Éligible à une allocation de type : UCA-EDSTIC-EUR-DS4H

Titre du sujet : Enhanced Localization and Range Extension in LPWANs

Mention de thèse : Informatique

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Description du sujet :
Low-Power Wide Area Networking (LPWAN) technology offers long-range communication, which provides network access for IoT applications over large distances with low power consumption. LoRaWAN is an interesting medium access control mechanism developed as an open standard in unlicensed spectrum. However, it was shown that the range suffers greatly when the LoRa infrastructure is deployed in urban areas. Two important problems when deploying LoRa-based networks in urban environments are therefore identified: 1) the localization of end nodes and 2) enhancement of the range and quality of the communication between the end nodes and gateways. In this PhD topic we propose to tackle these two problems with the following approach.

Concerning node localization, different techniques [1-5] can be used to extract useful data for localization from the network. These data include versatile metrics such as RSSI, time difference of arrival (TDOA) or Direction of Arrival (DoA), but also specialized ones tied...
to the nature of the signal of interest. Indeed, the signal is a bandwidth limited chirp which resembled the radar signals used to estimate the speed of the target. This data will allow an initial coarse estimation of the device location. However, as the localization accuracy increases with the number of gateways in the deployed network, the possibility of adding nodes acting as «secondary gateways» for a limited period of time seems interesting. This could be done by reconfiguring already existing nodes of the network (e.g., LoRa sensors already deployed at fixed and known locations in the network) into a receiving mode (secondary gateways) to collect additional network data (e.g., additional RSSI values, mobile Wi-Fi and BT Beacon position). The main challenges in this study will be focused on synchronizing the switching between sending and receiving modes for all nodes in the vicinity of the object to localize and scheduling in an optimal way the transmission of RSSI measurements towards the main gateway. The latter will process all the measurements to provide the localization information of the target object. The scheduling operation will be critical to avoid feedback implosion in presence of large number of nodes.

On the other hand, cooperative reception mechanism or a Distributed Receive Beamforming would be a robust and scalable way to extend the communication range wireless devices. In the case of a deployed LoRa network with a given number of nodes and gateways, relay nodes can help to realize the cooperation reception. This can be achieved by using reconfigurable LoRa devices, acting as either a classical end node or as a relay at the demand of the gateway. Each relay would be used to aid the communication according to different strategies e.g., Amplify-and-Forward, Decode-and-Forward, Estimate-and-Forward, then the gateway applies a cooperative decoding scheme by coherently combining the signals from the relays. It has been shown that similar approaches could yield a received SNR that grows linearly with the number of relays [6]. The main challenge is to achieve an optimal trade-off between decoding capacity of the gateway and the relaying strategy and its requirements (Power consumption, Duty cycle, ...).

Initial design of these reconfigurable devices is currently under study with LEAT in the context of the I’LL-WIN project funded by Academy 1 of UCAJedi IDEX.

In summary, in this proposed PhD, we will design new mechanisms for enhanced node localization and communication range extension in LoRa networks based on the use of LoRa reconfigurable devices. Our aim is to develop intelligent wireless IoT networks capable of self-reconfiguration to optimize a specific application scenario.

References

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References


