GUIDed: Assisted-Living Smart Platform and Social Communication for Older Adults

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Abstract. The aging population, the increased incidence of chronic disease, the technological advances and the rapidly escalating health-care costs are driving healthcare from hospital and day care centres to home. The GUIDed AAL EU project focuses on the challenge of keeping older adults independent and functioning in their own homes for as long as possible, by facilitating important activities of daily living through ICT solutions. Through a modular and customizable smart home platform, backened system and Android application, assisted-living solutions and services are offered to facilitate seniors' daily lives in their own home and the community. The main target areas are smart home control, home safety enhancement, city navigation, nutrition and health improvement, and socialisation/communication. In this paper, we present three of the five GUIDed services and report on our findings from the evaluation of the High-Fidelity (Hi-Fi) paper prototypes for these services. The Hi-Fi prototypes were tested by older adults and their caregivers using focus groups in four European countries, namely Austria, Cyprus, Norway and Poland. The results showed that all of the users found the GUIDed system understandable and easy to use, which is an encouraging finding considering older participants' low technological literacy.

Keywords: Assisted-living · GUIDed services · Smart home · Social communication · High-fidelity prototypes · Older adults

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1 Introduction

The combination of reduced birth rates and increased life expectancy has led to a restructuring of population demographics across the developed world [1, 2]. The share of older adults (65 or over) among the total population in the EU-28 in 2016[1] was recorded to be 19.2% and more specifically, in Norway (16.4%), Poland (16%) and Cyprus (15.1%)3. Therefore, population aging together with increased incidence of chronic disease, technological advances and the rapidly escalating health-care costs are driving healthcare from hospital and day care centers to home.

Increasing healthy life expectancy requires the introduction of support in the form of technological products and services. Technological developments have increased viability of homecare due to the miniaturization and portability of diagnostic and information technologies, remote monitoring, and long-distance care [3, 4]. Although many disjoint technological solutions and services are available, the ability of older adults to find, choose and combine such services is a critical issue. While most older adults feel that technology makes a positive impact on society, almost three quarters lack confidence in their ability to use devices to complete online tasks [5]. According to a recent review [6], internet use among older adults has increased over time. Nevertheless, studies have found that fear of technology is more prevalent in older generations who did not grow up with computers [7, 8]. Social issues, such as the "digital divide" have been found to be significant, where many older adults are still perceived as being resistant to modern technologies [9]. Given the near ubiquity of internet and electronic technologies in everyday life, there is an urgent need to enable older people to embrace the digital age [9]. Technophobia can be caused by anxiety about science or mathematical problems. People who feel intimidated by these subjects are more likely to experience technology anxiety [10].

Older adults who face this phobia respond better if they are provided with consistent support from younger adults. The younger generation, often children and grandchildren, or local program officers, assume the role of good mentors and reward small steps taken by technophobic to overcome their fears. Teaching skills only addresses part of the problem, of course; the costs of devices and of Internet service also keep older people offline, and so do physical limitations or cognitive impairment. Still, learning the technology is the key to the problem [10].

The GUIDed AAL EU project addresses the challenge of keeping older adults independent and functioning in their own homes for as long as possible, by facilitating important activities of daily living through IT solutions. GUIDed uses a modular and customizable smart home platform, a backened system and an Android application, consisting of assisted-living solutions and services to facilitate seniors' daily lives in their own home and the community. The main target areas are smart home control, home safety enhancement, city navigation, nutrition and health improvement, and socialisation/communication.

In this paper, we present three of the five GUIDed services and report on our findings from the evaluation of the High-Fidelity (Hi-Fi) paper prototypes for these services with primary end-users via focus groups. The GUIDed Hi-Fi prototypes were tested by older

[1] https://ec.europa.eu/eurostat/cache/infographs/elderly/index.html.

adults and their caregivers in four European countries with positive results. In addition, a technical description of the system, its architecture and the services are provided. The paper is consisted of six sections. Section 2 discusses Background and Related Work. Section 3 describes the methodology, while Sect. 4 presents the GUIDed platform from a technical point of view. The results of the evaluation of the Hi-Fi paper prototypes are discussed in Sect. 5. The paper closes with Conclusions and Future Work in Sect. 6.

2 Background and Related Work

In terms of EU funded projects aiming to offer ICT solutions for enhancing and supporting the home living of older adults, the IOANNA[2] (Integration Of All stores Network & Navigation Assistant) project aims at developing ICT-based solutions for seniors for everyday facilitation in shopping management and navigation, focusing on assistive mobility and social engagement through crowdsourcing. The FrailSafe[3] project aims to better understand frailty and its relation to other health conditions. It aims to delay frailty by developing a set of measures and tools, together with recommendations to reduce its onset. To achieve these objectives, FrailSafe combines state-of-the-art information technologies and data mining techniques with high-level expertise in the field of health and ageing. In terms of enhancing the social presence of older adults, the MedGUIDE[4] project offers an approach to social networking and e-learning focused on polypharmacy management, to support informal and formal caregivers of seniors with dementia. Seniors will be supported in their medication adherence using sensor technology and smart pill-boxes. The Many-Me[5] project builds a social interactive care system using ICT and user-centred services to help people with dementia, their relatives, informal and formal carers.

According to a research in [11], older adults already use existing digital tools in the form of smartphone applications to combat the effects of isolation due to the COVID-19 pandemic. The research categorizes the apps in 6 categories: Social Networking, Medical: telemedicine, Medical: prescription management, Health & Fitness, Food & Drink, and Visual & Hearing impairment.

In [12], the + Simple platform is discussed that groups content (news, procedures, social networks and pages of interest). Older adults were trained to use the tool through a 2-h course. The aim was to promote elderly adults' social inclusion through a digital literacy process [12]. The training involved 40 Digital online Classrooms. Moreover, 106,550 tablets with the " +Simple" platform were delivered to people over 60 years of age.

Guided Access Mode [13] is an app that supports older adults in their asynchronous communication with family and friends. The technology required an adaptation period but was a feasible communication tool. Use increased perceived social interaction with ties, but increased social connectedness (meaningful social interaction) was only reported

[2] https://ec.europa.eu/eip/ageing/commitments-tracker/d4/integration-all-stores-network-navigation-assistant-seniors_en.

[3] https://frailsafe-project.eu/.

[4] https://www.aal-europe.eu/projects/medguide/.

[5] https://many-me.eu/.

by participants with geographically distant relatives [13]. In addition, the sense of well-being and confidence with technology was also enhanced.

Social networking sites (SNS) such as Facebook (and Webcams) Twitter, can assist in creating and maintaining social relationships essential in contributing to the wellbeing of seniors [14]. Reduced mobility and geographical distance from family can cause loneliness among seniors. SNS can aid in overcoming these obstacles by allowing seniors to maintain involvement with their family and friends, despite their immobility or distance from them. In addition, technology such as video conferencing can also help older adults overcome mobility challenges that come with aging by staying connected [14].

WhatsApp is an app that can be perceived as user-friendly with a clean and simple to use design, meaning that groups that are normally excluded from using it, (e.g. older people) are able to use it [15]. In [15] it is supported that, by enhancing its usage further from just exchanging messages, it is much more likely that elderly will adhere to health advice they receive via this channel, as well as being much more likely to pay attention to any incoming messages from medical experts.

Connect2affect [16] is a new initiative that aims to create a network of resources that meets the needs of anyone who is isolated or lonely. Helps build the social connections older adults need to thrive. It requires taking an assessment quiz to establish the necessary next steps to each unique individual.

Although the abovementioned technologies contribute in enhancing the lives of older adults in areas such as healthcare, social communication, navigation, shopping and more, these are nevertheless offered in a disjoint manner. An integrated set of services under a common platform/application with a single, unique user interface (UI) is missing. Furthermore, scattered services with different UIs and different ways of user-system interaction only contribute to the older adults' lack of confidence in their ability to use them, as well as to the technophobia they may experience.

The GUIDed platform aims to reduce these effects caused by technology. It addresses the challenge of keeping older adults independent and functioning in their own homes for as long as possible by facilitating important activities of daily living through an integrated set of ICT solutions. To achieve this, GUIDed will offer a selection of smart devices and services integrated in a smart home platform based on budget options, while giving heavy emphasis on training the older users on using the service and maximizing their benefit. A common design will contribute to better adoption of the system and less abandonment of the technology. The service categories of the GUIDed solution are: Smart Nutrition and Health service (S1); Smart Home Control service (S2); Smart City Navigation service (S3); Smart Home Safety service (S4); Social Communication service (S5). In terms of addressing older adults' technology related anxiety, GUIDed offers services via which older adults may receive support from younger adults, such as relatives, on a daily basis. The support may related to daily activities related with technology, or even training in using the GUIDed services themselves. The training component will be incorporated in the GUIDed system via an innovative assistant, utilising Augmented Reality (AR) technology.

3 Methods

From a methodology perspective, a user-centred design approach is adopted, focusing heavily on a co-creation aspect. Considering this, we point out the different categories of end-users that are to be recruited in different phases of co-creation activities: **Primary end-users**: Older adults living independently in their own homes with no or moderate need for assistance; **Secondary end-users**: Family members and informal caregivers; **Tertiary end-users**: Care organisations (day-care centres, hospitals, clinics, retirement homes, nursery homes) and staff (healthcare professionals). Other: technology product vendors, telecare service providers, policy makers and the like.

To ensure that the end-users' demands are respected throughout the design and development of the GUIDed platform and its services, the following process was followed in sequence:

1. Older adults' recruitment process and an analysis of the respective demands and needs.
2. National strategies and governmental recommendations for Assistive Technologies were reviewed in Cyprus, Austria, Norway and Poland.
3. Based on 1 and 2, the GUIDed platform and its services were then defined and presented to the primary end-users via workshops in order to collect their initial impressions.
4. Based on 3, the platform and its services were defined and the specifications designed (see Sect. 4).
5. Experimental evaluation and feedback activities commenced and continue (see Sect. 5).

Focusing on the experimental evaluation and feedback activities (i.e., step 5 in the aforementioned process), in order to adequately monitor, discuss, evaluate and collect feedback based on the design and development activities, it was decided to divide the Testing phases (see Table 1).

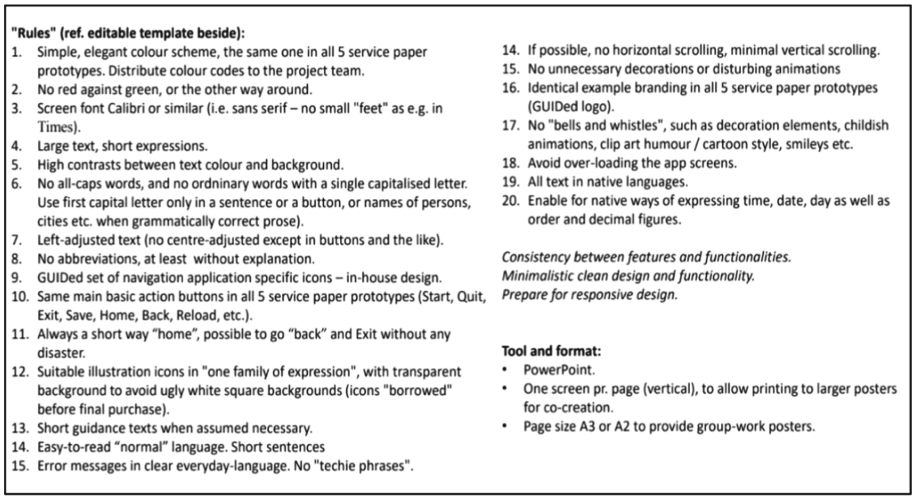
Table 1. Testing phases for the experimental evaluation and feedback activities.

Testing phase	Evaluation tool	Method to collect feedback
1	Paper prototype	Focus groups
2	Mock-ups (semi-functioning)	Questionnaires
3	First functional prototype	Living lab

In Sect. 5 of this paper we present the results from the first Testing phase that includes the design of High-Fidelity (Hi-Fi) paper prototypes for three of the services, as well as their evaluation with primary end-users utilising focus groups. The feedback collected in Phase 1 for each service is currently under review by the GUIDed team to determine which recommendations will be implemented and how to address specific considerations pointed out for the Phase 2 testing, i.e. in the design of the mock-ups (semi-functioning).

3.1 Paper Prototype

The first selected method for testing (whether the technical developments of the GUIDed system meets the needs of the older adults) was paper prototypes. Paper prototyping is a widely used method in the user-centred design process and utilised in the early design stages in order to test the functionalities and layouts of a graphical interface before programming begins [17]. Paper prototypes (e.g. sheets of paper or in online format) consist of an easy method for the end-users to understand the functionalities of a system/platform and provide valuable feedback, insights and issues with regards to its usability [18]. More specifically, this is done by presenting the functionalities to the end-user by using paper prototypes and encouraging her/him to comment on them ("talking aloud") while the researcher takes notes. Thus, paper prototyping assisted the project team pinpoint any design issues of the GUIDed platform for the end-users such as difficulties with navigating or comprehending the services and to identify potential points for alterations. While there are several techniques for conducting the paper prototyping method, the one utilised in this phase was wireframes. A wireframe is used to demonstrate the page layout of the interface. As seen in Fig. 1, the design of the paper prototypes was based on a set of 'rules' so as to facilitate the end-users and the focus groups activities.



"Rules" (ref. editable template beside):

1. Simple, elegant colour scheme, the same one in all 5 service paper prototypes. Distribute colour codes to the project team.
2. No red against green, or the other way around.
3. Screen font Calibri or similar (i.e. sans serif – no small "feet" as e.g. in Times).
4. Large text, short expressions.
5. High contrasts between text colour and background.
6. No all-caps words, and no ordinary words with a single capitalised letter. Use first capital letter only in a sentence or a button, or names of persons, cities etc. when grammatically correct prose).
7. Left-adjusted text (no centre-adjusted except in buttons and the like).
8. No abbreviations, at least without explanation.
9. GUIDed set of navigation application specific icons – in-house design.
10. Same main basic action buttons in all 5 service paper prototypes (Start, Quit, Exit, Save, Home, Back, Reload, etc.).
11. Always a short way "home", possible to go "back" and Exit without any disaster.
12. Suitable illustration icons in "one family of expression", with transparent background to avoid ugly white square backgrounds (icons "borrowed" before final purchase).
13. Short guidance texts when assumed necessary.
14. Easy-to-read "normal" language. Short sentences
15. Error messages in clear everyday-language. No "techie phrases".
14. If possible, no horizontal scrolling, minimal vertical scrolling.
15. No unnecessary decorations or disturbing animations
16. Identical example branding in all 5 service paper prototypes (GUIDed logo).
17. No "bells and whistles", such as decoration elements, childish animations, clip art humour / cartoon style, smileys etc.
18. Avoid over-loading the app screens.
19. All text in native languages.
20. Enable for native ways of expressing time, date, day as well as order and decimal figures.

Consistency between features and functionalities.
Minimalistic clean design and functionality.
Prepare for responsive design.

Tool and format:

- PowerPoint.
- One screen pr. page (vertical), to allow printing to larger posters for co-creation.
- Page size A3 or A2 to provide group-work posters.

Fig. 1. Design guidelines adopted for the Hi-Fi prototype designs instructions for the format of the evaluation tool format.

3.2 Focus Group

The paper prototype evaluation tool was used to conduct one-hour long focus groups, with participants. However, the number of participants for each focus group was influenced by the national social distancing measures against COVID-19 (see Sect. 5). Focus groups consist of a valuable qualitative research technique in an interactive interview

setting where end-users have interactive and directed discussions and can freely express their opinions, perceptions and beliefs towards a product/service/system. During this process, end-users together with other participants can freely interact and share ideas and opinions which in turn assists the researchers in data collection [19]. Due to the group setting, for many end-users focus groups constitute a more pleasant and stress-free process compared to one-to-one interviews [20]. Furthermore, the group dynamic as a process facilitates discussion and can lead to more in-depth and spontaneous conversations, debates and ideas regarding the service/system. As such, this technique assisted the GUIDed project team to acquire valuable feedback in these early design and developmental stages of the platform with regards to its services.

4 GUIDed Platform

4.1 Architecture

The GUIDed system is comprised of the smart home platform, the backend system, and the Android mobile application (see Fig. 2). In terms of the backend system, an open-source, widely used platform with good documentation was selected as the basis for our development, Drupal. The GUIDed Drupal-based hybrid CMS (Content Management System) resides on the public cloud and provides the administration web system, the Web APIs (Application Programming Interfaces) and the push notifications. The Web APIs and the push notifications provide the capability to interact with the Android mobile application using HTTP requests and event-driven push notifications that are initiated from the server. The smart home platform is based on a Raspberry Pi 3. The smart home platform, as well as the mobile app for the primary user (older adult) and the mobile app for the secondary user (healthcarer, family member) communicate with the backend system through the provided Web APIs.

The architecture components are described in the following sections.

4.2 Smart Home Control and Smart Home Safety Services

The smart home control service provides an augmented reality Android application that allows its users to control their home environment. A user can choose between a simple interface with buttons or a camera view with AR features to control devices such as lights or plugs.

The smart home safety service enables users to track the presence of smoke or carbon monoxide in their homes. As soon as dedicated sensors register smoke or carbon monoxide, a message is displayed on its user's device. This service also provides the capability to include further types of sensors such as temperature or humidity sensors. Analogue to the smart home control service, users have the option to use a simple interface or the camera view with AR features to review its sensors' status.

Technology

From the hardware perspective, the usage of the smart home and safety services is enabled by a smart platform (RPi in Fig. 2) that needs to be installed in the user's

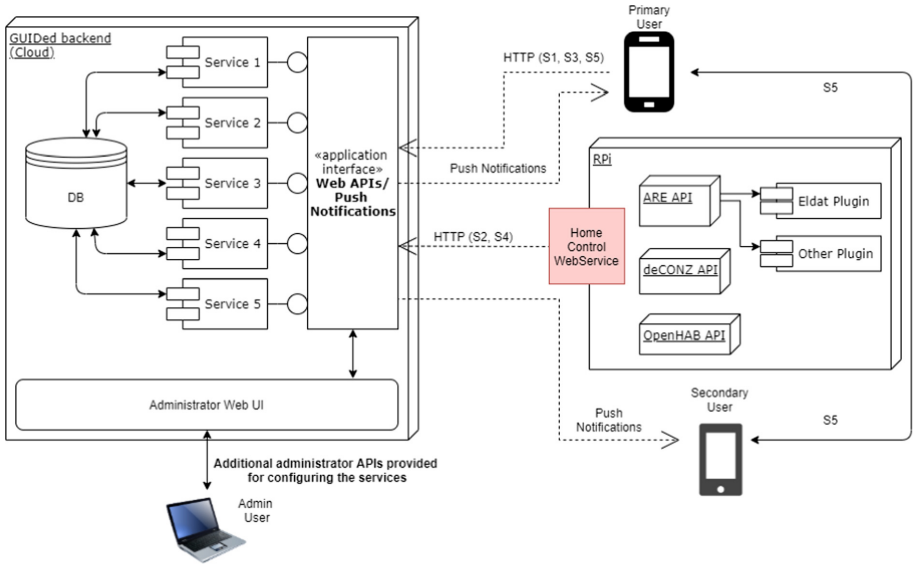


Fig. 2. GUIDed high-level architecture.

home. The platform is composed of the smart hub and a set of sensors and actuators which may be adapted to the individual user's needs. The smart hub, as the central component of the smart platform, is based on a Raspberry Pi 3 Model B + (RasPi) with the Raspberry OS and a "RaspBee II" Zigbee gateway. The Zigbee gateway serves as a bridge to communicate with Zigbee sensors and actuators. Raspberry Pi 3 was selected as it integrates well with established smart home and accessibility software, while offering an affortable price (around $40). "RaspBee II" was selected as it is a universal ZigBee Gateway, specifically made for the RasPi, that enables the integration of ZigBee smart home devices from different vendors, which usually require a proprietary gateway to control their devices.

The utilized software includes deCONZ, OpenHab, ARE, a proprietary middleware/backend application ("Home Control Web Service") and a proprietary front-end application ("Configuration Client"). The deCONZ software is responsible for the control of the ZigBee network and is required for the "RaspBee II" to operate.

OpenHab represents an open-source home automation software that enables efficient integrations of smart home systems or protocols such as deCONZ, KNX, MQTT, Z-Wave, etc. OpenHab was selected as it is open source with a strong community, while also facilitating the integration of different smart home systems. The ARE is an open-source system developed in the context of the EU project AsTeRICs[6] that executes plugins for smart home systems such as Hue or KNX. It is extensible and can therefore be used to support smart home systems that are not supported via OpenHab for example. The "Home Control Web Service" handles authentication, configuration, the routing for smart home operations and data exchange with ARE, OpenHab, deCONZ and the

[6] AsTeRICS EU FP7 Project: www.asterics.eu/.

GUIDed backend system on the cloud. The "Configuration Client" enables users to configure the installed devices so that the "Home Control Web Service" is aware of how and which devices to address. The communication between the distinct applications happens over Web APIs following REST architectural principles. An overview of the architecture is presented in Fig. 2.

Frameworks
Spring Boot is used for creating the "Home Control Web Service". After testing different frameworks such as Javalin, Spark and Spring Boot for the services' requirements, Spring Boot was chosen as it offers more features and a larger online community. VueJs with the Vue UI library Vuetify is used for creating the "Configuration Client". VueJs was chosen as it has a strong online community and the learning effort is lower compared to Angular or React. AsTeRICS (Assistive Technology Rapid Integration and Construction Set) is used for creating plugins that can be executed in the ARE.

4.3 Social Communication Service

The social communication service aims to offer a sense of real-life physical presence between the older adult and the communicating family member, healthcare provider or friend, avoiding thus social isolation and loneliness. Our objective is to provide a video calling service with a simple, easy to use UI, that is also appropriate for use by older adults. Using the service, older adults can keep in contact with family and friends while engaging in everyday activities such as eating together, drawing with the grandchildren and knitting.

Besides conducting video calls, the service offers a secondary functionality called "Meet Others". This functionality enables primary users, through the push of a (virtual) button, to conduct video calls to a random GUIDed primary user. The remote user will be randomly selected by the GUIDed system, provided that the remote user agrees to this communication and that the preferred languages of the two users match.

Architecture
The Social Communication Service was developed using the WebRTC framework. WebRTC is a free, open-source framework that enables Real-Time Communications with audio and/or video, by providing web browsers and mobile applications with the means for real-time communication via its APIs. The Social Communication Service includes two different architecture designs: a Client-Server architecture between Android devices (smartphone/tablets clients) and a signalling server, and a P2P (Peer-to-Peer) architecture between two Android devices. The Android devices and the signalling server communicate using WebSockets API. The server and client create a persistent connection between them (see Fig. 3), in order to hold an availability status at all times, to enable for reliable information exchange, when a request is made to create a Video Call connection between two Android devices. When a client-caller device (Android device) wants to initiate a Video Call with a client-receiver device, then the caller device sends a request to the server to notify the receiver device for the video call request. The server

then forwards this request to the receiver device and waits for a response. Immediately after the caller device sends the request to the server, it creates another request to the server that includes a WebRTC offer object and Ice Candidate object that the server will forward to the receiver device, after the video call request was accepted. The receiver device sends its response to the Video Call request, which is forwarded by the signalling server and waits for the server to forward the Offer and Ice Candidate information sent from the caller device. Then, the receiver device constructs an Answer and Ice Candidate object according to the Offer object received and sends the response to the server, which is then forwarded to the caller device. When both the caller and receiver devices forward through the server their Offer, Answer and Ice Candidates Objects to each other, then the communication through the signalling server ends and the P2P communication is initiated. It's important to note that the signalling server does not retain any information about the two clients during the video call: it deletes all WebRTC clients' data (Offer, Answer, IceCandidates) as soon as the signalling process is terminated. Apart from the signalling process, the server listens and handles any special case events e.g. client disconnection, client reset and client network changes.

As soon as the signalling process is completed, the two devices are connected through a process called PeerConnection (see Fig. 3 and Fig. 4) provided by the WebRTC API. The connection occurs on a private, full duplex communication channel throughout the lifetime of the video call. On this channel, each device shares its camera view (either front or rear) and receives the other device's camera view.

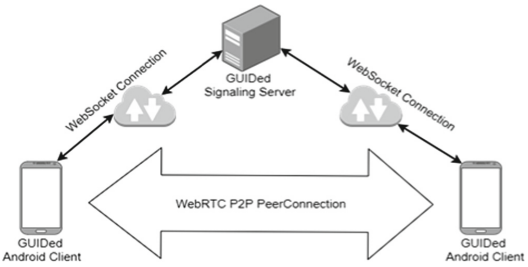


Fig. 3. Social Communication Service architecture schema.

Technologies, Frameworks and APIs

Table 2 depicts the technologies and frameworks used to implement the GUIDed signalling server and Android application.

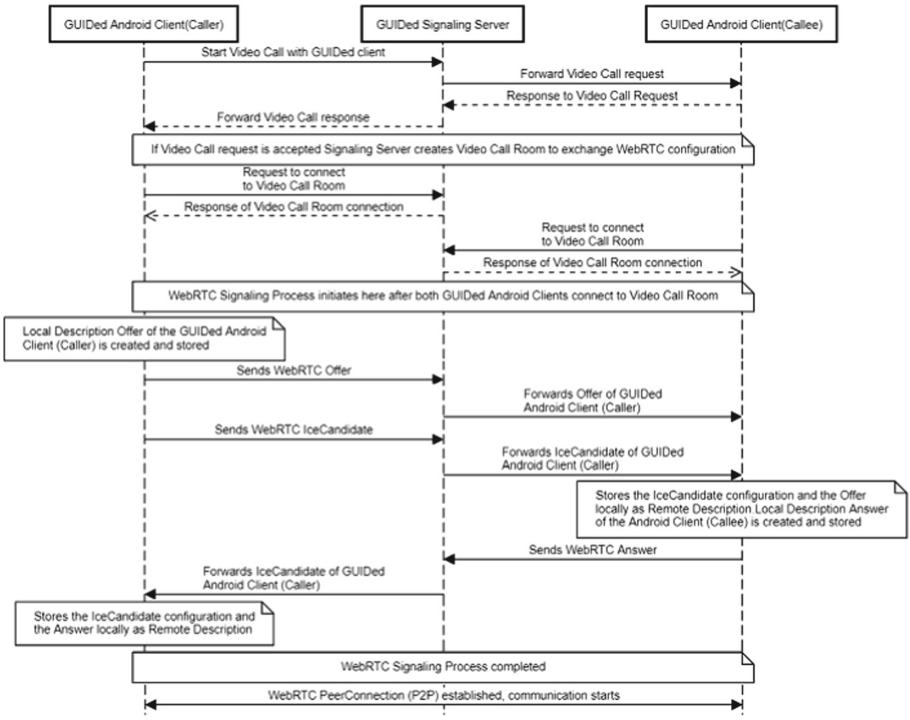


Fig. 4. Social Communication Service sequence diagram.

Table 2. Technologies & frameworks used for development of Social Communication Service.

Technology	Framework used	Version/API	Purpose in GUIDed
Node.js	Atom.io	Node version 12.13.0	Signalling server
Java	Android Studio 4	Java SDK 8	Android app
XML	Android Studio 4	Xml version 1.1	Android app
JSON	Atom.io & Android Studio 4		Signalling server & Android app
WebSocket	Atom.io & Android Studio 4	WebSockets version 1.3.2	Signalling server & Android app
Android	Android Studio 4	API 23 - API 30	Android app
Android OS	Android Studio 4	Android 6.0 - Android 11	Android app
WebRTC	Atom.io & Android Studio 4	Google-webrtc-1.0.32006	Signalling server & Android app

5 Results

The GUIDed Hi-Fi prototypes[7] were tested by older adults and their caregivers in four European countries, namely Austria, Cyprus, Norway and Poland. Due to the social distancing measures imposed amid the COVID-19 pandemic, each end-user site implemented the testing via focus groups, one-to-one meetings or virtual meetings according to their resources and national restrictions in place at the time of the recruitment.

In total, 39 older adults (*mean* age = 72.74, *SD* = 9.12, *range* = 59–94) and 9 caregivers (*mean* age = 48.55, *SD* = 10.05, *range* = 34–64) evaluated the prototypes. The majority of older adults were female (59%), had "little" technological literacy (41% as they stated that used technological devices only sometimes) and resided in urban areas (51.3%). Their caregivers were 55.6% male, 66.7% resided in urban areas and the majority of them (44.4%) had "great" technological literacy (stated that they used technological devices all the time).

Next, we present the Hi-Fi prototypes for three of the services and more detailed feedback, i.e. recommendations, that was collected from their evaluation with end-users. The focus is on the services of Smart Home Control, Smart Safety and Social Communication due to their advanced technical design and implementation (see Sect. 4) in this stage of the project. Moreover, the main user interface design of the app is also presented. Feedback collected, was based on the questions posed to primary end-users during the focus group sessions in order to evaluate the respective designs of the main UI and three services of the GUIDed app, and are presented in Table 3.

Table 3. Focus group questions on the three services and main UI.

Main UI	Social communication	Smart home control	Smart safety
Which of the two UIs you prefer and why?	Do you understand what the service does?		
What do you think about the screen brightness?	Do you think this service should be configurable on the mobile application or on the web interface?	Not applicable	Not applicable
What do you think about the screen colors?	What features are missing? (if any)		
What do you think about the font and buttons size?	Does anything seem out of place or unnecessary? Would you add or remove anything?		
Do you understand what the icons/buttons mean and their functions?	What do you think it might be difficult when using this service? (if anything)		
	What do you think will be easy when using this service? (if anything)		
	Any comments?		

[7] Hi-Fi User Interface Prototypes: URL.

5.1 Main UI of the GUIDed App

It is through the main UI of the GUIDed app that users can acquire access to one of its five available services, as presented in Pages[7] 3 and 4. End-users first need to register and create an account on the GUIDed web interface. Older adults can create their accounts on their own, as primary end-users, or if they require assistance, accounts can be created by secondary and tertiary end-users. Via the GUIDed main UI, the end-user journey includes the following steps: 1) User account is created initially using the web interface (CMS); 2) User types username or email and password to login the first time. The user remains logged in to the app unless he/she manually logs out; 3) The main screen of the app is loaded; 4) The user can click icon on top left corner for the extended menu to appear; 5) The user can click to logout from the application.

5.2 Social Communication Service

Once logged-in to the GUIDed app, end-users are able to access the social communication service by clicking on the "Communication" button (see Page[7] 4) of the main UI. Pages[7] 6 to 9 present screens of the UI designs for this service. Via the Social Communication service, the end-user journey includes the following steps: 1) User clicks on the Communication tile/button from the main UI of the app; 2) The service loads in contacts mode; 3) The user can use the scrollbar to navigate to one or more contact screens; 4) The user can click on a person to initiate a video call for social communication or for assistance and support; 5) The user can click the "Meet Others" button to connect with other users that are not in his/her network – connect with new people, but registered in the GUIDed system; 6) Once selected (known or unknown contact), the user to call loads up centrally in the app; 7) The user can click to make a video call, e.g., with his/her granddaughter; 8) The receiving user can click to accept/reject the video call; 9) The calling user is shown centrally in the app; 10) The calling user can see and socially interact in an augmented camera view, e.g., with granddaughter, likewise the called user can also see and socially interact in an augmented camera view, e.g., with granddad. It is the wide-angle lens that enables the augmented camera view; 11) Both users can switch camera view and terminate the call at any time.

When using the "Meet Others" option: 1) The user clicks the respective button to connect with new people; 2) A person is selected (matching or randomly) to meet new people and engage socially in the GUIDed community, 3) The user can click to call the person that was selected or click to go back to the contacts screen; 4) The user that receives the call sees the photo of the caller; 5) The user receiving the call can choose to accept or reject the call. In the case that the communication happens, it follows the same approach from hereon as with having a conversation with a person that is already a contact; 6) Any of the two users can invite the other contact to connect. A user can accept or reject the new connection.

5.3 Smart Home Control Service

Once logged-in to the GUIDed app, end-users are able to access the smart home control service by clicking on the "Home control" button (see Page[7] 4) of the main UI. Pages[7]

11 to 13 present screens of the UI designs for this service. Via the Smart Home Control service, the end-user journey includes the following steps: 1) User clicks on the Home Control tile/button from the main UI of the app; 2) The camera view opens within the GUIDed app – AR mode; 3) The user can point to a synchronised smart sensor device to control it; 4) The appropriate controls of that device are augmented in the camera view and the user can interact with the device, e.g., turn on/off, dim light, choose colour; 5) The user is able to click the "UI" mode button to receive a list of rooms and devices he/she can control; 6) The UI view opens within the GUIDed app; 7) The user can click in any room (e.g., Living Room) to access it's smart devices; 8) The user can drag the circle to control the light intensity; 9) The user can click the button to turn on/off the device (e.g. light); 10) The user can click on any colour to change the light ambience; 11) The user can click the "AR" button to return to AR mode; 12) The user can click back button on the mobile device to return to the previous screen.

5.4 Smart Home Safety Service

Once logged-in to the GUIDed app, end-users will be able to access the smart home safety service by clicking on the "Safety" button (see Fig. 2) of the main UI. Pages[7] 15 to 17 present screens of the UI designs for this service. Via the Smart Home Safety service, the end-user journey includes the following steps: 1) User clicks on the Safety tile/button from the main UI of the app; 2) The camera view opens within the GUIDed app – AR mode; 3) The user can point to a synchronised smart sensor device to retrieve its status; 4) The user can click the "UI" button to enter UI mode; 5) The UI mode of the GUIDed app is loaded; 6) The user can check the status of the sensors and act accordingly; 7) The user can click the "AR" button to return back to AR mode; 8) The user can click the back button on the phone to return to the main UI. When an emergency is detected, text and loud sound reminder/notification pops up.

5.5 Results, Recommendations and Considerations from Hi-Fi Prototype Evaluations

In overview, the results of the Hi-Fi prototype testing showed that all of the users found the GUIDed app understandable and easy to use, which is an encouraging finding considering older participants' low technological literacy. Some suggestions for improving usability included increasing the contrast of the screen colours and taking under account colour blindness when choosing the palette, changing the labels of some buttons (e.g., replacing the term 'user interface' with something more intuitive), and replacing some of the icons with more appropriate ones. Despite the fact that participants rated the app as intuitive and easy to use, most of them requested an introductory training to support them while using it. The training component has already been planned to be incorporated in the GUIDed application via an innovative assistant, utilising augmented reality technology.

In regards to appearance, most participants showed a preference towards user interface design No 2 with tiles (left design on Page 4[7]) since, according to them, it seemed cleaner with larger buttons than user interface No 1 (with typical buttons, right design on Page 4[7]). The only remark was that all tiles referring to individual services should be the same size (not underestimating the importance of any service).

Table 4. Primary end-user feedback

Main UI	Social communication	Smart home control	Smart home safety
• Both screens are easy to use with a slight preference to design No 2 (tiles based) • Make the tiles size even • Square tiles are cleaner • Add high contrast for persons with visual impairments (lighter background) • Change the colour for communication service icon as it is difficult to see • Make 'Welcome to" label more visible • Provide option to increase the size of the font • Add an emergency button • When choosing colours consider color blind people (e.g., avoid using green and red together) • Change the Health icon with a 'heart' or 'first aid kit' icon, the home icon with a 'home' and the communication icon maybe with a 'phone' icon, navigation with "pedestrian" icon • To change the "Navigation" as it can be misinterpreted as the art of navigating in an application to "Moving around", the "Home control", if this is only for lights, suggested to call it "Light control" and the "Communication" can mean a lot, suggested to call it "Contact with others". • Rename the 'exit' button to 'log out' • Important for older people that the app remembers passwords • App should be functioning in both a smartphone and a tablet (accessibility issue) • Offer the availability of a training, maybe through a gamified component • Add a fall detection service as this would be an added value (especially for people living alone)	• Offer ability to work with normal telephones as well in case the other user does not have the app installed • Add names under photos • Add voice commands • Add contacts and contact list creation in web interface is not shown and will probably be difficult for older adults • Increase width of sidebar to make it more visible • Add larger in size buttons • Add a favourites section • Offer option to turn off camera and mute the voice • Offer ability to define some availability windows • Tap on a picture of a contact should initiate a call • Offer option to transfer the contact list directly from the phone • Provide a list of people contacted more often. Also offer the option to import a telephone contact list or manual registration of contacts on the administration web interface. • Offer option to have more than two persons be part of the conversation (e.g., family meeting). In this case, how many can participate and must everyone have the app installed? • Clarify where do the persons in the 'Meet others' option come from • "Meet Others" label should be "Meet others" • Web or in app registering was found to be conflicting by end-users as to why this is different or what they prefer • "Meet Others" was worrisome for many end-users. Maybe add a safety disclaimer in the app (related to Ethics and Safety)	• Add voice control for the service • Add option to be able check the whether the gas is on • Add option to be able to close the shutters in the house • Enlarge on/off button • Change the UI button to 'rooms list' and the AR button to 'back' (or to more general labels like "Buttons mode" and "Camera mode") • Add option to control TV or front door • Add option to control devices when user is not home (e.g., switch off the stove) • Offer option for guidance/training on what one will be able to do with this service and how to use it • Slider will be difficult to move • Clarity on who will add and synchronise the devices on the service • Add option to be able check the radiators and doors • The AR and UI modes are confusing and need more explanation. • Clarity on how to access devices in other rooms if the user is at home and whether there is still access to the devices from outside the home • Concern about cost and number of smart devices that will need to be purchased and from where. Concern whether all commercially available smart devices will be controllable by the app and how many devices can be controlled in total • AR component seems artificial. Better to control the devices from the app, not by pointing at device option. • Add option to be able to work with different systems to reduce the number of apps one needs e.g., turn on light automatically when it gets dark, remote control for heating, check the garage door is locked, control the coffee machine and stove, manage music and see who is ringing the doorbell, also when not at home. • Integration of GUIDed to user's smart home system via APIs would be nice • Provide a list of devices which can be operated through the service	• Add option to be able to reset or cancel the sensors in case of mistake • Add more sensor options in the service: flood sensors, opening windows, doors for burglars, water leakage and fire alarm • Ensure pop-ups for alerts are in large font size and have a sound notification too • Add customisable options about the handling of an emergency alert and automatically notifying: e.g., when smoke is detected to notify the fire department via an automatic call or notify secondary user, like a son or daughter • Make the colour bar more distinguishable as it was deemed difficult to understand by users • Training will be needed for end-users to • Change screen order: first see the UI screen when starting the service and then camera screen (if needed) • Change the UI button to 'sensors status' and AR button to 'back' • Camera view (AR) is a bit confusing • Concern in the case that the sensors provide incorrect information • Add option for voice notifications • Add option for the service to provide information about maintenance of devices without asking for the status by pointing to a device • Consider moving temperature and humidity to the smart home control service since they do not concern the safety • Add documentation of maintenance (e.g. when did you change battery last time) • Consider a backup plan or a liability strategy if sensors stop working

Participants valued all of the services included in the GUIDed app. As they stated, the GUIDed app combines "all important services in one" constituting it an "everyday life companion" and "assistant". Two of the services rated as most useful included the *Smart Home Control service* and *Smart Safety service* as they simplify everyday procedures and offer convenience and safety, respectively. Some participants valued less some of the services due to personal lifestyle preferences. For example, older adults who did not take medication stated that they would not use so much the *Health and Nutrition service.* Moreover, all participants provided the GUIDed team with recommendations for additions and improvements in order to suit their individual needs. More specifically, participants requested the addition of an emergency button in the GUIDed app home screen to provide an easy means to call for help in case of an emergency.

Regarding the Smart Nutrition and Health service, participants requested the addition of a reminder to measure their blood pressure or sugar levels and fields to insert those measurements in the app. For the Smart City Navigation service, people requested the implementation of voice guidance apart from visual notifications as it seemed easier for them to have auditory assistance while walking around. With regards to Smart Home Control service, users stated that it would be helpful for them to have the ability to control their TV or front door. Finally, for the Smart Home Safety service and Social Communication service, users requested the incorporation of anti-theft devices and the simplification of the calling process (e.g., a call should be initiated when the user touches the photo of a contact stored in the app) respectively.

Table 4 summarises the main recommendations and considerations resulting from the end-user feedback collected during the evaluation of the main UI of the GUIDed app, and the Social Communication, Smart Home Control and Smart Home Safety services.

6 Conclusions and Future Work

Three of the five GUIDed services were presented in this paper, reporting on our findings from evaluating their respective Hi-Fi paper prototypes with primary end-users via focus groups. In addition, a technical description of the GUIDed system and the three services was also provided.

In conclusion, the results from the first end-user testing phase of the GUIDed Hi-Fi prototypes were very promising and insightful. The GUIDed system was rated as easy, intuitive and valuable, which will provide a great level of self-confidence, independence and convenience to older adults with some modifications, additions and adjustments required. For three services per se, Smart Home Control, Smart Safety and Social Communication, the recommendations and considerations collected from the end-users were specifically reported.

The feedback collected in Phase 1 for all of the five services, including that for the services of Smart Nutrition and Health, and Smart City Navigation, are currently under review by the GUIDed team to determine which recommendations will be implemented and how to address specific considerations pointed out. This process will lead to preparing for the second Phase of testing. For this, we will improve the designs of the services accordingly, and the evaluation tool will be mock-ups (semi-functioning), that will be evaluated by the end-users, using questionnaires.

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