# Opportunistic protocol for distributed update of an IoT-based environmental observation system relying on participatory science

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**Location:** IRISA Lab (Vannes)
**Team:** CASA (http ://www.irisa.fr/casa)
**Supervisor**: Yves Mahéo (yves.maheo@univ-ubs.fr)
**Co-supervisors:** Nicolas Le Sommer (nicolas.le-sommer@univ-ubs.fr) / Lionel Touseau (lionel.touseau@univ-ubs.fr)

## 1 Description

Climate change effects on ecosystems are more and more noticeable. In order to mitigate these effects, our habits must be adapted to the environment and the availability of resources. The impact of these efforts should also be measured in order to encourage practices with virtuous effects on ecosystems. To do this, it is necessary to observe the state of the environment and resources through the deployment of numerous sensors.

This thesis aims at studying and proposing a secure protocol for distributed updating of a large-scale environmental observation system based on participatory science. This system, made up of low-cost components that communicate via LoRa radio technology and multi-hop opportunistic transmission techniques, should make it possible, with the help of citizens, to increase the number of sensors, and thus improve the quality of observation and the capacity to prevent risks linked to climate change. The opportunistic transmission techniques considered are intended to facilitate the deployment of the system in the absence of a pre-existing network infrastructure, and to tolerate connectivity disruptions resulting from the sleep of relay nodes or their mobility. Over-the-air update solutions exist, but they rely on a centralised approach and single-hop point-to-point communications. In this thesis, shared data structures such as CRDTs can be considered to improve the consistency of the system state. The security mechanisms built into this update protocol may be based on signatures, but also on reputation mechanisms. The propositions resulting from this thesis will be integrated in the platform that will be developed in the ANR Ladybird project.

## 2 Research questions

The distributed update protocol considered in this thesis should allow the observation system to evolve, and also errors or security flaws to be corrected. Not all the devices composing this system are directly and permanently connected to the infrastructure. Some of them may be mobile, or put on standby for long periods of time for energy saving reasons, or may not be within the coverage area of the Internet gateways. They must therefore rely on intermediate devices to transmit and receive data. The lack of end-to-end connectivity, does not allow for a centralised administration of such a system. In this context where devices are not reachable, administration operations such as software updates are usually performed offline, device by device. When the number of deployed devices becomes too large, update procedures should be performed remotely, in a distributed manner.

This thesis will therefore have to answer the following questions:

- What mechanisms can be implemented to ensure a global update of the nodes of a system, taking into account that the objects involved have low processing and storage capacities?

- How to maintain the system in operational condition when updating the communication modes, when heterogeneous versions co-exist?

- More generally, can convergence of the system state (i.e., version of the different nodes) be guaranteed, and how can this be achieved?

- What is the impact of connectivity disruptions and dynamic network topology on the propagation of updates?

- Finally, to what extent can a node trust an update, and more generally how can the update process be secured without any guaranteed connectivity to a trusted authority?

This thesis will be based on the preliminary work carried out by the CASA team of IRISA on the opportunistic communication protocol for LoRa, named LoRaOpp [1].

# 3 Context and location

The PhD position will be located at IRISA laboratory in Vannes (University of South Brittany). In addition, the Ladybird project will lead to cooperation with other institutions such as small tech companies, Environment and Geoscience Institute or the Computer science laboratory from Grenoble university, or even international partners like Hydro-Meteorology laboratories from South Vietnam.

# 4 Application form

- CV
- cover letter
- Master 1 and Master 2 notes

# References

[1] Nicolas Le Sommer and Lionel Touseau. Loraopp: A protocol for opportunistic networking and computing in lora networks. In *18th International Conference on Wireless and Mobile Computing, Networking and Communications, WiMob 2022, Thessaloniki, Greece, October 10-12, 2022*, pages 308–313. IEEE, 2022.