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Presenting A Distributed Algorithm For The Energy Consumption Reduction in Underwater Sensor Networks, Using The Learning Automata in Heterogenic State

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Abstract: *A sensor network is a set of sensor nodes, which attach to each other via links that may cause energy loss in sensor network. Clustering the nodes is an applicable and effective way that prevents the energy loss. Cluster head relates the clusters and base station. It also collects the gathered data from sensor nodes and send them to the base station. The nodes proximity to the CH and neighborhood considering for nodes are the important problems that the most protocols did not consider them. Suggested algorithm tries to balance the energy consumption and increase the network longevity, considering the neighborhood criterion. This algorithm has the lower energy consumption and longer life than the previous algorithms such as Deterministic Cluster-Head Selection (Leachswdn) and Leach-Sliding window and Dynamic Number of Nodes (Leachdchs). In addition, it had the better performance in data transmission to the base station.*
Keywords: *underwater sensor network, learning automata, clustering, reduction of energy consumption.*

I. Introduction

Sensor networks consist of the number of sensor nodes. Sensor nodes sense the especial properties of surrounded environment such as temperature pressure etc. and send to the environment. Underwater sensor networks are the kind of sensors that have Navigation, under sea Monitoring, Mine identification, Ships Routing etc. applications. However, there are many challenges for these networks such as more emission delay than the other networks, lesser battery charge, physical protection need in unsuitable climate and finally the more complex routing.

Wide researches have been done in underwater networks fieldrecently. LEACH is a kind of them that presented by Heinzelman (2002). In this protocol, the time is divided to equal parts called period. Each period has two phases. The CH does the TDMA regulation and node timing. In phase one the clusters form based on distributed algorithm called initiation phase. At second phase that is the stable phase the information transmission occurs. In this algorithm, the number of optimum clusters obtained as below:

(1)

Where N is the number of nodes, ε_{fs} and ε_{amp} arethe consumed energy of amplifier for the short and long paths respectively. The area dimension is M*M and dtoBs explains the distance to BS. Clusters generated as the energy load distributed between the nodes justly. Since the CH increases the energy consumption, the nodes turned to CH respectively. The I sensor node change itself to CH with $p_i(t)$ probability in r+1thround. Since the nodes start with the same initial energy, the $p_i(t)$ calculated as the CHs average equals to k in each round. $P_i(t)$ calculated as below:

p (2)

Where k is the number of clusters, $C_i(t)$ is the CH being evaluator of node I at (r mod N/K). As the node I is not the CH, $C_i(t)$ returns the amount 1.

If the nodes did not have equal energy, the nodes with higher energy will be CH for more times. Leachswdn Protocol developed by the sun et al (2012) chooses the CH as below:

p (3)

Where $E_{i\_Current}$ is the remained energy of node and E_{i_max} is the initial energy of node. This protocol is similar to Leach that chooses energy via the relation 4. Where $r_s$is the number of consequence round that is the CH.

(4)

p

Kumar et al (2013) studied the routing method and clustering based on LEACH method. Kumar (2014) developed two new protocol for the increasing the life of asymmetric wireless sensor called M-EECP and S-EECP. EECF protocol or distributed clustering algorithm presents a different procedure, optimizing the energy consumption.The CH nodes are chosen via the triple messages among the sensor and its neighbors. Selection act is performed as the chain form. EDETA routing protocol based on AHP clustering. EDETA is divided to the beginning phase and normal operation phase. This protocol is not suitable for the underwater environments because the cluster generation and nodes timing needs the frequent messages that has low reliability because of the long lag of aquatic environment. In 2015, Wayzeng et al chose the initial CH, using the K-means algorithm. If the network size was L*L*L, N and K was the number of nodes and initial CHs respectively, then the number of nodes in each cluster is equal to N/K. in this algorithm the lifelong improved, using the water depth and density.

Learning Automata

In the most of problems, there is no information about the correct answers;therefore, a Reinforcement Learning program will be developed, conjugating the dynamic programming and supervised learning. Learning automata is a kind of reinforcement learning methods. It tries to find the answer without knowing anything about the optimum operation. In reinforcement learning,a learner factor reaches to an optimized control policy during the training by the frequent interactions with environment. The main benefit of it is the lack of need to any information about the environment. Automata choses the operation randomly and performers at environment then the response is given and the operations updated; this operation repeated. Learning automata is divided into two group: constant structure and variable one. Variable automata is shown as E $\equiv \{\alpha, \beta, p, T\}$ where $\alpha \equiv \{\alpha_1, \alpha_1, ..., \alpha_r\}$ is the automata operation set, ، $\{\beta_1, \beta_2, ..., \beta_m\} \equiv \beta$ is input set, $p \equiv \{p_1, p_2, ..., p_r\}$ is selection vector probability and $p(n+1) = T[\alpha(n) + \beta(n) + p(n)]$ is the learning automata. Here if the αi operates at step n and receives the acceptable answer, the $p_i(n)$ will increases and other probabilities will decrease. However, the changes done to $p_i(n)$ summations always remain constant and equal to one. Acceptable answer occurs based on relation 5 and unacceptable based on relation 6:

$$P_i(n+1) = P_i(n) + a[1 - P_i(n)]$$
$$Pj(n+1) = (1-a)P_j(n) \quad \square j \quad \square j \# i \qquad (5)$$

$$P_i(n+1) = (1-b)P_i(n)$$
$$Pj(n+1) = \frac{b}{r-1} + (1-b)P_j(n) \quad j = i\square \square j\square \qquad (6)$$

Model of Consumed Energy

Consumed energy in wireless sensor network consists of three part, data sending, receiving and processing. The model of energy based on relation 7:

E

(7)

E

Where $E_T(l,x)$the node consumption energy for sending the l is bit data to the distance x. in addition, p_0 is the minimum signal energy that receiver can understand it. In addition, k is the energy distribution factor that equals to 1.5 for sphere emissions (relation 8).

a (8)

α

In relation, eight f is frequency; $E_R(l)$ is the consumed energy because of l bit receiving data considering the relation 7. In the event that sent data is, lesser the lesser energy will be consumed.

II. Material And Methods

Suggested algorithm has two phases same as LEACH algorithm, cluster generation (installation) and Setting up phases. In the installation phase the clustering operation is done, using the learning automata and energy model of underwater sensor network. It assumed that the mobile network nodes distributed randomly and each node has a linkage domain. This domain for each node is assumed as a three dimensional space that is spherical. Nodes are heterogeneous that means have different saving energy.

The CL Automata algorithm steps

Suggested algorithm has the below steps:

1. Random distribution of n node in distinct three dimension space
2. Choosing the CH by the suggested algorithm
3. The nodes role determination
4. Setting up or the data transmission phase
    - Data transmission from the general nodes to the CH
    - Data receiving by CHs and sending them to main station
    - CH energy consumption based on suggested energy model
    - CH role replacement among the sensor nodes
5. Iterating the steps 2 and 3 until the sensor nodes life Is not completed

CH Selection

In suggested method, the CH selection is done, using the Automata intelligent algorithm. Each mobile sensor node is considered as spherical form and determines its neighbors. After neighbor recognition, each node saves them in variable k. each node has learning automata. Learning automata select the $P_i(0)$ =1/k as the probability vector. Then each automata select its CH using the probability vector. During this operation, the automata selects the best operation and lastly the final CH is chosen.

Clustering Step

The shorter distance from CH, the lower consumed energy, therefore each sensor node links to the nearest CH to minimize the energy consumption and the lifelong be longer. After clustering and energy level fluctuations, a threshold considered for the second clustering. For the first clustering, the 30% of energy is extracted and remain energy is saved for the further steps.

Data transmission phase

General nodes transmit the data to the CH and send them to the base station after the data combination.

Simulation Results

The intelligent simulation has been done in an assumption network. The assumed environ is a three dimensional underwater acoustic networks consists of n node.

The CLAutomata algorithm results

The MATLAB software has been used for the experiments operation. The network assumptions are in table 1.

Table1. Simulation Parameters

Parameters	Scene1	Scene2	Scene3
Number of nodes	**100**	**200**	**300**
Environment dimension	100 × 100 × 100 cubic meters		
Location of central node or sink	(50,50,150)		
Initial energy	100 kj		
	0.001 kj		
	0.0002 kj		
	10 KHz		
	500 bits		
	1.5		
Package size	4000 bits		

The results of CLAutomata setting up are in table 2.

Table2. The death time of sensor node in CLAutomata algorithm

Table2- Scine the death of sensor nodes in Algorithm CLAutomata			
The number of nodes	100	200	300
first node death time	112	122	115
Half of the nodes death time	125	147	159
Last node death time	130	157	162

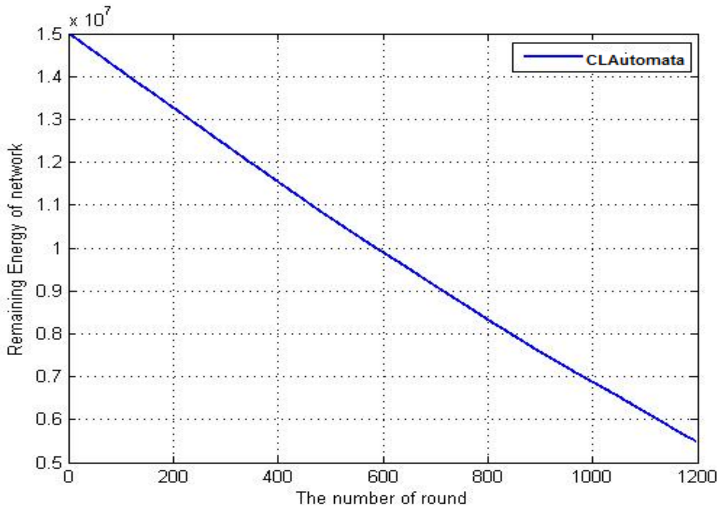

Fig1. The remained energy amount in CLAutomata algorithm

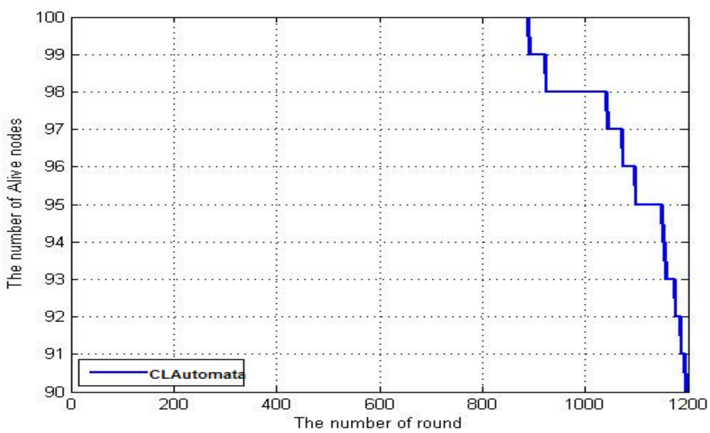

Fig2. The live nodes in CLAutomata algorithm

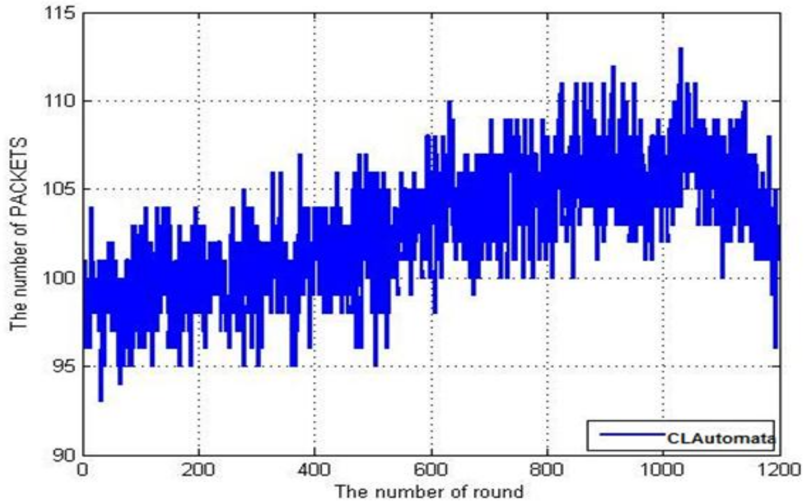

Fig3. The amount of received data in CLAutomata algorithm

The results of LEACHSWDN algorithm performance

The results of LEACHSWDN algorithm implementation are shown in table 3.

Table3. The death time of sensor node for LEACHSWDN algorithm

Table3- Scine the death of sensor nodes in Algorithm LEACHSWDN			
The number of nodes	100	200	300
first node death time	47	62	68
Half of the nodes death time	62	70	71
Last node death time	68	71	71

Table 4 shows the results of LEACHDCHS algorithm implementation

Table4. The death time of sensor node for LEACHDCHS algorithm

Table4- Scine the death of sensor nodes in Algorithm LEACHDCHS			
The number of nodes	100	200	300
first node death time	42	58	58
Half of the nodes death time	49	82	70
Last node death time	64	84	72

Figure 4 shows the comparison between the suggested algorithm with LEACHSWDN and LEACHDCHS.

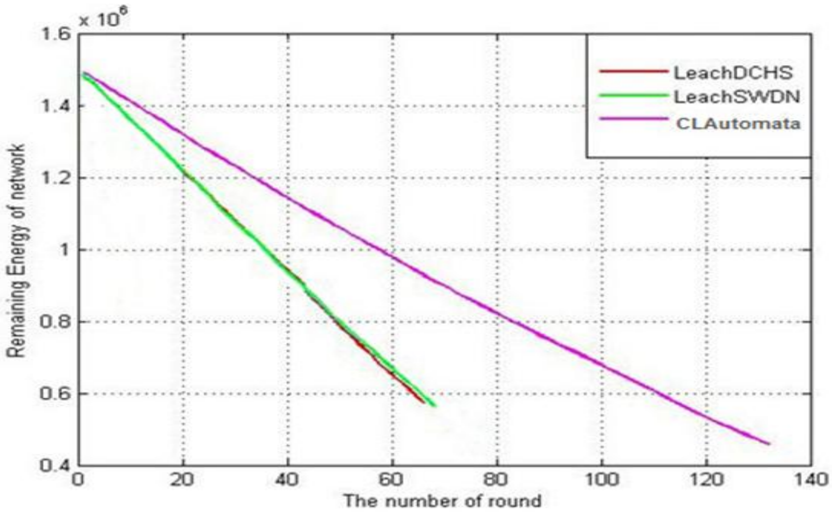

Fig4. Comparison of remained energy in CLAutomata with other methods

Figure 5 shows the received data by the base station in suggested algorithm with LEACHDCHS and LEACHSWDN. Because of the data integration in a linkage radius for each CH in suggested algorithm and sending them to the base station, this algorithm is better than algorithms.

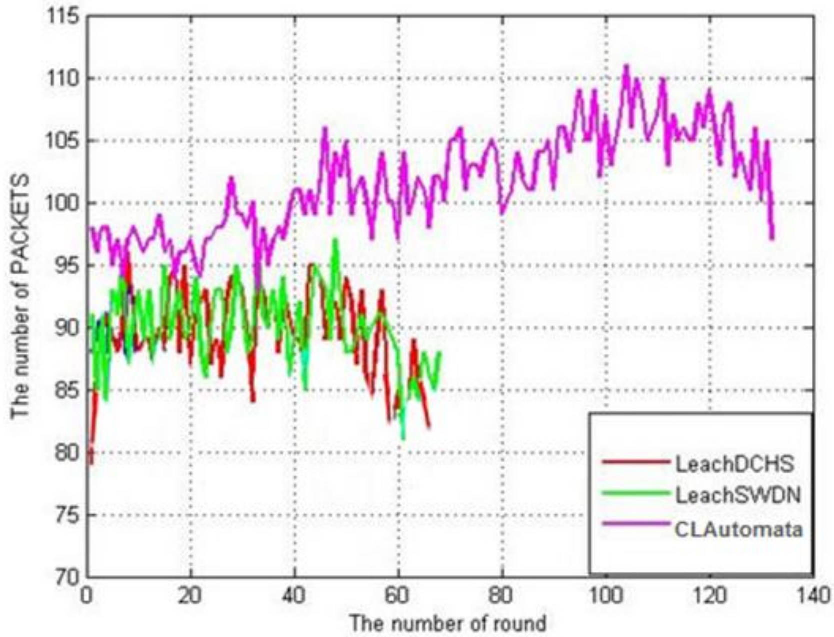

Fig5. The comparison of received data amount in CLAutomata with other methods.

Figure 6 compared the network lifelong in suggested method with LEACHDCHS and LEACHSWDN. Table 4, 5 and 6 compared the death time of sensor node based on three criteria. The standard criteria are the time of first sensor death time, the time of half nodes death time and the time of last node death time. Results obtained by the statistical society averaging (10 performance per each algorithm).

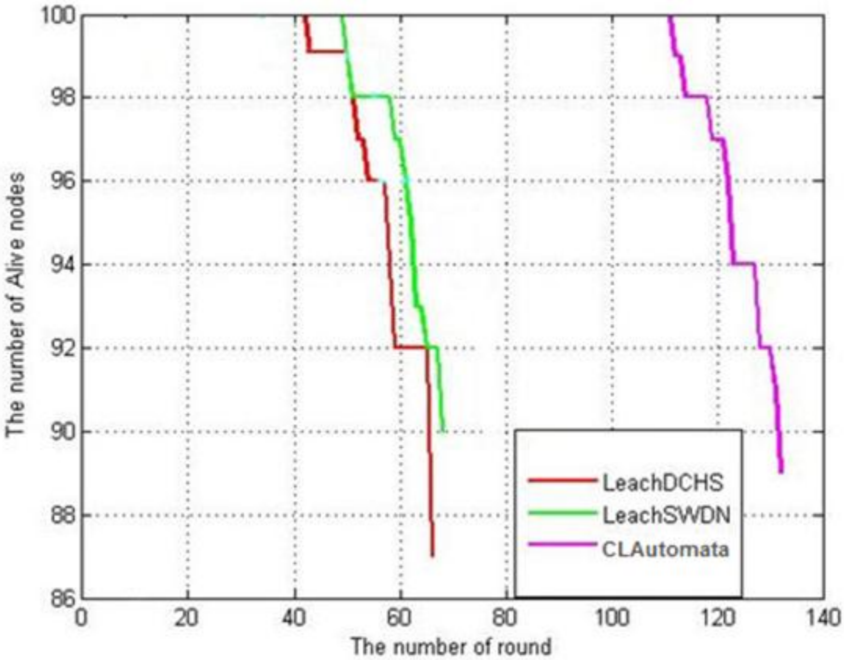

Fig6. The lifelong comparison of suggested protocol to the other methods

Table 5, 6 and 7 compare the death period in three aforementioned methods with different nodes 100, 200 and 300.

Table5. Death Compared Sensor nodes with 100 nodes			
Algorithm	LEACHSWDN	LEACHDCHS	CLAutomata
first node death time	47	62	68
Half of the nodes death time	62	70	71
Last node death time	68	71	71

Table6. Death Compared Sensor nodes with 200 nodes			
Algorithm	LEACHSWDN	LEACHDCHS	CLAutomata
first node death time	47	62	68
Half of the nodes death time	62	70	71
Last node death time	68	71	71

Table7. Death Compared Sensor nodes with 300 nodes			
Algorithm	LEACHSWDN	LEACHDCHS	CLAutomata
first node death time	47	62	68
Half of the nodes death time	62	70	71
Last node death time	68	71	71

Table 8 shows the network size effect on lifelong in different states in 100*100*100, 200*200*200 and 400*400*400 m^3 and the 100 nodes in network. As it can be seen,the size increasing rises the energy consumption and reduces the network lifelong.

Table8. The environment size effect on network lifelong

Size of the environment										
300x300x 300 Square meters			200x200x 200 Square meters			100x100x 100 Square meters				
Last nod	Half of nodes	First nod	Last nod	Half of nodes	First nod	Last nod	Half of nodes	First nod	Life Time / Algorithm	The number Of nodes
15	14.5	13	31	30	22.5	68	62	68	**LEACHSWDN**	**100 nodes**
13	12.5	10	31	30	24	64	49	42	**LEACHDCHS**	
13	12.5	8	46	45	17	130	125	112	**CLAutomata**	

III. Conclusion

In this research, a novel routing protocol for the wireless sensor networks presented called CLAutomata. This protocol is a routing method based on clustering, using the nodes energy level and the linkage radius. The algorithm is completely distributed, after the clustering, the cluster members send the information to the CH and it send the information to the base station. Based on results, the suggested algorithm shows 40% lifelong increasing than the other algorithms (LEACHDCHS and LEACHSWDN). In the future, it can be possible to conjugate the suggested algorithm with other routing protocols for the cluster generation and using the neighborhood functions for the cluster optimization.

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