Underwater acoustic monitoring sensors network

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1. INTRODUCTION

This paper presents an experimental wireless sensor network for monitoring underwater acoustic noises. Each sensor node consists of a floating platform anchored in the location of interest, powered by solar panel and storing excess electricity in Li-Ion batteries for uninterrupted operation. The communication between the sensor nodes and the central node (gateway) will be made by a radio link operating with the LoRa standard on the frequency of 433 MHz, a link that allows minimizing consumption and maximizing the distance between the sensor nodes and the central node (several km). The network implements the star topology. The sensors continuously monitor the sounds in the underwater environment and are triggered to store 5s of noise and then send it over the radio link to the gateway where it is stored locally on a server or sent to the cloud, in a database for further processing. The trigger level is configurable. Sound acquisition can also be started on demand, remotely.

2. EXPERIMENTAL SETUP

The proposed sensor node uses a DolphinEar PRO-10 wide-band (1-24 kHz) omnidirectional underwater sound transducer for capturing underwater sounds [1]. The conditioning of the signal captured by the hydrophone is done by means of a precision amplifier based on the operational amplifier INA333. Local digital signal processing is implemented on an Arduino Due development board with ARM Cortex-M3 microcontroller.

The radio communication is implemented on the basis of a LoRa modem type RFM 98 operating on 433MHz.

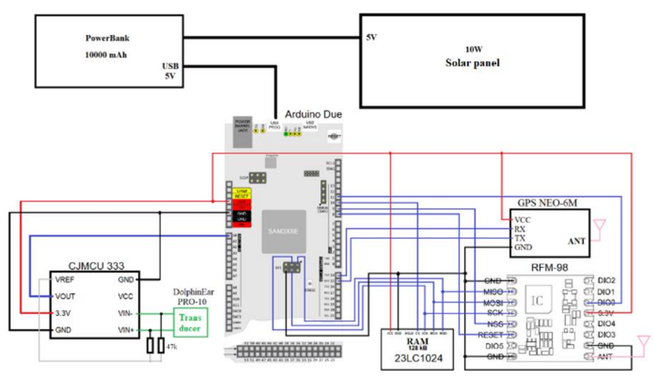
As the internal RAM memory of the microcontroller in the Arduino Due board is insufficient for the temporary storage of the acoustic signal until it is transmitted by radio, an external 128kB memory type 23lc1024 has been added. The sampling rate is 12kHz and the resolution is 12bit.

A NEO-6M GPS module is used to accurately determine the timing of an acoustic signal of interest as well as to monitor possible movements.

The complete electrical diagram of a sensor node platform is detailed in figure 1, as well as its practical implementation. The flowchart describing the operation of the software running on a node platform is presented in figure 2.

The sensor network implements a star configuration. The Central node or Coordinator of the network connects via a USB emulated serial interface to a Gateway connected to the Internet or to a computer that stores the received data locally.

Figure 3 depicts the schematic diagram and practical implementation of the Central node or Coordinator. The flowchart describing the operation of the software running on the Central node is presented in figure 4.



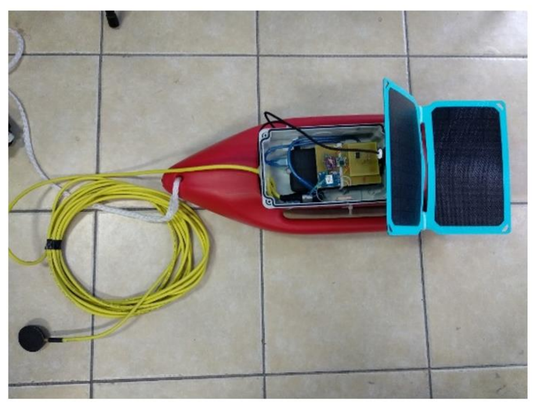


Fig. 1. Sensor node.

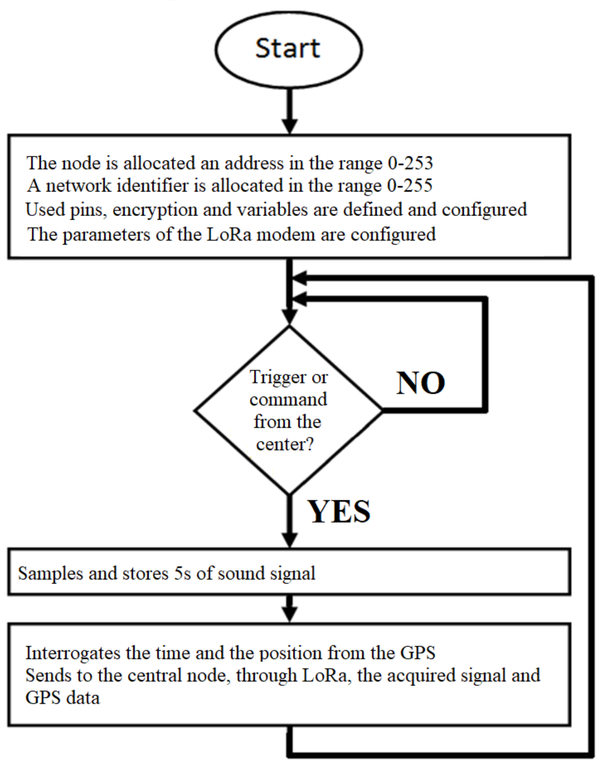
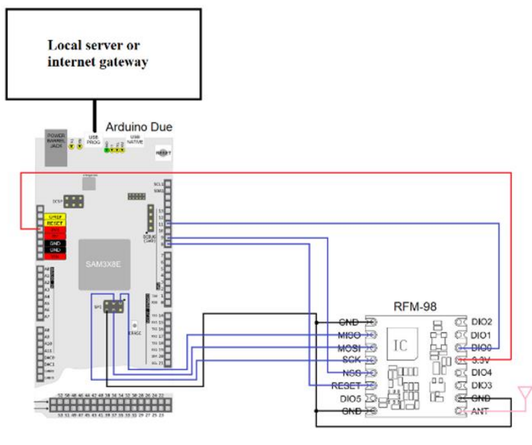


Fig. 2. Software running on a sensor node.



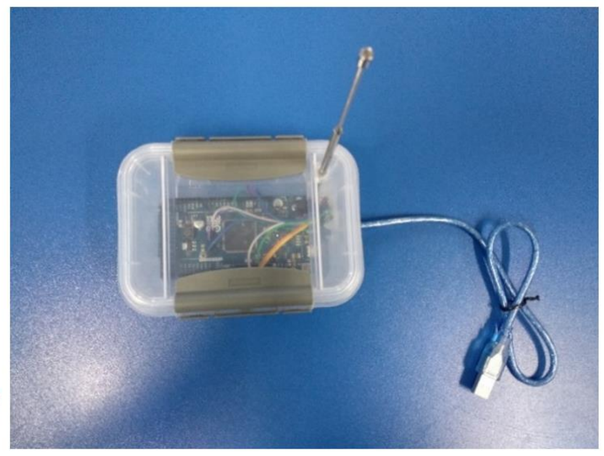


Fig. 3. Central node.

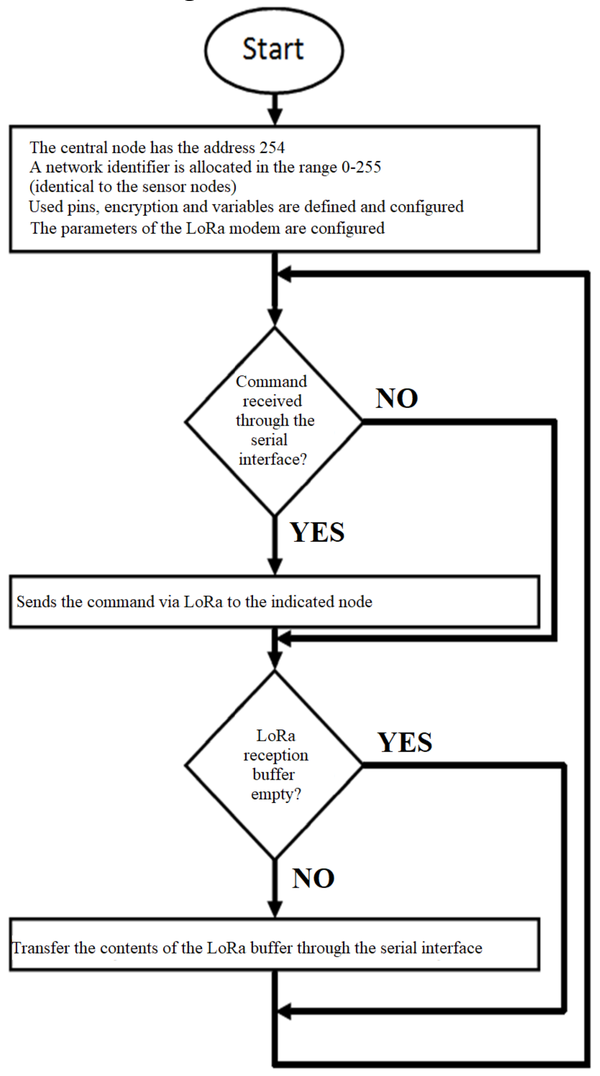


Fig. 4. Software running on the Central node.

3. RESULTS

For the experimental validation of the underwater acoustic monitoring system in real operating conditions, the continuous monitoring of a sector of the aquatic area where the experimental nodes were deployed was carried out. During the monitored period, multiple events were recorded that produced detections from the nodes, events generated by incursions of motor boats into the monitored area.

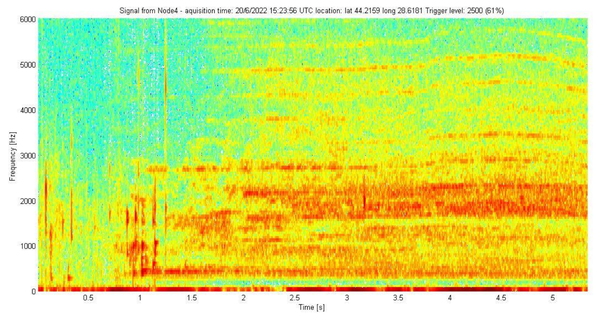


Fig. 5. Signal picked up by a sensor node in the presence of a motor boat.

4. CONCLUSIONS

After testing the system in real operating conditions, the correct operation of the developed experimental system was found, thus validating its ability to detect the entry of motor boats into the monitored area and the transmission of the acquired acoustic signal to the command center for possible further processing.

REFERENCES

[1] Degregorio, B., Wolff, P., Rice, A. "Evaluating hydrophones for detecting underwater-calling frogs," Herpetological Conservation and Biology, 16(3), 513-524 (2021).

ACKNOWLEDGEMENT

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