Long Range Low-power Localization

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GPS has long been the reference for outdoor positioning; however, high power consumption and lengthy warm up time make it unsuitable for future low-power IoT applications. The advent of low power, Long Range (LoRa) localization technology, enabling relatively precise positioning of connected objects based on existing hardware, opens the door for future IoT applications, for example, in the domain of smart cities, facility management and supply chain, requiring low power outdoor positioning.

The introduction of a precise (<30 ns) time stamping of LoRa frames by Semtech opened the possibility of using a LoRaWAN infrastructure to permit the accurate localization of objects. Given the fact LoRa was developed for long-range and low-power IoT applications, this new feature is seen by some providers as a potential alternative to the energy-intensive GPS system.

The localization solver developed at CSEM as part of a CTI project with Semtech receives the data produced by the infrastructure (Localization data in Figure 1). This data is then used to generate a cloud of particles (intermediate potential positions) that is, in terms, used to generate a position [1].

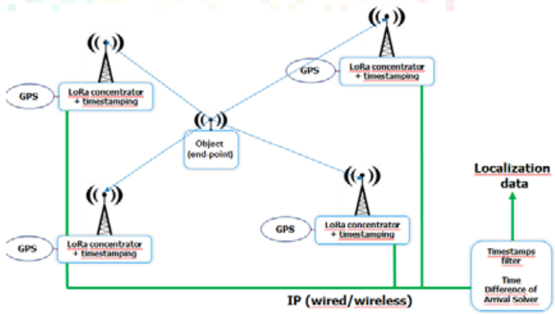

Figure 1: Typical LoRa infrastructure for localization.

Over the course of numerous measurement campaigns conducted both within the project (with Semtech) and outside the project (with potential customers), a large amount of data was collected and analyzed. This data enabled us to validate the algorithm as well as to assess its capabilities with respect to various use cases, ranging from open field to urban areas, with the aid of a set of custom tools that enable monitoring of the quality of the position estimation.

One tool, which is quite important for our solver, is called Variability of the Cumulated Distribution Function (VCDF). This function, depicted in Figure 2, allows for the representation of the performance of the algorithm used in terms of the error (i.e., cumulative error in % and error in meters). As particles are distributed and moved randomly, this graph illustrates the range of possible Cumulated Distribution Function calculated on different runs with the same data set.

The data from one of the measurement campaigns was selected in order to illustrate the algorithm. This data set is composed of about 100 measurements obtained from a single location in a typical urban area. The measurement setup is composed of 9 gateways spaced 800 m to 12 km apart (average >3 km). The gateways do not have antenna diversity and are communicating with a spreading factor of 12. The positions of the gateways and the computed result are presented in Figure 3.

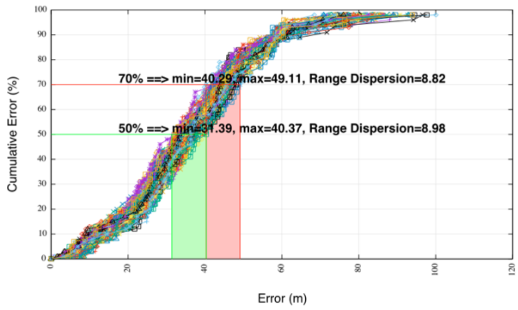

Figure 2: Variability of the cumulated distribution function.

Based on this setup and on the prior knowledge that the object was not moving, a set of estimated positions were computed using CSEM's solver. The solver was configured not to reinitialize its set of possible locations (belief) between each sequence sent by the object. The results show that the difference between the real position and the calculated position ranged from 30 m to 40 m 50 % of the time, and between 40 m and 50 m 70 % of the time (Figure 3). These results do not reach the accuracy that the GPS is able to achieve. However the goal of the project was not to compete in accuracy with the GPS, but to provide a solution that offers a good enough localization for some applications by benefitting from the regular communication with the object, thus without additional energy.

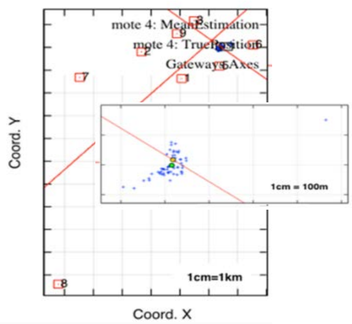

Figure 3: Geographic representation of the test site, CSEM IoTLoc, Mote position estimation (back figure), expanded view (insert).

The results presented above show that a reasonable accuracy can already be obtained without additional energy consumption in the context of communicating objects. The improvements yet to come in the time stamping and the solver, together with the lessons that will be learnt in big scale deployments to come will continue to improve the precision.

[1] A. Restrepo Zea, M. Sénéclauze, J.-D. Decotignie, "IoT objects localization based on time difference of arrival measurements", in this report, page 120.