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Energy Aware Algorithms For Wireless Sensor Networks

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Abstract

The study of Wireless Sensor Network is focused mainly on increasing the values of two main parameters like network lifetime and information reliability. All the algorithms and routing techniques applied on such networks try on their best effort to improve the performance and to have as result the most convenient values of both parameters. Lifetime and reliability are crucial in all kind of WSN application but especially in underwater as the case of this work. The main contribution of the paper consists in studying the behavior of the network while varying the different parameters like node distance from each other, node selection criteria for the different node roles in the network, definition of network lifetime duration, etc. Simulations show that due to these parameters the network decides itself when to stop functioning. The network lifetime becomes flexible based on the specific requirements of user applications.

*Keywords:*UWSN, depth, network lifetime, reliability, topology dispersion

1. Introduction

Greatest part of the earth is covered by water and exploration of this environment with new technologies provides us with larger number of data. Those data give information by helping us in preventing natural disasters, for offshore exploration, and for monitoring environment pollution, and also for scientific studies over the climate changes. The

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Underwater Wireless Sensor Networks (UWSNs) is a network made of smart sensing nodes that have computing and communication capabilities. So, the distributed nodes of a UWSN measure the quality of water or its temperature. Nodes allocated at sea bed have to transmit data to the other nodes that are located at the surface, and this activity will spend all their energy in a brief time by reducing significantly their lifetime, [1]. So, UWSNs as well as other networks require a multi-hop communication that can be assisted by the right routing scheme. Due to the absence of a common standard for the propagation of the acoustic wave in the underwater environment, it is difficult to compare the performance of the different routing schemes. Also, when these networks are designed the environment conditions have to be taken seriously in consideration, because they may alter the signal propagation, [2]. Because of temperature variation, pressure or the noise of the underwater environment it is difficult for signal propagation and receiving of it without any distortion and attenuation added to it. Due to the relatively low absorption rate of the acoustic signals, those frequencies are used for the communication in this kind of environment. In such conditions the choice of a robust routing scheme will play an important role for the communication between the source and the destination. The environment conditions change so its behavior is dynamic and it will impact the signal propagation and the communication between the source and the destination, so the model built might be very similar to reality. It can be expected to have significant delays introduced in communications, to have dynamic topologies of the network and an increase in the number of packets lost due to the dying nodes. As it is impossible to recharge or replace the nodes batteries of the sensor nodes placed at the sea bed. This paper presents an algorithm with the main purpose to study the data routing and the localization of nodes in UWSNs in different scenarios. The energy is the main constraint for these networks and all the parameters for performance measurement refer to it. So, the improving of network lifetime, the residual energy and the quantity of information transmitted with high reliability are critical for UWSNs, and are these parameters performance that are studied in different nodes distribution topologies.

The remainder of the paper is organized as follows. In Section 2, after having recalled some definitions regarding: the depth and node classification bases, network lifetime, and network reliability we will propose the new concepts of network reliability based on different concept of node reliability. Section 3 outlines our simulation results, and in Section 4 are brought the conclusions of this work.

2. Theoretical considerations of UWSN

The UWSNs have other concerns that are different from those of WSN applied on the earth's surface. It is impossible for them to use the solar energy for recharging their batteries, and recent researches are working on the possibility of self generating energy in nodes. So there must be paid attention to using node's energy by applying a very efficient routing scheme. The signal propagation speed of the acoustic signal is $1.5 * 10^3$ m/s in an underwater acoustic channel and the bandwidth is limited ($< 100KHz$) due to attenuation and absorption. The water depth will influence in the propagation delay of the acoustic wave, and the power consumption of the sensor nodes will depend as well on it. The information for neighbor's allocation will also influence on the speed of the information delivery. So, perhaps the information for location can be delivered with the data packets. The UWSNs are composed of the surface stations, relay nodes and sensor nodes placed near the bottom of the sea bed.

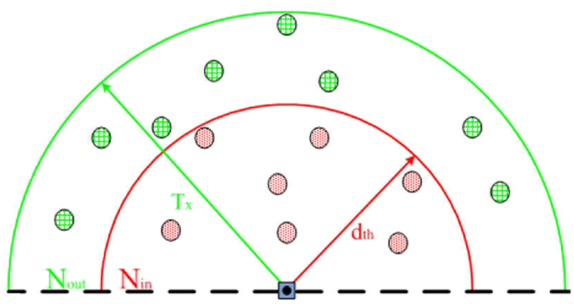

Fig.1. The distribution of the nodes based on the depth where those are placed.

The acoustic signal used for these communications will vary depending on the water pollution, noise in the underwater environment or of salinity. In this work sensor nodes are randomly distributed and at the beginning broadcast information is distributed to the nodes. Information tells the node about the one hope neighbors around it and the residual energy. After specifying the maximal depth D from the event (sensor node that is allocated in a depth zone and has to transmit), the whole zone is divided in three zones, Fig.1. Let's define node depth limit, a single node depth depends on the distance from the event. In our simulations we applied two thresholds as regarding to Fig.1. It is done a classification of the nodes depending from their position where those are distinguishable as: Source, Relay and Destination node [3]. So, nodes whose depth is $d_{th} > d_{hard}$, will be part of the set of Destination nodes (N_{out} noted with green color the ones belonging to this zone), Fig.1. When nodes depth is within the interval of values $d_{th} < d_{hard}$, nodes will be part of the set of Nin, and they can be chosen as Relay nodes (N_{in}) if they have the highest energy or will be set by random as Source nodes. Relay node will connect source node with destination nodes by following a path. All the three types of nodes (source, relay, and destination) are redefined every time there is required a communication of data packet from a node. The value of d_{th} is selected according to the average value of all the active surrounding neighbor nodes, the averaging is done for all network nodes and then by rounding its value to the upper floor. At the beginning during the initialization where the number of active neighbors is high also the value of the d_{th} is large. The choice of d_{th} is important because it helps on the dividing of node sets and also it is crucial for the routing scheme. The main constrain of UWSNs is energy and the algorithms applied try to minimize its usage. Network lifetime is the duration of a network when the first nodes die, [4]. While in some other cases it is defined [5], as the time when the last nodes dies. Depending on the node role in the network the quantity of energy that each node posses will change during the time. So, if the node is chosen as source node, its initial energy will decrease with the energy value required for transmission. For the relay node the quantity of energy that will be subtracted will be the sum of energy required for the receiving and for transmission. Instead the destination node the energy will be decreased with the energy value required only for receiving. All the other nodes who do not take part in the communication of information, their energy will decrease with the smallest value that of the node standing in the idle state. Differently from our previous work, [6], where we took the network reliability as the average of all nodes reliability, here the concept of node reliability is considered a bit different. With node reliability in [6] as per information reliability obtained by a node it depends on node vicinity to the event. The nearest the node is to the event more accurate will be the data obtained from the sensor node. In this work the reliability of the node depends on the number of active neighbors each node has around itself. The greatest this number is the more reliable will be the information obtained. Because there are more nodes to transmit this event data so the information is more reliable. So network reliability will be the rounded value of the mean of nodes reliability or better said the depth parameter introduced before.

3. Simulation results with Matlab

There are taken in consideration different random topologies where the number of nodes is not changed while the dispersion is changed (7 random distributions). The first simulation, Fig.2, indicates that the normalized energy decreases with the increasing of nodes dispersion as it can be expected. This occurs because as the network is more dispersed the same nodes that need to communicate between them now have to spend more energy. As the distance between them now is larger than in the beginning. This also depends on the number of active nodes, d_{th}, at that time.

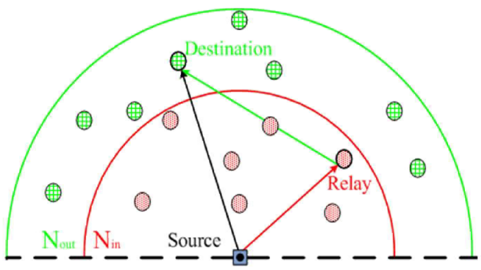

Fig.2.Nodes classification depending on depth parameter value.

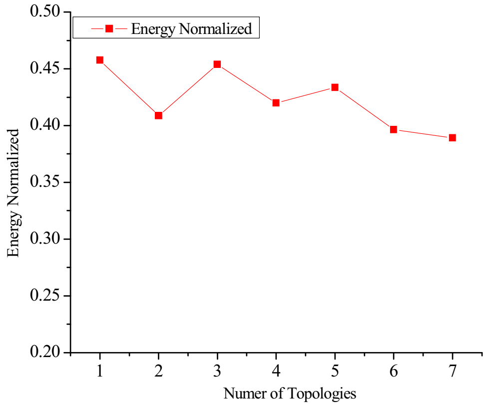

Fig.3. Normalized energy as a function of different topologies

The death of a network is determined by the value of d_{th}, which indicates that the number of active nodes is low. The choice of d_{th} depends on the distribution of the nodes, so it will depend from the different distributions generated randomly in the simulations. Fig.4 demonstrates that by increasing the distribution of the nodes, it results in decreasing the number of actives nodes, d_{th}. The normalized residual energy as well decreases, because it is a parameter that is influenced by the position of nodes. Network lifetime, in some studies is chosen as the time duration of a network that ends when the first nodes die, [4]. While in some other cases it is defined [5], as the time when the last nodes dies. During our simulation we have chosen the second case because the network can transmit even when only one node is alive. The network lifetime value and network reliability help us to find approximately the quantity of information that a network collects [7].Fig.5 illustrates the results of the network lifetime and the normalized number of active nodes, d_{th}, as a function of different nodes dispersion. The value of network reliability that also depends on the number of active nodes is a function of nodes distribution. So, for the first dispersion topology where the distribution of the nodes is very low, the possibility to have a higher number of nodes at the N_{in} is bigger, where there can stand the Relay and Source node.

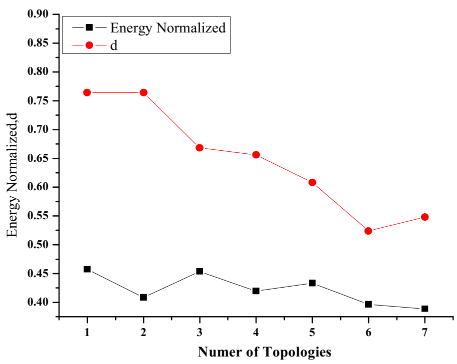

Fig.4. Network residual energy and d_{th} function of different topologies.

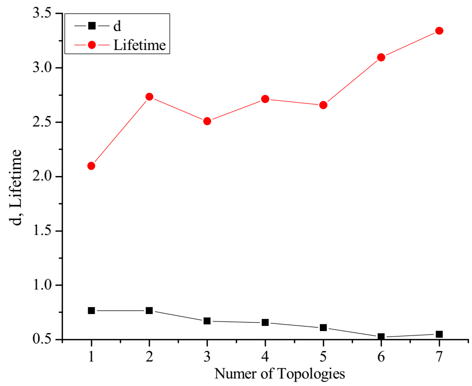

Fig. 5. Network lifetime and nodes active d_{th} function of different topologies

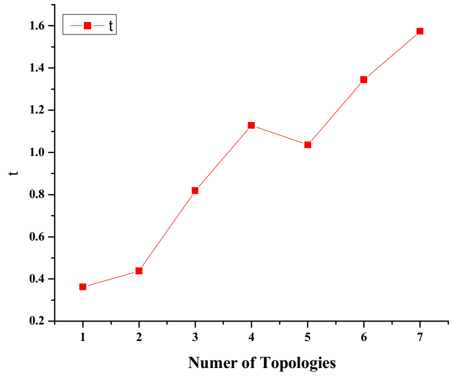

Fig.6. Network range of transmission as a function of different nodes distribution

The result of the output with a larger distribution is more different because only a small part of the nodes are at a zone. The results of our simulations are taken as the mean of 50 iterations for each of the different topologies.
During the simulation it may happen that a source can not find a relay node or a relay node can not find in its neighbourhood a destination node. So, due to this constrain by increasing the range of transmission it will help in finding some other nodes to communicate. But by increasing the range of transmission it will reduce the energy because of the long vertices and the network lifetime will become smaller. Fig.6, shows the results as expected that by increasing the distribution of the nodes the range of transmissions need to be increased. It will be helpful in finding the best transmission distance after having simulated the networks distribution. Then the Euclidian distance is calculated, and it is used to set the best R. This parameter will be the threshold for link definition, the mean value between R_{min} and R_{max} is found. Where the R_{min} is the minimum Euclidian distance between two nodes while R_{max} is the maximum. But it can also happen that by the value of R, found as described here the N_{out} set can be empty, so the network will be constrained to have another value for R that is increased by t. So as conclusion it can be said that where the nodes distribution increases so does the value of t. This variable represents a number that is required to be increased too as shown in Fig.6.This is important, because the network should not have a large value of t, not greater than R_{max}.

4. Conclusions

This study has taken in consideration the simulation of an existing algorithm by simulating the behaviour of it through different nodes distribution. The simulations show that the algorithm replies well to parameters that have been chosen for the simulation. This definition depends on the number of simulations, whose confidence level depends on their number. The choice of different topologies relies on the real interface of this algorithm with the environment of UWSNs, where it is impossible to intervene in changing the battery of the nodes set at the sea bed.

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