D3.3 4-Connect My Social Network Module

Project Acronym:	**MARIO**
Project Title:	**Managing active and healthy aging with use of caring service robots**
Project Number:	**643808**
Call:	**H2020-PHC-2014-single-stage**
Topic:	**PHC-19-2014**
Type of Action:	**RIA**

D3.3

Work Package:	WP3	
Due Date:		M24
Submission Date:		31/01/2016
Start Date of Project:		01/02/2015
Duration of Project:		36 Months
Organisation Responsible of Deliverable:		NUI Galway
Version:		2.2
Status:		Final
Author name(s):	Christos Kouroupetroglou Lazaros Penteridis Stratos Arampatzis Ilias Trochidis Alessandro Russo Dympna Casey Adam Santorelli	CNET Ortelio Ortelio Ortelio CNR NUIG NUIG
Reviewer(s):	Geoff Pegman Massimiliano Raciti	RURobots R2M Solution
Nature:	☐R – Report ☐P – Prototype ☐D – Demonstrator ☒O - Other	
Dissemination level:	☒PU - Public ☐ CO - Confidential, only for members of the consortium (including the Commission) ☐ RE - Restricted to a group specified by the consortium (including the Commission Services)	
Project co-funded by the European Commission within the Horizon 2020 Programme (2014-2020)		

Revision history			
Version	**Date**	**Modified by**	**Comments**
0.1	11.10.16	Keith Cortis NUIG	Initial Document, Table of Contents
0.2	07.11.16	Eva Barrett NUIG	Redraft Initial Document, Table of Contents
0.2	23.11.16	Dympna Casey (NUIG)	Drafted section 3.1.1 -3.1.4 and 4.1.1 to 4.1.4
0.3	08.12.16	Alessandro Russo (CNR)	Drafted section 4.2.4
0.3	08.12.16	Lazaros Penteridis Ortelio	MyMemories App Privacy and Security Aspects
0.3	11.12.16	Adam Santorelli NUIG	Completed sections on Anticipated Development and Measuring Effectiveness for each app
0.4	22.12.16	Dympna Casey NUIG	Revised sections 3.1 to 3.14 and 4.1.3
0.5	09.01.2017	Andy Bleaden Stockport	Added elements and raised questions related to case studies and security
0.6	10.01.17	Alexandros Gkiokas	Additions on MyMemories App Privacy and Security Aspects
0.6	10.01.17	Alessandro Russo (CNR)	Additions to section 4.2.4; drafted section 4.2.1
0.7	12.01.17	Christos Kouroupetroglou	4.2.2, 3.2.2 and 3.2.3 completed
0.8	12.01.17	Arlene Mannion (NUIG)	Formatted Table of Contents
0.9	12.01.17	Massimiliano Raciti (R2M)	Drafted sections 3.2.1 and 3.3
0.9	12.01.17	Alessandro Russo (CNR)	Additions to section 4.2.1; drafted sections 4.2.3 and 3.2.4
1.0	12.01.17	Adam Santorelli	Additions to Executive

		(NUIG)	Summary and Conclusion
1.1	16.01.17	Eva Barrett	Editing and proofing
1.2	16.01.17	Arlene Mannion (NUIG)	Editing and proofreading
1.7	25.01.17	Geoff Pegman	Provided internal review
1.8	25.01.17	Massimiliano Raciti	Provided internal review
1.9	26.01.17	Adam Santorelli	Incorporated reviewer's feedback
2.0	27.01.17	Alessandro Russo	Added figures and formatted ToC
2.1	28.01.17	Dympna Casey	Edit and proof reading
2.2	31.01.17	Eva Barrett	Final edits

Copyright © 2015, MARIO Consortium

The MARIO Consortium (http://www.mario-project.eu/) grants third parties the right to use and distribute all or parts of this document, provided that the MARIO project and the document are properly referenced.

Executive Summary

This document describes two specific applications (apps) that are deployed on the MARIO robot as part of the My Social Network Module. These apps, namely the My Chat app and the My Memories app, have been designed to help mitigate the effects of isolation and loneliness that people with dementia experience. The development and selection of these apps was driven by the desires and requirements identified by end users, that is, people with dementia, and caregivers. This deliverable follows the following schema for each developed app: Requirements, Vision and Objectives, Application Design, and Privacy and Security Aspects.

Specifically, these apps help the user connect with their family, allowing them to easily stay connected in their family's lives, and will allow PWD to interact with MARIO about past events and memories. These two apps will target the feelings of both isolation and loneliness that PWD often experience. The My Chat app will allow the user to communicate with their family. The app will be developed to easily allow the user to contact family members, at specific times. The app is designed to work with the limitations of the family member's availability (work schedules, for example), thus, while being easy to use by PWD, it is also easy for the family as the app will only allow communication during pre-allotted times. If the user tries to contact a family member outside these hours, or tries to contact the family member too many times in a row, MARIO will simply divert the user to another activity. Thus, the app will help both the user and the family members. The My Memories app will help stimulate conversation for the user. One example of how it will do this will be through presenting photographs from the user's past, MARIO will then start up a conversation about the specific content of the photograph, prompting the user to discuss the event and share a happy memory This conversation will mimic a real life conversation with a human, thus helping PWD feel connected to MARIO by engaging in a meaningful conversation about an event in their past.

The impact of these apps on the lives of the PWD will be assessed in a variety of ways, specifically: i) interviews with carers, ii) interviews with family members of the PWD, iii) observational data during sessions with MARIO on how the user enjoyed the app, and iv) the use of specific scales, such as the Observational Measurement of Engagement (OME), Social Dysfunction Rating (SDR), Quality of Life in Alzheimer's Disease, Brief Resilience to quantify the engagement of PWD as well as the social impact of the app.

These apps are user driven and specially designed and developed to ensure that they are easily accessible and usable by PWD, allowing them to easily access a means to remain connected with their community; thus, the struggles and difficulties that arise from the feelings of isolation and loneliness are mitigated.

Table of Contents

List of Figures

1. Introduction

This document is a short report to accompany the software for the group of apps named the 'My Social Network' that forms the second group of apps (of the evidence-based toolkit of apps being implemented in MARIO to support social connectedness. D3.4 4-Connect My Hobbies Module being the first).

1.1 Work Package 3 Objectives

This WP investigates how service/companion robots can be used to change perception of loneliness, build resilience, be a tool for the prevention and mitigation of loneliness, and support the independence of persons with dementia. WP3 aims to provide the necessary foundations that will contribute to a change of attitude in the way that service/companion robots are employed as a means of promoting and maintaining connectedness to the community, reducing isolation and loneliness as well as reducing risks related to being alone rather than being seen as a replacement for human contact.

As such, WP3 objectives are:

- To investigate and determine how service robots can best be used to change perceptions of loneliness, to build resilience and to address challenges surrounding dementia
- To work with end users to determine the issues of importance to them, specifying what matters to them which enables the specifications of what a robot needs to be able to do. This in turn allows the development of the 4Connect + modules associated with their community, a person's social network and a person's hobbies and interests.
- To address understanding, attitude, and acceptance related to service robots
- To construct a network of researchers in this topic domain that outlasts the project

Deliverable 3.3 reflects the output of the first and second objectives above.

1.2 Purpose and Target Group of the Deliverable

The purpose of this deliverable is to describe the selected applications that constitute the 4-Connect Community module, specifically:
- My Chat app
- My Memories app

This deliverable is targeting several parties that are interested in service/companion robots. For example, robotics experts will be interested in all aspects of how such

robots work, health experts will be interested in how these robots can improve the lives of people with dementia, software engineers will be interested in the technical details of the apps, and pilot users will be interested in how such robots can help them in their everyday life.

1.3 Relations to other activities in the project

WP3 receives as input user requirements, system architecture, information management and ethical framework from WP1. From WP2, a service robot is available. An iterative design process involving the RDI WPs (WP3-WP6) brings the progress of these other WPs (moods and expressions from WP6, semantics from WP5, a holistic approach and assessment from WP4) into the development cycle of WP3. WP3 provides as output (for integration in WP7 and validation in WP8) modules that bring MARIO's capabilities to stakeholders and also the science dedicated to the treatment of PWD/loneliness/isolation. The human network in WP3 will fold into the larger MARIO Stakeholder community project-wide efforts in WP10.

1.4 Document Outline

Following this introductory chapter, Chapter 2 presents the Application Design and Development and Chapter 3 and 4 presents detailed information about the two robotic applications developed-My Chat and My Memories. Conclusions reached from this deliverable are provided in Chapter 5.

1.5 About MARIO

MARIO addresses the difficult challenges of loneliness, isolation and dementia in older persons through innovative and multi-faceted inventions delivered by service robots. The effects of these conditions are severe and life-limiting. They burden individuals and societal support systems. Human intervention is costly but the severity can be prevented and/or mitigated by simple changes in self-perception and brain stimulation mediated by robots.

From this unique combination, clear advances are made in the use of semantic data analytics, personal interaction, and unique applications tailored to better connect older persons to their care providers, community, own social circle and also to their personal interests. Each objective is developed with a focus on loneliness, isolation and dementia. The impact centres on deep progress toward EU scientific and market leadership in service robots and a user driven solution for this major societal

challenge. The competitive advantage is the ability to treat tough challenges appropriately. In addition, a clear path has been developed on how to bring MARIO solutions to the end users through market deployment.

2. Application Design and Development

The application design, development, and testing for the robotic apps is consistent across the different modules, and as such a similar development archetype is followed. Please refer to Section 2 of D3.1 4-Connect Community Module for the principles of Application Design and Development.

3. My Memories App

3.1 Requirements, Vision and Objectives

3.1.1 The Purpose

Reminiscence is a psychosocial intervention commonly used in dementia care (Wang, 2007). It is a verbal interaction between people whereby a person recalls personal events or experiences from their past which are memorable to them and shares this with others. it is a process of "using the recall of past event, feelings and thoughts to facilitate pleasure, quality of life, or adaptation to present circumstances" [7]. It may be undertaken in pairs or in groups and it focuses on long term memory, in particular attempting to stimulate and access the person's autobiographical memory which remains relatively intact for people with dementia well into the later stages of the disease.

The purpose of My Memories reminiscence app in the context of MARIO is to work with the person to help them unlock their preserved pleasurable memories using a conversational approach and highly focused triggers. This type of reminiscence is often called 'simple reminiscence' (Lin et al., 2003) and may be structured and or spontaneous.

3.1.2 Why this app is important

International evidence suggests that reminiscence may improve the quality of life and behaviour of people with dementia (Moos & Bjorn 2006; Woods et al., 2005) and positively change staff attitudes (McKeown et al., 2006). Lin et al. (2003) undertook a systematic review of the effect of reminiscence on older people. They found that reminiscence can increase socialisation, maintain self-esteem and life satisfaction. The most recent Cochrane review undertaken by Woods et al. (2009) concluded that although, at the level of individuals trials, the evidence supporting reminiscence for PWD was inconclusive, they indicated that at a meta- analyses level the combined effects of studies showed that it can improve cognition and mood, reduce the strain experienced by caregivers and relatives and reduce symptoms of depression.

The focus of the My Memories app is to encourage and support the PWD to focus on happy positive memories. This is where 'knowing the person' and having factual knowledge about the individual and their family is key. The events and memories recalled by the PWD may not be in sequential order or historically accurate but that

doesn't matter, the focus is on encouraging socialisation, and connectedness, increasing the person's concentration, giving the person a sense of accomplishment as reminiscence confirms and validates the person's contribution that they have made throughout their lifetime. In summary, this app is important as it provides PWD with the means and opportunity to more readily and easily engage in reminiscing about key past events and achievements. This therefore has the potential to promote social engagement with others and improve the PWD's sense of wellbeing and quality of life.

3.1.3 What the My Memories app will do

The Items or methods that will be used in the app to kick off and trigger reminiscence will mainly target the PWD's sense of hearing and vision. The My Memories app will use factual information gathered in the form of a life history from the PWD, their families and carers to create some individualised topics. The relevant topic and life events that may form the topic of conversation about which reminiscence takes place will then be triggered through the use of photographs and images, and YouTube clips displayed on MARIO based on different themes and events relevant to the person's background. Some of these triggers may be unique to the individual whereas others may be more generic. For example, generic images of 'harvest time' might be an appropriate topic for individuals who once lived in the countryside. The aim of these triggers is to stimulate the person's ability to recall their memories, in particular their autobiographical memory, trying to access the person's memories of – general events, (what it felt like stepping into the sea for the first time), specific personal events, (first day at school) and personal facts, (who was Pope when you were born?), as well as flashbulb memories, (where they were when they heard Princess Diana had died). Appendix 1 (a) shows an example of a use case scenario that demonstrates how the app will work.

3.1.4 Anticipated Development

In the initial trial phase in which the app will be released (Phase 2, which represents supervised trials), the aim is to test the extent to which a PWD can interact with MARIO and make use of the My Memories app, take note of any difficulties they encounter, and use this feedback to develop solutions for future interactions. The feedback from the actual use of the My Memories app by PWD will guide the development of the app; ultimately, this app will be fine-tuned for use by the PWD. These first interactions will be guided by the researcher. The researcher will be tasked, in collaboration with the local caregivers or family members, to ensure that
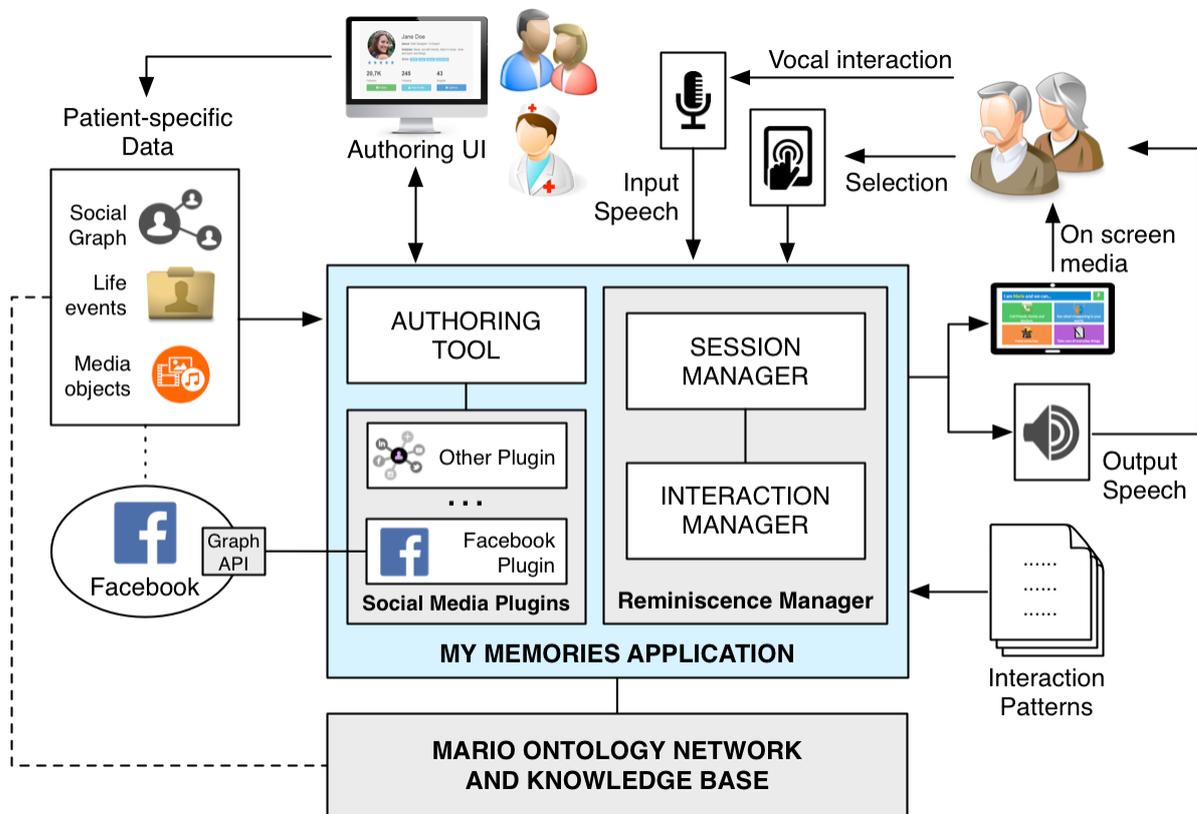
accurate information relevant to the past life experiences of the PWD are uploaded onto their user profile in the MARIO platform. This may include personal photos, photos of landmarks, or sporting events. The researcher will then be tasked with ensuring that the app is functioning correctly for each PWD prior to being tested in a 'live' scenario. These tests will include ensuring the right information is being displayed and the associated voice interactions with MARIO are relevant to the subject matter. The first 'live' tests of the app will involve the researcher demonstrating how to use the app, acting as a mentor and observer to ensure that the PWD is able to understand how to use the app and what they can get out of its use. The goal is to slowly make the interactions more autonomous; the ultimate goal for the app is for the PWD to use the My Memories app unprompted by the researcher and in an unsupervised and autonomous fashion.

3.2 Application Design

3.2.1 General technical infrastructure

The My Memories application is designed to actively prompt the PWD and engage him/her in an interactive and personalised reminiscence process, where dialogue-based interaction patterns are complemented with multimedia content associated with relevant memories, people, places and life events part of user's life history. The reference architectural model of the My Memories app is shown in Figure and the main components are described in the following sections.

Authoring Tool and UI. The availability of a profile that covers biographic information, family and social relationships, life events and related multimedia objects of the PWD represents a fundamental prerequisite for enabling the reminiscence process. The My Memories application provides a *Web-based Graphical User Interface* and *Authoring tool*, designed to allow the authorised clinicians/friends/relatives to set up, configure and update the user's profile and life history. Although potentially available using the touch-screen device on the robot, the interface is intended to be accessed through an external device (e.g., a laptop computer or a tablet connected to the robot via a local wireless connection). Standard account-based authentication mechanisms ensure access is limited to authorised care staff members, family members and/or friends, and HTTPS connections protect the privacy and integrity of the exchanged data.

Figure 1: My Memories application architectural model

The *Authoring tool* supports and guides the user in the process of building a user-specific knowledge base, centred around the PWD's profile, relationships and life events. The tool thus directly interacts with the underlying knowledge base and the UI is structured to reflect the knowledge and informational elements represented in the MARIO Ontology Modules supporting the My Memories application, detailed in Section 3.2.4. Through a set of form-based dynamic pages, the tools enable the user to:

- define basic biographic information about the user and other relevant people (names, birth dates, birthplaces, hometowns, current living places, etc.), along with family and social relationships that relate people to each other;
- define life events and their constituent elements (temporal dimension, places, participants, descriptions, etc.), grouped and structured according to a basic categorisation scheme that includes work and education experiences, personal and family events, living and travel experiences, and hobbies and interests;

- upload and store multimedia content (e.g., pictures) and associate (or tag) media objects with other entities (people, places, events, etc.).

In particular, the upload, provisioning and tagging of multimedia content is a fundamental step supported by the authoring tool. Media objects can be contextually uploaded while defining specific profile information or life events, establishing a semantic association between the uploaded content and the information being defined. Typical examples include photographs of the PWD (e.g., as a child) and his/her family members, photos of important places (such as their hometown or school), pictures taken during a holiday or an event (e.g., PWD's wedding).

Data and knowledge elements entered through the dedicated interface and gathered by the authoring tool are stored in the MARIO Knowledge Base. In order to interact with the knowledge base and access the corresponding data, the authoring tool exploits the functionalities and API provided by the *MARIO Knowledge Management System*, described in detail in Section 4 of Deliverable 5.1, which provides programmatic access to the Knowledge Base and MARIO Ontology Network (MON) via an HTTP-based REST layer.

Social Media Plugins. The knowledge required and managed by the My Memories application, including people profiles, social relationships, life events, interests and tagged multimedia content, corresponds to the data and information that is typically available on online social media and social networking services such as Facebook. The My Memories app thus includes the possibility to build social media plugins to interface with social networking services in order to gather and import data and content form on online social media. On the one side, the authoring tool can be considered as the primary means for building and managing the profile and life history of the PWD when there are no pre-existing social media accounts associated with the person. On the other side, under the assumption that a pre-existing social media account associated with the user does exist, a social media plugin can be used to complement the authoring tool by importing existing data and reduce the initial manual effort required to set up the knowledge base for the user.

The role of a social media plugin is thus twofold. On the one hand, it is responsible for interfacing with an external social networking service in order to collect the available information, exploiting the API provided by the target platform. On the other hand, it is in charge of mapping the gathered data to the internal representation model and format (as defined by the ontology modules) and locally storing the data in the knowledge base, relying again on the API provided by the MARIO Knowledge Management System. The need to locally store the data gathered from external sources aims at addressing the privacy and security

requirements of the MARIO platform, as well as to ensure that the overall framework is able to operate as a standalone solution, without strong dependencies on external services and on the continuous availability of a connection to the Internet.

As part of the iterative development approach, a social media plugin for the Facebook platform will be considered. This aims at addressing the scenarios where pre-existing Facebook profiles are available for the specific user and/or his/her family members or friends in charge of managing the users profile in the context of the My Memories application. As one of the main online social media and social networking services, Facebook manages information about people's profiles, including biographic information, social relationships and life events, as well as associated media objects (mainly photos and videos), that collectively define a social graph. By exploiting the so-called Graph API made available by the platform[1], it is possible to access the social graph and retrieve users' data.

Reminiscence Manager. The *Reminiscence Manager* is responsible for engaging the PWD in the interactive multimodal reminiscence process. It manages the overall execution and status of reminiscence sessions, coordinating the interaction with the user and with the other components in the MARIO software framework. In line with the overall MARIO control architecture and applications design and development principles, the My Memories app operates under the control and supervision of the MARIO *Task and Ability Manager*. The *Reminiscence Manager* is responsible for interacting with the *Task and Ability Manager* subsystem, according to message-based interaction patterns that allow the *Task and Ability Manager* to control the application (by starting, stopping, suspending and resuming its execution), and enable the My Memories application to notify status changes.

The application can be triggered as a result of a direct request issued by the person with dementia, either through the GUI provided by the MARIO framework and available on the touchscreen, or via vocal commands, exploiting the multimodal interaction capabilities provided by the robot. In addition, MARIO could trigger the app as a suggestion to the user or autonomously initiate a reminiscence session if specific contextual conditions are met, as discussed in Section 2.2. This includes, for example, the user explicitly mentioning a person, a place, or an event that MARIO is able to recognise because of the presence of knowledge elements and semantic tags available in the knowledge base.

When activated, the *Reminiscence Manager* is in charge of initiating and conducting a reminiscence session by interacting with the PWD and exploiting the available

---

[1] https://developers.facebook.com/docs/graph-api

factual knowledge. In particular, the interaction is driven by an extensible repertoire of pre-configured parametric *interaction patterns*, that allow prompting the user through specific questions, possibly associated with media objects such as pictures that are contextually shown. An *interaction pattern* is basically composed by:

- an optional *precondition*, with one or more constraints defined in terms of queries over the knowledge base that express the applicability of the interaction pattern, i.e., under which conditions the prompting question can be used;
- a *prompting question* to be used for triggering reminiscence; the prompting question can be parametric, i.e., represented as a partially-formulated question template containing placeholder elements or variables to be instantiated in order to have a complete question formulation;
- one or more *queries* to be executed over the knowledge base in order to provide a binding for the parameters/variables in the case of a partially formulated parametric prompting question.

Interaction templates are conceptually associated to the different classes and properties defined in the ontology modules supporting the reminiscence app, so as to cover the different dimensions of the available factual knowledge about the PWD . As an example, a photo is linked to information concerning where and when it was taken, and who appears in the picture, as already described. Each constrained by the existence of the corresponding data/object property, possible prompting questions include the following:

- `userName`, is that `personName` in the photo with you?
- Can you remember where this was taken?
- This photo taken in (name of the place) is very nice! Who's in the picture with you?
- Is there anyone else in this photo that you recognise in addition to `personName`?

The presence of social/family relationships concerning the people in the photos can also be exploited to refine the prompting questions, such as:

- Is that your `familyRelationship` `personName` in the photo with you?
- That's you `userName` in the photo with your `familyRelationship` `personName`. Where was this taken?

Similarly, the association between photos and life events can be exploited to formulate targeted questions about the specific life event. For example, in the case of a photo associated with a travel event, possible prompting questions such as "Was this taken when you went to `travelEventPlace`?" are part of the repertoire.

Basic biographic knowledge can be exploited as well, to formulate questions like "`userName`, you grew up in `homeTown`. What was it like?".

Targeted questions are also defined for the different types of life events and their properties. Assuming, for example, that there is a marriage life event where the PWD is one of the partners, prompting questions such as "`userName`, you got married to `partnerName` in `eventDate`. Tell me about you wedding day!" are considered. Photos and other media objects can be the main subject of the prompting questions (as in the examples above), or can be used to support and stimulate reminiscence. For example, questions conceived to prompt the user and remind him/her of his/her children's names can be formulated by contextually showing pictures of them.

Complex interaction patterns that range over multiple knowledge elements can be defined as well. For example, under the constraint that there are at least four people linked to the user PWD by a *siblingOf* relationship and for each of them the birth date is known, prompting questions like the following can be considered:

- `userName`, you were one of `numSiblings+1` children. Who was the oldest/youngest?
- `userName`, you where one of `numSiblings+1` children. Who was your favourite? `oldestSiblingName` the oldest or `youngestSiblingName` the youngest?

From the examples introduced so far, it is evident that prompting questions can take the form of *(i)* general open-ended questions (e.g., "Tell me about your `socialRelationship personName`") that aim at stimulating the user to talk about people, places, events etc.; or *(ii)* targeted questions that assume a specific answer (e.g., "Who's in the picture with you?") which is known to the application. In the first case, the understanding capabilities provided by the *Understanding component* (cf. Deliverable 5.2) are mainly exploited in an attempt to recognise frames potentially matching with life events and named entities such as people or places, so as to drive the selection of the subsequent interaction pattern and prompting questions. For example, when asked about one of his/her children, the PWD may mention the place where he/she lives; other people or events related to that place can then be retrieved from the knowledge base and considered for the next prompting question. In the case of prompting questions with known answers, the language interpretation domain is constrained (e.g., to a specific place, date, etc.) and understanding capabilities are exploited to check user's answers and then either providing the PWD with the expected answer (and thus helping the reminiscence) or moving to the next prompting question. In general, the selection of

the interaction patterns is a dynamic process, driven either by the user's replies or by traversing the links in the knowledge graph. So, for example, a prompting question about when a photo was taken can be followed by a question concerning one of the people that appear in the picture, and then move to a life event in which the specific person participated in and so on, exploiting the semantic properties in the represented entities and the semantic roles in the represented frames. It is also anticipated that the My Memories app will work the other way around, i.e. if a person says "I want to see the pictures of my 50th birthday" the task manager should pass this to the reminiscence manager. If a rule matches, the app is launched.

3.2.2 User Interaction design

Applications for reminiscence are not quite widespread and they just now starting to appear as functionalities within larger apps especially ones related with photos such as Facebook, Google photos etc. Usually their aim is to remind users of events (that may be rather personal) that have happened in previous years based on the timestamps on the photos or videos uploaded to them.

As already described, the My Memories app in MARIO will be different in its purpose and functionality to the other apps. It will aim to trigger a conversation with the user trying to reply with messages that will help the user remember related events, persons, places, etc. The user interaction therefore does not need to be overloaded with many elements but instead it need to focus the attention of the user on the media presented and on the point of the discussion. Therefore, when the app is started it will just display a picture or video and a short message on the top aiming to trigger the discussion with the user.

The app, based on the user's response will be able to move to different media in the next steps or just change the message on top by replying to the user's speech. Therefore, the apps user interaction flow is a series of similar steps that each display a media and a message. The messages and media to be shown will be determined by the app itself according to the description in the general technical infrastructure above.

3.2.3 Designing for a robot app

The My Memories application relies on the basic principles taken into account in the design and development of the robotic applications that constitute the 4-Connect My Hobbies module, presented in Deliverable 3.4. The design and development

strategy for the app aims at gradually adapting, extending and improving the available features and capabilities, on the basis of a continuous assessment process driven by trial results. In order to exploit the situated and embodied nature of the robot, and thus its physical presence, since the early stages of the validation phase the provision of core app functionalities will be enriched with the added-value coming from the capabilities of the robotic platform hosting the My Memories application. Sensorimotor capabilities are considered as a viable solution for further improving the user experience during the reminiscence process. This includes the ability of MARIO to orient itself towards the user, as well as the ability to dynamically approach the user and adjust its position and distance. This is particularly relevant for the My Memories application, which relies on multimodal interaction patterns, where voice-based communication is combined with the provisioning of digital media objects, in particular photos/videos shown on the screen.

The *personalisation* perspective can be considered as an intrinsic pre-requisite and distinctive feature of the My Memories app, as it is conceived and designed to be a fully individualised application, capable of making available user-specific content or information based on personal relevance and personally meaningful events, persons, places, etc. The personalisation dimension directly contributes to the definition of *robot-initiated* engagement strategies to contrast apathy and lack of initiative, which in the case of the My Memories app include MARIO's abilities to actively prompt and engage the user in the reminiscence process. While the app can be explicitly initiated by the user, the robot is able to autonomously identify socially and contextually appropriate moments for proposing a reminiscence session. More specifically, both the availability of common knowledge shared among applications (via the knowledge base) and contextual information can be exploited to identify triggers for a reminiscence session. For example, if the current date has a correspondence with a temporal property associated with a family member (e.g., it is the birthday of one of user's children) or life event (e.g., it is the anniversary of the PWD's wedding), a reminiscence session that focuses on (or starts from) the specific person or event can be initiated. Similarly, the presence in the knowledge base of a calendar event (as described in Deliverable 3.1) related to a family member (e.g., PWD's daughter is coming to visit him/her) can be exploited and used as a trigger for a reminiscence session about that person.

The expected introduction in the MARIO software framework of additional features can provide added value to the My Memories application. In particular, the introduction of so-called sentiment analysis capabilities (mainly investigated in Work Package 5) can be leveraged with the aim of assessing emotional aspects and the user's mood when prompted to reminiscence about a specific subject. In the long term, the goal is to identify which relevant elements associated with the user

(people, places, events, pictures, etc.) generate positive feelings and emotions and then favour these subjects in the reminiscence sessions.

3.2.4 Integration of knowledge base

The My Memories app strongly relies on the availability of user-specific information, directly used to drive the interaction and engage the PWD in reminiscing about key people and past events of his/her life history. In order to represent, structure, store and make available this heterogeneous information, specific ontology modules were defined as part of the MARIO Ontology Network (MON) introduced in Deliverable 5.1. In line with the overall ontology design approach outlined in D5.1, the ontology modules presented here were designed and developed following the eXtreme Design (XD) methodology. The ontology requirements elicitation stage was thus driven by a direct interaction with health professionals and PWD from the different pilot test sites (NUIG-Ireland, Stockport-UK and IRCCS-Italy) and by the definition of user stories representative of the intended use case scenarios. User stories and reference scenarios were then used to identify the set of Competency Questions (CQs) and tasks that the ontology is expected to address.

Based on the Use Case scenario outlined in Appendix 1 (a), below are some of the main competency questions that were defined.

Competency Questions	
CQ1	What is the user's basic biographic information (name, date/place of birth, etc.)?
CQ2	Where did s/he grow up?
CQ3	Which places has s/he visited?
CQ4	Who are the user's family (husband/wife, children, siblings, etc.) and social relationships (e.g., friends)?
CQ5	What was user's job?
CQ6	What are/were the user's interests and hobbies?
CQ7	What are the basic biographic information of the user's relatives and friends?
CQ8	What are/were the interests and hobbies of the user's family members and friends?
CQ9	What are the main life events in the life history of the user and his/her family and friends?

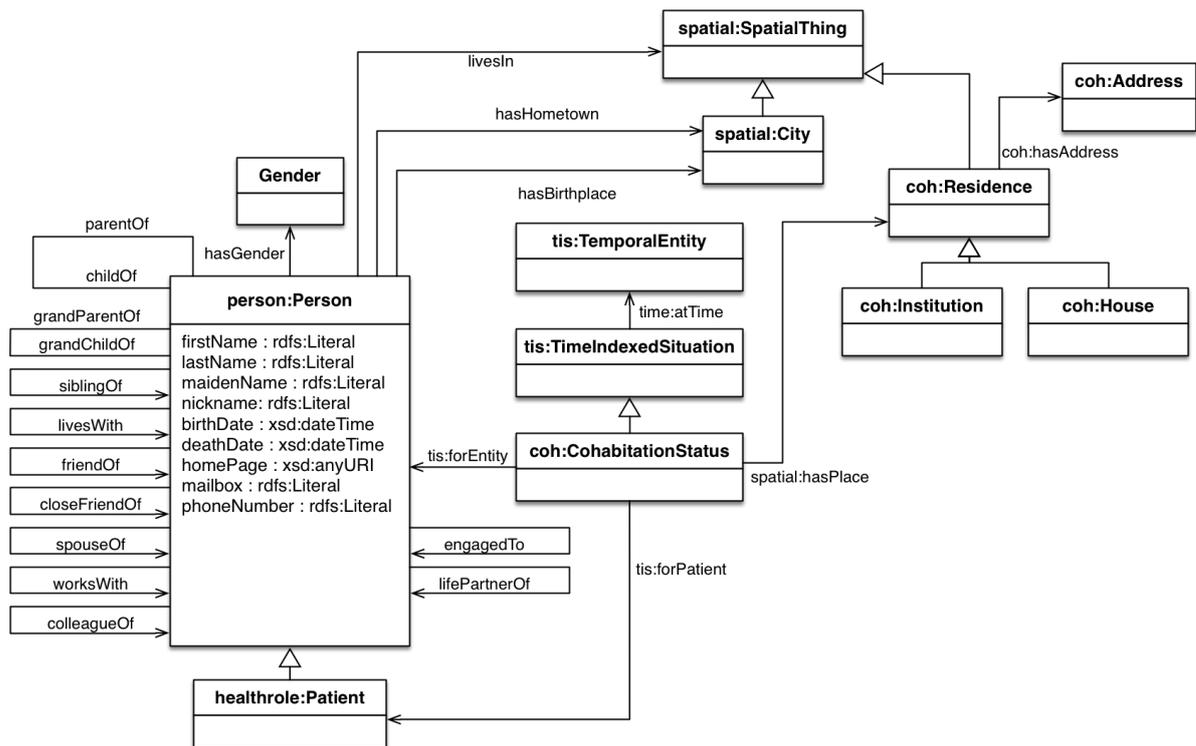| CQ10	Where and when did an event take place?
CQ11	Who was involved in an event?
CQ12	What are the multimedia objects (e.g., photos) associated to a life event?
CQ13	Where/when was a photo taken?
CQ14	Who appears in a photo?

Abstracting from the user stories and generalising the CQs, the design of the ontology model was driven by the need of representing:

- persons and their basic biographic information
- family and social relationships among persons
- persons' jobs and interests/hobbies
- life events in the life history of a person, including where and when the events took place and which persons were involved/participated (and potentially their role in an event)
- multimedia objects and their association with persons (who), places (where) and events (when/what)

The ontology modules providing support to the My Memories app thus cover three of the main knowledge areas identified in D5.1: personal sphere, life events, and social and multimedia content. Main design choices are discussed and presented in the following.

Biographic information and social relationships. Basic biographic information about persons and their social relationships are defined in the Person ontology module[2], whose basic structure is shown in the simplified UML class diagram in Figure . Basic biographic information includes person's first name, last name, gender, date of birth and date of death. Additional appellations are considered, including nicknames and women's maiden names, along with contact details, such as personal home pages, mailboxes and phone numbers. The birthplace, hometown and current living place are defined as well. Each person can be related to an image that represents him/her, which can be considered as a "profile picture" and should be particularly representative of some person from the user's perspective.

---

[2] http://www.ontologydesignpatterns.org/ont/mario/person.owl

Figure 2: Simplified UML class diagram of the Person ontology

By relying on the cohabitation status ontology module[3], the residence of a user can be further characterised, so as to specify whether s/he lives at home or in an institution and who lives with him/her. As the co-habitation status for a PWD is a time-indexed situation (i.e., has a temporal dimension), different cohabitation statuses can be considered over time. This allows representing the different places where the PWD has lived in his/her life.

By relating persons to each other, different family and social relationships can be represented. Generic kinship relationships, such as *(grand)child/parent of*, *sibling of* and *spouse of*, are further specialised taking into account persons' gender, so as to define specific relationships including *(grand)son/daughter of*, *(grand)father/mother of*, *brother/sister of*, and *husband/wife of*. Other social relationships are covered as well, including living (*lives with*) or working (*works with*, *colleague of*) together, friendship (*friend/close friend of*), and sentimental engagement (*engaged to*, *life partner of*). These properties enable the definition of a potentially complex family and social graph/network for the user.

---

[3] http://www.ontologydesignpatterns.org/ont/mario/cohabitationstatus.owl

Life events. Life events are characterised by a common structure that allows the definition abstract, generalised representational schema, which includes the primary properties of a life event. Specifically, a life event is characterised by:

- a *title* and a *textual description*;
- a *temporal dimension*, to allow representing events that occurred in a specific *date* (e.g., a marriage) or over a *period of time* (e.g., attendance to college); a life event can thus be considered as a time-indexed situation[4] for which more than one date can be defined (e.g., begin date, end date) and expressed in different formats (xsd:gYear, xsd:dateTime, etc.);
- a set of *participants*, to express the participation of potentially multiple agents/persons in the event;
- a *location* where the event took place;
- a set of *multimedia objects* (photos, videos, etc.) associated with the event.

While this generic representational structure is flexible enough to support the definition of different types of life events, supporting the needs of the My Memories application requires narrowing of the scope of the modelling approach so as to provide a precise characterisation of specific life events. In particular, there is the need to specialise the conceptualisation of biographic and life events to cover specific domains (such as work, education, travels, etc.) and to characterise and define the role covered by event participants with respect to a specific event.

A suitable representational strategy that meets these requirements relies on the adoption of a frame-based approach. A *semantic frame*, introduced in Section 3.3.1 of Deliverable 5.1, provides a schema for conceptualising the description of a type of event and the participants in it, i.e., *frame elements* or *semantic roles* that can be either obligatory, optional, inherited, reused, etc. For example, the concept of *marriage* typically involves two persons participating as partners, and takes place in a specific location and date. Similarly, a birth event is characterised by a person having the role of offspring (i.e., the person that was born) and typically involves two persons participating with the roles of mother and father; additionally, the place where the person was born and the date when the birth took place can be considered. As can be seen from these examples, an explicit representation of life events allows going beyond simple properties (such as *parent/child* or *spouseOf* relationships) by providing a precise characterisation of events and participating entities. In addition, in line with the generic event representation schema introduced before, multimedia objects can be associated with specific events, complementing simple tagging approaches that allow defining, e.g., where/when a photo was taken

---

[4] http://www.ontologydesignpatterns.org/cp/owl/timeindexedsituation.owl

and who appears in the picture. This "advanced" tagging approach that basically allows defining a life event as a tag for a multimedia content is in line with the *Tagging ontology*[5] defined in Section 3.3.3 of Deliverable 5.1. The Tagging ontology was already designed so that any object can be used to identify, categorise or describe the entity being tagged, allowing richer descriptions such as a frames and named graphs to be used as tags for an entity.

With respect to the reference scenario, basic social relationships can be used to define, for example, that Maggie is the spouse of Matt (and vice-versa), and more specifically that Maggie is Matt's wife and Matt is Maggie's husband. In addition to these direct relationships, it is possible to explicitly represent their marriage as a specific life event, so as to specify that they got married in 1952 and the marriage took place in Galway. Maggie's relatives may then associate one or more photos of the wedding day to the *marriage* event (i.e., the marriage event semantically tags the pictures) and further characterise the pictures by specifying who appears in the photos (e.g., a photo may show Maggie, Matt and Maggie's sister, Anne).

While, as already mentioned, the generic representational schema for life events enables the definition of arbitrary events in a person's life history, specific life events (or frames) and their characterising properties (or frame elements/semantic roles) were explicitly modelled and defined, so as to accommodate typical life events and scenarios. In particular, the following domains were considered.

- *Work and education*, to represent working experiences and jobs (e.g., Maggie started working as a teacher in the national school in Mayo in 1950), as well as school attendance (e.g., Maggie attended the St Loretto's school with her friend Erin); retirement events and military service periods are also considered, as potentially relevant for the target users.
- *Personal and family events*, to represent a marriage (e.g., Maggie got married to Matt in 1952), a honeymoon (e.g., Maggie spent her honeymoon in Dublin with Matt in 1952), the birth of a child, a birthday event and the acquisition of a pet.
- *Living and travel experiences*, to represent places where a person has lived (as also described above in terms of co-habitation status, complementary to the birth place, hometown and current living place properties) and travels/holidays (e.g., Maggie travelled once to Boston and to Sydney).
- *Hobbies and interests*, to represent interests and hobbies (e.g., Maggie's son, John, likes to play the fiddle, while Maggie is interested in gardening, reading, music, card playing and dancing).

---

[5] http://www.ontologydesignpatterns.org/ont/mario/tagging.owl

3.3 Privacy and Security Aspects

There are several layers to addressing the security and privacy concerns this app introduces. The primary data storage will be an encrypted database hosted locally on the robot. It is going to be encrypted with a key in compliance with industry security standards. Furthermore, the access of the caregivers or relatives to the web part of the application will happen only through a secure connection (TLS 1.2). An external encrypted disk backup will also be kept by the project technical representative at the pilot site in the case of a hard drive malfunction.

Each user's data will be encrypted using a unique per user key that allows only the user to retrieve and query his or her data. Caregiver access can be obtained or can be given only by using the unique encryption key. In the case of the communal usage of MARIO it will be the carer who has access to the user keys so that the robot can be personalised for each usage. This step will first require help from the project technical representative at first, however, once MARIO becomes autonomous, the carer will be able to easily make these changes for personalised use. Should the key get lost, it is impossible to retrieve the user's data. This is done in order to ensure no unauthorised access can take place by adding multiple layers of security.

4. My Chat App

4.1 Requirements, Vision and Objectives

4.1.1 The Purpose

Many PWD find it difficult to manage mobile phones as they not only lack the dexterity to use them but also because the technology itself can be quite complex. The purpose of the My Chat app is to empower and enable PWD to more easily connect and have voice conversations with their relatives and friends.

4.1.2 Why this app is important

The interviews with people with dementia and carers confirmed that relationships often change when someone has dementia and therefore the PWD often become isolated and lose contact with friends and family. Social robots have been shown to improve communication with family, friends and carers (Moyle et al., 2014; Roger et al., 2012). Social robots can effectively improve the quantity and quality of conversation available to PWD by functioning as a conduit conversational partner through which they can speak remotely to other people. One example is that of Giraff, a non-zoomorphic telepresence robot that has successfully facilitated telephone contact between PWD and their families (Moyle et al., 2014). The experience for PWD communicating through Giraff elicited positive emotions and high engagement levels with minimal negative emotion (Moyle et al., 2014). Likewise other studies report that social robots can increase the amount and quality of social interactions for PWD and increase engagement in social activities (Libin & Cohen-Mansfield, 2004; Moyle et al., 2013; Tamura et al., 2004). They do this through providing opportunities to trigger and stimulate conversations (Shibata, 2012), through facilitating face to face communication (Roger et al., 2012; Moyle et al., 2014) and acting as a conduit to communication between people at a distance (Yamazaki & Nishio, 2012; Moyle et al., 2014; Yamazaki et al., 2014). Affording PWD with the opportunity to communicate with family and friends in this way was also found to be associated with a reduction in stress levels (Wada et al., 2004; Wada et al., 2005; Wada & Shibata, 2007) and a reduced sense of isolation (Moyle et al., 2014).

The provision of the MARIO My Chat app will provide a simple and easy way of supporting existing relationships and encouraging continued participation in social groups and activities. It will also help to restore some autonomy to the person with

dementia, which our interviews with PWD and carers highlighted, as they are then no longer dependent on a relative or carer to place a call for them or to remember where they have left their phone.

4.1.3 What the My Chat app will do

This app is designed as a voice activated, easy to use system that responds to the requests of the person with dementia and prompts them to chat with their relatives and friends and in this way stay connected. However, depending on the stage of dementia some people may not remember that they have already chatted with their relatives a few hours previously and thereby place multiple calls to the same person in a short timeframe. The My Chat app has therefore been designed to call relatives/friends only during specific time slots which have been given to the researchers by the relatives/friends, i.e. in the evening time when they are not at work. The effectiveness of these approaches will form part of our testing during the trials.

This app will differ from other similar apps, (softphones or instant messaging systems) as it will take into account the simplified input required for the PWD to be able to use and to interact with the My Chat app. In addition, MARIO will be able to adjust its position to stay at an adequate distance from the PWD so a high audio quality of the interactions with family and friends is maintained and the volume is at an appropriate level. MARIO will also engage the person by asking whether s/he would like to chat with a relative or friend if they haven't done so for some time. MARIO will also keep a record of who and when the PWD has contacted within a specified time frame and will remind the person if they have already spoken to that person recently and encourage them to chat with someone else or engage in a different activity. The use case scenario in appendix 1 (b) shows how the My Chat app will work.
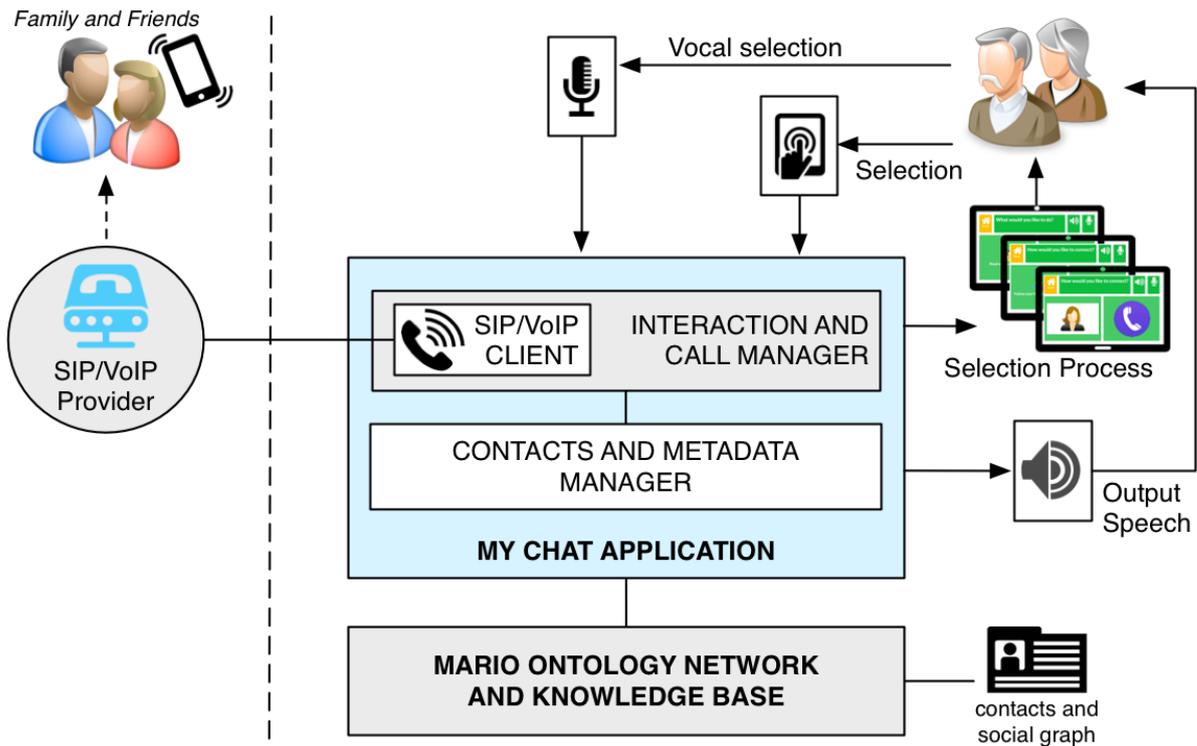
4.1.4 Anticipated Development

In the initial trial phases in which the app is introduced (Phase 2, which represent supervised trials), the aim is to test the extent in which a PWD can interact with MARIO and make use of the My Chat app, take note of any difficulties they encounter, and use this as feedback to develop solutions for future interactions. The feedback from the actual use of the app by PWD will guide the development of the app; ultimately, this app will be fine-tuned for use by PWD. These first interactions will be guided by the researcher. The researcher will be tasked, in collaboration with the local caregivers or family members, to ensure that accurate contact information

of family and friends are inputted for each specific user. This will include contact information (phone number, email, WhatsApp, Messenger, or other points of contact), and the times in which they can be contacted by the PWD (to ensure they are not being contacted during work or sleeping hours). The researcher will then be tasked with ensuring that the app is functioning correctly for each PWD prior to being tested in a 'live' scenario. These tests include ensuring that the contact information is correct, the time-limitations for contact are functioning correctly, and that the app allows for easy contact (simple one-click operation). The first 'live' tests of the app will involve the researcher demonstrating how to use the app, acting as a mentor and observer to ensure that the PWD is able to understand how to use the app and what they can get out of its use. The goal is to slowly make the interactions more autonomous; the ultimate goal for the app is for the PWD to use the My Chat app unprompted by the researcher and in an unsupervised and autonomous fashion. Additionally, it is possible to build certain behavioural functionality into the My Chat app, for example, MARIO can prompt a user at 6pm every Tuesday to call their daughter.

4.2 Application Design

4.2.1 General technical infrastructure

The My Chat app, as shown in Figure is a very simple and user-friendly application that allows PWD to place phone calls through the Internet. The app has two components: the contact list manager and the robot app. The contact list manager is aimed to be accessed by the caregiver and will be an extension of the current user configuration to input the user's contacts information. This information will be stored in the MARIO ontology network and will be retrieved by the robot app.

Figure 3: My Chat application architectural model

The robot app is the actual MARIO app that allows the user to place phone call. The technology chosen to place phone calls is VoIP (Voice over IP), using an external SIP provider. The application, which moves most of the underlying complexity towards the UI, is basically a softphone that registers itself to a SIP provider (username and password for the user need to be created in advance and stored through the contact list manager) and allows the user to call the contacts simply by clicking on the person's name or by saying the name of the person. The application uses sipML5[6], an open source HTML5 SIP client library. There are several SIP providers available and most of them allow both SIP calls end-to-end (softphone to softphone, in that case they are usually free of charge) or bridge them to landline or gsm network, to place calls to landline or mobile phones.

4.2.2 User Interaction design

VoIP callers and softphones usually need people to create a contact list, configure them and use them to make phone or video calls. In our case the set of contacts is

---

[6] https://www.doubango.org/sipml5/

limited to a select group of friends and family members so there is no need to include any live functionality for adding or editing contacts list since this will be provided in the configuration by the caregivers.

The user interaction flow therefore is quite simple. When the person triggers the app he/she is asked to select one of the persons in his/her contact list. Once the person is selected, a phone call is placed to the selected person and the user presses the hang-up button when the call is finished (additionally, if the PWD forgets to hang up the action will be automatically completed when the phone call is terminated on the other end).

The app, however, in this case controls the interaction of users with their relatives to avoid having the user placing an overwhelming number of calls in short time periods. So, when the user selects to call a person the app checks on its call log files and determines if the last call to the identified contact person was placed recently. If there was indeed a recent call, the robot reminds the user of the call with a message displayed on a modal box and asks the user if s/he would like to do something else instead as a means of distraction. The modal box is used so that users stay in the same context of the application.

4.2.3 Designing for a robot app

As pointed out in the requirements of the app maintaining contact with family and friends is an important aspect in the health care of people with dementia. Therefore, the app enables people to maintain contact by using a simple interface to call them on the phone. However, the difference in the case of the robot app is that since the app maintains call log files, it can figure out the frequency that the person is contacting specific contacts and control this interaction. When a person tries to phone their daughter when s/he already called her 1 hour ago, it is important that the robot knows this information, blocks the interaction and distracts the user by suggesting another activity. This way the user will not be frustrated at the robot for not being able to contact a person and also gets a reasonable explanation of why they should not call again at that time. The app will also reassure the person that they will be reminded to call their identified contact when it is more appropriate.

On the other hand, when the user loses contact with a specific person the app can also remind them to phone and catch up with that individual. This way, apart from protecting friends and family from overwhelming and really frequent communication, it could also help them stay connected with persons they neglected to contact lately. Being a robot app, this kind of functionality can be combined with moving the robot

close to the user or prompting the user after another activity is finished, for example, when the user has read some news about their friends and family in the other respective apps.

4.2.4 Integration of knowledge base

As is apparent from the reference user case scenario and collected requirements, the My Chat application relies on being able to set up and retrieve a list of contacts, including relevant people having a social/family relationship with the PWD (friends, family members, etc.) or having a specific role (e.g., a doctor) and for which a contact endpoint/phone number is defined. For each contact, basic biographic information needs to be provided, including first/last name and living place, along with the social/family relationship or role with respect to the PWD, and a reference picture. In addition, basic metadata about interaction session (audio calls) are to be recorded, including the callee and start/end date and time of the call. Below are some of the main competency questions that were identified based on the interview data in WP3 and the subsequent case scenario listed in Appendix 1 (b).

Competency Questions	
CQ1	Who has a family (husband/wife, children, siblings, etc.) or social relationship with the user (e.g., friends) and has a phone number defined as contact endpoint?
CQ2	What is the basic biographic information of the user's contacts (relatives and friends)?
CQ3	Is there a reference picture associated with a contact?
CQ4	What are the phone calls made by the user?
CQ5	When did a certain call start/end?
CQ6	Who was the callee for a given call?
CQ7	How long did a call last?
CQ8	When was the last call to a certain contact performed?

The ontology requirements induced by the competency questions C1-C3 and related to the PWD's contact list are clearly addressed by the *Person* ontology module that is presented in the context of the My Memories app. The module allows representing people having a family or social relationship with the user, as well as

their biographic information that covers first/last name and living place. A reference picture can be associated to each person and can thus be exploited by the My Chat application when showing the contact list and during a call, as a continuous visual reminder that allows the PWD to identify the person involved in the call.

The additional questions and requirements concerning past calls and related metadata (C4-C8) are addressed by the concepts and properties defined in the *Action*[7] and *Activity*[8] ontology modules part of the MARIO Ontology Network (MON) presented in D5.1. An *Activity* allows representing an *Action* carried out at a certain time (or in a time interval) by at least one *Person* that participates in it. This concept is further specialised in the *Calling* ontology module[9] designed to represent calling actions/activities. In this module, the roles of the participating persons are specialised to identify a *caller* (i.e., the person that initiates the call, typically represented by the PWD) and a *callee* (i.e., the person who is called). This representational structure thus allows recording the calls performed by the PWD using the application, including the callee and the temporal interval associated with the call, so that additional information such as the duration of the call can be derived.

Access to the knowledge base is again provided by the already mentioned functionalities and API made available by the MARIO Knowledge Management System (cf. Section 4 of Deliverable 5.1), which was submitted previously.

4.3 Privacy and Security Aspects

My Chat has two main aspects that require attention from the point of view of security and privacy: the user's contact list and the VoIP data containing the phone conversation. For the first, as the contacts lists is going to be stored locally, data encryption will be done using industry security standards and only the caregiver will be given access to the unique private encryption key. For the latter, eavesdropping phone calls is a risk similar to other technology (gsm, cabled networks, etc.). When possible, secure channels will be adopted (TSL) to place VoIP calls if the provider supports it.

---

[7] http://www.ontologydesignpatterns.org/ont/mario/action.owl
[8] http://www.ontologydesignpatterns.org/ont/mario/activity.owl
[9] http://www.ontologydesignpatterns.org/ont/mario/calling.owl

5. Conclusion

The applications that have been discussed in this deliverable – My Chat and My Memories - do not fully reflect the full capabilities of the MARIO robot, but only a part of it i.e. the ones that are related to the 4-Connect My Social Network Module. An iterative approach is being adopted by the project consortium, where the apps will be improved once we get feedback from the first trials at the pilot sites.

There is great benefit in having MARIO offering such easy-to-use apps to PWD as it will help mitigate the feelings of isolation and loneliness that are often experienced by PWD. The MARIO robot will allow the PWD to easily communicate with family members; at the same time, the app is designed to minimize the intrusion on the family member's lives by controlling when these notifications from MARIO can get through to the family member based on their availability. Additionally, the My Memories app will allow the user to engage in meaningful conversations with MARIO regarding important people and events from their past. This will not only actively engage the PWD, thereby reducing loneliness but will also, through the process of sharing and remembering happy memories, enhance their sense of wellbeing and overall quality of life. wellbeing. help the PWD to share and enjoy happy memories and events, be more confident in interacting with the outside world and feel accepted by their relatives and friends, with MARIO by their side.

References

Libin, A., & Cohen-Mansfield, J. (2004). 'Therapeutic robocat for nursing home residents with dementia: preliminary inquiry.' *American Journal of Alzheimer's Disease and other Dementias*, 19(2):111-116.

Lin, Y.C, Dai, Y.T., & Hwang, S.L. (2003). 'The Effect of Reminiscence on the Elderly Population: A Systematic Review.' *Public Health Nursing*, 20(4):297-306.

McKeown, J., Clarke, A., Repper, J. (2006). 'Life story work in health and social care: systematic literature review.' *Journal of Advanced Nursing,* 55(2):237-247.

Moos, I. & Bjorn, A. (2006) 'Use of the life story in the institutional care of people with dementia: a review of intervention studies.' *Ageing and Society*, 26:31-454.

Moyle, W., Cooke, M., Jones, C., O'Dwyer, S., & Sung, B. (2013). 'Assistive technologies as a means of connecting people with dementia.' *International Psychogeriatrics,* 25:S21-22.

Moyle, W., Jones, C., Cooke, M., O'Dwyer, S., Sung, B., & Drummond, S. (2014). 'Connecting the person with dementia and family: a feasibility study of a telepresence robot.' *BMC Geriatrics*, 14(7):1-11.

Roger, K., Guse, L., Mordoch, E., & Osterreicher, A. (2012). 'Social commitment robots and dementia.' *Canadian Journal on Aging*, 31(1):87-94.

Shibata, T. (2012). 'Therapeutic Seal Robot as Biofeedback Medical Device.' *Proceedings of the IEEE,* 100(8):2527-2538.

Tamura, T., Yonemitsu, S., Oikarwa, D., Kawakami, K., Higashi, Y., & Fujimooto, T. (2004). 'Is an entertainment robot useful in the care of elderly people with severe dementia?' *Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 59(1):83-85.

Wang, J.J. (2007). 'Group reminiscence therapy for cognitive and affective function of demented elderly in Taiwan.' *International Journal of Geriatric Psychiatry,* 22, 1235-1240.

Wada K., & Shibata, T. (2007). 'Living with seal robots- Its sociopsychological and physiological influences on the Elderly at a Care House.' *IEEE Transactions on Robotics*, 23(5):972-980.

Wada, K., Shibata, T., Saito, T., Sakamoto, K., & Tanie, K. (2005). 'Psychological and Social Effects of One Year Robot Assisted Activity on Elderly People at a Health Service Facility for the Aged.' In: *Proceedings of the 2005 IEEE International Conference on Robotics and Automation*, 18-22 April 2005, pp 2785-2790.

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2004). 'Effects of robot-assisted activity for elderly people and nurses at a day service center.' *Proceedings of the IEEE,* 92 (11):1780-1788.

Wang, J.J. (2007). 'Group reminiscence therapy for cognitive and affective function of demented elderly in Taiwan.' *International Journal of Geriatric Psychiatry,* 22: 1235-1240.

Shibata, T. (2012). 'Therapeutic Seal Robot as Biofeedback Medical Device.' *Proceedings of the IEEE*, 100 (8):2527-2538.

Woods, B., Spector, A., Jones, C., Orrell, M., & Davies, S. (2005). 'Reminiscence therapy for dementia.' *Cochrane Database of Systematic Reviews*, 2(2):1-30.

Yamazaki, R., & Nishio, S. (2012). 'Teleoperated Android as an Embodied Communication Medium: A Case Study with demented elderlies in a care facility.' Paper presented at the The 21st IEEE International Symposium on Robot and Human Interactive Communication, Paris, France, September 9-13.

Yamazaki, R., Nishio, S., Ishiguro, H., Nørskov, M., Ishiguro, N., & Balistreri, G. (2014). 'Acceptability of a Teleoperated Android by Senior Citizens in Danish Society.' *International Journal of Social Robotics*, 6(3):429-442.

Appendix 1: Use case scenarios

(a) Use Case Scenario: My Memories App

Maggie is a 75-year-old lady living in a nursing home. Maggie was a school teacher and lived with her husband Matt until he died 4 years ago. Maggie grew up in Castlebar and was one of 10 children. Her sister Anne, the youngest, went off to America and now lives in Boston. Maggie went to Boston once. As a child, she attended the St Loretto's school and her best friend at school was Erin. Maggie got married to Matt in 1952 and they spent their honeymoon in Dublin. As a school teacher, she started her career in the national school in Mayo in 1950. Maggie has three children, Chloe lives in Australia (where Maggie has been once), Mary lives in London, and John lives in Ireland. In particular, John was born in Cork and he always liked to play the fiddle. Maggie had several interests, including gardening, reading, music, card playing and dancing. Maggie began to show sign of dementia around 5 years ago when she began to forget people's names, where she left her keys and became increasingly confused. She was diagnosed as having Alzheimer's. Matt her husband cared for Maggie at home until he died. Maggie was then admitted to the local nursing home a few months ago. Her granddaughters visit her often but Maggie struggles to remember their names or to have any meaningful conversations with them or with her children and care staff, she is becoming more withdrawn, lonely and isolated.

The staff in the nursing home with the help of her children create a life story/history for Maggie and have collected old photos of her family, friends which MARIO has access to. MARIO now engages Maggie by talking to her about her time as a school teacher, when she got married and sharing photos of her wedding day, etc. He knows not to ask questions that are too interrogative and dependent on her memory but instead asks questions which help Maggie to recall and prompt a response for example, "Hi Maggie, tell me about your first day at St Loretto's school, what was it like?", "Maggie, your English teacher was Mrs Crotty and you were very good at English, what was your favourite poem that you learnt?", "Maggie, you got married to Matt in 1952, tell me about your wedding day…what was it like?", "Was your younger sister Anne your bridesmaid?", "Was your honeymoon in Dublin nice?". The staff in the nursing home and Maggie's family soon notice a change in Maggie, she seems more cheerful and engaged and when her children visit she recounts the conversations that she has had with MARIO. Maggie is now less withdrawn and lonely.

(b) Use Case Scenario: My Chat app

Betty is admitted to the long stay residential care unit from her home. She often feels lonely as she misses her family and friends and neighbours. She feels less lonely when MARIO helps her make phone calls or video calls with her relatives and friends. Betty also feels empowered and in control as she is not dependent on the nurses who are so busy. She also tends to forget whom she has contacted and when she has

done this. MARIO is able to remind Betty details on the date, time, and name of the person she contacted. When Betty forgets and tries to contact the same person too often, MARIO reminds her and suggests that she might call someone else or maybe play some music instead. Betty is happy to be reminded as she doesn't want to annoy her friends.