

Copyright: The author/s
This work is licensed under a CC-BY 4.0 license
(*) Corresponding author
Peer review method: Double-blind
Review article
DOI:10.20544/HORIZONS.1.1.23.P02



DESIGNING WIRELESS SENSOR NETWORK FOR MONITORING DOJRAN LAKE

Milica Avramovska, PhD Student*
*Industrial Engineering and Management,
Faculty of Technical Sciences – Bitola*
Email: milica.avramovska93@gmail.com

Elizabeta Hristovska, PhD
Full professor
*University St. Kliment Ohridski - Bitola,
Faculty of Technical Sciences – Bitola*

Sevde Stavreva, PhD
Associate professor
*University St. Kliment Ohridski - Bitola,
Faculty of Technical Sciences – Bitola*

Vangelica Jovanovska, PhD
Full professor
*University St. Kliment Ohridski - Bitola,
Faculty of Biotechnical Sciences - Bitola*

Abstract

This scientific work describes a wireless sensor network which can be placed in Lake Doiran. The purpose of this network is to monitor the water temperature and predict the algal bloom. Based on this measurements and predictions, the people can know when to visit the lake and enjoy the curing effects of the water. The weather changes have great impact in the process of algal bloom and from there comes the need for sensor network to monitor the temperature. This paper describes the type of nodes which are needed for the appropriate monitoring, their placement and position inside the lake, their localization and routing.

Key words:Sensors, Algae, Algorithms, Localization.

1. INTRODUCTION

Lake Doiran is located in the southeast part of the Republic of Macedonia. The lake's total surface area is 42,66 km². The west side of the lake belongs to Republic of Macedonia with surface area of 27,3 km²; the other and smaller side belongs to the Republic of Greece with surface area of 15,8 km². The lake's maximum depth is 10 m, the average depth is 6,5 m and the altitude above sea level is 148 m. Lake Doiran's maximum width is 7 km and the maximum length is 8,9 km [1]. This lake has many interesting features such as warm and turbid water with green color. The experts claim that the mud inside the Lake Doiran has curative properties and it

is rich with ingredients from the decomposed plants. The lake has Mediterranean climate as a result of the way it was created [2]. The reason for this paper is the great amount of features the lake has so that people can be familiar with the properties of this lake. In the sections below we will describe the lake's characteristic in details and the sensors we are going to use.

2. LAKE CHARACTERISTICS

The most important parameters in the construction process of the wireless sensor network are: the algae grown at depth between 1 and 10 meters; they can spread across the whole surface of the lake; in order to bloom they need a lasting temperature between 15 and 25 Celsius degrees. On lower temperatures they often grow slower or die and on higher temperatures they die very fast due to the process of denaturation of proteins [3]. In the presence of longer lasting temperature around 20 Celsius degrees, algae bloom much earlier than expected.

Table 1: Average water temperature in Dojran Lake in July over a decade [9]

2015	2016	2017	2018	2019	2020	2021	2022	2023
26.7°C	27.1°C	26.7°C	25.1°C	25.6°C	26.1°C	27.6°C	26.5°C	27.6°C

Average water temperature in Dojran Lake in July is 26.5°C and therefore suitable for comfortable swimming. The warmest water in Dojran Lake in July is 31°C, and the coldest is 22°C.

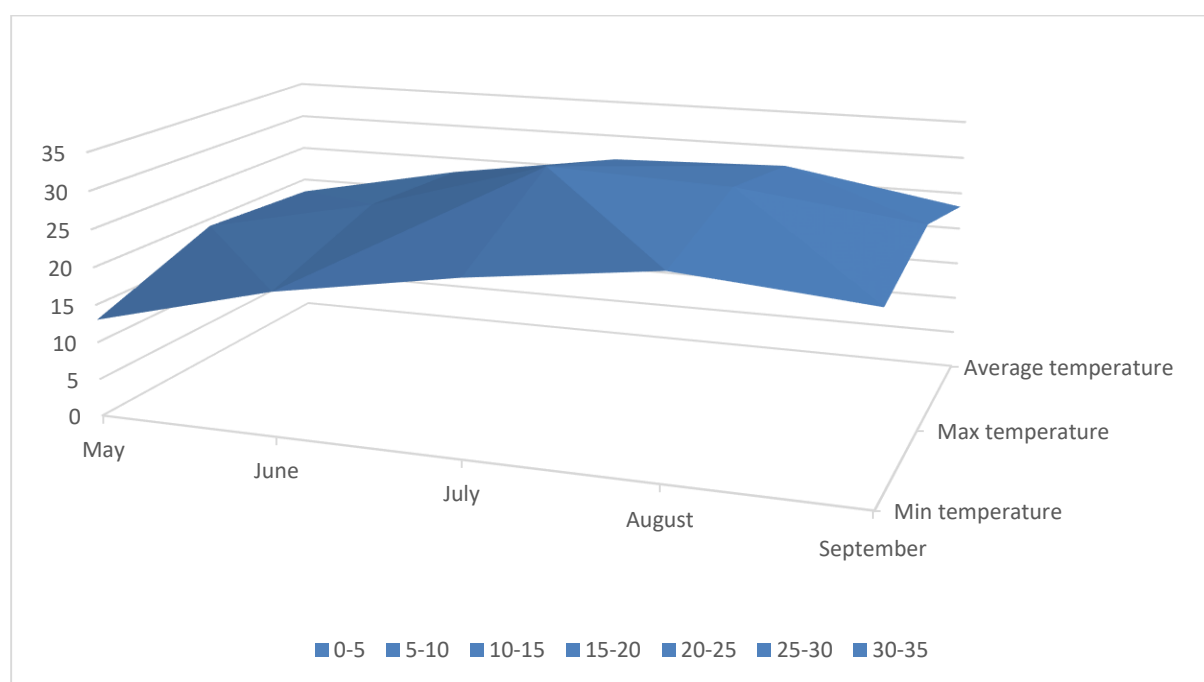


Chart 1: Visual representation of potential algae blooming according to measured water temperatures from May to September 2023

3. SENSORS CHARACTERISTICS

According to the constraints and characteristics above, sensor for temperature monitoring it is going to be used which will be placed inside a waterproof box. This sensor has an antenna, electronic interface, bandwidth and a microcontroller. The sensor also has a charger connector and battery slot. It is very likely that some of the sensors run out of battery power so it will become isolated; therefore, in the next section we will describe and elaborate the network architecture and the way how we will group (grouping) of the node.

4. CLUSTERING

The nodes will be grouped in Cluster architecture because it is believed it will be much easier and more efficient to monitor (or measure) the temperature in clusters, where each main cluster will send data to the base station, wherefrom the data can be accessed and monitored via Internet. The network is separated in several areas of nodes; each area has one main (primary) node which receives the data from the other nodes in the area and then the main nodes from each area send the data to the base station. The main node in each cluster will be chosen in random fashion and after some period of time this role will be assigned to other node. The purpose of this process is to prevent the node to spend its whole energy. According to the lake's surface area of 27,3 km², there will be placed 82 sensor nodes and one extra node for the base station which will have better performances compared to the others. We are going to add three extra backup nodes. The total number of sensors is 86, in average 3.1 sensors per 1 km². The sensor will not have GPS unit, mostly because they will stay underwater, which will reduce the price and the energy consumption. The network will have 17 clusters, each with 5 nodes. The next section describes the localization algorithms that we are going to use in the localization of the nodes in the network.

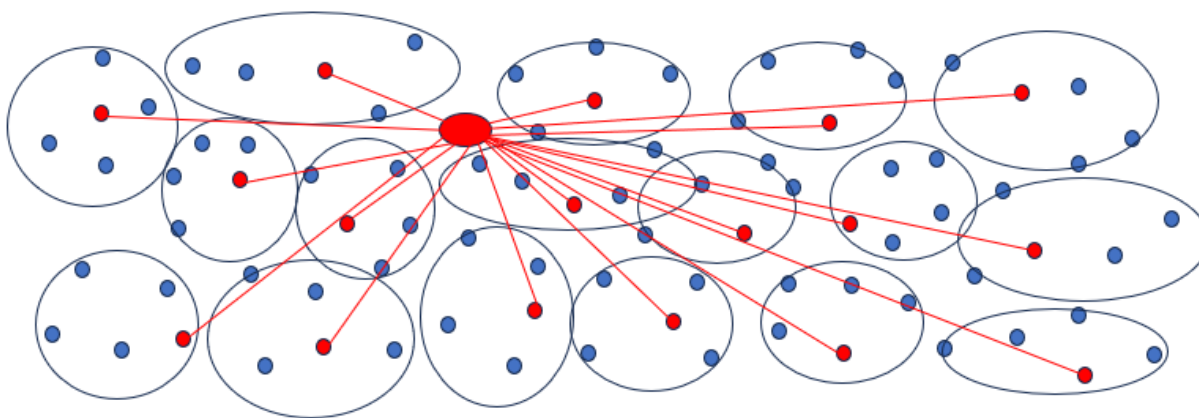


Figure 1: Example of communication between base station and main nodes separated by regions

5. NODE LOCALIZATION

The first thing is to be distributed the nodes. The nodes will be randomly thrown from a helicopter. After that we need to localize the nodes. I has been decided to use the time localization algorithm, i.e. distance estimation. Each node will send broadcast signal and then will wait for a response from the other nodes. The node whose answer will arrive first is the closest node. The five closest nodes will create a cluster. This method is efficient and cheap. We compare the signal strengths from the received signals with the signal strength from the current node. Based on these parameters, we can calculate the distance from two neighbor nodes very easy [4]. The main node will be chosen randomly for each cluster and he will communicate with the base station. This procedure will be applied on each node which does not belong to any cluster, i.e. every fifth node. The signal travel with the speed of light $3 \cdot 10^8$ m/s. This localization method is efficient, but requires very precise synchronization.

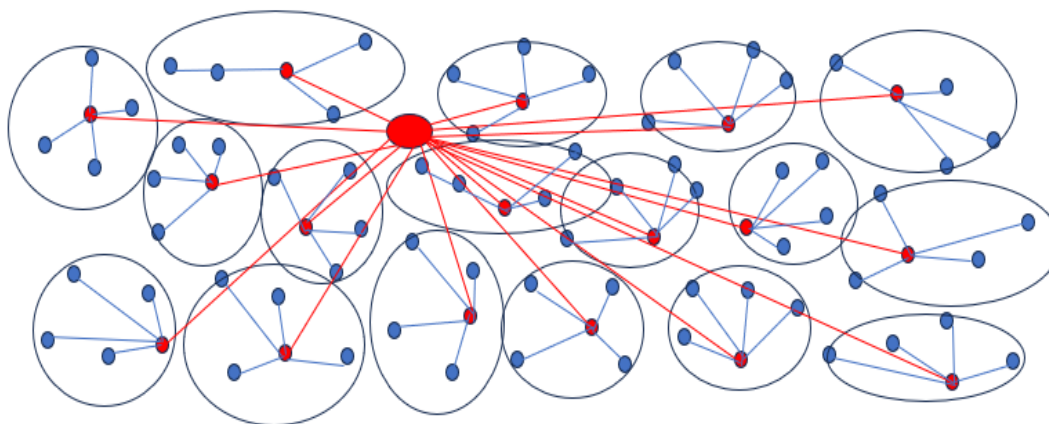


Figure 2: Example of complete communication between nodes separated by regions

There is no such thing as best localization method. The efficiency of an algorithm is calculated based on the error during measurements, linking, network topology, node capability, application requirements and etc. Some of the localization methods are fast, but not very accurate. We need to be accurate; therefore, we will use distributed algorithm, which will take a longer time to execute, but it will give us accurate results. Each sensor which collects data and information, which process the data and then it will send them to the main sensor. The distributed algorithm has good and optimal coverage and it is based on the Fritzke's Growing Neural Gas artificial neural network model [5]. In order to save more time, energy and money will be used Range-free algorithm. With the help of this algorithm, the nodes are localized based on their reference points. Each node will measure the temperature. When the water temperature will be above 20 Celsius degrees, we can expect and algal bloom in the next seven days. Not every algae bloom at the same temperature. It depends on their form and size. Some of them

need a higher temperature in order to bloom. The base station will tell if there is a fair chance for algal bloom.

6. SENSOR NETWORK USAGE

With the help of this network, we can create a statistic about different kind of algae and their bloom temperature. In the same time, can monitor the temperature variations in the lake. The sensors can be used during winter to detect and predict water freezing in different parts of the lake, because different parts of the lake do not freeze at the same time. Also, can easily detect which part of the lake is the coldest and which is the warmest. This statistic can help us in early detection in case of dying of some species according to their characteristics. We can measure water, plant and animal density and detect possible sensor strangle.

7. NODE ROUTING

This protocol is selected because it guarantees no redundant (duplicates and overspill) data flow. Some researchers have shown that this protocol is safe and guarantees secure communication between the nodes [6]. The format semantics of the meta-data is application specific and it is not specified in the SPIN [7]. The sensors can use their unique id in order to send meta-data if they cover some known region. SPIN has access to the energy level in the current node and adapts the protocol which is in use, based on the current energy level. These protocols are time driven and they distribute the data across the network even if the client does not explicitly ask for them. If make an assumption that each node in the network can be a possible base station, the client can send query to each node and retrieve the needed information. These protocols exploit the fact that close nodes have similar data and information; therefore, only the data from the other nodes should be distributed across the network. The efficient of this algorithm is tested on extension time interval from the beginning of the lifetime on then network until the death of the first node and it is a significant question when is expected a response. They completely describe the collected data (meta-data) and negotiate the meta-data format before the data transfer [8]. The SPIN family is specifically designed to overcome the classic data overflows problems using negotiating and adaptation.

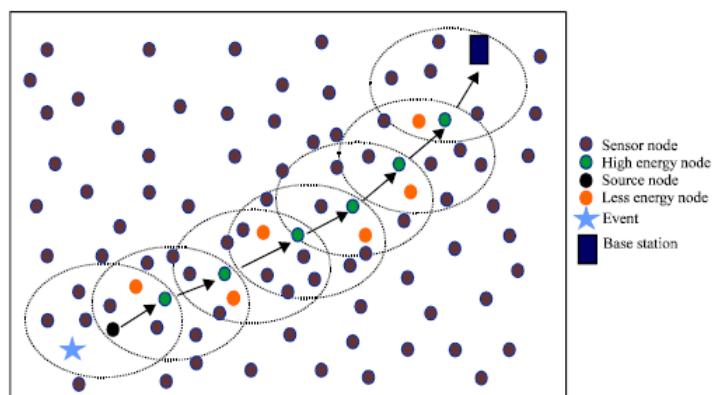


Figure 3: Nodes routing

8. CONCLUSION

The wireless sensor network which will monitor the temperature inside the Lake Doiran and which will help to predict and detect the algal bloom, is described in the Introduction. This network should be very good localized and routed optimally in order to save more energy, because the sensors are underwater and once they exhaust their energy source it cannot be replaced with a new one. Our goal is more lasting sensor nodes which will help each other in order to prevent region isolation. This sensor network can be used in the prediction and early detection of the algal bloom and help us to create a statistic of the water temperature variations. This data can be accessed from a computer, smart phone or a tablet and can be used in a future scientific work related to this lake including the water characteristic and the algae. We are witnesses of the fast weather change, which cause fast nature changes; therefore, we need a modern, fast, accurate and an easy way to access and monitor these changes and gather the new data.

REFERENCES

Journal Papers:

- [1] Korovchinsky, Nikolai M., and Trajan K. Petkovski. "The ancient Balkan lakes harbor a new endemic species of *Diaphanosoma* Fischer, 1850 (Crustacea: Branchiopoda: Cladocera)." *Zootaxa* 3784.5 (2014): 539-549.
- [2] Zhang, Xiaosen, et al. "Lateglacial and Holocene climate and environmental change in the northeastern Mediterranean region: diatom evidence from Lake Dojran (Republic of Macedonia/Greece)." *Quaternary Science Reviews* 103 (2014): 51-66.
- [4] Stojkoska, Risteska, Biljana. "Data Fusion in Wireless Sensor Networks." FINKI. Skopje. 2013.
- [5] Kulakov, Andrea, and Danco Davcev. "Distributed algorithm for a mobile wireless sensor network for optimal coverage of non-stationary signals." 1st Workshop on Spatial Stochastic Modeling of Wireless Networks (SpaSWiN'05), Riva del Garda, Italy. 2005.
- [6] Xiao, Debao, Meijuan Wei, and Ying Zhou. "Secure-spin: Secure sensor protocol for information via negotiation for wireless sensor networks." *Industrial Electronics and Applications*, 2006 1ST IEEE Conference on. IEEE, 2006.
- [7] Xiao, Debao, Meijuan Wei, and Ying Zhou. "Secure-spin: Secure sensor protocol for information via negotiation for wireless sensor networks." *Industrial Electronics and Applications*, 2006 1ST IEEE Conference on. IEEE, 2006.
- [8] Tripathi, Ashutosh, Narendra Yadav, and Reena Dadhich. "Optimization of Clustering in SPIN-C and LEACH for Data Centric Wireless Sensor Networks." *Proceedings of Fourth International Conference on Soft Computing for Problem Solving*. Springer India, 2015.

Books:

- [3] Data from book „Талофита“ from Zlatko Levkov. A.R.G. Gantner Verlag. K.G. 2012.

Web pages: [9] <https://seatemperature.info/july/dojran-lake-water-temperature.html>