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Implementation of a wireless system architecture of conductivity temperature and pressure sensors for support the identification of the salt wedge and its impact on safety Maritime in estuary of the Magdalena River - A case study

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Abstract

This article aims to show the components of a wireless sensor system to measure temperature, conductivity and pressure at the mouth of the Magdalena River - Colombia. This analysis was carried out jointly with the General Maritime Directorate of Colombia. The measurements will be carried out underwater, with the buoys currently available in the navigable channel, which will work with solar energy and the data will be sent via Bluetooth, Wifi or Ethernet. With the data received by the sensor network, different analyzes will be carried out through the implementation of different data mining techniques, which will support the decision making of government entities. Through the implementation of this architecture, different behaviors found in the estuary will be identified and there will be real-time information that favors maritime safety in the navigable channel.

Keywords: Wireless System, Conductivity Sensor, Temperature Sensor, Pressure Sensor

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1. Introduction

The port of Barranquilla, has established itself as a link of high importance for both the region and the country, due to the transit of inputs from the different vessels mobilized by the Magdalena River. Currently, the port of Barranquilla has had a decrease in the amount of tons that it has been able to transport in the year 2019, compared to the previous year, 184,863 tons less has stopped mobilizing this port unlike in January and February of year 2018, because the passage of large vessels caused by the sedimentation that the river currently has is restricted. Such situations generate delays in the process of disembarking vessels from different parts of the world and generate additional costs for the port from the logistic point of view, and security of the navigability of the canal. Additionally, these situations create a danger to the safety of navigation, cargo and of course the environment of the estuary and the adjacent coastal sector.

Having a coastal observation system (SOC) that in our case would be estuarine, with instruments based on information and communication technology that contribute to the identification of different variables that affect sediment generation of this national tributary, results in the good and efficient management of the port of Barranquilla, consolidating it as the fourth port of national importance in Colombia.

The information provided to the port sector, after an analysis, evaluation and confirmation of data in the field, will provide accurate information on the sector to be studied, and may be shared with the maritime authority, associations and companies in the maritime sector. That is why, the Departmental Development Plan of the department of Atlántico - Colombia, “Atlántico Líder” [1] expresses the importance of greater industrial, commercial, and logistic development for the improvement of the living conditions of the inhabitants of the department and the need for its economy to be stable and sustainable over time, actions must be developed to increase productive capacity, the generation of quality employment and new businesses to support the diverse communities of society, such as women, young people, artisans, artists, etc., for which it is proposed: to promote activities related to the manufacturing, agricultural [7,8] and agribusiness sectors with generation of added value for which there are easy access to marketing and transportation services given the proximity to local ports and airport.

For this, an Atlantic department must be consolidated with the development of multiple activities on the eastern band and the so-called Caribbean Route, with an emphasis on agribusiness, taking into account the potential of using this area to interconnect with both sea and river ports. Taking into account the above, the optimal and proper functioning of the port results in benefits and achievements of local, departmental, regional and international order, the implementation of this wireless system will seek to strengthen the different actions that can be performed in the port to identify the wedge saline as a fundamental aspect for the location of sedimentation in the river that results in an improvement in the attention to the different vessels that make use of the port.

2. Brief Review of Literature

In the review of the work related to monitoring marine environments using wireless sensor networks, a clear distinction is observed between two types [2]: Wireless Aerial Sensor Networks (abbreviated Aerial Wireless Sensor Network, abbreviated A-WSN) and Sub-Aquatic Acoustic Sensor Networks (from English Under Water Acoustic Sensor Network, abbreviated UW-ASN).

UW-ASNs consist of a variable number of sensors and vehicles that are deployed to develop collaborative monitoring tasks over a certain area. In the work of Akyldiz [2] there are a set of 15 projects with UW-ASN technology and the main research challenges that these entail. In the work and research consulted, it is mentioned that water is not a very efficient means of propagation for radio waves, since it is only possible to transmit signals of very low frequency (30 - 300Hz) .and special antennas and a more robust power source.

The problems of underwater acoustic networks are: a very limited bandwidth, delays in signal propagation are five times slower than ground RF signals, high error rates, temporary connectivity losses, limited energy resources for an energy collection system due to the lack of sunlight, among others [3]. UW-ASN-based communication systems are ideal when equipment deployment at great depths is required.

A wireless network of aerial sensors (A-WSN) consists of a set of nodes, where each node has a limited power source and communicates with another by means of low-consumption radio modules. In addition, there is one or more nodes equipped with more robust energy sources that act as a sink.

The work of Ong [4] presents a proposal in which underwater acoustic communications are used, while the gateway node converts the acoustic signals into radio frequency, completing the link to the base station through the air medium. It is important to mention that there are also works in which radio frequency communications are used in aquatic environments.

The SEMAT project Trevathan [5] for its acronym in English Smart Environmental Monitoring and Analysis Technologies, proposes a proposal in which they decide to use this scheme, the author suggests that it is convenient when working in too noisy environments. However, it is clear to note that its main limitation is the short range of transmission [6].

Holbox-Mexico buoy. It was implemented to make measurements of water quality, direction and speed of current, salinity, dissolved oxygen and other measurements near Holbox Island, Quintana Roo. CINVESTAV-Mérida buoy. CINVESTAV-Mérida maintains an oceanic buoy in operation north of Telchac Puerto, in Yucatán, on the Yucatan Platform. RENOM-IMT buoys.

The National Network of Oceanographic and Meteorological Stations (RENOM) is made up of measurement systems that continuously record the conditions of the waves, the variations of the sea level and the characteristics of meteorological variables [7].

Mazatlan-UNAM buoy. The Coastal and Port Engineering Group of the Engineering Institute of the UNAM, attached to the Institute of Marine Sciences and Limnology (ICMyL), in collaboration with the Academic Unit of Mazatlan, Sinaloa, have an Oceanographic Buoy in operation on the coasts of Mazatlan carrying out meteorological and oceanographic measurements for its transmission in real time, with the purpose of preventing tsunamis. ICMyL-Puerto Morelos buoy.

The Academic Unit of Reef Systems (UASA) in Puerto Morelos, Quintana Roo, attached to the ICMyL of the UNAM, in collaboration with the Institute of Engineering of the same institution, have an oceanographic buoy in operation near its facilities in Puerto Morelos [8].

3. Architecture of the Solutions

For the design of this architecture, the system was considered to have low energy consumption. Telemetry - UHF outside low power and free band in the radio spectrum. It is important that the system is modular and allows the network and measurement points to be expanded without limitations. Having a short range (1km) and long range (20km) repeater, which will allow you to have a network in the future up to 1000 RTU, which allows you to monitor countless points and cover large areas without limits. See Figure 1.

3.1. Elements that make up the Network.

The A850 Telemetry Gateway is the central device through which you configure all your RTUs. It is here that you connect the sensor controllers and insert the sensor calibration information, establish connection and calling routes, establish call schedules, analyze the quality of the communication, the regularity of the connection, data delays and much more. Initially the equipment is configured remotely and the Monitoring Points respond if the configuration has been successful or not, subsequently and according to the sampling intervals and called the Gateway requests the information and the Monitoring Points respond with the information.

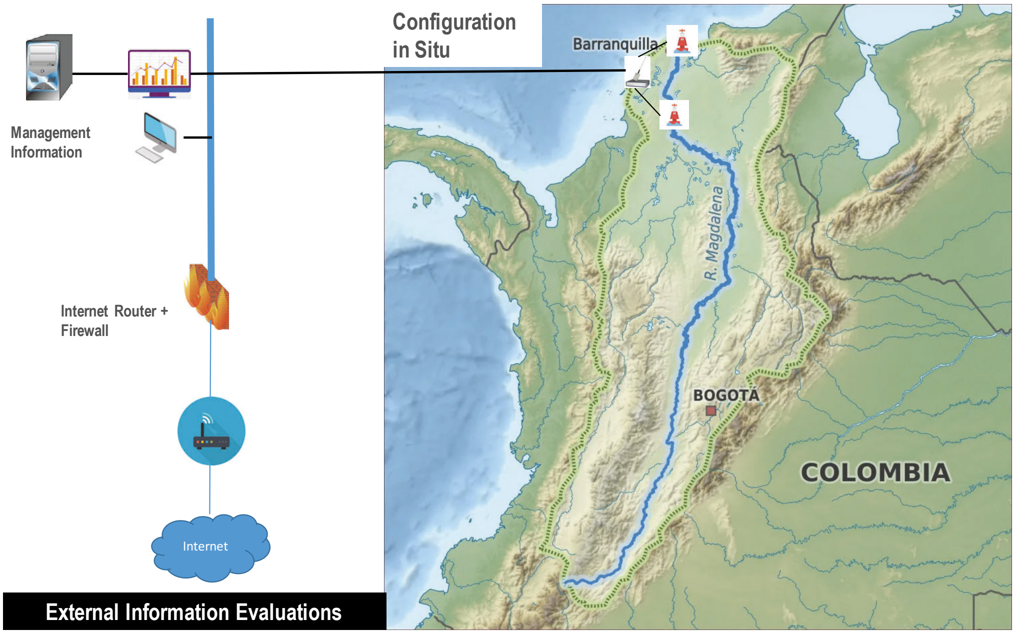

Fig. 1. General Network's Arquitecture.

RTU A753 addWave transmits with an output power of 500 mW in 70 cm the frecuency band is between 430 and 470 MHz, and can reach distances of up to 20 km (12 miles), with proper installation. Each RTU A753 can be used simultaneously as a data logger and as a relay station for other ADCON RTUs. This allows distances of more than 100 km (60 miles) to be reached between the base station and the most remote location: data breaks from one station to the next. This also allows the installation of radio stations on very difficult topographies. The 36 Xi W Series (CTD) is based on the proven technology of the 36 XW Series, where the high quality 10L Series pressure transducer is used. All X Series level transmitters have an RS485 interface, which provides standard pressure and temperature, as they are multi-parameter probes equipped with pressure, temperature and conductivity sensors (CTD - Conductivity, Temperature, Depth) the length is approximately 90 mm longer.

The OTT RLS sensor uses pulse radar technology to measure the water level without direct physical contact. It is easily installed directly above the sheet of water to be measured. Its low power consumption and standard interfaces make the OTT RLS an extremely flexible sensor. The wide measuring range of up to 35 m allows you to measure accurately over large distances. The value of the solution is 34,668.42 US dollars, at the 2019 price.

The system implemented in 2 buoys in the Magdalena River in Colombia, has allowed the following conductivity analysis that can be seen in Figures 2 and 3.

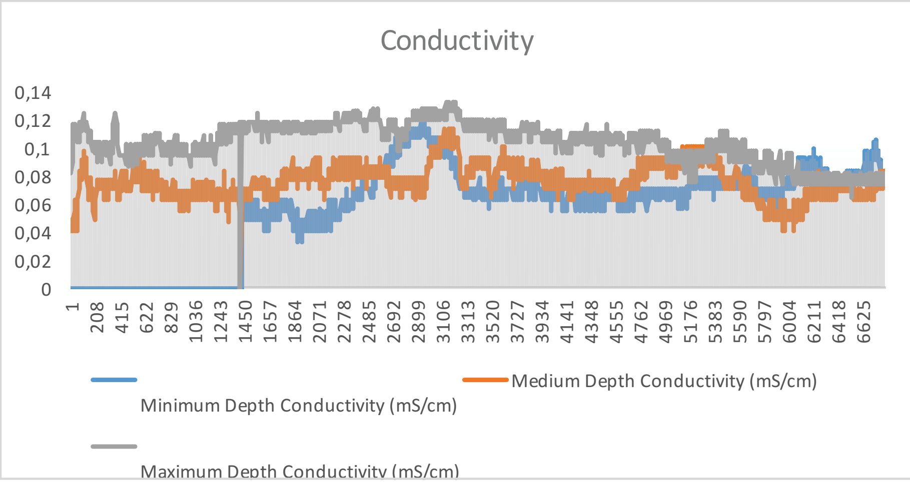

Fig. 2. Conductivity Analysis for buoys 1.

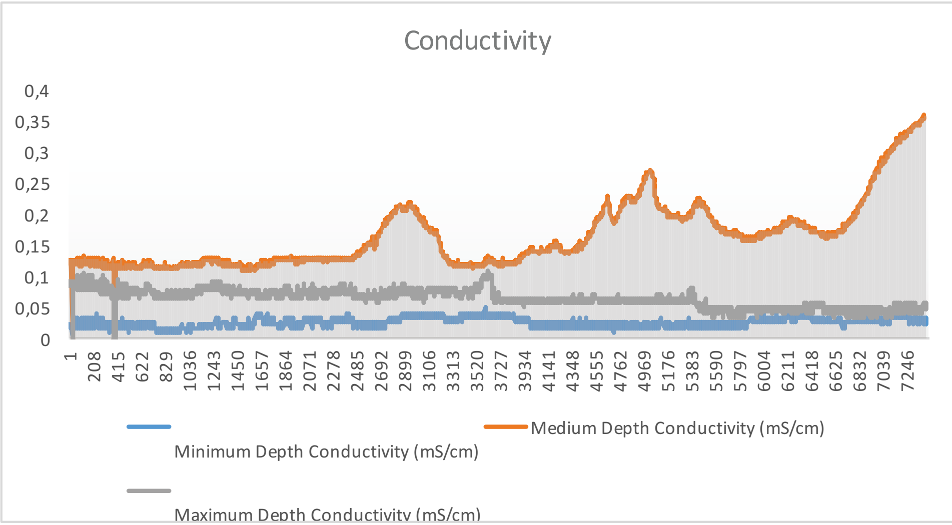

Fig. 3. Conductivity Analysis for buoys 2.

With the analysis shown in the previous figures and considering that the presence of the salt wedge is in medium depth, which indicates that it may be directly affecting the Barranquilla aqueduct, which can lead to public health problems. This proposed system is allowing support to the authorities in determining the impact of this phenomenon on the health of the community.

This architecture can be implemented in other estuaries, the Magdalena River in Colombia has been taken as an initial pilot study case. And this architecture differs from the others because it is allowing to evaluate the navigable channel of the river in a continuous way unlike the others exposed in the literature.

4. Conclusions

It is important to note that at the regional level there is no software application that supports the provision of such services. That is why the development of this application encourages the development and consolidation in the port of Barranquilla of solutions that serve as support for decision-making in the maritime sector, providing for the safety of navigation.

This proposal aims to have leadership in the implementation of Information and Communication Technologies in the maritime sector of the Colombian Caribbean region, allowing to improve the use of this water resource of high importance for the region and the country.

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