have to perform more communication and hence the sensor network may get isolated. The energy consumption for the proposed A5GMemetic is presented in table 5.

Table 5. Comparison of Energy Consumption

Time (Sec)	**Total Energy Consumption (J)**	
	RERTC	**A5GMEMETIC**
100	5	2
200	17	7
300	29	11
400	48	17
500	69	28
600	77	34
700	89	46
800	97	57
900	117	66
10000	138	74

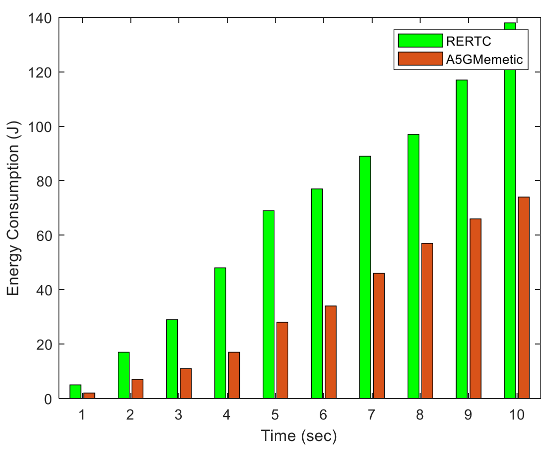

Figure 7. Comparison of Energy Consumption

This Hot-Region problem has been avoided in both RERTC and A5G MEMETIC techniques. RERTC used small and large clusters and it says the CH of small clusters only acts as an intermediate and it has been chosen based on their energy, so that nodes has been lived long in the network as shown in figure 7. In this way, RERTC avoids the Hot-Region problem but it is not efficient than A5G MEMETIC. In A5G MEMETIC, the AUV trajectory has moved after a certain period based on the coverage distance of sensor nodes to avoid the coverage of the same node for the second time after the trajectory got moved. Different nodes are closer to the trajectory after trajectory adjustment. So every sensor node in the region should act as an intermediate at least once which means every node should present in the hot region at least once. Due to this adjustment, every node has an equal amount of work. It avoids the Hot-Region problem by consuming less amount of energy through trajectory adjustment.

6. Conclusion

This paper proposed an Autonomous5GMemetic algorithm for the unique feature reduction and avoidance in the underwater environment. It also figured with an efficiency analysis of how this technique excelled a technique currently used. Most of the time, the transmission is carried out by source-GN-AUV and some nodes only need the next-hop forwarding node. Hence the energy consumption of the node was reduced and balanced through the trajectory adjustment scheme. Because of the reduced energy consumption, the lifetime of the network is stable. When compared to other protocols, the average residual energy is larger for A5GMEMETIC since the proposed system uses dual AUV. Therefore, the node will be stable until the residual energy persists. With the increasing size of the deployment region, the packet delivery ratio is decreased due to the large size of the deployment region. But the packet delivery ratio was high for A5GMEMETIC as it uses dual AUVs. If AUV moves towards the BS, it can move faster. At the same time, if the AUV wants to collect the data from GNs, it can adjust its speed. In A5GMEMETIC, the delay was reduced by velocity adjustment than the other three protocols. Both the approaches are fully based on the AUV trajectories that are mainly proposed for achieving Hot-Region Avoidance, Increasing Network Lifetime and Increasing Delivery Ratio. The proposed techniques are providing best results when compared with existing works but the final result proves that A5GMEMETIC is more efficient than RERTC when compared with each other.

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