

DESIGN AND DEVELOPMENT OF THE GPS TOOL

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1. Preface

Alzheimer's disease is a neurodegenerative disease that slowly and progressively destroys brain cells. As the most common cause of dementia, it affects 60-65% percent of people with dementia (<https://www.alzheimer-europe.org/Dementia/Alzheimer-s-disease-and-Alzheimer-s-dementia>). At this time, this disease requires European society to reflect on how to support people suffering from dementia and their families. In fact, among older people in the European Region, dementia is the leading cause of dependency and disability. Dementia currently affects around 10 million people in the Europe area ((who, [http://www.euro.who.int/en/health-topics/noncommunicable-diseases/mental-health/areas-of-](http://www.euro.who.int/en/health-topics/noncommunicable-diseases/mental-health/areas-of-work/dementia#:~:text=Among%20older%20people%20in%20the,expected%20to%20double%20by%202030.)

[work/dementia#:~:text=Among%20older%20people%20in%20the,expected%20to%20double%20by%202030.](http://www.euro.who.int/en/health-topics/noncommunicable-diseases/mental-health/areas-of-work/dementia#:~:text=Among%20older%20people%20in%20the,expected%20to%20double%20by%202030.)). From our point of view, a great effort must also be made in the management of those forms of cognitive decline that are prodromal to the onset of severe forms of dementia. Therefore, great attention will be given to MCI, i.e. mild cognitive impairment.

If we focus our attention on the future evolution of this disease, we understand how we need to develop truly innovative responses to ensure that the management of this phenomenon will be sustainable for our communities. According to 'Dementia: A Public Health Priority', a report published by the World Health Organization (WHO) in 2012, it is estimated that by 2030 nearly 14 million will have some form of dementia in Europe, rising to over 18 million by 2050 (<https://www.healtheuropa.eu/>).

Among the emerging technologies that seek to provide answers to the problems related to dementia, from a non-pharmacological perspective, it is necessary to consider first of all the opportunities offered by GPS tracking solutions. It is known that dementia affects person's ability to navigate. It is estimated that 40% of people diagnosed with a dementia will get lost at some point, and 5% of these people will get lost repeatedly, sometimes with fatal consequences (Carr et al., 2010). GPS tracking solutions in senior's field try to answer first of all to this problem. But not only that, the disorientation associated with dementia could cause distress for the individuals and families concerned and a financial burden for the services involved (https://www.idunn.no/tidsskrift_for_omsorgsforskning/2019/03/using_gps_technologies_with_people_with_dementia).

So in this deliverable we will propose a GPS tracking system (gps is a satellite navigation system used to determine the ground position of an object) whose characteristics are the result of the analysis of the solutions on the market and the needs of elderly people and their caregivers identified locally.

2. Good practices to develop a model for GPS tracking technology implementation

Over the last ten years, numerous solutions have been developed to support the elderly through the use of GPS tracking technology. They have been developed both by private investors and by public consortia of various kinds in projects funded by a wide variety of



Community programmes. The latter are of particular interest to the NiCE-LIFE project, as they generally, in addition to developing technological tools, have deepened the models that make the implementation of these technologies particularly effective.

Among the many European programmes that have funded research into the use of GPS technology to support older citizens, particular attention should be paid to H2020, AAL and the regional interreg cooperation programmes. For the development of the model we intend to create within the NICE-LIFE project, we consider the results of the SPES, ECARE and FOLLOWME projects particularly interesting, on the results of which we have built the approach set out in this deliverable. Below we will explain some features of these projects in order to better understand in the following pages how the NICE-LIFE project will contribute to the development in this specific field.



The first project to be mentioned is called SPES (Support Patients Through E-service Solutions - <http://www.spes-project.eu/>), whose priority was the deployment, testing and adoption of scalable and portable e-health instruments at regional/local level. The project dealt with the implementation of different technologies in some of the Pilots located within the cooperation area of the Interreg Central Europe programme. Among these, of particular interest was the experimentation carried out at the pilot site in Vienna where, as in the case of the implementation of

GPS solutions in the niCE-LIFE project, the overall objective was to enhance the quality of life and self-determination of older persons with dementia, supporting them in case of emergency with the help of localization devices without restricting their movements. This led to a decrease in the number of admissions to nursing homes due to dementia. Moreover, applications tested to support reality orientation and memory training for users offered them visual and audio programmes on screens.

Another project, whose results are useful for the full understanding of the state of the art and for the development of the gps tracking usage model is called FOLLOWME (<http://www.aal-europe.eu/projects/follow-me/>). It differs considerably from SPES, first of all for the composition of the partnership that here sees protagonist research centres and some private companies, therefore interested in developing an approach in which economic sustainability was a key aspect. Follow.Me aimed to satisfy people's desire - mainly family members and doctors - of monitoring the position of elderly people with different forms of dementia and Alzheimer, in order to prevent danger situations. Of particular interest is the fact that the project tried to build not only a tool, but an integrated platform (GPS tracker, smartwatch app and web app) aimed to create an easy to use system to locate people and provide information when they leave a specific area (the house, the hospital, the surrounding streets). In addition, the key role reserved in the project for family members and informal caregivers in general should be highlighted. They were in fact able to track their patients and loved ones using geofencing



technologies in order to know when they leave or enter a given area, the speed they are traveling, send them notifications that appeared on the watch and even call them.

One last implemented project worth mentioning to understand the usefulness of a GPS tracking wearable device connected with a mobile/web application accessed by caregivers (both formal and informal), is the E.CA.R.E. Project (<https://ecareproject.eu/>). The main partners involved in this project are nursing homes aiming to provide a combined ICT solution for both social isolation and better health self-management. End users of



E.CA.R.E. project were seniors between 65 and 85 years old with a mid-high risk of social isolation. Users were given a tablet to access services related to social activities, mutual support and health monitoring and a smartwatch provided

with GPS tracking and alarm call function. This smartwatch could be used by users for regular calls to selected informal caregivers (up to 10) and to send, in case of need, an emergency call through an automatic dial to caregivers. Caregivers receiving the emergency call could check the position of their beloved one via phone/web app thanks to the smartwatch GPS function. Through the web app caregivers could also set a geofence in a specific place (i.e. the house of the user) and get notified when the selected area was left by the user. Through a specific setting option caregivers could receive the exact position of the user on request. Since the smartwatch was provided with a SIM card with both data and calls enabled, caregivers could call the users through a regular phone call.

3. Goals of GPS tracking implementation

The objectives that we intend to achieve through the implementation of GPS tracking technology and the model described in these pages, are the following:

- Increasing the safety of the person with MCI and at the risk of developing dementia, while supporting the formal and informal caregiver in the care activity;
- Supporting orientation, not surveillance of persons, but the possibility to reach persons in case of emergency and the possibility to offer help, if necessary;
- Preventing dangerous situations, reducing the risk of people getting lost and reducing those methods of restraint that limit people's freedom;
- Reduce caregivers 'anxiety. In fact, concern about the safety of one's relative is a variable that can produce an increase in the level of stress, leading, among other things, to a worsening of the quality of life of the informal caregiver.

4. Target groups and model of care

The target groups of the gps tracking solutions are:

1. older people with Mild Cognitive Impairment (MCI)
2. formal and informal caregivers

4.1 Older people with Mild Cognitive Impairment (MCI)

The target includes older people aged 65 or more, with MCI living in cohousing alone or with an informal caregiver and older people that live in nursing home with formal caregivers assistance. Mild cognitive impairment (MCI) is defined as cognitive decline greater than expected for an individual's age and education level, which does not interfere affect basic activities of daily living. In people aged 70 years and older, the reported prevalence of MCI ranges from 14 to 18% and the progression rate to dementia is 5-15% per year. MCI is widely considered a transition stage between normality and dementia, however not all patients with MCI convert to dementia: several studies reported that about 60% of these patients remains cognitively stable in a time range of about 2-3 years¹. However, MCI represents an extremely heterogeneous condition. MCI may represent the clinical manifestation of an incipient neurodegenerative process, thus constituting the early stage of Alzheimer Disease and other dementias.

MCI has two broad categories of symptoms. The first category primarily affects memory. For example, forgetting certain details such as doctor's appointments or not being able to recall the name of a good friend. This type of impairment is known as "amnestic MCI."

The second category of symptoms has to do with thought process, such as planning and completing a complex task like balancing a checkbook or exercising good judgment in risky situations. This type of impairment is known as "nonamnestic MCI."

The main cognitive problems could be:

1. Changes in memory (is the patient misplacing things more, using notes and reminders more, repeating questions, having trouble keeping track of dates and appointments?)
- 2.Changes in language (word-finding difficulties?)
- 3.Changes in visuospatial function (new driving difficulties, including being slow to identify roadway hazards, late to apply brakes, or difficulty staying in lane?)



4.Changes in attention/executive function (easily distracted, new difficulties preparing meals or using household appliances, new difficulty writing checks, new safety concerns from family members?)

The decline in someone with MCI is greater than in normal ageing. For example, it's common in normal ageing to have to pause to remember directions or to forget words occasionally, but it is not normal to become lost in familiar places or to get distracted several time as the result of a lack of attention or to have problem in driving.

Involving MCI, as a target that could develop a type of dementia, is crucial in order to **detect** the increasing severity of impairment and as **prevention** of developing a dementia. ALSO OLDER WITH EARLY STAGE OF DEMENTIA WILL BE CONSIDERED.

Counselling and treating older people with MCI is crucial in order to prevent the develop of impairment in a real dementia. Think about driving safety, discuss home safety, including kitchen safety, firearms, poisons, and potential fall risks are part of treatment of MCI. In this way, the platform of GPS tracking has first an orientation support aim. Using this technology, the older people enhance the independence in going out alone in safety, contact the caregiver or care facility actively and easily, be contacted in an easier way maintaining also the possibility to continue with their social life. The purpose is not surveillance of persons but the possibility to reach persons in case of emergency (for ex. memory loss looking for the way home) and being able to offer help if necessary. Diagnosis of MCI could also be in comorbidity with depression and it is crucial for this target to stimulate that social life (work, friends, physical activity etc) that an orientation problem could stop because of the fear of getting lost with the consequence of self-isolation. In synthesis, supporting people's orientation plays a key role in:

- Reducing the risk of severely disoriented people getting lost (with associated risk of falls);
- Ensuring greater freedom also for people living in retirement homes;
- Reducing those methods of restraint that limit people's freedom
- Protect users in cases of intrusions into their rights to freedom

4.2 Formal and informal caregivers

The second target involved consists of informal caregivers such as wife/husband, relatives and formal caregivers such as nurses, home care assistants. Concerning informal caregivers, the diagnosis of MCI for a loved one, causes different emotional states. The caregivers, usually become overprotective because of the fear that something bad could happened. The continue struggle between the patient that want the autonomy and independence he/she is used to, and the fear of caregivers of letting this autonomy, brings to some important conflict that increase the burden of care with major risk of developing depression and anxiety disorders. The aim is involving the caregivers in using the platform in order to reduce the conflict between caregivers and older with MCI and to reduce the anxiety referred to the fear of a fall or orientation problem.



Through a mobile or web based application the informal caregiver:

- will be the first in the chain of care in case we consider elderly person not living in a nursing home;
- Seniors will be able to live with greater serenity thanks to technological support

Concerning the formal caregivers in nursing home, the advantage of involving them in using the platform is fall detection when outside the building so letting the older people their autonomy and independence without giving up the monitoring and safety. The technology would allow older people to live the facility autonomously in predefined areas and be contacted in case of leaving certain pre-set areas. The care provider will make available to the care manager the monitoring station that will play a useful role in the monitoring. Besides, it will respond to requests from older people and enter the rescue chain in the event of emergency.

Involving the formal caregivers is crucial because, though a specific training, they will develop some new technology knowledge linked to the assistance, filling the gap of refusing technology that could cause the success of this type of platform

5. Use case scenarios

The adoption of GPS tracking and the mobile/web based application **in the context of the nursing home** has a significant impact since it permits constant monitoring of older adults interested by MCI and dementia, giving the staff the possibility to get information on their position.

By so doing, the safety of seniors that are autonomous in moving, but exposed to the risk of getting lost or fall, is ensured.

This result is reached thanks to the possibility to delimited a secure perimeter within which the elderly can freely move: if this limit is exceeded, or if the person falls, an alert is sent to formal caregivers, allowing a faster and effective intervention. Moreover, the older adults themselves have the possibility to send an SOS if in a situation of difficulty and in need of any kind of help.

This system enables professionals to have better and more precise patient surveillance, even when they are unable to guarantee a continuous physical presence next to the elderly person, which is not uncommon in care contexts, due to the numerous tasks to be performed, the number of older adults to take care of, the frequency in emergencies and problematic situations to solve.

The implementation of such a model in the context of the nursing homes enables a further increase in the safety of seniors and their quality of life as their autonomy and possibility to move is guarantee thanks to the help of a more capillary and continuous monitoring. Also, by so doing, it creates the conditions for an improvement of professionals quality of work, reducing anxiety. More generally, it sustains an considerable improvement in the quality of the service offered, ensuring an higher level of safety and protection.



In the context of elderly cohousing, the GPS tracking and the mobile/web based application gives a response to two principal issues:

- the need for safety from one side, required both from older adults living in it and from their informal caregivers;
- the demand for the maintenance of autonomy in a protected living environment from the other, that will be perceived even more safe since GPS will represent an additional element of guarantee.

The cohousing offers to older adults a balanced combination of autonomy and protection, as it foresees autonomous life in apartments furnished with an alert system and the presence of different services related to health care and active and healthy aging.

In this context, the adoption of GPS tracking for people with MCI represents a significant improvement in the sustainment of care providing. It in fact contributes to enhancing the quality of life of older adults that feel safer and freer to live their everyday life, giving response as much as possible to the difficulties in orienting themselves, avoiding the disconnection from sociality and the consequent state of frustration and depression. Their independence and autonomy are preserved, both in-home and when going outside, with the benefit of constant tracking and the possibility to easily ask for help.

Moreover, this model helps caregivers in monitoring their loved one more effectively, reducing anxiety and preoccupation, especially when out of home, enabling them to quickly intervene in case of need and emergency. It also reduces the need for too frequent contacts (for example telephone call or visit at home), which represent a possible source of stress for the caregivers and give older adult a feeling of intrusion, undermining the sense of independence and autonomy.

In conclusion, thanks to the GPS tracking, the autonomy of the living environment is not only maintained but also reinforced, guaranteeing an improvement in the quality of life, both from the point of view of psychological and physical well-being.

6. System design

In this section we present a general overview of the system, with a specific focus on the design and architecture.

6.1 Architecture

The overall architecture of the GPS tracking solution that we will implement will consist of the following elements:

- The actors: the person affected by MCI, the informal caregivers (mainly composed of the person's family members) and the formal caregivers, i.e. those nursing home employees with specific care management skills (mainly nurses).
- A cloud platform in which the platform is hosted. which allows the connection between elderly and caregivers, Moreover, Connectivity with cloud platform to transmit indoor and outdoor localization.
- A mobile application explicitly dedicated to informal caregivers or a third party service with similar features:
- A web based application dedicated to formal caregivers
- A set of sensors to be implemented at the home of the elderly person

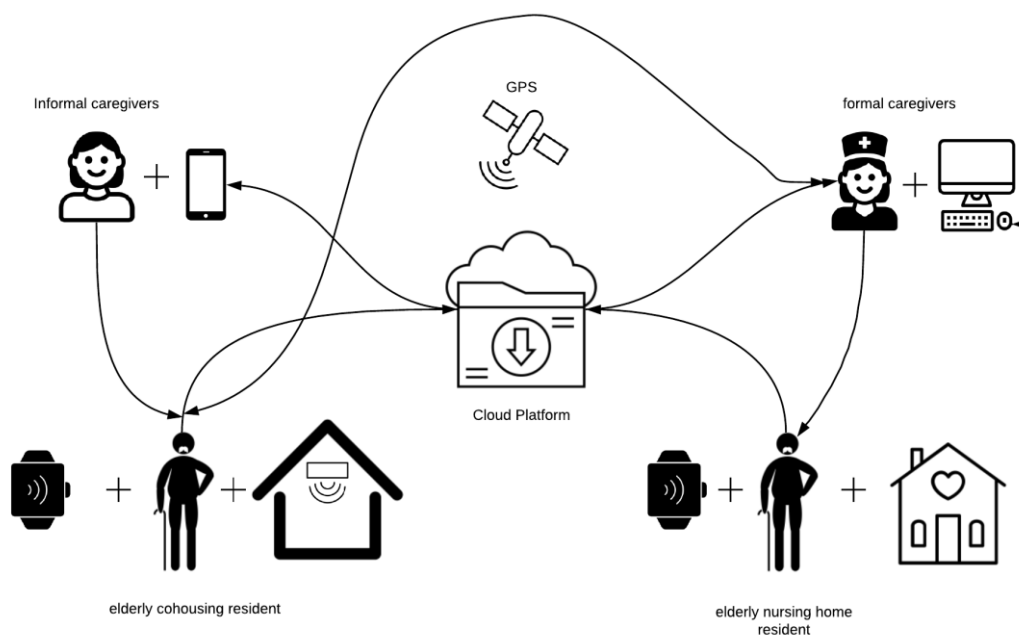


Figure 1: An architecture for a GPS tracking solution

6.2 The actors

The system foresees the presence of three different types of actors, respectively, the elderly affected by MCI and at risk of developing dementia, formal caregivers (mainly nurses) and informal caregivers (family members in most cases). Starting with the elderly, they will predominantly play a passive role, i.e. the technology will continue to function until they remove the wearable devices. Before the start of the trial phase, older people will undergo a short and simple training about the smartwatches that will be delivered.

As for informal caregivers, they will have access to a mobile app through which they will be able to monitor the position of the elderly person, in addition to the possibility of receiving notifications in case the elderly person leaves a certain area previously identified.



Formal caregivers will be able to access the platform through a web-based application, mainly through a special care management workstation. They will have the possibility to configure the monitoring process. In addition, they will receive alerts from the platform in case the elder leaves the predetermined area.

6.3 The cloud Platform and connected tools

One of the main features of the cloud platform will be the possibility to integrate the data with third software platform to manage the identity of senior and associate the data collected in compliance with privacy regulation. The data could be integrated using secure different tools (i.e. Restful API based on JSON methods and TLS certificate, integration of Google Cloud Healthcare API). Data integration will be a key element in achieving the overall objectives of the niCE-LIFE project.

Considering Middleware (computer software that provides services to software applications beyond those available from the operating system. It can be described as "software glue"), it will be probably based on MQTT protocol in order to get all the data from devices in a very efficient way minimizing amount of data to transmit and consequently power consumption. Communication will probably also be integrated with third party services in order to send reports and alerts through familiar tools to caregivers.

Finally, the localization capability must also be taken into account, as the gps tracking function is crucial, although not the only one, in the experimentation we would like to implement. The wearable device must be able to locate both inside and outside buildings. To guarantee this functionality it will probably have to use GNSS (Global Navigation Satellite System refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location) and Bluetooth. Thanks to GNSS features the device could use the cellular network signal to perform an approximate localization indoor or outdoor with very low power consumption and could add GPS information to perform precise outdoor localization.

6.4 Mobile Application and web based application

Through the web based application the administrator and the formal caregiver will be able to configure how the elderly person will be monitored. Different levels of permissions will be defined to optimize the use of the platform. The administrator should start by defining the operations that can be performed in the system such as create user, list user, monitor patient, create safe point. The web based application will also be the interface that the care manager will use to support the people involved in the experimentation.

About the mobile app, it will be used by family members who support their loved one. The final features have not yet been fully defined, as the integration of the app with agile tools for communication with the elderly and the care manager will have to be considered.

7. Evaluation

Fundamental in the context of experimentations such as the one carried-on by NiCE-LIFE project, it is to measure and make an evaluation of the impact of the use of technology on the quality of life of older adults involved and, at the same time, on that of their caregivers, both formal and informal.

For what concerns older adults, this analysis has to be conducted from two, deeply interrelated, perspective:

- on one side, it is crucial to understand the level of technology acceptance of end-users: to do this, an interview with a series of questions focusing on this aspect will be developed and submitted to participants. This focus will permit to individuate eventual problems (connected, for example, to the usability or to the ergonomics of the tools) and to fix them.

- on the other side, it will be useful to highlight which areas of the elderly person's life have improved through the adoption of these technologies.

At the beginning and at the end of the implementation, a “Quality of Life questionnaire” will be submitted to participants in the intent of make a comparison between *ex ante* and *ex post* information and, by so doing, to detect and evaluate a possible improvement in some specific areas of life, like for example psychological and physical wellness, level of autonomy in everyday life, quality and quantity of relationships.

Concerning formal and informal caregivers, factor of great importance is the level of anxiety related to caring activities and, particularly for what regards informal caregivers, its effects on the relationship with their loved one.

For what regards the formal one, collect information on the adoption of GPS and its effects on anxiety management will also help to understand its potentiality in improving the quality of work in a broader sense, potentially mitigating the risk of caregiver burden. It will be therefore important to make an evaluation on its possible reduction and the consequent potential improvement of the quality of the relationship.

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