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► **To cite this version:**

Fekher Khelifi, Benoît Parrein, Jean-Marc Rousset, Thierry Grousset, François Babin. Poster n°A n Underwater Acoustic Sensor Network Protocol for Monitoring Offshore Wind Turbines Fields. Seenergy2021, Sep 2021, Nantes, France. hal-03358237

**HAL Id: hal-03358237**

**<https://hal.science/hal-03358237>**

Submitted on 29 Sep 2021

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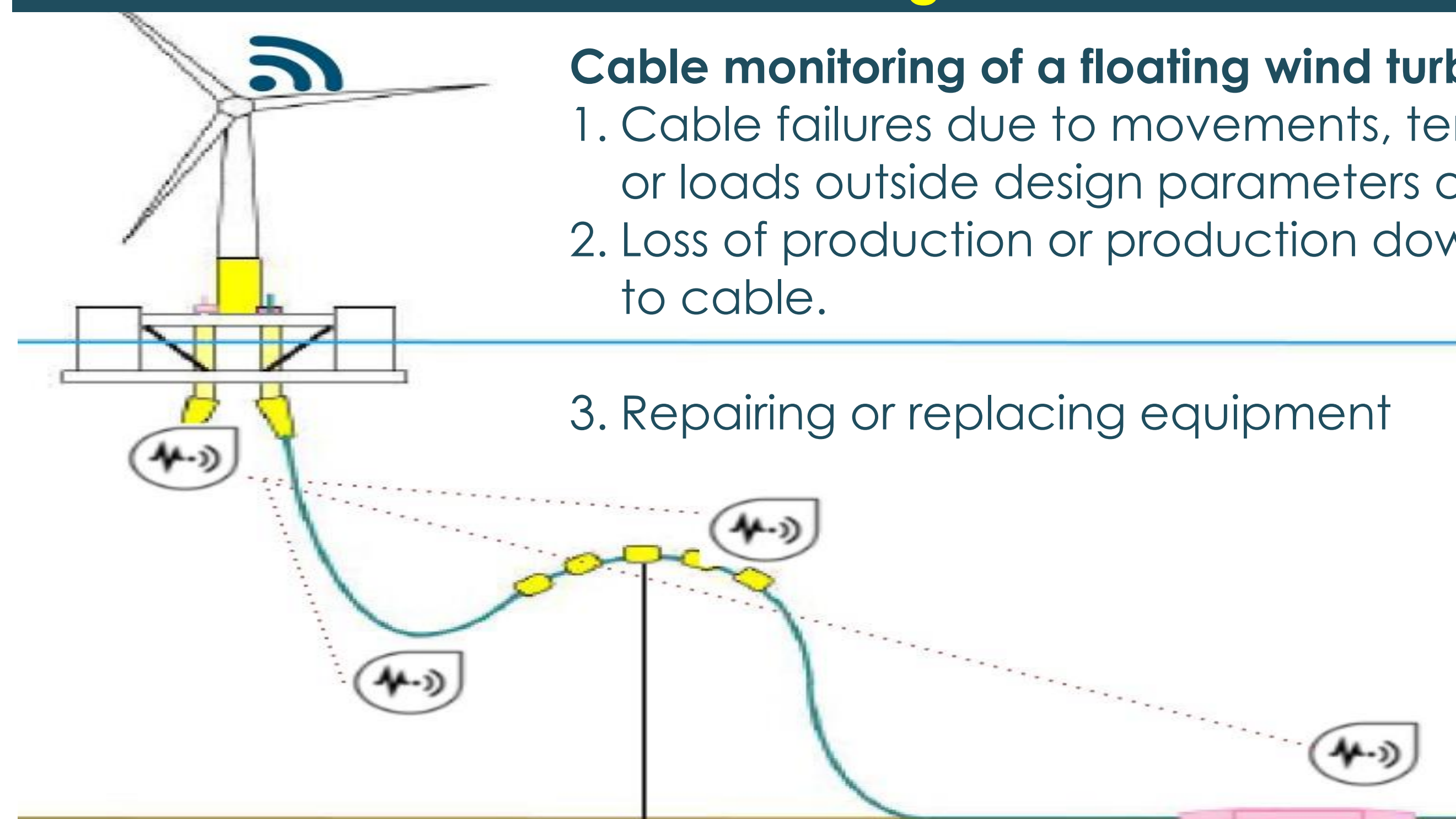
# An Underwater Acoustic Sensor Network Protocol for Monitoring Offshore Wind Turbines Fields

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## 1. Motivations

Offshore wind turbine monitoring is important to reduce maintenance and operating costs of safety-critical components and systems, and to optimize the design of future wind turbines. The acquisition of structural response data, local interrogation of collected measurement data, and wireless transmission of that data or analysis results to a UASN, which comprises other wireless sensing units[1]. These sensing units require the design of dedicated UASN networking protocols [2]. The objective of this poster is to demonstrate the first hardware implementation of the MAC Protocol for data collection in UASN, with very low throughput transmission devices (50 bps).

## 2. Offshore wind turbine monitoring

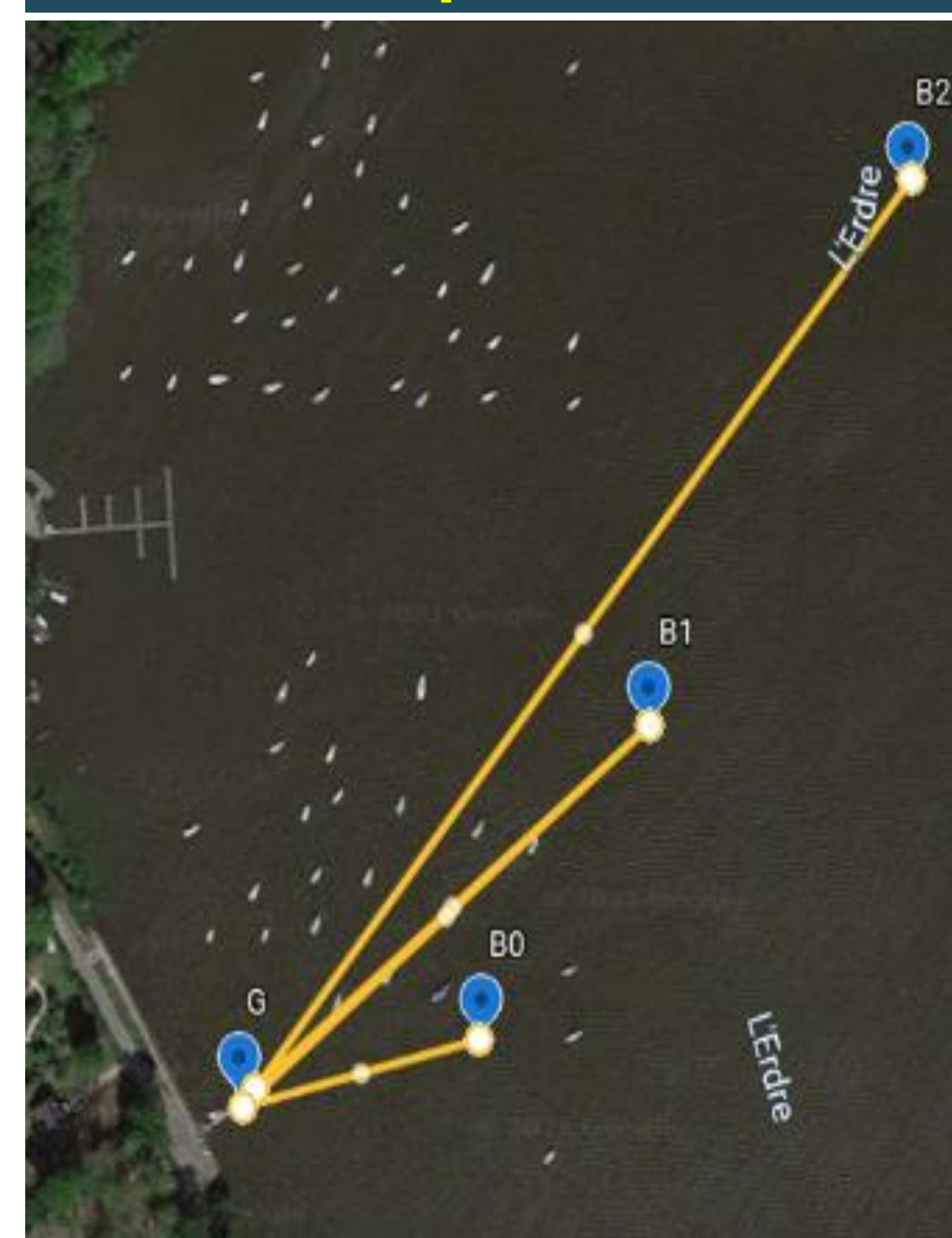


### Cable monitoring of a floating wind turbine:

1. Cable failures due to movements, temperatures, or loads outside design parameters of equipment
2. Loss of production or production downtime due to cable.
3. Repairing or replacing equipment

Figure.1: Cable monitoring of a floating wind turbine

## 4. Real experiments in Chapelle sur Erdre Nantes



To evaluate the mixed communication range, we set up an experimental scenario to implement the TDA-MAC protocol. Our scenario includes points placed in the Erdre, as shown in this figure. From these points, we create links with Gateway with varying distances. The goal of this scenario is to verify the mixed coverage range of the prototype in hardware.

Figure.3: Deployment in Chapelle sur Erdre

## 3. Transmission Delay Allocation MAC (TDA-MAC)

The (TDA-MAC)[2] protocol facilitates efficient scheduling of packets in UASNs without clock synchronization at beacons.

### A. Transmit Delay Instruction

- Estimate propagation delays between Gateway and Beacons by sequentially exchanging PING packets.
- Send a transmission delay instruction (TDI) packet to each beacon.
- Store transmit delay, mark link as active

### B. Data Request

- Transmit broadcast REQ packet
- Schedule packet transmission with allocated delay.
- Receive data packets from Beacons

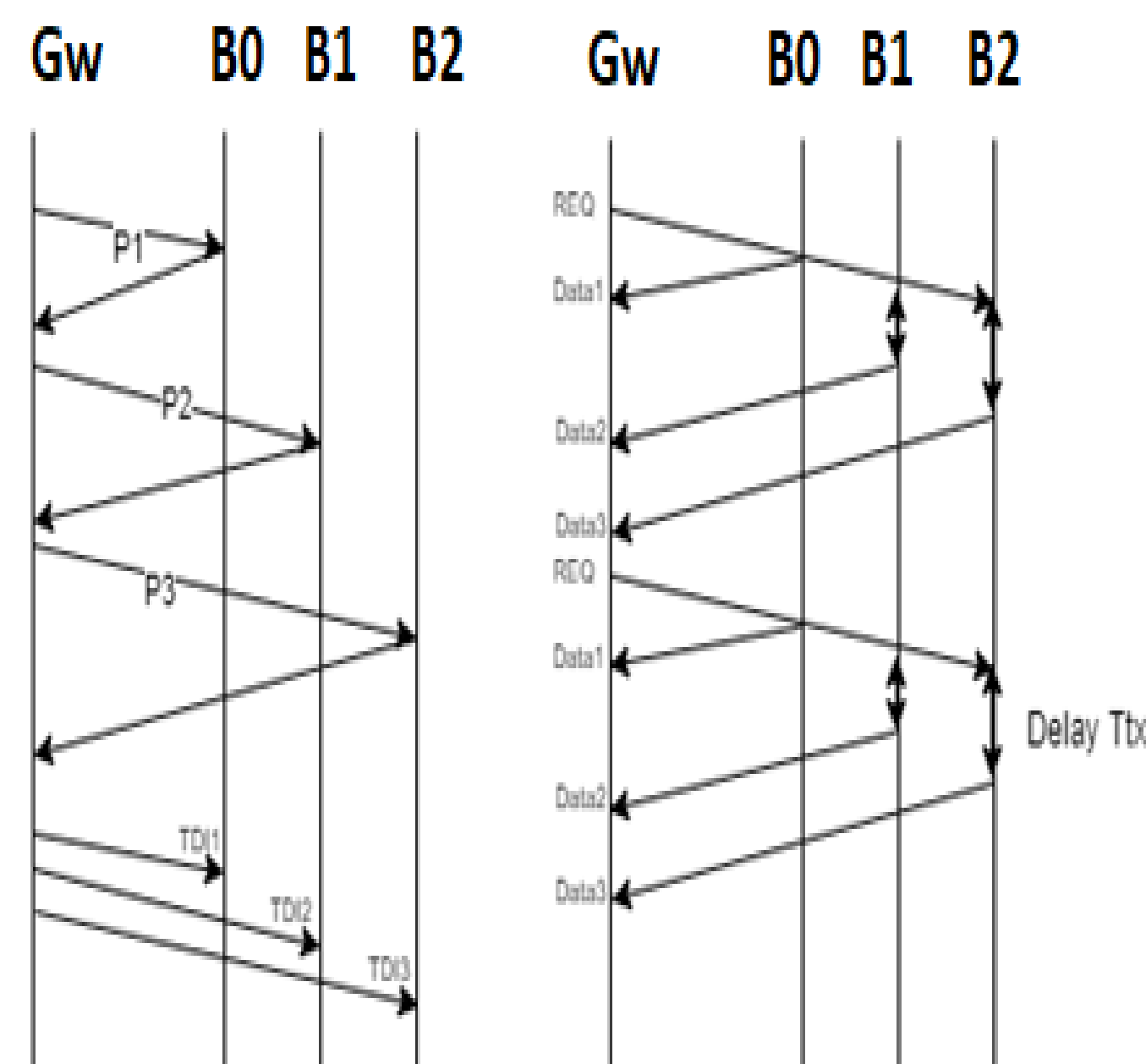


Figure.2: Work flow of TDA-MAC

## 5. Results

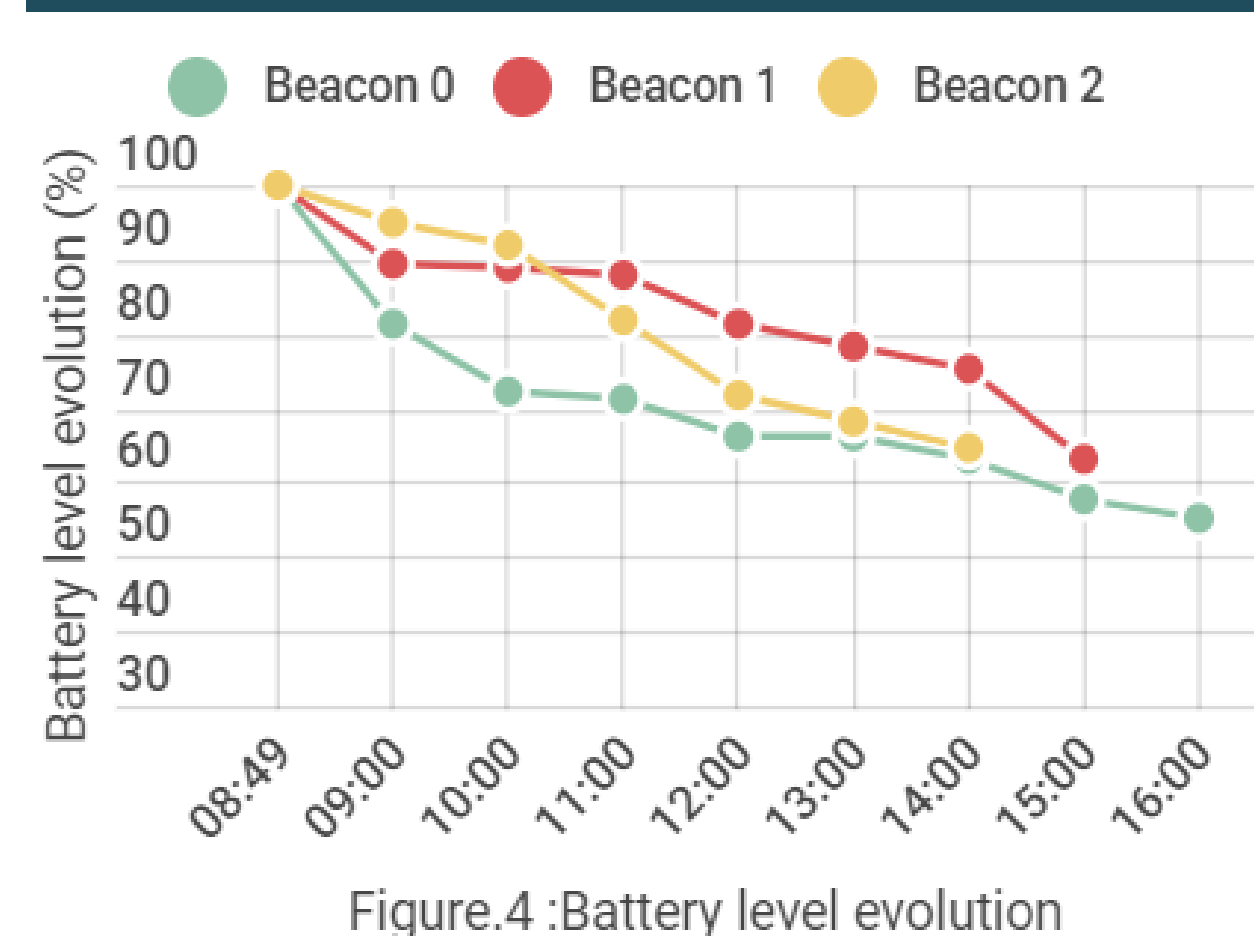


Figure.4 :Battery level evolution

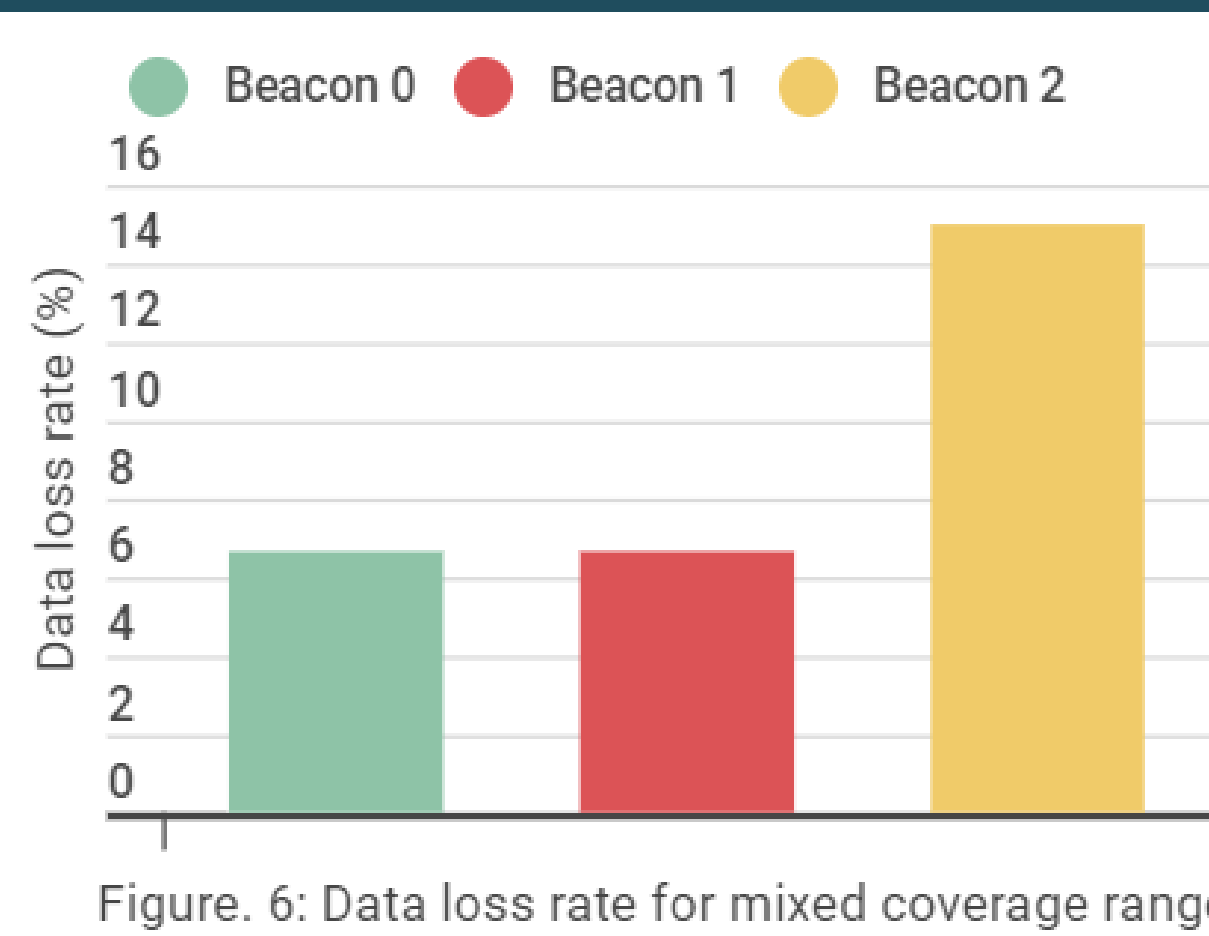


Figure. 6: Data loss rate for mixed coverage range

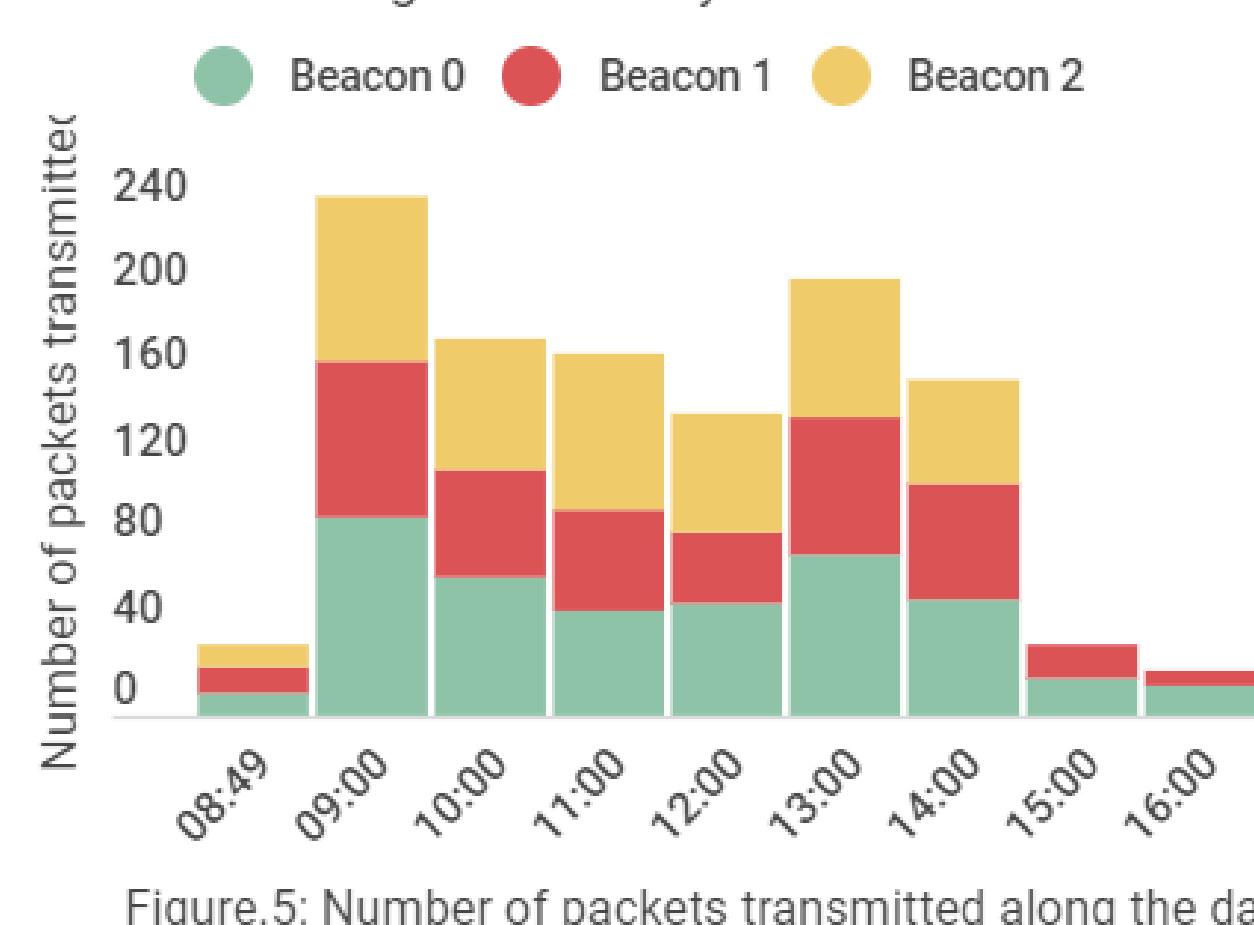


Figure.5: Number of packets transmitted along the day

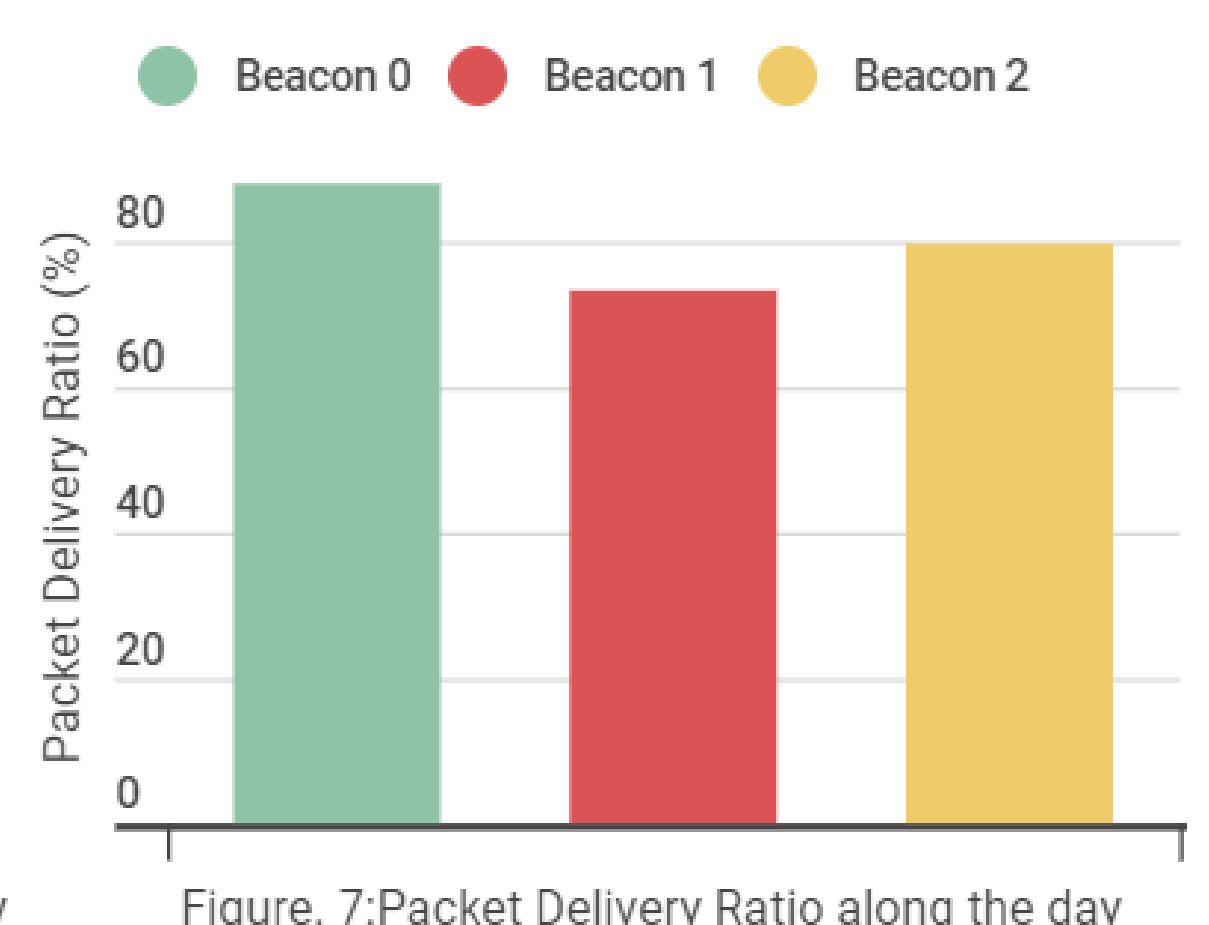


Figure. 7:Packet Delivery Ratio along the day

## 6. Conclusions

In figure 4, we see that the battery level decreases with the Number of packets transmitted . This is due to the higher number of packets, which send data (figure 5).

Figure3, It is possible to observe that beacon 0 and beacon 1 keep a similar behavior, with a DLR of less than 10%, for mixed communication range. In figure 7 , the experiments maintain the PDR higher than 80% for Beacon 0 evaluated with different communication ranges.

In this experiment, we conducted a performance evaluation study of the TDA-MAC protocol using underwater acoustic communication, through real experiments. The evaluation metrics we used are power consumption and delivery ratio.

In the future, it is recommended firstly, to decrease transmission delay instruction of the protocol in order to increase throughput. Secondly, to test prototype in a large du Croisic with a greater number of beacons This work was supported by the Région Pays de la Loire through the Blue IoT - EOLIA project.

## 7. References

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2. MOROZS, Nils, MITCHELL, Paul D., ZAKHAROV, Yuriy, et al. Robust TDA-MAC for practical underwater sensor network deployment: Lessons from USMART sea trials. In : Proceedings of the Thirteenth ACM International Conference on Underwater Networks & Systems. 2018. p. 1-8.
3. MOROZS, Nils, MITCHELL, Paul D., et ZAKHAROV, Yuriy. Dual-hop TDA-MAC and routing for underwater acoustic sensor networks. *IEEE Journal of Oceanic Engineering*, 2019, vol. 44, no 4, p. 865-880.