



D3.1 4-Connect Community Module

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Executive Summary

This document describes three specific applications (apps) that are deployed on the MARIO robot as part of the My Community Module. These apps (namely the My Family and Friends app, My Calendar\Events app, and the Remember My News 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 a set 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 community, allowing them to feel a part of the world around them, reducing the sensations of isolation. The My Family and Friends app allows users to stay up to date with what the people they care most about are doing. The My Calendar/Events app can be used to remind users of special events that are happening in their community or even of special life events (birthdays, anniversaries, etc.). Finally, the Remember My News app, as an extension of the News app, will allow the user to be up to date with local news events (such as community sports, church events, etc.). The combination of these apps will ultimately allow MARIO to provide relevant information about the specific people and things that the user cares about, helping them to stay involved in the events happening in the community.

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 have been specially designed and developed to ensure that they are easily accessible and usable by the 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.

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1. Introduction

This document is a short report to accompany the software for the '4-Connect Community Module'.

1.1 Work Package 3 Objectives

This WP investigates how service robots can be used to change perception of loneliness, build resilience, and be a tool for the prevention, mitigation and support the independence of persons with dementia. Beyond the end user individuals, WP3 also aims to provide the necessary foundations that will contribute to a change of attitude in the way that service robots are employed as a means of promoting and maintaining connectedness to the community, reducing isolation and loneliness, and reducing risks related to being alone rather than robots 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 to enable the specifications of what a robot needs to be able to do so as to develop the 4-Connect 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 3.1 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 Family and Friends app
- My Calendar/Events app
- Remember My News 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 can work beneficially, 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 output 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, Chapter 3 presents detailed information about the My Family and Friends application, Chapter 4 presents the My Calendar/Events application and Chapter 5 presents the Remember My News application. Conclusions reached from this deliverable are provided in Chapter 6.

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

2.1 Development process

The principles of the development process of the applications remains the same as those reported in D3.4 4-Connect My Hobbies Module, which can be summarised as follows:

- The applications are individualised.
- The PWD is given choices.
- The system is designed to prompt the person as a way of maintaining memory.
- The technology is designed so that it is simple and intuitive to use.

2.2 Design for a robot

The design of the applications for a robot remains the same as that reported in D3.4 4-Connect My Hobbies Module, which can be summarised as follows:

- Exploit the physical presence of a robot.
- Allow for multimodal interaction and speech recognition.
- Allow for personalisation of the interactions and apps.
- Robot-initiated engagement with the PWD.

2.3 Design for dementia

In designing an application for people with dementia we have to take into account three important aspects: Accessibility, Acceptability, and how to measure the effectiveness of the application.

2.3.1 Accessibility

For the accessibility of applications in terms of the physical and cognitive capabilities of the users we opted to use Web Content Accessibility Guidelines (WCAG) 2.0 as the main guidelines for accessibility issues, since applications design was based on the web as a platform. Given that WCAG 2.0 focusses on web

content and its accessibility through Assistive Technologies (AT) we realise that this is not exactly applicable to MARIO. MARIO enhances the AT and provides a multimodal interface to users rather than a visual one. Therefore, many of the specific techniques and guidelines are obsolete for the user interaction design of MARIO. However, three of the four guiding principles are still applicable. The user interaction and the content presented to users still needs to be perceivable, operable and understandable. However, robustness and compatibility with AT is not as necessary since the UI component is always using a specific browser configuration and no additional AT.

1. Perceivable	
WCAG Guideline	How the guideline was adapted and used in MARIO UI design
1.1 Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language	There was no actual need for providing alternatives since the accompanying auditory interaction is already presenting the necessary information on an alternative form. Moreover, users will not be using MARIO in combination with Assistive devices such as Braille displays etc.
1.2 Provide alternatives for time-based media.	This guideline is only partly applicable. For example, in the case of the music applications where there was no request and no need for alternatives to audio. In other cases (such as playing video), this might be needed. The UI component allows developers to provide alternatives for time-based media when needed. However, the UI is not able to decide and enforce such a requirement on different applications. This responsibility lies with the application developer.
1.3 Create content that can be presented in different ways (for example simpler layout) without losing information or structure	Content presented is controlled from the UI component and apps are not allowed to display content outside the specific templates provided by the UI component. Therefore, there is no need to present information in a different layout. However, whenever this is needed, the UI component is responsible for deciding the alternative way of presentation

	and inclusion of the information that is provided from apps through its API.
1.4 Make it easier for users to see and hear content including separating foreground from background.	Colours for foreground and background were selected after consulting experts and font sizes are controlled and defined by the UI component. This way app developers are limited to providing the information and the UI component makes sure that is presented in a consistent way according to user's needs without breaking the user experience.
2. Operable	
WCAG Guideline	How the guideline was adapted and used in MARIO UI design
2.1 Make all functionality available from a keyboard.	No keyboard is available for MARIO but all functionality is ensured to be accessible either through touch input or through voice interaction as well.
2.2 Provide users enough time to read and use content.	This rule is implemented by the UI component, especially in provided templates that are relevant like the one that displays the content of an article in the My News App. The user has to explicitly select an action to leave a specific article display even if the article is being read aloud by MARIO.
2.3 Do not design content in a way that is known to cause seizures.	Specific movements and interaction effects such as flashing content are excluded from interactions and movement of elements in general is kept to a necessary minimum.
2.4 Provide ways to help users navigate, find content, and determine where they are.	All interaction templates designed provide links to the home page and numbers of elements displayed on specific templates such as showing options to users are predefined in the UI component in order to not overwhelm and confuse users with too many options and to make navigation easier.
3. Understandable	

WCAG Guideline	How the guideline was adapted and used in MARIO UI design
3.1 Make text content readable and understandable.	Text in most interaction templates is kept to minimum and apps are forced through the UI component API to usually use simple short sentences. The general guideline is to keep the text short but as clear as possible.
3.2 Make Web pages appear and operate in predictable ways	This is handled by the UI component which makes sure that similar purpose pages have all the same look and feel and user experience.
3.3 Help users avoid and correct mistakes.	User interactions are designed in ways to minimize the possible errors. However, in the event of an error, MARIO responds accordingly trying to help the user understand what the problem is and respond accordingly.

Table 1. Web Content Accessibility Guidelines and how the guideline was adapted and used in MARIO UI design

Moreover, the draft guidelines and discussions in the Cognitive and Learning Disabilities Accessibility Task Force¹ of the World Wide Web Consortium (W3C) is also being followed for additional guidance especially for designing user interactions for people with cognitive disabilities.

As mentioned previously in D3.4, 4-Connect My Hobbies Module, to further ensure and assess accessibility, we designed early prototypes of the applications and tested them both with experts in the field and with real end users. These user tests involved people with dementia working on the prototypes of applications in laptops where the researcher was simulating the behaviour of the robot responding to vocal and touch commands of the users. Results from these tests influenced the design of the applications and the general interaction rules. For example, special care was taken during the tests to identify if users could read the text on screen and could understand the different interaction elements provided. Changes were made as a result of this process, for example, experts suggested to change the colour of specific icons on the screen to make it more evident that the icons have a specific functionality. Similarly, based on the user tests changes were made for configuring the timing of different prompts to the user. The other challenges related to

¹ <https://www.w3.org/WAI/PF/cognitive-a11y-tf/>

accessibility are similar to those already described in D3.4 (4-Connect My Hobbies Module) and continue to apply in developing the applications of this Module.

2.3.2 Acceptability

The strategies to enhance acceptability remains the same as those reported in D3.4,4-Connect My Hobbies Module, which can be summarised as follows:

- Keep functionality of each app to a bare minimum.
- Allow for the use and reuse of an app without prior knowledge or use.

2.3.3 Measuring Effectiveness

The effectiveness of the My Family and Friends, My Calendar/Events app, and Remember My News app will be judged in three ways. The first is that a qualitative evaluation will be undertaken, asking the PWD how they found their interaction with the apps. By using a simple scale, such as a rating from 1 - 5, and collating the user feedback with observer feedback (how did it seem the PWD enjoyed their time using the app), it will be possible to obtain a tangible value to this qualitative assessment. The second evaluation criteria will be based on the usage of each app. During the supervised trials, the observer will take note of how many times the PWD launches, or asks to launch, each app, and how long the PWD spends interacting with the application. Interest in the app will be determined by the time spent with the app and the desire to use the app, based on the feedback from the PWD user. These responses highlight that the PWD is interested in the app and finds it easy to use. The third method will be based on reviewing any change in rating on a selected number of scales, some of which, but not exclusively limited to, are; the Cornell Scale for Depression in Dementia, the Brief Resilience Scale, and the observational measurement of engagement scale. While the direct impact of each app will be impossible to separate from the other effects, inferences may be drawn from the ratings on these scales about overall impact of this application.

One of the primary objectives for the MARIO project is to reduce loneliness and isolation for people with dementia. It is therefore necessary to assess how each app can help to address these effects. In order to assess the impact of the My Calendar/Events app on reducing loneliness and isolation several specific strategies to be used are outlined below:

1. Observational data will be recorded during each testing session with the PWD by the research assistant. Items to be captured will include if there is

any change in the PWD's mood and activity level. Is there a noticeable changing trend? Also, what type of activities were they doing before/after the interactions (once again, exploring any trends). A number of questionnaires have been identified to capture the impact of MARIO as outlined in the Assessment Methodology in D1.3. These will be tested for use with PWD in terms of appropriateness and usability. In instances where the items on these questionnaires are not appropriate or understood, the reasons for this will be explored and the questionnaires will be modified for use with PWD.

2. Interviews with members of staff at the nursing home (NUIG) and the hospital setting (IRCCS) will be undertaken to capture their perceptions on the impact of MARIO on the PWD. Examples of areas to be explored include whether the staff member perceived a change in the social activity and social engagement level of the PWD; has the PWD a better sense of orientation in time and an increased sense of what is going on in the community, thereby may be more socially connected. In addition, interviews with PWD will be conducted to obtain their views on MARIO and the impact he has had on their lives.
3. Brief telephone interview with primary relatives at the end of each Pilot Phase will be undertaken to ascertain what their impressions are of their relative following the persons interactions with MARIO in terms of their mood, wellbeing, and whether their own interactions with the PWD has changed in any way following MARIO.

3. My Family and Friends App

3.1 Requirements, Vision and Objectives

3.1.1 The Purpose

The purpose of the My Family and Friends App is to enable the person with dementia to stay connected with their family and friends and to keep the person with dementia informed about what is going on in the day to day lives of their family and friends. The aim is to increase the quality of life of the person with dementia by giving them the capacity to engage with the people who are closest to them.

3.1.2 Why this app is important

Research suggests that PWD often experience social isolation (Kane and Cook, 2013). Many PWD, especially those living in residential care settings, become more disconnected from their family and friends (Sung et al., 2015). Focus group interviews with PWD conducted as part of this project revealed that many PWD recognised the potential for MARIO to be able to keep them connected with their close family and friends (Casey et al., 2016). The My Family and Friends app is important because it will provide a simple way to support existing relationships. It endeavours to provide PWD with the ability to remain in touch with family and friends by receiving information from them through Twitter, when they may not have regular face-to-face contact. It will also help to restore the PWD's autonomy and encourage social connectedness. Having a perception of autonomy and control correlates with quality of life, and independence and it may improve functionality for PWD (Mitzner, Chen, et al., 2014). This therefore has the potential to promote the PWD's sense of wellbeing and quality of life.

3.1.3 What the My Family and Friends app will do

The My Family and Friends app will use Twitter to provide the person living with dementia information about the people they care about in a user friendly and simple way. MARIO will ask the PWD if they would like to hear and learn about what their family and friends are doing (in relation to those family members who have a Twitter account). The My Family and Friends app will then read (and display) tweets posted by respective family members to them. The family and friends, with their own twitter account, can use a specific hashtag in order to direct tweets to MARIO (and the

user with dementia). The use case scenario (a) in Appendix 1 shows how the My Family and Friend app will assist the PWD and what is needed for this app to operate.

3.1.4 Anticipated Development

In Phase 1 and Phase 2, the aim is to test the extent in which a PWD can interact with MARIO and make use, inter alia, of the My Family and Friends 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 the PWD will guide the refinement 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 setting up the app to ensure that the profile for the PWD is connected to the social media platforms of family and friends. 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 that the PWD's 'feed' will only display posts that are relevant for the user; thus, the app allows the user to quickly find the information they want.

It will also be possible during these tests to fine-tune which posts appear at the top, or to assign weighted value to different people/social media platforms. 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 Family and Friends app unprompted by the researcher and in an autonomous fashion.

3.2 Application Design

3.2.1 General technical infrastructure

The My Friends and Family app is based on tracking Tweets from specific Twitter accounts that are configured by the researcher and include the Twitter accounts of the friends and family of the user. In addition, the configuration can include a specific hashtag for filtering tweets in order not to overwhelm users with irrelevant (maybe professional related) tweets from their family friends.

The architecture, shown in Figure 1, is based on the service titled Queryfeed which exports the tweets based on searches on RSS feeds. Querying the service on frequent intervals we will track new tweets made by users' friends and family members and import them on a local MongoDB database. This then will allow both online and offline access to the latest tweets made by friends and family which will then be communicated to the user using the UI component.

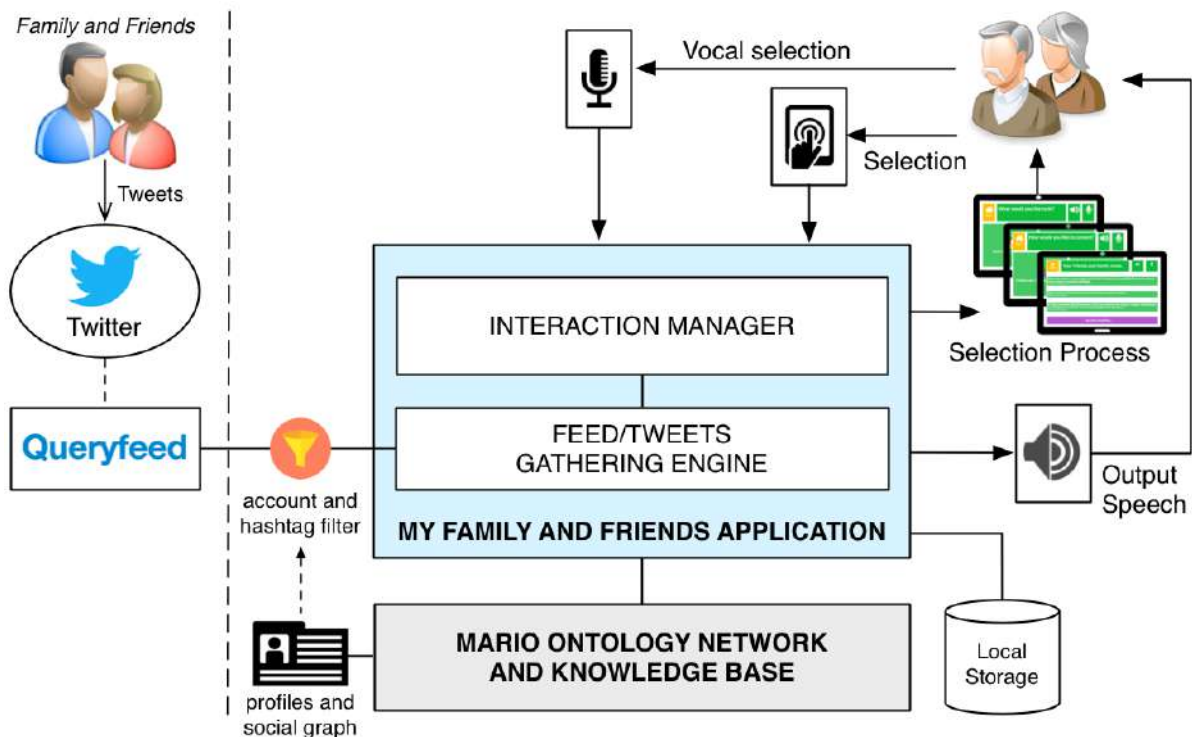


Figure 1: My Friends and Family architectural model

The infrastructure of the My Family and Friends app is quite similar to the implemented infrastructure for the My News app, which is presented in D3.4, 4-Connect My Hobbies Module. However, with the My Family and Friends app the RSS feed sources are now based on tweets; the tweets are converted to an RSS feed source through the Queryfeed service. The same service allows for querying similarly Instagram and Facebook which might be included in later iterations of the app based on feedback from the PWD, their friends and family members.

3.2.2 User Interaction design

Given the general technical architecture description the My Family and Friends app works as a very specialized and limited twitter client only for reading selected tweets of specific people. The traditional Twitter clients would allow users to interact with tweets by retweeting and liking them and in general include a number of additional functionality which is not necessary for the users in our case. The processes for example of finding, adding, and interacting with new followers on Twitter could be very challenging for any user with dementia. Moreover, issues like small letters, font contrast, big lists of irrelevant tweets and ads with infinite scrolling, navigation between profiles etc., pose significant challenges in the interaction of people with dementia. Finally, the existing Twitter clients usually require users to have registered with Twitter and maintain an account. In our case, since Twitter is going to be used only for one-way communication from friends and family to end user, this is not really necessary as the end-users will not need to post any tweets. Therefore, the creation of an account by the PWD is not required.

For all the above reasons, the design of the My Family and Friends app in its initial implementation follows a simplistic approach aiming to help people achieve their goal in the simplest possible way. That is why specific choices are made in the implementation, such as allowing the user to access the tweets in a straightforward way presenting only a limited amount of items at the same time, so that they can easily be distinguished, understood and digested by the user. Moreover, giving control to the user over the infinite scrolling mechanism, read more tweets or exit provides an easy exit point whenever users are bored or fatigued. Finally, one of the biggest benefits of the multimodal interaction through vocal and touch interface allows the user to listen to tweets being read aloud while also presenting them on screen in large font letters so that they are easily read on the screen as well.

The following steps describe how the interaction is designed in its first most simplistic implementation that will gradually evolve as MARIO learns more about the user and as the user learns more about using and working with MARIO.

Step 1: MARIO asks (vocally) the user if he/she wants to read all the news from their family and friends or select a specific person of interest accompanied by a respective screen.

Step 2: If the user selects to read all news MARIO starts reading the three most recent tweets of the all available tweets and waits for the user to either exit or continue on to the next page. If the user selects to continue to the next page the step repeats by reading the next three tweets until step 5.

Step 3: If the user selects to read news from a specific person, a list of the user's family and friends' topics is presented vocally to the user, which is accompanied by a respective screen for the user to choose the specific person to follow.

Step 4: When the user selects a person, MARIO starts reading the three most recent tweets of that person and waits for the user to either exit or continue showing the next page of tweets. If the user selects to continue to the next page the step repeats by reading the next three tweets until step 5.

Step 5: If the list of tweets finishes or the user selects to exit the app the app terminates. If the tweets list reaches its end, then a respective message is presented to the user before exiting.

The User Interaction flow of the first iteration of the application is kept similar to the one used in the My News app described in D3.4 because the two applications resemble each other in terms of functionality. The My News app is for reading general news from newspapers and selected sources and the My Family and Friends app is actually for reading the news provided by the user's family and friends. That is why the interaction flow is kept similar in order to use this similarity to reduce the cognitive load needed for operating two different apps.

Included below in Figure 2 and Figure 3 are screenshots of the My Family and Friends UI.

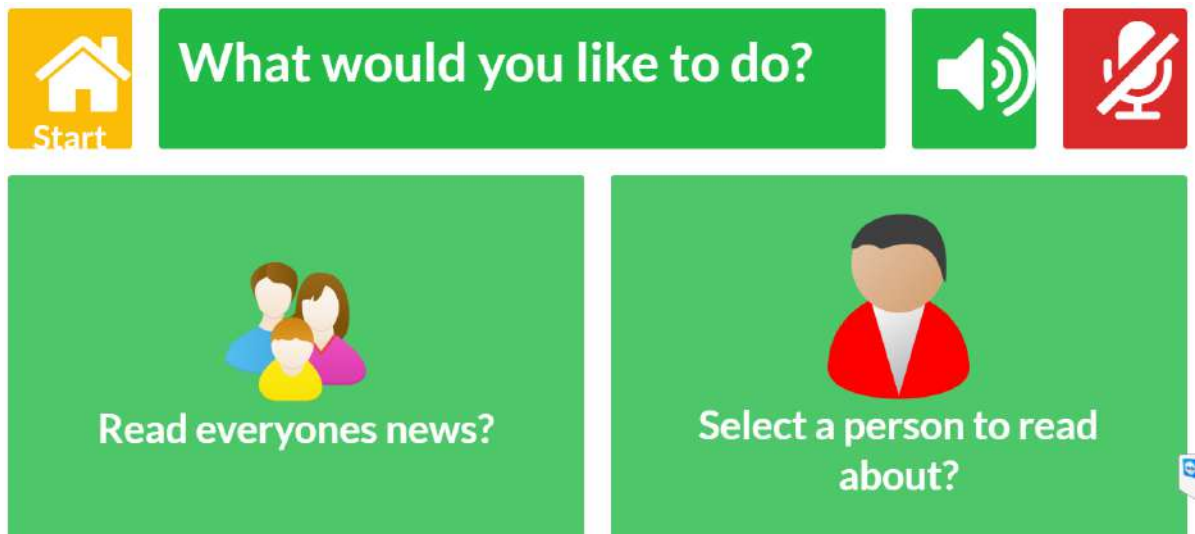


Figure 2: MARIO presents the two options for My Family and Friends app, reading everyone’s news or reading about a specific person.

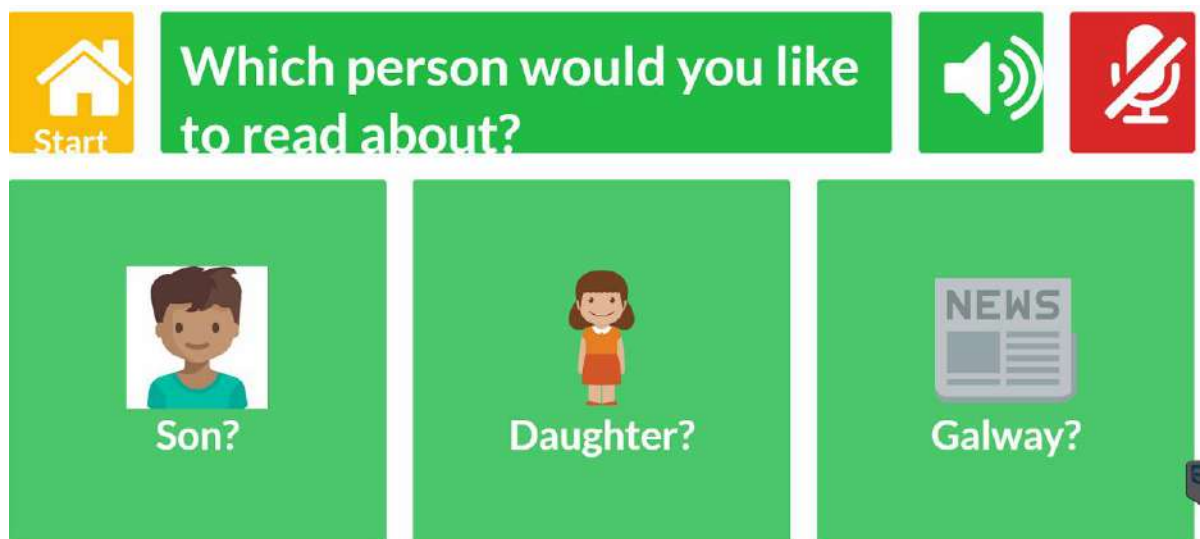


Figure 3: If the user chooses to read about a specific person, the app presents a set of pre-determined options to choose from, each option is accompanied by an icon.

3.2.3 Designing for a robot app

The My Family and Friends application developed for Mario can differentiate from any other Twitter clients in a number of ways. Firstly, by tracking how often the PWD is using the app and when was the last time s/he read something about a specific contact. Secondly by being able to adjust its interface to suggest, based on knowledge of the user, whose news to read about. Moreover, the frequency of Tweets by family and friends can also help in defining such adaptations. If a person

is Tweeting more often over a specific period, then Mario can suggest to the PWD that they select the news input from that specific person more frequently.

Similar to My News application described in D3.4, keeping the person with dementia engaged, requires robot-initiated engagement strategies that take advantage of the robotic platform's capabilities. Mario's ability to recognise user's posture, as well as to autonomously approach the user, enables the robot to actively prompt the user and stimulate his/her interest by proposing a specific person to read about. For example, by recognising that the PWD is in a sitting posture together with a recent lack of user interaction will alert MARIO to prompt the user to engage and for example to suggest accessing his/her grandson's news.

In addition, the semantic capabilities of the underlying software framework can provide an added value for the application compared to existing solutions. Machine reading and semantic parsing of the collected Tweets coupled with information extracted from text classification and/or sentiment analysis such as places, persons, events, positive or negative emotions etc. can help provide more interesting and engaging entry prompts. For example, after tracking a lot of Tweets from the son of a PWD who is visiting Spain and tweets about the wonderful time he is having there, could prompt the PWD to read about their son with a prompt such as "Your son seems to be having a great time in in Spain these days. Do you want to read/hear about what he's up to?"

3.2.4 Integration of knowledge base

In line with the overall ontology design approach outlined in Deliverable 5.1, Mario Ontology Network, the ontology modules presented in this document and part of the MARIO Ontology Network (MON) 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 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, as reported for each application. User stories and reference scenarios were then used to identify the set of Competency Questions (CQs) that the ontology is expected to address.

As it emerges from the use case scenario (a) outlined in Appendix 1 and the collected requirements, the My Family and Friends application relies on the possibility of setting up and retrieving a list of relevant people who have a social/family relationship with the PWD (friends and family members) and who have an online account for the Twitter social networking service. For each family or friend

who will provide their account, basic biographic information will be provided, such as first and last name, along with the social/family relationship with respect to the PWD and a reference picture. For the purposes of the application, a Twitter account is fully characterised by the username (e.g., Mario_Kompai is the account name of the MARIO project) and can be optionally associated to hashtags that will be used as filters for the tweets produced by the account. Based on the use case defined in Appendix 1 (a), below are some of the main competency questions that were defined.

Competency Questions	
CQ1	Who has a family (husband/wife, children, siblings, etc.) or social relationship with the PWD (e.g., friends) and has a Twitter account?
CQ2	What are the basic biographic information of these family members and friends?
CQ3	Is there a reference picture associated with the identified family member or friend?
CQ4	What is the Twitter account name for the identified family member or friend?
CQ5	What hashtags should be used for filtering the tweets written by an account?

The ontology requirements needed to address the competency questions C1-C3 and related to PWD's family members and friends are fully addressed by the *Person* ontology module¹ presented in detail in Deliverable 3.3 in the context of the My Memories app. The module is able to represent the people who have a family or social relationship with the PWD, as well as their biographic information that covers first and last names. A reference picture can be associated with each person and can thus be exploited by the My Family and Friends application when showing and reading the corresponding tweets, as a visual reminder and prompt that allows the PWD to identify the person who produced the tweet.

The additional questions and requirements concerning Twitter accounts and related properties are addressed by the concepts and properties defined in the *Online Account* ontology module², which allows a person to be related with his/her online accounts.

¹ <http://www.ontologydesignpatterns.org/ont/mario/person.owl>

² <http://www.ontologydesignpatterns.org/ont/mario/onlineAccount.owl>

An *OnlineAccount* generically represents the provision of some form of online service by some party to some *Person*, and is characterised by an *accountName* property intended as a textual representation of the unique account name associated with the account. The *OnlineAccount* class is specialised to explicitly model Twitter accounts, where the *accountName* is used for the Twitter username and an additional specific property is defined for representing hashtags to be used as filters for the gathered tweets coming from the account.

Access to the knowledge base is enabled by 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 via an HTTP-based REST layer.

3.3 Privacy and Security Aspects

As explained in the general technical infrastructure of the app, although the app is using Twitter, we are not creating or maintaining any account for the PWD on Twitter. So there are no additional privacy concerns in terms of using social media. Twitter is merely used as any other news information source and friends and family of the PWD will be informed of the use that will happen to their tweets so that they can control the information that is being delivered through MARIO and can only explicitly share specific information. Friends and family members participating in this flow will have to have a Twitter account of their own but there will be no obligation for them to create one if they don't want or have one. Accepting the privacy terms of Twitter is up to them and if they already maintain a Twitter account then this acceptance is not related with the project per se but with their choices even before the project started. They will be notified that accepting the privacy and terms of usage of Twitter is merely up to them.

4. My Calendar/Events App

4.1 Requirements, Vision and Objectives

4.1.1 The Purpose

The purpose of the My Calendar/Events app is to improve the temporal orientation of the PWD. It will facilitate prompting and planning of activities and events in which the PWD has an interest in.

4.1.2 Why this app is important

Progressive memory loss and reduced temporal orientation are characteristic features of dementia (Moyle et al., 2013). This challenges the ability of the PWD to recognise time of the day, day of the week or the date. It also reduces their capacity to remember important dates such as birthdays, anniversaries or events that they would like to attend. This is a barrier to the PWD being active participants in society. These were confirmed as problems in the interviews undertaken to date in the project and were identified as areas where help was required (Casey et al., 2016). For example, in these interviews the PWD expressed that at the start of the day they would like MARIO to tell them the time, day of the week, date, and year and a list of the activities/events planned for that day. In addition to the personal burden that reduced orientation to time creates, it also places a strain on the individuals surrounding the PWD. For example, in residential care settings, the person with dementia may ask the staff 'is it time for lunch yet?' on repeated occasions. In this context, MARIO will be able to tell the PWD the time of lunch or if they have already had lunch, based around a calendar of their typical day. It has also been shown that prompting can potentially improve social connection by supporting a PWD in their basic activities of daily living (Thomas & Marsiske, 2014). Therefore, the My Calendar/Events app will prompt the PWD ahead of a scheduled event.

4.1.3 What the My Calendar/Events app will do

Through discussion with the PWD, their family and the relevant staff, the researcher will define a set of events for the PWD on the Calendar and input these. The My Calendar/Events app will remind the person of what appointments they have and items that they have planned to do. The My Calendar/Events app will contain important calendar events (e.g. Christmas, Easter). The calendar will also provide

the opportunity to count down towards these major calendar events in the immediate lead up to the event (e.g. 7 days until Christmas Day). It will also include birthdays of the resident and their loved ones, wedding anniversaries and other dates of significance to the individual. The calendar will link with weekly events of the person (e.g. some people may get their hair done every Thursday or go to their daughter's home every Saturday) and MARIO will remind the PWD of these events. The PWD will be able to see their events for today or upcoming events as well as switch on or off an alarm for each event, which will act as a prompting technique. When the event is nearing, notification occurs and MARIO (regardless of what it was doing) shows the notification to the PWD. The My Calendar/Events app will also help the PWD to note an event on their calendar that they would like to attend/participate in. The use case scenario (b) in Appendix 1 provides an example of how the My Calendar\Events app will assist the PWD.

4.1.4 Anticipated Development

The aim is to test the extent in which a PWD can interact with MARIO and make use of the My Calendar\Events 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 the 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 information has been added to the My Calendar\Events app. This will include adding in all necessary information with regards to important life events, and key events of interest; for example, birthdays, anniversaries, sporting events, local competitions, etc. 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 My Calendar\Events app will correctly display the appropriate events that are in the immediate future, the events that are specific to each user, and that the app can update properly as the date changes (manually changing the computer date to see how it reacts). The first 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 he/she 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 Calendar\Events app unprompted by the researcher and in an autonomous fashion. Additionally, there is the possibility that the My Calendar\Events app can always be

operational in the background, and will prompt the user at each start up screen about the events on that day or that are upcoming in the immediate future.

4.2 Application Design

4.2.1 General technical infrastructure

The My Calendar\Events app is composed of two components: a web and a robot app. Each one has its own UI and backend, although they both share the same calendar and event data, stored in a MongoDB database. The web app is designed to be accessed through a laptop or a tablet by the caregivers, for them to input the calendar and event data of those that they care for, and it is the one that stores those data in the database. The robot app handles all of the interaction with the PWD. It is the one that accesses the calendar and event information provided previously by the caregiver and either presents them to the PWD upon their request or uses them to schedule notifications.

The My Calendar\Events application is designed to be invoked (executed) on user demand either via vocal commands (via speech-to-text) or by the *graphical user interface* (GUI) on the MARIO screen, or on its own, when it is time to notify/remind the PWD of an event that he/she or a caregiver marked as a worthy reminder.

4.2.2 User Interaction design

As already explained in the general technical infrastructure, the app can be triggered by the PWD selecting it from the available apps on the home screen or it can be self-triggered when the time approaches for one of the important events. In usual calendar applications, users can observe events in a calendar by displaying a weekly, daily, monthly or annual calendar and selecting to get more information or change the properties of an event. In the case of the MARIO project, the calendar application does not need to provide all of this functionality to the PWD (at least for its initial introduction to the PWD). Therefore, given that the configuration will be provided by the researcher, the PWD can then get updates on what events are coming up and get notified when their time approaches.

Therefore, the User Interaction includes two different flows. The first is used when the PWD triggers the app to check for upcoming events. Secondly, the app may be self-triggered because of an approaching event. In the first case the steps followed are the following:

Step 1: When the user triggers the app MARIO asks (vocally) the user if he/she wants to see today's events or the upcoming events for the following month.

Step 2: In both cases, the user is presented with a list of the 3 nearest upcoming events and the app waits for the user to either exit or continue on to the next page. If the user selects to continue to the next page the step repeats by reading the next upcoming events until step 3.

Step 3: If the list of events finishes or the user selects to exit the app the app terminates. If the events list reaches to its end a respective message is presented to the user before returning to the initial screen.

The second interaction flow, when the app is self-triggered, is much simpler. In this case, given that the notification might pop up at any time, we opted for a short interaction that temporarily interrupts MARIO's activity at that time and then returns back to it. To achieve this short interruption without disorientating the PWD, we utilized the concept of a modal window. The modal window dims the current screen and pops up on top of it with a short message to notify the PWD of the upcoming event. To make sure the PWD received the notification, there will be an OK button on such modals in order to prompt the PWD to respond with a confirmation that they have read the message. The PWD can also reply vocally to that request to make the modal disappear and then return to the previous interrupted action. This flow allows for displaying such notification either when the PWD is using another app or when MARIO is idle. In both cases, the notification will be displayed and MARIO will return to its previous state.

Figure 2 and Figure 3 are screenshots of the My Calendar\Events app UI.

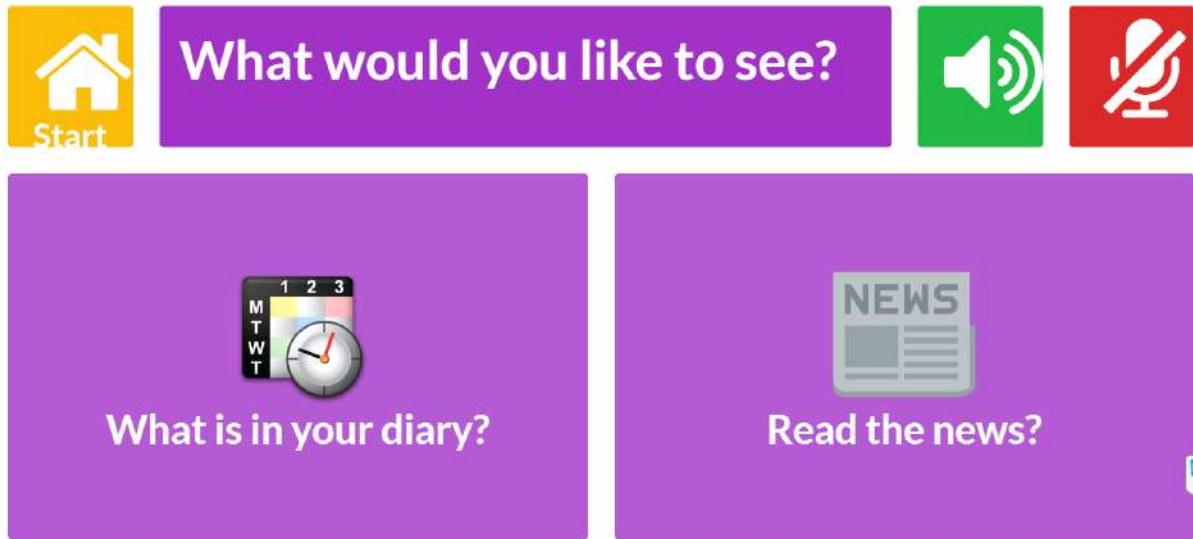


Figure 4: An example of the options presented to the user as part of the social apps. The My Calendar\Events app is described as checking the user’s diary, with an image of a calendar to further quantify the app.

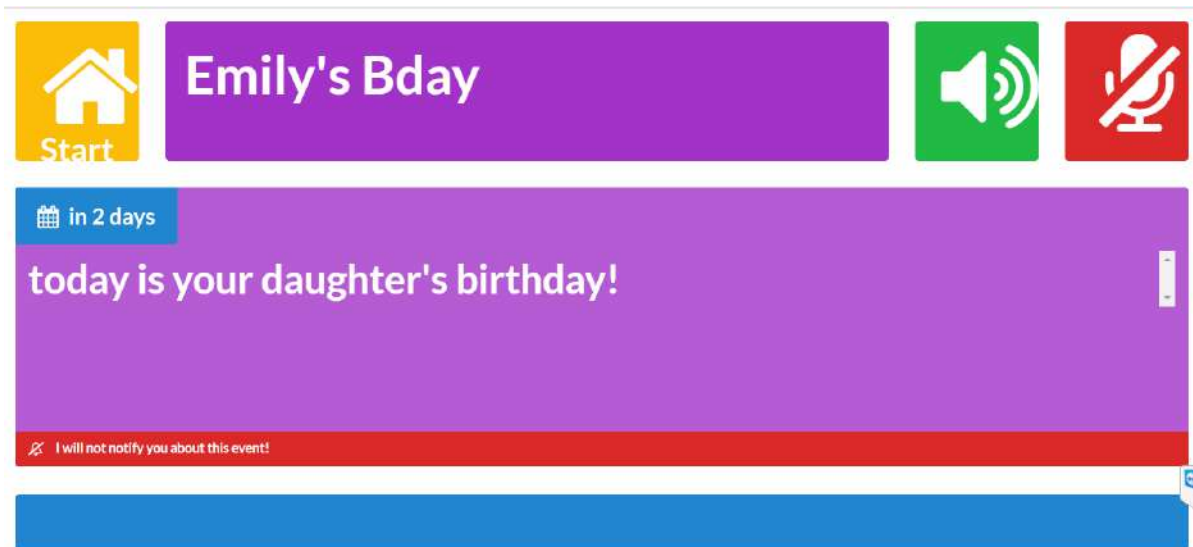


Figure 5: An example of the details of an event that can be entered into the calendar app.

4.2.3 Designing for a robot app

The part of the My Calendar\Events application that runs on the robot is separated into two components: the back-end (description of which follows) and the front-end (described above in Section 4.2.2). The back-end uses Node.JS and creates a topic in Marvin (underlying task manager) called “calendar”, where it posts messages (responses/requests). Furthermore, it subscribes to the task manager and UI components Marvin topics, as they subscribe to the calendar app’s one. This is how

the communication of the app with the other software components/resources of the robot will be achieved. The *task manager* and the UI will be responsible for delegating requests/commands through Marvin to the application, and the application will respond appropriately in its own topic (“calendar”). The main requests are to delegate to the UI, the current PWD’s upcoming events of the next month and his/her schedule for the rest of the day, which the My Calendar\Events app will answer by querying the database appropriately. The opposite flow is followed when it is time for a notification about an event to pop up. All messaging follows the publisher-subscriber pattern. Usually the application sits idle while waiting for messages which activate it, except when a notification is triggered by the several Cron (time-based job scheduler) jobs, scheduled for each event, depending on the notification preferences set by the researcher on event creation.

4.2.4 Integration of knowledge base

While calendar and event data are stored in a database supporting the My Calendar\Events application logic, a semantic representation of calendar data enables the definition of semantically enriched events with additional contextual information. On one side, existing ontologies such as the Networked Environment for Personal Ontology-based Management of Unified Knowledge (NEPOMUK) Calendar Ontology (NCAL)¹ and the Resource Description Framework (RDF) Calendar ontology (RDFCal)² are used as a basis for the definition of calendar events, as they provide vocabularies for describing calendaring data. Typical event properties include start/end dates and time, event descriptions or summaries, recurrence rules (e.g., for scheduling weekly events) and notification/alert settings. In particular, the RDFCal ontology allows retaining compatibility with the Internet Calendaring and Scheduling Core Object Specification (iCalendar)³ standard and open format.

On the other side, from the use case scenario outlined in Appendix 1 (b), the need to enrich the calendar event specifications by explicitly linking them to relevant people having a family or social relationship with the PWD, and to important life events (e.g., a calendar event representing the anniversary of PWD's marriage) becomes apparent. Based on the use case scenario outlined in Appendix 1 (b), below are some of the main competency questions that were defined.

¹ <http://www.semanticdesktop.org/ontologies/2007/04/02/ncal/>

² <https://www.w3.org/TR/rdfcal/>

³ <https://tools.ietf.org/html/rfc5545>

Competency Questions	
CQ1	Who participates or is involved in a calendar event?
CQ2	Which family/social relationships exist between an event participant and the PWD?
CQ3	What life events are related to a calendar event?

As presented in detail in Deliverable 3.3 4-Connect My Social Network Module, in the context of the My Memories application, the *Person* and *Life Events* ontology modules were designed to enable the representation of basic biographic information about persons, their social/family relationships, and life events. These concepts can thus be linked to calendar events, so that people, places and life events can be used as "advanced tags" for calendar events. This will link, for example, a calendar event representing the visit of a family member with the corresponding person profile (e.g., PWD's daughter). These connections will give access to the different properties/relationships defined for the specific person (biographic info, relationship with the PWD, pictures/photos) that can be used by the My Calendar\Events application. As described in the context of the My Memories application (cf. D3.3), these semantic links can also be exploited as triggers for the reminiscence process. Similarly, a calendar event representing a PWD's wedding anniversary can be linked with the life event representing a PWD's marriage, from which additional details can be accessed, such as a PWD's partner, pictures and where the wedding took place.

Access to the knowledge base is again provided by the already mentioned functionalities and API made available by the *MARIO Knowledge Management System*.

4.3 Privacy and Security Aspects

The privacy and security concerns that this app could introduce, are addressed by storing the calendar/event data of the PWD locally on the robot. Access to this information can only be obtained with the correct username and password combination. Thus, caregivers alone would have access to this information through the robot after they log in with this username and password combination. Data, in compliance to industry standards, are encrypted.

5. Remember My News App

5.1 Requirements, Vision and Objectives

5.1.1 The Purpose

The purpose of the Remember My News app is to provide the PWD with an opportunity to read or listen to local news sources. This will be a sister app to the News Update App described in D3.4 4-Connect My Hobbies Module, delivered in Month 17. Remember My News will build on the functions of the News Update App by allowing the person with dementia to remain connected to local events that are occurring within the person's community, rather than exclusively regional or national news. As such, this app aims to facilitate social connectedness and reduce feelings of isolation and loneliness.

5.1.2 Why this app is important

People with dementia often suffer from social isolation (a lack of physical contact with social networks) and emotional isolation (feelings of lack of companionship). Many people with dementia tend to withdraw from society, as they cease attending local events and actively engaging with their communities (Tamura et al., 2004). The literature demonstrates that these feelings of isolation and loneliness have a negative impact on mental and physical health and are risk factors for many chronic conditions including depression, anxiety, stress and cardiovascular disease. The Remember My News app will serve as a motivation and encouragement to allow people with dementia to remain in touch with society, through accessing local and community based news feeds. This app will allow the PWD to choose news items which are of interest to them as an individual, thus enhancing and maintaining their individuality and personal taste and increasing their level of engagement with the app.

5.1.3 What the Remember My News app will do

The Remember My News App will allow the PWD to select local news about the community in which the person currently lives and/or grew up in. This will include both news relating to upcoming community events and reports on activities that have recently taken place. This app will provide information about local sporting events (e.g. results of a football match), parish activities (e.g. special masses),

farming events (e.g. local agricultural shows), local cultural or entertainment events, among others. The PWD will have the option of either reading the news from the screen or receiving a verbal report of the news from MARIO. In addition to this app providing information to the person with dementia, this app will be able to link with YouTube clips, if available, associated with the event. For example, following a local traditional music festival, not only can the information about this be selected but some of the YouTube clips of music by local musicians could be made available for the person to listen to. MARIO will be able to select the appropriate news, update the person, engage in a simple conversation about the news item, and then check the person's interest and enjoyment. Furthermore, the person with dementia will be able to ask MARIO to save a piece of news that they find interesting so they can refer back to it again and remind themselves about it at a later time, e.g. if they want to talk with their family or friends about it in the future. Therefore, this app will also contain news articles that the people with dementia liked and want to keep for future reference.

5.1.4 Anticipated Development

The aim is to test the extent in which a PWD can interact with MARIO and make use of the Remember My News app, take note of any difficulties the PWD encounters, and use this as feedback to develop solutions for future interactions. The feedback from the 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 information has been added to the Remember My News app. This will include adding in all necessary information of events occurring in the place that the PWD lived and has past ties to, and finding the appropriate newspapers and news sites that contain all the important local information that the PWD may be interested in. The researcher will then be tasked with ensuring that the app is functioning correctly for each PWD prior to being tested in a scenario. These tests include ensuring that the PWD's Remember My News app will properly display the appropriate news articles that are only related to key areas from the PWD's life. The first 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 Remember My News app unprompted by the researcher and in an autonomous fashion.

5.2 Application Design

5.2.1 General technical infrastructure

The functionality described above will be implemented as an extension to the already implemented My News app. Thus, the application infrastructure is exactly the same as the one described in D3.4 4-Connect My Hobbies Module, delivered in Month 17.

The only addition in terms of technical infrastructure, required to offer the above extra functionalities, is providing the extra feature of storing a news item as a favourite. This requires adding the “add to favourites” choice in the UI and an extra boolean column in the news collection of the MongoDB to indicate whether the item document is marked as favourite. The remaining goals of the Remember My News App can be achieved by identifying appropriate RSS feed sources for the topics related to the person’s own community.

The Remember My News application is designed to be invoked (executed) either via vocal commands (via speech-to-text) or by the *graphical user interface* (GUI) on the MARIO screen. The *task manager* and *Marvin* are responsible for delegating the requests/commands to the application. This is shown in Figure 6, where the applications sit within the ecosystem. All messaging will follow the publisher-subscriber pattern, and thus the application will sit idle waiting for messages which activate it.

The activation of the application will be either parametrised (e.g., the user must specify a keyword) or it will be non-parametrised and generic (e.g., request for “news” will use previous keywords or a list of user’s interests). For version alpha (0.1.0) we will implement the parametrised version only, whereas the beta version (0.2.0) will include history of searches and a user profile, so that the application can *infer* which news may interest a particular user.

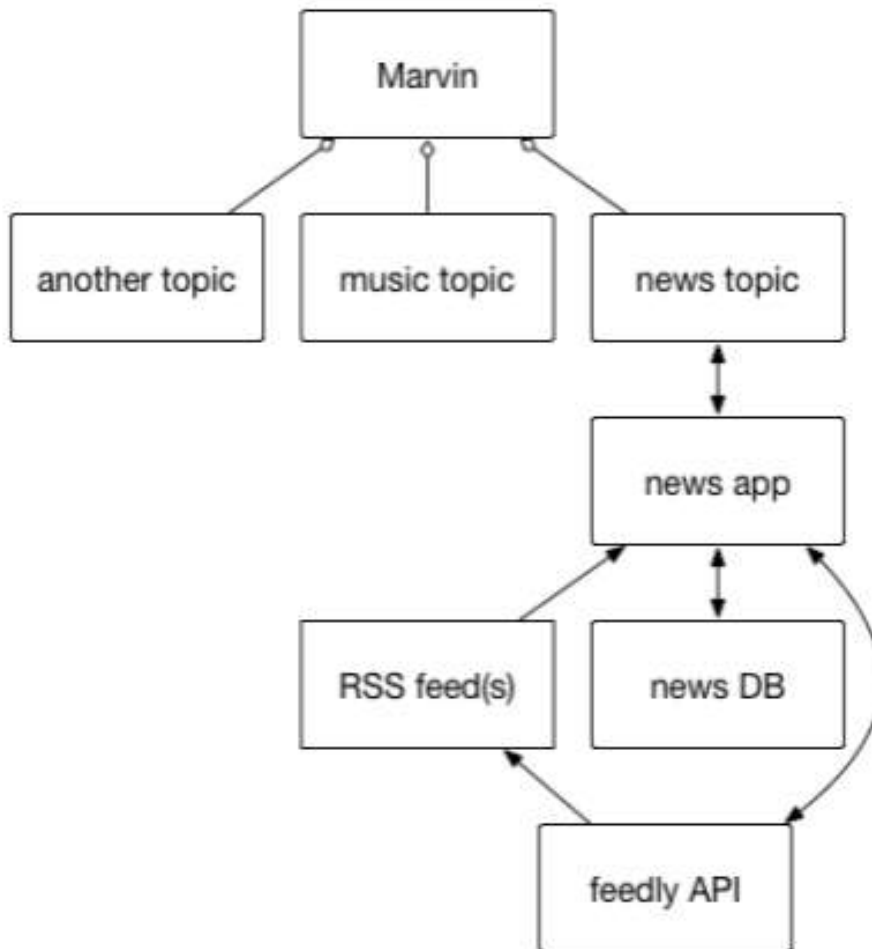


Figure 6: Block diagram depicting how the news app, the database, and the task manager interact.

5.2.2 User Interaction design

Since, as noted, this is an extension of the functionality provided in the My News app described in D3.4, the user interaction of the initial My News app was slightly adapted to facilitate the new functionality requested by end-users. In particular, there are two major changes requested in the app in this version. The first one concerns the configuration that needs to be able to include RSS feeds from local sources. This will be mainly undertaken by the researcher and so will not require a major change in the interface apart from including the option of local sources in the available news topics. The second one is the ability to note down interesting news items in order to refer to them at a later stage. To facilitate this requirement, when the PWD is reading an article from the news items we will add an icon on the screen that allows him/her to record this article and keep it in a specific list of noted articles.

This means that after Step 4 of the initial News app description in D3.4 there is an additional option. The existing Step 4 was:

“Step 4: When the user selects a topic, MARIO starts reading the first four headlines of the available news titles for that topic and waits for the user to either exit or continue on next page of news. If the user selects to continue to the next page the step repeats by reading the next four headlines until step 5.”

We now have an option for the PWD to enter in a news headline and read more about the specific headline. At that point the PWD can either vocally, or by touching the screen, select to note down this article for future reference.

Similarly, an addition was made in the first step of the My News app. Instead of:

Step 1: MARIO asks (vocally) the user if he/she wants to read all available news or select a specific topic of interest accompanied by a respective screen.

It now asks the user if he/she would like to read all headlines, select a topic (which then includes the option of local news) or read the already saved articles.

In the initial iteration the additional functionality will be implemented within the existing My News app. However, the ability to read the saved articles might in the future be separated as a different app selection. Similarly, based on the feedback from initial acceptability tests, we are considering adapting the flow of the news and other apps to simplify even more the process and make it even easier for users to reach their final goals (e.g. listen to music, read news etc.)

5.2.3 Designing for a robot app

The Remember My News application retrieves RSS feeds using the Feedly API, which provides a JSON reply of crawled RSS URLs containing RSS news feeds, relevant to the keyword query. The search is further parametrised by locale, and thus the news is targeting RSS news which are specific to a country/region or language, or even to the PWD's community. The news app parses all RSS news acquired by the Feedly API response, and extracts the title, content, author, URI, and timestamp of each news feed (albeit not all fields may be set). Once the news feeds are acquired, they are stored in a MongoDB database, local to the MARIO robot, and indexed by a unique id. Thus, they can be retrieved multiple times, and indexed.

The backend uses Node.JS and creates a topic called “news”, on the Marvin eventbus mechanism, where it posts messages (responses/requests). Furthermore,

it subscribes to the task manager and UI components' Marvin topics, as they subscribe to the news app's topic. In this way, the communication of the app with the other software components/resources of the robot will be achieved. Once a request is received (either vocally or via the GUI) the *task manager* and the UI are responsible for delegating requests/commands through Marvin to the application, and the application will respond appropriately in its own topic ("news"). In order to respond to requests for news articles it queries the online Feedly API, as well as its MongoDB database for the relevant articles. Filtering can be done by most recent news and limit number of news. The returned text will then be spoken to the user (using text-to-speech) in order to provide an interactive session.

5.2.4 Integration of knowledge base

As described in the previous sections, news items managed by the Remember My News application are dynamically retrieved (when access to the Internet is available) and locally stored to enable offline access. The main contribution and added value coming from the MARIO Knowledge Base are thus not strictly related to the representation and temporary storage of news items, but rather comes from the ability to provide user-specific knowledge about the PWD's interests to be used to retrieve relevant items from local news sources. Based on the use case scenario outlined in Appendix 1 (c), below are some of the main competency questions that were defined.

Competency Questions	
CQ1	Where did the PWD grow up?
CQ2	Where does she/he live now?
CQ3	What are/were the PWD's interests and hobbies?

The user profile and life history set up on the basis of the Person and Life Events ontology modules, detailed in D3.3 4-Connect My Social Network Module, are a valuable source of information in the process of retrieving personalised news items. Properties covered by these ontology modules, such as the PWD's birth place, home town and current living place, as well as his/her hobbies and interests, can be used by the researcher as filters for the news feeds. A PWD may be particularly interested in news items and events related to his/her hometown. Similarly, he/she may favour news items whose topics match with his/her current or past hobbies and interests. By querying the knowledge base using the API made available by the

Mario Knowledge Management System, the application will have access to these knowledge elements and properties as part of user's profile data.

5.3 Privacy and Security Aspects

Minimal privacy and security concerns exist when using the *news* app: data is stored locally, communication with the *feedly API* is encrypted via industry SSL/TLS standards, and no personal information is acquired, retained or distributed. All queries to the system are anonymous (version 0.1.0) and later in beta (version 0.2.0) will be identified by a simple UID, in order to index keywords of interest. No information, data or otherwise personal identifiers are distributed.

6. Conclusion

The applications that have been discussed in this deliverable – My Family and Friends, My Calendar\Events and Remember My News - 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 Community Module. An iterative approach has been 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 user to have easy access to photos, news events, and reminders of the people and the community they care about. They will be able to keep up to date with where their family has gone on holiday, the result of the latest sporting event from their old neighbourhood, and be reminded of any special events that might be coming up. The combination of these apps will allow a PWD to find out about what is happening in their area, what activities their family has planned, save this information into their calendar, and MARIO will help remind them of these future events as they approach. This will help people with dementia be more confident in interacting with the outside world and feel accepted by their relatives and friends, with MARIO by their side.

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Appendix 1: Use case scenarios

(a) Use Case Scenario 1: My Family and Friends app

Betty lives in a residential long stay care unit. She often finds it difficult to stay connected to her family and friends. However, with the help of the staff at the nursing care unit and her family, they have used the My Family and Friends app on her MARIO companion to facilitate viewing tweets from Betty's inner circle. Betty can now easily stay up to date on what her friends and family are posting through one simple app, without having to log in to twitter or search across the web.

(b) Use Case Scenario 2: My Calendar\Events app

Betty lives in a residential long stay care unit. She often finds it difficult to remember appointments (e.g. physiotherapy clinic visits); or when family members are coming to visit. However, MARIO her companion has made remembering easier for Betty as he prompts and alerts her at the start of each day regarding all appointments and planned events. In addition, it provides notification near the time of the event to again act as a prompt.

(c) Use Case Scenario: Remember My News app

Betty is admitted to the long stay residential care unit from her home. She often feels lonely and she misses hearing about her county football, hurling and rugby teams as well as parish events. She feels less lonely when MARIO reads out the local parish newsletter and also shows her highlights of key national football, hurling and rugby team matches. MARIO is able to tell Betty how well her favorites are performing.