D7.1 First MARIO System: Achieved Functionality

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Executive Summary

This report details the outcome of the first MARIO integration task, T7.1. It provides a record of the MARIO system and its available functionality into the start of the Phase 1 Pilot trials. It also provides a baseline statement against which further incremental updates can be made.

This report provides a statement of the delivered status of the MARIO system at the start of the Phase 1 Pilots. It is essentially an updated an update statement on D1.1 (“MARIO System Specification for Pilot 1”) and is best understood when read alongside D1.1. It represents not only the culmination of the current efforts within T7.1, the first pilot integration task, but also the outputs of the technical work packages WP4, WP5 & WP6 which fed the integration.

The Phase 1 Pilot MARIO systems have a range of functionality aimed at providing assistance to the user and entertaining the user. These will enable evaluations to be conducted that will assist the definition of functional improvements that will be made for the further pilot trials.

The unexpected withdrawal of Robosoft from the project have presented some difficulties to the final integration tasks which are currently being evaluated and assessed. An update to this document is proposed after the withdrawal process is completed and its implications fully assessed.

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1. Introduction

This interim report details the outcome of the integration work carried out within WP7.1 and the resulting MARIO system that has been delivered to the Phase 1 trials at each of the three pilot sites. The report is being issued in an interim stage due to the recent withdrawal of Robosoft, who are the manufacturers of the MARIO robot hardware, from the project. Until the details of the withdrawal are finalised it is not possible to detail the final configuration and capabilities of the MARIO robot that will be used throughout the Phase 1 trials. Nevertheless, this report details the position at the start of the trials and will be subject to an update once the final Phase 1 trials configuration has been determined.

The key outcome of the work leading to the functionality described in this report is a MARIO robot system that will be used to assess how well People With Dementia (PWD) can interact with, and benefit from, robot delivered support functions. The trials will also be used to assess any changes needed in the MARIO functionality in order to improve the assistance that can be provided to PWD.

1.1. Work Package 7 Objectives

The main objectives of Task 7.1 that are covered by this report were as follows:

- The maintenance and updating of inter-organisation interface specifications established in WP1
- The on-going step-wise integration of software modules developed in WP4, WP5 and WP6 to test achieved functionality while supporting an iterative development approach
- The final integration of software and hardware modules on the first prototype systems
- Full system testing
- Roll-out of integrated systems
- Production of operations manuals for the pilot sites.

This report focuses primarily on the output of the tasks to meet the above objectives, although the penultimate section summarises some of the processes involved.

1.2. Purpose and Target Group of the Deliverable

The purpose of this deliverable is to identify the functional state of the robots being used in the Phase 1 trials and to form a baseline against which further functional improvements can be made. The target groups for this deliverable are:

- The pilot site staff: so that they may understand the functionality available within the Phase 1 trial
- The MARIO system developers: so they have a record of the functionality delivered into the Phase 1 trials against which iterative improvements can be made

- The wider community: so that they can see the capabilities of the MARIO system being trialled

1.3. Relations to other Activities in the Project

As stated above, this report documents work integrating the outputs of WP4, WP5 and WP6. The documented work primarily feeds the Phase 1 trials of WP8 although it also inputs to the follow on iterative development work in the later stages of WP7 (Tasks 7.2 and 7.3.

The baseline document for this report is D1.1, the MARIO system specification document for Pilot 1. D1.1 details the intended system for the Phase 1 trials as conceived at the end of the requirements definition work. In contrast, this report details the delivered system based upon changes resulting from a combination of factors but primarily those of achievable results given the resources and the actual difficulty of the task, some improvements to the manner in which functionality was achieved and some changes in the requirements following early trialling with PWD.

1.4. Document Outline

The following two sections of the report provide a description of the system hardware and system software architecture developed for the Phase 1 trials, particularly noting differences from those detailed in D1.1. Section 4 provides a review of the major functionality available within the MARIO system and is the primary description of what is being delivered into the trials. Section 5 gives an overview of the processes used during Task 7.1 to achieve the integration. Finally there is a conclusions section providing a summary of the overall activity to date.

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. System Hardware

This section summarises the status of the major hardware components delivered to support the Phase 1 Pilots.

2.1. Major hardware components

The primary system hardware identified in D1.1 was:

- The robot
- A charging station
- A health monitor per person
- Long range RFID (for recognising objects important to the user)
- Short range RFID (for identifying the user)

The status of the delivered hardware is as follows:

Item	Status
Robot	The production of robots is complete with 11 robots manufactured by Robosoft (reduced from 12 as previously agreed with the Commission). At least one robot has been delivered to each site together with other robots delivered to development and testing sites. This fulfils the needs of the Phase 1 Pilots. The remaining 3 robots will be required for the later phases. The major hardware change from the system specification is the removal of the anti-collision laser. The functionality provided by this laser was to be replaced by the Kinect sensor, although to date the work has not been completed by Robosoft. It is hoped that this can still be completed but, if not, the fall back for Phase 1 pilots is to carefully control the environment in which MARIO is operating. Note that this is not a safety related function as the other collision detection sensors will still work with any object that has a floor level presence, such as people. The potential problem is with objects that do not have an obvious ground projection (e.g. the centre of a long table). The immediate work-round is to prepare the environments in which MARIO will be operating. Other less significant hardware changes to the robot have been the removal of the ipad support dock and the basket. These have been removed as they are no longer seen as necessary to the robot's support function and indeed the basket could have presented a safety risk if PWD tried to use that to help them stand.
Charging Stations	The charging stations (which allow the robots to auto-dock to recharge) have been built but not delivered. It is hoped that they will be delivered in time for a proportion of the trials. However, up to that point the robot automatic return to base for recharging will not be implemented and the robots will be manually recharged, as necessary using the manual chargers already provided.
Health Monitor	Development of the health monitor has continued with a Fitbit as the first

Item	Status
	device to be identified for testing. However, in early assessments there were some problems discovered with the use of the device by PWD and therefore the assessment has been deferred to a later Phase of the trials. However, the health monitor assessment environment is available to evaluate by Health Care Professionals.
Long Range RFID	A single range RFID system has been procured and is fitted to the robot system. This potentially covers both the short and long range use mentions in the specification. However, it is not intended to evaluate its use during the Phase 1 trials.

2.2. Sensing systems

Most of the sensing systems used within the MARIO system are supplied with the platform and changes to the specification have been discussed above. The exceptions are sensors placed in the environment or on persons. For the Phase 1 Pilots only the health monitoring sensor and the RFID tags were in the specification. However, the use of both these sensors has been deferred to later phases of the pilot trials.

2.3. Communications systems

The communications system external to the MARIO robot consists of a Wireless LAN with a Data connection from the Windows PC on the MARIO PC. The facilities in Ireland and Italy have both equipped to handle the requisite communications with the MARIO robot. For the UK, suitable communication infrastructure will be a selection criteria for siting the trials.

A direct wireless LAN from the Linux system on the MARIO robot is possible but not used since it's not necessary for the fuctions in Phase 1. Internet Connectivity is provided to the Windows PC and that is all that is needed (for the text-to-speech only, no other data is exchanged to the outside of MARIO). As all Pilots for the Phase 1 trials have WiFi installed there is no need for a 3G/4G connection. Bluetooth will not be used in the Phase 1 trials.

together with a Bluetooth connection and a 3G/4G mobile connection have not been implemented as the relevant functions are not being implemented in the Phase 1 Pilots.

3. Software Architecture

The software within the MARIO system is divided into a 3 layer hierarchy, as shown in Figure 1. At the lowest level are the system support functions. The middle layer contains the user interaction system and the top layer consists of a series of discrete applications that essentially deliver the functionality of MARIO to the user. The system is controlled and coordinated by and event driven decision manager that distributes control between the applications.

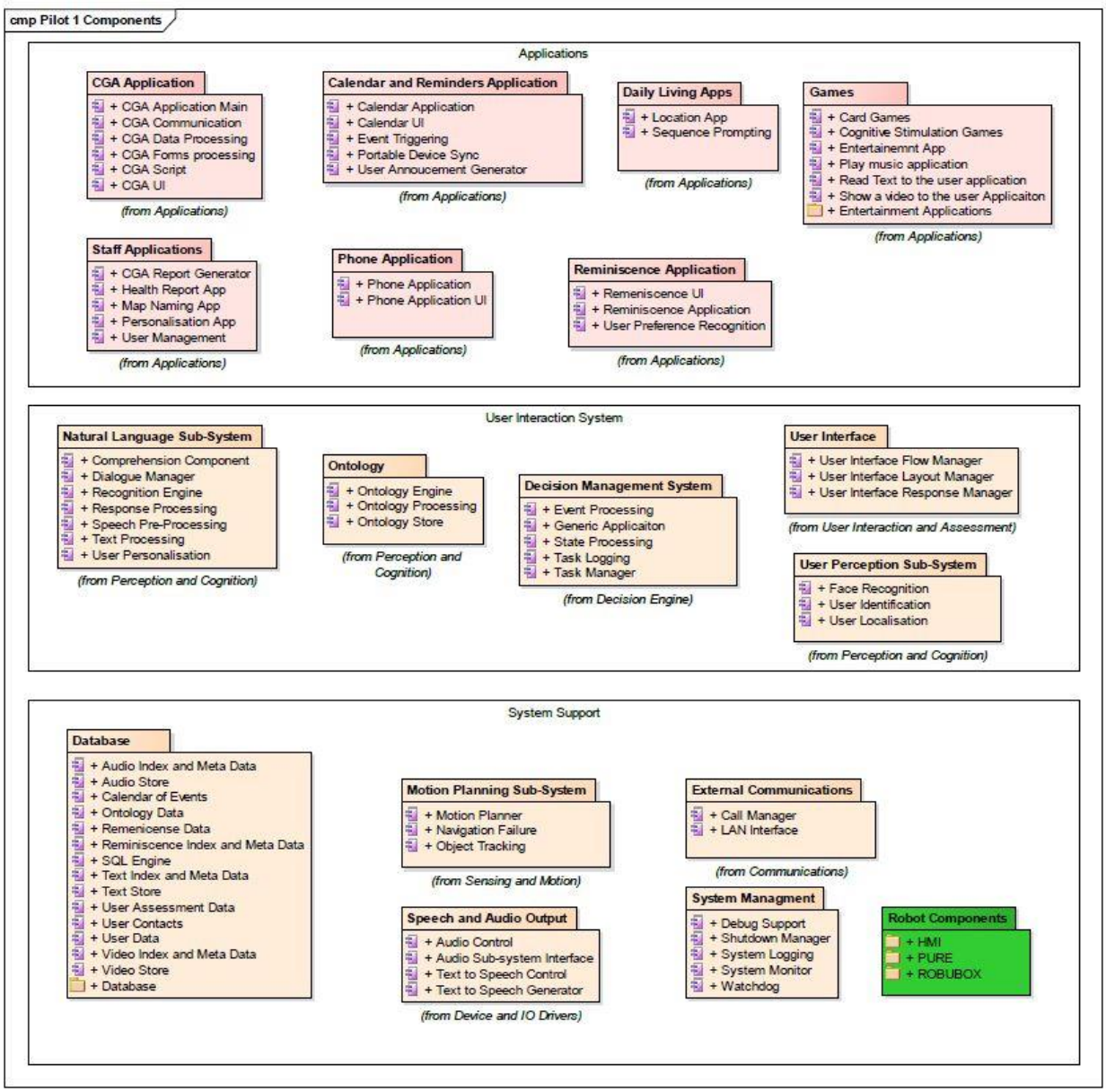

Figure 1: Pilot 1 Package Hierarchy

The software architecture for the Phase 1 Pilots adheres to the architecture in the specification, shown above. The deployed software differs to that of the specification in only two noteworthy ways:

- The number of Applications developed and deployed. Due to a number of factors the number of applications originally envisaged for the Phase 1 Pilots has had to be reduced. This is partly due to the difficulty of the tasks experienced within the development process versus the resources available but also due to limitations in the underlying MARIO system, particularly in terms of some of the low level robot system

support functions. It is expected that both these limitations will be fully addressed in later Phases.

- Although not detailed in the specification, there have also been changes to the interfaces within the architecture particularly between the applications and the low level robot system. A new interface has been developed to account for both new functionality and the higher data bandwidth resulting from increased use of sensor data by the applications. A further modification to the interface between the applications and the low level motion controller was planned for the Phase 1 pilots by Robosoft but has not yet been implemented. This was to allow greater sophistication of control of the robot movements from the applications. It is anticipated that this software will be completed before the end of the Phase 1 Pilots but if not then the interactions during the remaining part of Phase 1 pilots may be restricted.

4. Achieved Functionality

This section covers the main functionality available for assessment during the Phase 1 Pilots as delivered by the implemented through the applications. The interface to the applications is implemented via voice commands and through a touch screen, which can be used independently of each other.

4.1. Available Applications

Not all of the applications envisaged in the specification for the Phase 1 Pilots have been implemented at this stage. This is primarily due to a combination of task difficulty versus the resources available and the available support functionality within the MARIO system. However, the applications that are available will allow the Phase 1 Pilots to assess the relative utility of a range of applications and help- guide the development for later pilots.

The applications available for the Phase 1 Pilots are:

- Entertainment
- Reminders and events
- Connecting to friends and family
- CGA Assessment
- User location

There is also one ‘engineering’ applications, namely:

- MARIO Configuration

4.1.1 Entertainment

The purpose of the Entertainment application is to provide tailored entertainment to the user. Currently this consists of playing music to the PWD on request. Care staff can tailor the music available to the PWD through the configuration application. The music application operates through either voice commands or touch screen. The main functions available to the PWD are:

- Selection of music by type or by music track (name)
- Start and stop music
- Change volume
- Through the tests performed in Trial 1 the result gathered from end user’s feedback suggested that the apps should be simplified even further, as the type or track selection process is difficult for the moderate dementia patients. The app then has been parametrised so that it can skip the select process and play music straight ahead.

4.1.2 Reminders and Events

The purpose of the Reminders and Events application is to provide a handy diary and reminder function to the PWD. The Reminder and Events application allows Care Staff (and Family and Friends) to enter events onto the user’s calendar. The MARIO system will inform the user of upcoming events at a pre-determined time. The PWD can query their own calendar at any time.

4.1.3 Connecting to Family and Friends

The purpose of the Connecting to Friends and Family application is to enable the PWD to maintain their social network and be kept informed of activities within their social network. For the Phase 1 Pilots the available functionality of the application is to monitor a specific Twitter Feed and to display the relevant Tweet(s) to the PWD at an appropriate time.

4.1.4 CGA Assessment

The purpose of the CGA assessment application is to carry out part of the CGA assessment thereby relieving Health Care Professionals of some of the time involved in carrying out such tasks but, because of this, enabling the CGA to be carried out more frequently potentially giving earlier indication of any deterioration in the health status of the PWD.

Currently the CGA assessment application carries out those parts of the CGA that are administered through query and answer questionnaires (as opposed to those parts that are administered through direct observation of behaviour or actions). The CGA application asks the PWD questions verbally and the PWD can respond either verbally or through the touch screen.

The CGA application is started by the Care Staff but thereafter the PWD 'controls' the interaction through the speed of their responses.

The data collected by the CGA application is made available to the Health Care Professionals in an off-line computer database.

4.1.5 User Location

A key requirement for the MARIO system to be able to deliver its services to the PWD is that it can locate the user and correctly position itself with respect to the PWD. This is achieved through an interaction of three primary functions:

- Search for the User in the Operating Environment
- Identify the User in the Immediate Area
- Approach the User

These functions operate iteratively when MARIO is locating and approaching the user.

4.1.6 MARIO Configuration

Configuring MARIO for a specific user and environment consists of three main tasks, each of which is supported by the on-board application. These tasks are:

- Mapping the operating environment
- Set-up of user(s)
- Personalising the system for a new user

When MARIO is introduced into a new environment that environment has to be mapped before MARIO can operate successfully. This task, which is performed by engineering staff as part of the installation process involves manually driving the MARIO robot around the environment so that it can build up a map with its on-board sensors. This allows MARIO to identify its location within the environment in order to plan routes. The second part of the process involves naming various locations so that various applications can require MARIO to go to those locations or to allow the user to request that MARIO goes to a location.

Setting up of the user involves identifying the user to MARIO and associating them with their name. This is again carried out by engineering staff.

The personalisation of the MARIO system is carried out by CARE staff and, for the Phase 1 Pilots involves pre-loading music for the user together with loading personal data, such as family connections.

5. Integration Activities

Task 7.1 consists of the integration of the outputs of the technical partners in order to deliver a first version of the MARIO system to each of the pilot sites. The major activity covered has been the integration and test but maintenance of the major inter-partner interfaces and the production of user documentation has also been covered within this task.

The maintenance of major (i.e. inter-partner) interfaces has been carried out largely on a bi-lateral basis within the project but with regular monitoring and review by the Project Management Team (PMT) both with weekly telephone conferences and with as-needed physical meetings.

The development process adopted within the project is distributed amongst the various technical partners. The integration activities have been incremental and also, to a certain extent, distributed (i.e. both Robosoft and CNR had direct access to a MARIO robot on-site and could therefore perform partial integration tests). An integration and test of the hardware with the Robosoft software was carried out by Robosoft at their premises before the release of the MARIO robots to the pilot sites. Final sign-off of the achieved functionality will be carried out pilot sites..

There is the facility to remotely deploy updates to each of the sites which will allow both upgrades and bug fixes to be implanted during the pilot trials. It had been intended to roll-out updates following functional testing at Robosoft. However, this testing will now be undertaken by technical partners either with direct access to a robot on-site or at one of the pilot sites, before distribution to the other sites.

An operating manual was produced by Robosoft.

At least one MARIO robot has been delivered to each of the pilot sites and initial commissioning has been undertaken.

6. Conclusions

A first version of the MARIO system has been produced which will allow the MARIO system to be used with PWD in order to evaluate the effectiveness and utility of the functionality provided and to provide the baseline against which further incremental development needs can be established.

The MARIO robot has been delivered to each of the pilot sites and has been commissioned.

The withdrawal of Robosoft from the project has presented some difficulties in terms of uncomplete functionality. The issues raised are being addressed by the Project Management Team. It is hoped that a clearer picture of the situation will be available once the withdrawal procedure is complete and an update of this document will be produce d at that point.