Design of an Indoor Localization Service in AAL Scenarios: The Project Tuscany Health Ecosystem Experience

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***Abstract*—This paper describes the design of an Indoor Localization System (ILS) based on proximity detection designed to estimate the user's sedentariness. The ILS is based on the Bluetooth technology and it will be tested in the context of the AA@THE project (Active Aging at Tuscany Health Ecosystem) co-funded by European Union under next Next Generation EU program.**

***Index Terms*—Indoor localization, Proximity, Ambient Assisted Living.**

I. Introduction

Active Ageing represents a key-challenge in the near future. A number of research projects addressed such challenge, with the goal of experimenting technology suitable for services supporting user's Active Aging in the modern society.

Under this respect, the AA@THE (Active Aging at Tuscany Health Ecosystem) co-funded by European Union under next Next Generation EU program, adopts a multi-domain approach. In particular, the goal of the project is to design and test an ecosystem of services monitoring different user's domains, ranging from nutrition and body composition, sleep quality and sedentariness. This paper focuses on the sedentariness domain and how localization technologies can be adopted to address such domain. In particular, we describe the design of an Indoor Localization System based on proximity detection that we expect to implement and deploy in the context of the AA@THE project.

II. The AA@THE project

The AA@THE (Active Aging at Tuscany Health Ecosystem) project focuses on daily monitoring services, aimed at preventing risky conditions and unhealthy behavior in daily life. In particular, we focus on nutrition and body composition, sleep quality and sedentariness to provide a daily monitoring of the involved subjects, based on the use of novel technologies, commercially available, integrating and analysis the collected data to provide personalized feedback and suggestions. To these purposes, a ICT technologies will be adopted to provide such service and to test their effectiveness with a pilot site based in the Tuscany region, Italy.

III. The Design of the Indoor Localization System

The localization system we need to conceive and deploy should be an easily installable and low-maintenance system that can effectively locate a person within the rooms of a house. For this reason, the Indoor Localization System (ILS) will be based on technical features of RF-based technologies. More specifically, we rely on the adoption of short-range network interfaces to design a system able to estimate the proximity of a user with a number of points of interest in their homes [1]. More specifically, we exploit the Bluetooth technology, available with commercial devices such as smartphones, wristbands and smartwatches. In particular, the Bluetooth technology offers a specific feature referred to as beacon-mode. It enables low-power devices, namely tags, to broadcast messages, namely beacons, containing few pieces of information, such as a MAC address and a payload. The payload can be format according to different formats: EddyStone, iBeacon and AltBeacon. The beacon messages can be collected with receiving device by exploiting numerous software libraries. The receiving device estimates the received signal strength (RSS), according to which the higher the RSS, the closer the tag to the receiving unit.

As we are interested in monitoring users inside their homes, we plan to assign a Bluetooth tag to each of the users joining the THE project. Moreover, each home will be equipped with several receiving units, able to collect and estimate the RSS of the received beacons [2]. By collecting data from these beacons, it becomes possible to determine various factors such as the user's presence at home and the specific locations within the home that the user visited over time, such as the kitchen, living room, bedroom, and so on.

We report in Figure 1 a schematic representation of the ILS architecture we plan to deploy. Every user's home is equipped with some Bluetooth's gateways, in the case of figure 1 we show 3 monitored environments: kitchen, living room and the bedroom. The user is also equipped with a Bluetooth tag, broadcasting short-range messages. Gateways listen and record such messages, and they upload them to the cloud server, where the analysis is executed.

A. The adopted hardware

The adopted hardware will include two typology of of components. **Tags** are required to estimate the proximity between the user and the environment. To this purpose, we plan to adopt different kinds of tags, such as coin-tag encapsulated in a wristband, coin-tag locked to the key-chain or a smartwatch

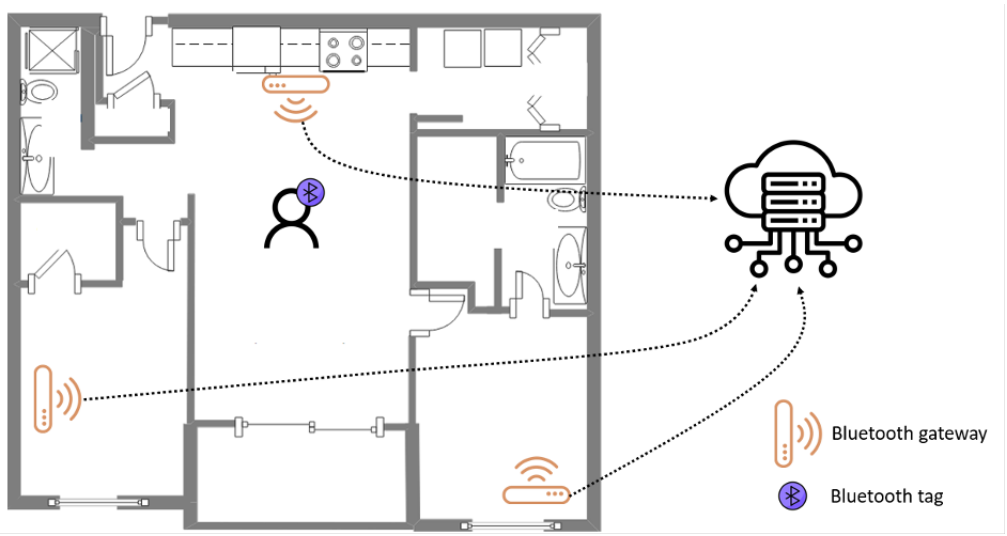

Fig. 1: Schematic representation of the service's architecture.

acting as Bluetooth tag. We will assign a tag to each of the monitored users. The type of adopted tag will vary according to the target users, as shown in the left-side of Fig. 2.

Fig. 2: The required hardware to implement the Indoor Localization System.

Bluetooth gateways are required to collect and upload Bluetooth's beacons emitted by tags in proximity. The gateway connects to the local WiFi network and it periodically uploads via MQTT protocol the collected beacons. The number of gateways deployed at home, will vary according to the target users, as shown in Fig. 2.

B. Evaluation Metrics

Data collected will be uploaded to a cloud infrastructure where data will be processed. Expected evaluation metrics will possibly include:

- A measure of the time spent by a user at home;
- A measure of the time spent by a user in the different home's environments.
- The more frequent path the user takes.

All these metrics can be elaborated at periodic intervals, e.g. daily/weekly or monthly reports. We show in Fig. 3 an example of the format of the reports we can expect from this service.

user	starting period	ending period	kitched	bedroom	livingroom	total
user 1	01-01-2023	01-07-2023	8h	15h	8h	31h
user 2	01-07-2023	01-14-2023	6h	20h	4h	30h

Fig. 3: Example of evaluation metrics considered for the Indoor Localization System.

IV. Conclusion

This work presents a preliminary discussion of the design of an Indoor Localization System based on proximity detection. The goal of the presented system, is to provide a measure of the user's sedentariness by exploiting commercial technologies, such as Bluetooth. The service will be implemented with a cloud infrastructure. We consider two key-aspects for a successful deployment of this service: privacy and hardware adoption. Concerning the privacy, it is important to design the system minimizing the type and amount of collected data, following the EU GDPR recommendation. Concerning the hardware adoption, we consider crucial adopting unobtrusive long-lasting tags, so that to minimize the maintenance and increasing their use by users involved in the experiment.

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