Geolocation Solver of IoT Devices for Active and Assisted Living

Abstract: Latest enhancements in IoT devices and in communication technologies has brought new ideas that are capable of providing advanced sensing of the surrounding environment. On the other hand, average life expectancy has grown, resulting in a considerable increase in the number of elderly people. Consequently, there is a constant search for new solutions to support an Active and Assisted Living (AAL) of these people. This paper aims to propose a solution to help in knowing the location of IOT devices that could be helping these people. The proposed solution takes into consideration the risk factors of the target persons, at any given time and as well as the technical constraints of the device, such as available power and communications. Thus, a profile-based decision is taken autonomously either by the device or its integrated system to ensure the use of the best geolocation technology in each situation.

Keywords: Internet of Things, Low Power Wide Area Networks, Geolocation, Active and Assisted Living

1. Motivation

By 2050 the amount of people with dementia will be tripled to 132 million, with societal economic costs accounting for 1% of global GDP [1]. Dementia is characterized by progressive loss of memory, as well as other mental faculties including language, judgment, planning, social interaction and leads to serious problems coping with activities of daily living, including orientation and wayfinding simple tasks. One of the most common forms of disruption for people with this health status is wandering. According to the Alzheimer's Association, 6 in 10 people with dementia will wander [2] . This problem induces a great risk to the safety, well-being and reduces drastically the quality of life of the person, therefore, is a critical concern for caregivers and family having a major impact on their lives. Even though there is still no cure, efforts can be made to help prevent such behaviors, that's why there is a continuous search for solutions to support an Active and Assisted Living of such people, not only the ones with dementia but more extensive to all the elderly population.

Alongside with a fast-growing in the elderly populations across the world, caused by the augmented life expectancy, there is also an expected increasing number of Internet of Things devices, these devices can be key components to mitigate some of the problems caused by this aging. These devices have special requirements and technical constraints, such as low power consumption or low-cost hardware, but they can provide valuable sensor data over long distances, and the ability to retrieve location data, which is especially useful for the Carelink [3] project, which consist of an innovative personal tracking for people with dementia.

With the use of these devices it is possible to detect, try to predict and prevent risk behaviors, such as falls or wandering events, also with the ability to geolocate them, there is the opportunity to discover wandering patterns, helping to prevent such events in the future, thus ensuring a better quality of life for the patient as well as for those responsible for them.

2. Research questions

The work presented in this paper focuses on the following technologies: LoRa, Wi-Fi, GPS. In addition, sensor data will also be collected. The objective is to evaluate the use of these technologies based on the different operation modes. These different operation modes will have as consequence different energy consumptions. The dynamic activation of each mode, where only selected hardware is enabled, can be used to improve the overall energy consumption of the wearable device. The usage of these operation modes is dependent on several conditions: for LoRa the number of gateways available, for GPS the number of satellites available to fix the location, and for Wi-Fi the minimum amount of APs in range to perform the assisted location.

Can the geolocation technologies, dependent on the usage scenario, be managed dynamically to improve the precision of the results, and the energy consumptions of the wearable devices?

3. Methodology

To respond to the previous problem, the presented work explains the development of a Geolocation (model, algorithm, architecture) able to autonomously decide the best location method. This choice will be based on several variables, such as remaining battery and availability of communication technologies. The availability can be analyzed through an advanced sensing of the surrounding radio environments. Besides this, the model should be aware of the environment in which it is working, and with all of this information in mind create a profile-based decision system.

For this to happen several tests will be conducted into two different scenarios, urban and rural. It is required tests for geolocation technologies both GPS, GPS-free, and assisted location, as well as communication methods, LoRa, NB-IoT, or others to evaluate power consumption and geolocation accuracy.

Furthermore, these tests will consist in gathering information from different location points, at different speeds as well as stationary, to evaluate the performance of each technology against each other, using a geo-fencing polygon in both scenarios. At a later stage these tests are going to be conducted with real patients.

Currently, work already done consists in connecting the end device to the Carelink [3] platform, passing in the middle through a server that can perform the hierarchical location.

4. Solution/Discussion

The goal of the presented work is the development and implementation of a model, able to process geolocation data from different sources, so that they can later be used for knowing the actual position of the person wearing the device.

This work will be separated in three different stages, all of them always take into consideration the availability of location source, being the first stage called hierarchical, where de decision is made using the approximate accuracy of each method. The second one is advanced, where the chosen location takes into account the available battery level, for deciding in that moment which is the best location to use. In the last stage a solution is proposed to do a smart decision-based in the surrounding environment, if it is a safe place, or if the person is not showing any activity by long period of time, or by combining other sensor data, for example, accelerometer, to detect if the person has fallen, and therefore give priority to the method with the best precision, combining all of these factors to categorize and do a profile-based decision.

The system architecture is illustrated in Figure 1, to which the work presented will be contributing, as one of the building blocks. The first step in the system is to collect sensor data from the person wearing the device. This task is done by the device, afterward a specific transmission method is selected, of which the options may vary from LoRa to NB-IoT. The second step, already inside of the platform, is to combine the previous information in the purposed Geolocation solver, in order to get the best location possible. This information is then passed on to the corresponding service, in this case, the tracking service, and then sent to the GUI. Once in the GUI the user responsible for the patient can be alerted when a geofencing alert is raised.

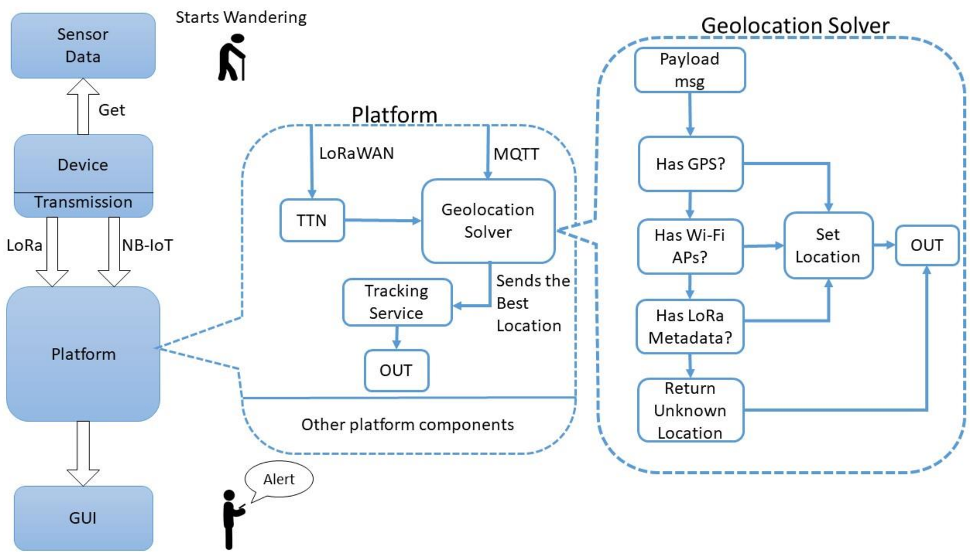

Figure 1 System and Model Architecture

The second dotted square represented in Figure 1 shows the workflow behind the Geolocation Solver block. An input is received containing a json, which contains an object with the status of the device, in the format: *“{"timestamp":"YYYY-MMDDThh:mm:ssZ","location":{"lat":float,"lon":float,"alt":float,"hdop":float,"vdop":float,"pdop":float},"batteryLevel":integer,"accompanied":boolean,"sensor":{"accelerometer":{"x":float,"y":float,"z":float}},"wifiAPs":{"mac_1":string,"rssi_1":integer,"mac_2":string,"rssi_2":integer,"mac_3":string,"rssi_3":integer}}”.*

In the “Has GPS?” block, the location field of the JSON is analyzed, and if the coordinates provided are valid, this information is passed to the “Set Location” block, where the location is set and then passed to the Carelink platform. In case this field is empty or the coordinates are not valid, the following block is “Has Wi-Fi APs?”, the Wi-Fi APs field is checked, if it is different from null, this payload is utilized for doing assisted location based on the Wi-Fi data, after that is also sent to the platform. The last available resource for getting the location in case of the previous communication method used was LoRa, will be the LoRa metadata whereby applying geolocation algorithms, such as multilateration, based on received signal strength or the time of difference of arrival, the result is the device location. For this to work a minimum of three gateways in range is necessary.

An analysis of related work shows the advancements in individual technologies and techniques, but few cases that leverage multiple solutions, depending on the scenario conditionings.

In [4] an IoT tracking system is presented, using LoRa where the geolocation is calculated through a multilateration algorithm, on the gateways timestamp, with an accuracy of around 100m in statically test scenario.

In [5] a dataset of messages was created from LoRa and Sigfox containing the GPS coordinates, and respective RSSI (Received Signal Strength Indication). The results of the median error in an urban scenario, were 514.83 meters for SigFox and 273.03 meters for LoRa.

In [6],a Hybrid (Time of Flight and RSSI) approach for Geolocation system using LoRa, and the results are similar to the work mentioned in [5], with a median error of 272 meters .

In [7] the performance and accuracy of the Google API , for geolocation using WI-FI Aps is evaluated, the results in a urban environment, achieving a maximum accuracy of 20 meters, minimal 187 meters and median 39 meters.

In [8], an indoor localization monitoring system, is presented and a wearable device was developed, using FleckTM-3 wireless sensor platform, with a position error of 1 to 3.5 meters. The main disadvantage of this solution is that only works indoors, and the technology is similar to ZigBee so only works for short range applications.

The implementation presented by the authors improves the aforementioned works, with an adaptive geolocation solution that combines the different methods, resulting in an overall localization that provides the best results in terms of precision and performance wise, meeting the dynamic changes of the utilization scenarios.

5. References

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