



SHAPES

Smart and Healthy Ageing through People Engaging in supporting Systems

D5.2 – SHAPES Digital Solutions V1

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Lead author	Tatiana Silva (TREE), Colleen McMillon (TREE)
Contributors	George Bogdos (FINT), Barbara Guerra and Marco Manso (EDGE), Fotis Gonidis (GNO), Paul Isaris (SciFY), Donal McClean (AELTD), María José Santofimia and Xavier del Toro (UCLM), Óscar Villacañas Pérez (CH), Sara Cooper (PAL), Meftah Grissi (KOM), Víctor Fernandez and David González (TREE), Luis Unzueta Irurtia, Manex Serras Saenz, Naiara Muro Amuchastegui and Nekane Larburu Rubio (VICOM), Christoph Kokelmann (MedSyn), Iraklis Skepasianos (HMU), Andreas Andreou (UNRF), Constandinos X. Mavromoustakis (UNRF), Wai Hang Shek (OMN), Ioanna Dratsiou, Maria Metaxa, Annita Varella and Evangelia Romanopoulou (AUTH), Telmo Silva and Anabela Silva (UAVR), Lucia D'Arino (WFDB), Tereza Norbertova (FNOL)
Peer reviewers	Michael Cooke (NUIM), Sonja Grigoleit (FhG)
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Table of Contributors

Table 2 Deliverable Contributors

Section	Author(s)
Table of Contents	Tatiana Silva (TREE)
1 Introduction	Tatiana Silva (TREE)
2 SHAPES Digital Solutions	Tatiana Silva (TREE)
3 Digital Solutions for an Intelligent Living and Care Environment	George Bogdos (FINT), Barbara Guerra and Marco Manso (EDGE), Wai Hang Shek (OMN)

4 Application Suite for Healthy Ageing	Fotis Gonidis (GNO), Paul Isaris (SciFY), Ioanna Dratsiou, Maria Metaxa and Evangelia Romanopoulou (AUTH), Donal McClean (AELTD), María José Santofimia (UCLM), Óscar Villacañas Pérez (CH), Fotis Gonidis (GNO), Wai Hang Shek (OMN), Anabela Silva (UAVR)
5 Robotics and Assistive Technologies	Sara Cooper (PAL), Meftah Ghrissi (KOM), Victor Fernandez and David González (TREE), Luis Unzueta Irurtia (VICOM), Paul Isaris (SciFY), Manex Serras Saenz (VICOM), Wai Hang Shek (OMN)
6 Decision Support, Risk Assessment and Prediction Services	Tatiana Silva and Colleen McMillon (TREE), Andreas Andreou and Constandinos X. Mavromoustakis (UNRF), Naiara Muro Amuchastegui and Nekane Larburu Rubio (VICOM)
7 Solutions for Health and Care Service Providers	Fotis Gonidis (GNO), Paul Isaris (SciFY), Ioanna Dratsiou, Maria Metaxa, Annita Varella and Evangelia Romanopoulou (AUTH), Christoph Kokelmann (MedSyn)
8 Lifestyle Management and Wellbeing Assessment Solutions	Naiara Muro Amuchastegui and Nekane Larburu Rubio (VICOM), Colleen McMillon and David González (TREE), Tereza Norbertova (FNOL)
9 Security Assessment as a Service	Iraklis Skepasianos (HMU)
10 COVID-19 response Digital Solutions	Tatiana Silva (TREE), Barbara Guerra and Marco Manso (EDGE), Fotis Gonidis (GNO), Naiara Muro Amuchastegui (VICOM), Sara Cooper (PAL), Dewar Finlay (ULS), Matt McCann (AELTD)
11 Conclusion	Tatiana Silva (TREE)
12 Ethical Requirements Check	Tatiana Silva (TREE)

Table of Acronyms and Abbreviations

Table 3 Acronyms and Abbreviations

Acronym	Full Term
AELTD	Access Earth Limited
API	Application Programming Interface
AUTH	Aristotle University of Thessaloniki
CH	Clinica Humana
DS	Digital Solutions
EDGE	EDGEENGINEERING Lda
FINT	Future Intelligence Limited
FNOL	University Hospital Olomouc
GNO	GNOMON Informatics SA
HMU	Hellenic Mediterranean University
KOM	KOMPAI Robotics
MedSyn	MedicalSyn GmbH
OMN	Omnitor AB
PAL	PAL Robotics SL
PT	Pilot Theme
SciFY	Science for You
SDK	Software Development Kit
TREE	Tree Technology SA
UAVR	Universidade de Aveiro
UC	Use Case
UCLM	Universidad de Castilla - La Mancha
ULS	University of Ulster
UNRF	University of Nicosia Research Foundation
VICOM	VICOMTECH
WFDB	World Federation of the Deafblind

Keywords

Digital Solutions, intelligent living, remote monitoring, accessibility tools, COVID-19 response, older persons, analytics, predictive systems.

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Executive Summary

This deliverable provides a comprehensive description of the different Digital Solutions which will be used in SHAPES project. The Solutions cover a wide spectrum of areas like IoT and Big data Platforms, online communication and accessibility tools, cognitive stimulation and rehabilitation, conversational assistants and chatbots, solutions based on robotics, health and wellbeing platform, solutions to ensure the overall security, COVID-19 responses tools, as well as solutions in the area of data analytics, like predictive systems and wellbeing assessment tools, between others.

These tools will be adapted to meet the SHAPES user requirements and needs and integrated to support the different pilot themes and associated use cases defined in SHAPES and will be evaluated by the end users (older persons, informal and formal caregivers) during the pilots.

This deliverable integrates the work carried out in the different tasks of WP5 so far, from T5.2 to T5.8. The content included in this document is useful for being used as manual of the Different Solutions and their technical details, for the SHAPES partners but also for external stakeholders.

The deliverable contains the following twelve chapters:

- 1. Introduction
- 2. SHAPES Digital Solutions
- 3. Digital Solutions for an Intelligent Living and Care Environment
- 4 Application Suite for Healthy Ageing
- 5. Robotics and Assistive Technologies
- 6. Decision Support and Risk Assessment and Prediction Services
- 7. Solutions for Health and Care Service providers
- 8. Lifestyle Management and Wellbeing Assessment Solution
- 9. Security Assessment as a Service
- 10. COVID-19 response tools
- 11. Conclusion
- 12. Ethical Requirements Check

This is the first version of the deliverable, which will have two updates in the future (D5.3 SHAPES Digital Solutions v2, due to M24, and D5.4 SHAPES Digital Solutions v3, due to month 36). In the upcoming versions, relevant details concerning the adaptation work of the different Solutions described in this report will be included.

1 Introduction

1.1 *Rationale and purpose of the deliverable*

In this document, the reader will find the description of the different Digital Solutions (DS) that will be used in SHAPES project, as well as their technical specifications and the Pilots themes where they will be used in the project. When already defined, the specific use case within the Pilot theme where the DS will be used is identified. This report contains relevant information for the SHAPES consortium and external stakeholders and can be used as a manual of the available Digital Solutions in SHAPES. As the project evolves and the Use Cases are further detailed, pilot sites can identify additional Digital Solutions relevant to address the objective of the Use Cases and decide to include them as DS to be used. Besides, this report provides relevant information for WP4, where the different Digital Solutions will be integrated in the SHAPES Technological Platform.

The SHAPES Solutions cover a wide spectrum of areas like IoT and Big data Platforms, online communication and accessibility tools, cognitive stimulation and rehabilitation, conversational assistants and chatbots, solutions based on robotics, health and wellbeing platform, solutions to ensure the overall security, COVID-19 responses tools as well as solutions in the area of data analytics, like predictive systems and wellbeing assessment tools, between others (Figure 1). These tools will be adapted/improved to meet the SHAPES user requirements and needs and integrated to support the different pilot themes and associated use cases defined in SHAPES and will be evaluated by the end users (older persons, informal and formal caregivers) during the pilots.

The Digital Solutions described here also present a set of mock-ups that will serve as the basis and guidance to the overall adaptation work to be performed across the different tasks within WP5.

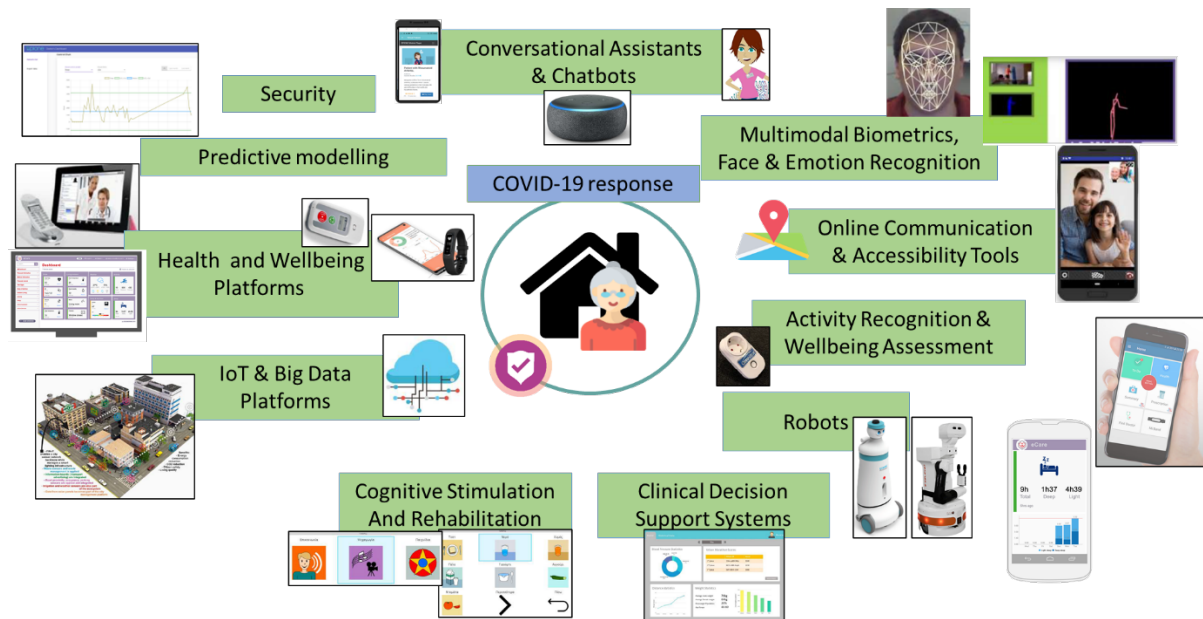


Figure 1 SHAPES Digital Solutions: different areas.

1.1.1 Key inputs and outputs

This deliverable incorporates the results from the work carried out in T5.2 Solutions for SHAPES Intelligent Living and Care Environment, T5.3 Applications Suite for Healthy Ageing, T5.4 Robotics and Assistive Technologies, T5.5 Decision Support and Risk Assessment and Prediction Services, T5.6 Solutions for Health and Care Service Providers, T5.7 Lifestyle Management and Wellbeing Assessment Solution, T5.8 Security Assessment As a Service, and provides valuable information to the overall project, in particular WP4 SHAPES Technological Platform, where the different solutions will be integrated and WP6 Pilots.

1.2 Structure of the document

This report is divided into the following chapters:

- **SHAPES Digital Solutions** – Chapter 2 introduces the reader to what SHAPES Digital Solutions are and their main areas, that are presented in detail in the next Chapters.
- **Digital Solutions for an Intelligent Living and Care Environment** – Chapter 3 is related to the solutions of Task 5.2 and identifies a set of solutions where the main input comes from smart devices from an “intelligent environment”.
- **Application Suite for Healthy Ageing** – Chapter 4 is related to the solutions of Task 5.3 and identifies several digital health solutions which enable self-management of the condition with the use of IoT medical devices.

- **Robotics and Assistive Technologies** – Chapter 5 presents the solutions related to Task 5.4, based on robotics solutions. Some solutions which can be integrated in the robots are also described.
- **Decision Support and Risk Assessment and Prediction Services** – Chapter 6 is related to the solutions of Task 5.5, and describes predictive tools and tools which supports the identification of patients at high risk of suffering an adverse event or disease.
- **Solutions for Health and Care Service providers** – Chapter 7 is related to the solutions of Task 5.6, and describes solutions focused on caregivers and health and care providers, to improve the delivery of health and care to older individuals.
- **Lifestyle Management and Wellbeing Assessment Solution** – Chapter 8 is related to the solutions of Task 5.7, and describes solutions based on advanced analytics.
- **Security Assessment as a Service** - Chapter 9 is related to the solutions of Task 5.8, and describes a framework for authentication/Authorization for SHAPES.
- **COVID-19 response tools** – Chapter 10 describes several solutions proposed by the SHAPES partners to support the COVID-19 response.
- **Conclusion** – Chapter 11
- **Ethical Requirements Check** - In the last section of this report – Chapter 12 the ethical requirements/topics relevant for SHAPES Digital Solutions were identified.

2 SHAPES Digital Solutions

SHAPES ambitions to promote a large-scale piloting campaign, integrating a range of Digital Solutions. Within the piloting campaign, the project will provide significant body of evidence of the impact of SHAPES solutions in the quality of life of older individuals, their families, and caregivers and, simultaneously, in the efficiency of Health and Care delivery in Europe. The Digital Solutions will be integrated in the SHAPES Technological Platform, being developed in WP4. Digital Solutions range from assistive robots to eHealth wearables, IoT devices and Apps, cognitive stimulation and rehabilitation tools to conversational assistants and chatbots, wellbeing assessment tools to analytics and predictive systems.

This deliverable presents the different Digital Solutions to be used in SHAPES project, its technical specifications as well as the Pilot Themes they will be supporting. The partner bringing each Digital Solution to the project is also identified.

They will be presented by area, which are related to WP5 tasks, from Task 5.2 to T5.8.

3 Digital Solutions for an Intelligent Living and Care Environment (Task 5.2)

The continuous introduction of artificial intelligence (AI) capabilities in mobile devices, wearables, robots and home appliances has led to an ecosystem of products and services where everything is interconnected, acting as a unified contextual information and making possible the provision of timely services to users. Living and acting in such environment is now known as “Intelligent Living”. Such kind of services and smart devices help users get through their daily lives more efficiently and with extended autonomy or independence so that they may contribute to building healthier lifestyles and safer ambientes and focus on what truly matters to them. This benefit becomes even greater when such technologies solve true human problems especially related to health and social care.

Nowadays, many technological systems and platforms target the domain of improving health and social care environments, bringing together a wide range of devices, applications and solutions within the living environment adapted to remote health monitoring, fitness programs, monitoring of chronic diseases, and elderly care providing fundamental blocks for sense, awareness and interaction. Many of these platforms utilize the concept of Internet of Things (IoT) because it allows to have a platform connecting multiple devices (or things) to create and manage applications, to run analytics, and to store and secure data. IoT-enabled platforms are designed to

deploy applications that monitor, manage and control various connected devices, often a particularly challenging task if the devices that need to be controlled are diversified and located in areas with bad connectivity. Notwithstanding, IoT-enabled platforms support intelligent living and care environments and are instrumental in the redesign of modern health and social care with promising technological, economical, and social prospects.

Medical equipment, health sensors, imaging devices and data analytics are viewed as smart devices or things constituting a core part of an IoT infrastructure and associated healthcare services are expected to reduce costs, increase the quality of life, and enrich the users' experience. Compliance with treatment and medication at home and monitoring of the health and wellbeing conditions of older individuals are increasingly important to improve the quality of life of the elderly population, while considering the budgetary constraints in health and social care systems.

This section describes the SHAPES IoT-based platforms, components and eHealth applications that will become part of the SHAPES Platform to assist in the creation of intelligent living and care environments, integrating homes, neighbourhoods, and cities.

3.1 *FINoT Platform (FINT)*

FINoT platform is an a FIWARE-based IoT cloud management platform able to orchestrate embedded systems, to interconnect almost any kind of sensor, actuator and data logger and it is dedicated for industrial and semi-industrial usage. The platform provides data intelligence services while is capable for real-time handling of data artefacts including data fusion. The integration of FINoT Platform into SHAPES TP will bring significant advantages allowing the shifting of various services to the cloud, provide required computational resources and handle massive chunks of collected data at a location-transparent centralized infrastructure and at the same moment retain historical data.

The main purpose of FINoT Platform in SHAPES will be to provide smart neighbourhood and city capabilities like data acquisition and handling for weather, air quality, pollution, local public works, local transportation, local activities and other based on pilot's needs while also collect and provide information for the day to day activities within a specific community like available readings, exhibitions etc.

The main objective is to provide to SHAPES intelligent living ecosystem capabilities for supporting smart neighbourhood, community, city and rural areas.



Figure 2 Various Applications Running on FINoT Platform.

Table 4 FINoT Platform Data.

Data Category	Measurements Type	Collection Method
Sensors	Acquire the output of a sensor that detects and responds to some type of input from the physical environment (e.g. home level, neighbourhood level)	Automated (from connected devices)
Actuators	Acquire the output of a device and provide input based on specific parameters and measurements (e.g. home level, neighbourhood level)	Automated (from connected devices)
Internet Data	Local public works Parking Local transportation Local activities Local Useful Information	Automated (from connected devices)
Environmental Data	Climate Air quality Pollution Urban noise levels	Automated (from connected devices)
Data from Industrial Devices	Energy Water Mobility	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances	Automated (from connected devices)

3.1.1 Technical specifications

FINoT Platform is an IoT ecosystem based on Kubernetes for remotely located devices supporting various data sources and application types, it is easy deployable and configurable exploiting microservices (e.g Tenant Creation, Instance Creation, GW configuration). It has three layers of Intelligence that are supported (Device Level, Gateway level, Cloud Level). The main purpose is to provide the appropriate data

management middleware for intelligent handling of different kind (heterogeneous) data sources.

FINoT is fully compatible with FIWARE providing a great interoperability features allowing the scalable and adaptive expansion both in Hardware (various devices) and Software (services). Almost any sensor and actuator can be connected on the core platform and become a managed asset instantly. It also incorporated build in custom functionalities for reminders, notifications and alerts services.

3.1.2 Interfaces and interoperability

FINoT Platform's front-end is a Web application while back-end provides APIs for 3rd party interconnection. Also, FINoT Platform will be used as a mediation layer for connection to SymbioTe platform and SHAPES Gateway. The supported data type is based on NGSI protocol while interconnection to the platform is supported through HTTP REST, JSON and MQTT for inputs and outputs.

FINoT Platform will provide to SHAPES' users relevant information on climate, air quality, pollution, urban noise levels, energy, local public works, parking, local transportation and local activities where this information will be available.

Table 5 Summarised Technical Description of the FINoT Platform.

General Description	A FIWARE-based IoT platform used as cloud orchestrated embedded systems' management solution able to interconnect almost any kind of sensor, actuator and data logger, dedicated for industrial and semi-industrial usage.
Features	<ul style="list-style-type: none"> • Main goal of FINoT® Platform is the Creation, Development and Integration of an intelligent living and care environment for SHAPES • FINoT® Platform is an IoT ecosystem for remotely located devices Interconnection and Intelligent Management, supporting various data sources and application types • It is easy deployable and configurable exploiting Microservices (e.g. Tenant Creation, Instance Creation, GW configuration) • Three layers of Intelligence are supported (Device Level, Gateway level, Cloud Level) • FINoT ® is fully compatible with FIWARE providing a great interoperability features • The scalable and adaptive core platform allows the effective expansion both in Hardware and Software. • Almost any sensor and actuator can be connected on the core platform and become a managed asset instantly. • Build custom reminders, notifications and alerts.
Application Areas	Provide smart neighbourhood and city capabilities (e.g. data acquisition/handling for: weather, air quality, pollution, local public works, local transportation and local activities and other)
TRL	From TRL6 to TRL8
Data Type	NGSI protocol, any data type (Boolean, data/time, integer, number, text, geo:json, file)

Inputs	http(s) rest, JSON, MQTT
Outputs	http(s) rest, JSON, MQTT
Actions to be performed	<ul style="list-style-type: none"> • Provide to SHAPES users relevant information on climate, air quality, pollution, urban noise levels, energy, local public works, parking, local transportation and local activities • Provide to intelligent living ecosystem capabilities for supporting smart neighbourhood, community, city and rural areas (e.g. data acquisition/handling for: weather, air quality, pollution, local public works, local transportation and local activities and other based on the pilot's needs) • Provide the appropriate data management middleware for intelligent handling of different kind (heterogeneous) data sources • Provide the interfaces and APIs for 3rd party solutions, systems, sensors and applications
Interface	FInoT® Platform (front-end): Web application FInoT® Platform (back-end): APIs for 3rd parties

3.1.3 Pilot themes

In SHAPES, the FInoT Platform will be adapted to meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

Pilot Theme 1 (PT1): Smart Living Environment for healthy ageing at Home

PT2: Improving In-Home and Community-based Care

All other pilots that will to utilise SHAPES Gateway and IoT data management middleware.

3.2 eCare – Personalised Care Intelligence Platform (EDGE)

eCare is EDGE's smart and personalised ambient intelligence platform that, collecting and integrating well-being, quality of life and environmental data, empowers individuals to create smart living environments that promote healthy lifestyles and independent living conditions.

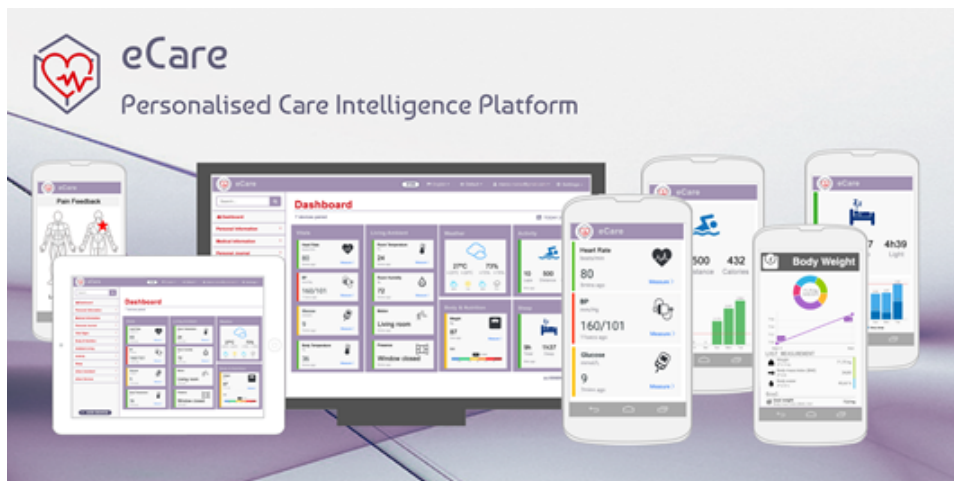


Figure 3 EDGE's eCare Platform.

EDGE's ambient living intelligence solution provides (1) day-to-day non-intrusive and responsible monitoring of wellbeing parameters of individuals as well as (2) the delivery of remote monitoring of health parameters of patients at home who live with a chronic condition requiring periodic or permanent monitoring or who have undergone a medical intervention and need further observation.

Fostering a non-intrusive, privacy-by-design, secure and patient-friendly experience, **eCare** enables a reliable and highly-scalable monitoring environment, ensuring the individuals' safety on a continuous 24/7 basis and contributing to improve the level of care in home environments.

eCare gathers a wide range of measurements acquired through sensors and devices that are seamlessly embedded in the living environment or are worn or interacted with by the individual. Amongst the measurements registered in **eCare**'s intelligence ambient platform are vital signs, physical measurements, health data and lifestyle and wellbeing data. In addition to wellbeing-related data, **eCare** includes the **MAESTRA** module that delivers ambient living data (room temperature and humidity, air quality, motion) and facilitates the integration of environmental data including pollution, dust and pollen levels, especially relevant for individuals suffering from asthma and chronic obstructive pulmonary disease.

Table 6 eCare Health and Wellbeing Data

Data Category	Measurements Type	Collection Method
Vital signs	Body temperature Heart rate (and variability), Blood pressure (diastolic and systolic) Oxygen saturation Respiratory rate Blood glucose level	Automated (from connected devices) or Manual
Physical	Height, Weight, Waist circumference	Automated (from connected devices) or

		Manual
Health	Medication Allergies Medical conditions Disability Symptoms Side effects	Manual (fill-in questionnaires)
Lifestyle and Wellbeing	Habits Diet and nutrition Mood Sleep quality Physical activity	Automated (from connected devices) or Manual (fill-in questionnaires)
Ambient Living (in house)	Room temperature Room humidity Air quality (e.g., PM levels) Detection of gas/smoke Motion detection (movement) Appliances (on/off) Energy (metering)	Automated (from connected devices)
Environmental (outdoor)	Weather Air quality (pollution, dust, pollen) Water quality	Automated (from existing open access databases)

Individuals interact with the **eCare Platform** through the **eCare App** that enable an easy manual or automatic collection of health and wellbeing parameters. Automated parameters may be collected via health and medical devices and wearables. Also, the App allows individuals to answer to simple and short questionnaires and feedback forms on symptoms (e.g., pain, anxiety), medication adherence, nutrition and diet, mental state and quality of life.



Figure 4 eCare App for Individuals.

Overall, **eCare's** key features for individuals or patients are:

- The efficient collection of health and wellbeing-related parameters:
 - Health data, including vital signs;

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- o Body measurements;
- o Lifestyle and wellbeing data.
- The efficient collection of information from smart living environments;
- An App for easy use, incorporating reminders and alerting mechanisms

Through the eCare Platform, health and social care professionals are able to easily and efficiently remotely monitor the health and wellbeing parameters of a large number of individuals or patients under their care (significant high scalability is given to the one-to-many monitoring healthcare model), by means of intuitive dashboards and rich visualisation tools that highlight localised risks of relapse or hospitalisation, being aware of their condition at all times and receiving notifications or alerts in case any patient symptoms become severe and their condition worsens, thus warranting the patient's immediate hospitalisation. Moreover, the eCare Platform monitors the individual's conditions, enabling the application of smart analytics and AI-based algorithms to deliver early diagnosis, risk prediction (enabling prevention measures) and adjustment of personalised treatment plans on-the-fly, to the benefit of individuals. These, in turn, can generate alerts that may feed into the remote eCare monitoring platform installed at the point of care (hospitals, clinics, day care units and medicalised residences).

Upon the individuals' or patients' explicit consent, the data are shared with the healthcare professionals (care team) responsible for accompanying the individuals or patients, allowing the former to remotely access the (self)reported health and wellbeing parameters, easily update their health and wellbeing status during domiciliary visits or following telemedicine consults or phone calls, follow the evolution of the individuals' or patients' condition and to act promptly if needed (e.g., adjustment of medication, change of treatment, immediate phone contact).



Figure 5 eCare Platform for Healthcare Professionals.

eCare's key features for professional caregivers, namely medical teams, and care service providers, particularly healthcare organisations:

- 24/7 monitoring of patients' conditions, via intelligent dashboards, with status indication in near real-time;
- Follow-up of the evolution of a particular condition or disease;

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- Early identification of health and wellbeing deterioration signs;
- Generation of alerts in case of anomalies or worrisome signs;
- Application of smart analytics and AI-based algorithms for:
 - o early diagnosis;
 - o risk prediction;
 - o adjustment of treatment plans on-the-fly

eCare provides Healthcare and Wellness Services customised data access, personalised scores, rich visualisation tools, alert functions and services for professionals (e.g., doctors and nurses), enabling the follow-up of multiple patients or users by hospitals, clinics, day care units and, even, informal carers. Those services are provided over multiple channels (e.g., browsers, mobile apps) and enable individuals or patients to be empowered on their health and wellbeing care and the accompanying medical staff to be constantly aware of the individuals' or patients' health and wellness status and alerted in case of need for assistance.

Data quality and security are also key concerns of the **eCare Platform** that uses advanced technologies to ensure an efficient access to trustworthy data. **eCare** deals with a high degree of personal and sensitive information pertaining to individuals, thus it is critical that high standards for security and privacy (fully adopting GDPR) are implemented, resulting in a highly trusted platform among its users and stakeholders. **eCare** adopts a privacy-by-design scheme to guarantee full compliance with EU and national legislation and regulations (e.g. GDPR) on data privacy, especially in regard to the use of personal and/or sensitive data. Likewise, security-by-design principles is assumed not only for the **eCare Platform** itself and security mechanisms, but also for the communication channels with external sources and components.

For any patient data to be sent, shared or anyway exchanged with the healthcare professional, it is required that the individual authorises, consents and enables the so-called data transfer. **Strict authentication, authorisation, and accounting security measures** are in place in the **eCare Platform** to guarantee the safeguard of the users' privacy and the protection of all personal data. Robust authentication mechanisms and secure access protocols are adopted and strong end-to-end encryption (e.g., transport layer encryption SSL/TLS) is used. Individuals or patients always retain the power to individually grant access to the different elements of their reported health and wellbeing information to healthcare professionals, thus remaining in control of their own data. Individuals have the option to delete all their data and their account with the **eCare Platform**, effectively leaving the Platform, in full compliance with GDPR's article 17 *Right to be forgotten*. The **eCare Platform** records in a secure log system all actions involving the data and information held within, that is, all access, creation, modification, archival and deletion actions concerning the Platform's data, including the identification of the user responsible for the action. Data access management is based on an Attribute-based Access Control (ABAC) approach, enabling finer grained data access control and a system better fitted to operational efficiency.

3.2.1 Interfaces and interoperability

The **eCare Platform** includes an Application Programming Interface (API) that supports the interoperability of the Platform with third-party applications or software. Following a pre-defined data model, the **eCare API** enables the exportation of anonymised data collected by the **eCare Platform** to third-party applications or software. The **eCare Platform** may also be extended to import data provided by external applications and devices.

Table 7 Summarised Technical Description of the eCare Platform.

General Description	Big data platform presenting the older individuals' health (psychophysiological parameters), wellbeing and lifestyle data captured by diverse information sources, including smart home devices, health devices, wearables and open source databases, to support the creation of intelligent environments capable of promoting superior quality of life.
Features	<ul style="list-style-type: none"> Gathering and presentation of the older individual's <ul style="list-style-type: none"> health (psychophysiological parameters) information, based on data captured by health devices and wearables (automatic or manual input); wellbeing and lifestyle behaviour information, based on data provided by the individual in the eCare App (forms, surveys and questionnaires); living environment information, based on data captured by smart home devices and open source databases. Integration of real-world data to improve the quality of care; Statistics on the evolution of the older individual's health and wellbeing conditions; Remote monitoring of patient condition by healthcare professionals (workload reduction); Delivery of reminders, notifications and alerts.
Application Areas	<ul style="list-style-type: none"> Remote monitoring of health and wellbeing conditions by health and care service providers; Patient empowerment (manage own care plan and adoption of preventative behaviours); Support to the creation of intelligent environments fostering independence, autonomy and superior quality of life.
TRL	From TRL5 to TRL7
Data Type	JSON format. Used standards: <ul style="list-style-type: none"> Openmhealth (https://www.openmhealth.org); SAREF (https://saref.etsi.org). EDGE extensions for specific fields.
Inputs	HTTP(S) REST, JSON messages.
Outputs	HTTP(S) REST, JSON messages.
Actions to be performed	Older individuals use the eCare App or the eCare Portal to insert information to the eCare Platform. Professional and informal caregivers use the eCare Portal to insert information to the eCare Platform. Compatible smart devices provide automatic information to the eCare Platform.
Interface	eCare App: Smartphone

	eCare Portal (front-end): Web browser eCare Portal (back-end): API for third-parties to access eCare information (using HTTP(S) REST) eCare Platform: API for third-party systems (e.g., data analytics) to insert automatic information in eCare (using HTTP(S) REST)
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3.2.2 Pilot themes

In SHAPES, the **eCare Platform** and specific comprising modules will be adapted to meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

- PT1: Smart Living Environment for Active Ageing at Home;
- PT2: Improving In-Home and Community-based Care;
- PT3: Medicine Control and Optimisation;
- PT4: Psycho-social and Cognitive Stimulation Promoting Wellbeing;
- PT7: Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

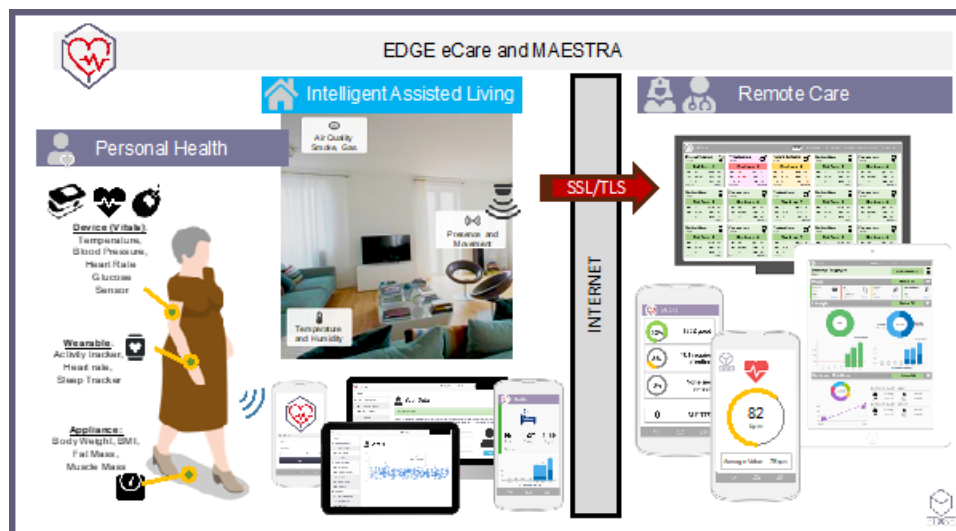


Figure 6 Application of the eCare Platform in SHAPES Pilot Themes.

3.2.3 Mock-ups

The following mock-ups of the eCare Platform are the basis for the adaptation work to be conducted in SHAPES, taking into consideration the applicable SHAPES users' needs and requirements and the functional specifications of the SHAPES Technological Platform.

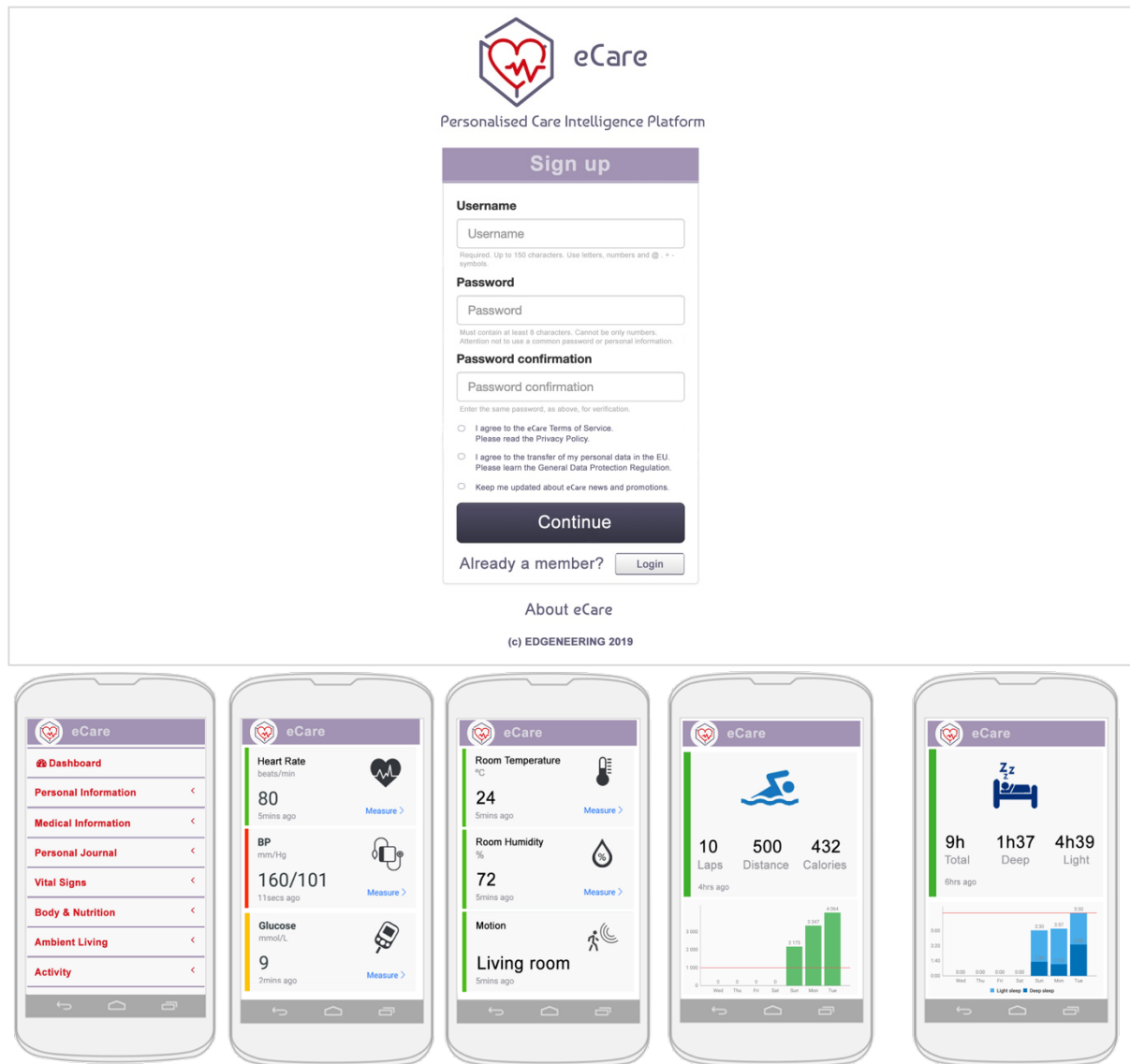


Figure 7 eCare Platform Mock-ups.

3.3 NOTiFY (OMN)

Omnitor **NOTiFY** is a cloud-based platform currently used to make citizens aware of incoming Total Conversation calls. This can happen in several different ways, e.g. flashing lights. However, NOTiFY is a general alerting platform that can be used for any type of alerting (not limited to Total Conversation).

Omnitor has developed two different versions of NOTiFY, the NOTiFY Smart plug and NOTiFY v1. NOTiFY smart plug consist of a built-in relay that can remotely be switched on/off and offers energy monitoring capability. NOTiFY V1 consists of four exposed relays that external alerting devices can be connected to. This version lacks the energy monitoring capability.

NOTiFY will be able to push energy consumption information to the SHAPES TP or other partners in SHAPES. It is possible to see if a device is turned on/off at an abnormal time through energy monitoring. It is also possible to remotely turn on or off the smart plug. As well as providing the user with a general alerting platform that can alert people on incoming calls with e.g. flashing light or tactile vibration.

Table 8 Summarised Data collected with the NOTiFY Platform

Data Category	Measurements Type	Collection Method
Sensors	Energy monitor for Smart plug	Automated (from connected devices)
Internet Data	Remote activation Settings Device health	Automated (from connected devices)
Data to Industrial Devices	Turning on/off relay	Automated (from connected devices) or manual
Data from Industrial Devices	Energy	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances Service appliances	Automated (from connected devices)



Figure 8 The two versions of NOTiFY.

3.3.1 Technical specifications

Omnitor NOTiFY is an IoT device based on either Raspberry Pi or ESP8266. The Raspberry Pi contains four exposed relays but without the capability to monitor energy. The smart plug contains an ESP8266 which is easily deployed. The purpose of NOTiFY is to provide the user with a general alerting platform but at the same time provide raw data to the caregivers.

Almost all “alerting systems” that are relying on relays for on/off can be connected to NOTiFY. NOTiFY also have a configurations list on what units are going to be turned on/off.

Technical specifications for the Smart Plug;

- Wireless IEEE Standards: WIFI 2.4Ghz
- Voltage Range: 110-240V AC
- Maximum Current: 16A
- Max Power: 3500W (resistance load)
- Any household appliances over 2000W are not recommended.

3.3.2 Interfaces and interoperability

The front-end of the NOTiFY platform is a web interface. The back-end is powered by the NOTiFY server, which supports SQL for inputs and outputs. API's can be provided for SHAPES TP and SHAPES partners.

Table 9 Summarised Technical Description of the NOTiFY Platform

General Description	<ul style="list-style-type: none"> • Omnitor NOTiFY cloud-based platform with IoT-devices currently used to make citizens aware of incoming • Total Conversation calls in a number of different ways e.g. flashing lights. However, NOTiFY® is a general alerting • Platform that can be used for any type of alerting (not limited to Total Conversation).
Features	<ul style="list-style-type: none"> • Main goal of NOTiFY is to help deaf and hard of hearing people with incoming calls. • Built-in relays can be switched on or off. NOTiFY v1 have 4 exposed relays, NOTiFY Smart plug uses a built-in relay. • NOTiFY Smart plug offers energy monitoring capability. The information can be sent to other systems. • Used together with the eCtouch app to notify (alert) the citizen with a disability about an incoming call (e.g. flashing lights, tactile vibration). • NOTiFY can be connected to already installed alerting systems. • NOTiFY is a general notification platform (not limited to eCtouch calls) and consist of a cloud service and IoT devices.
Application Areas	<ul style="list-style-type: none"> • Provide a general alerting platform (able to alert people on incoming calls with e.g. flashing light, tactile vibration). • Energy monitoring (monitor connected devices, e.g. microwave, TV, computer and other).
TRL	From TRL7 (NOTiFY v1) From TRL5 (NOTiFY Smart plug)
Data Type	SQL
Inputs	Vendor's who can access NOTiFY, NOTiFY settings
Outputs	Vendor's who can access NOTiFY, Position (IP address), NOTiFY settings
Actions to be performed	<ul style="list-style-type: none"> • Provide SHAPES TP with information regarding energy consumption, can be used to determine if a device is on or off. • User will be able to remotely turn on or off devices that are connected.

	<ul style="list-style-type: none"> • User will be able to alert people with e.g. a flashing light or tactile vibration. • Provide data for 3rd party concerning energy consumption.
Interface	NOTiFY web interface

3.3.3 Pilot themes

In SHAPES, the **NOTiFY Platform** will be adapted to meet the SHAPES user requirements and the pilot specifications associated with the following use cases:

- PT1-001 - Remote In-Home Wellbeing Monitoring and Assessment
- PT7-001 - Monitor older patient with chronic diseases when traveling abroad
- PT7-002 - Foster older people's (with physical disabilities) independent living by identifying accessible locations and routes in other locations (domestic and abroad)
- PT7-003 - Preventing and/or handling a medical emergency while visiting another country

4 Application Suite for Healthy Ageing (Task 5.3)

Europe is ageing: the number of people in Europe aged over 65 will almost double to 151 million in 2060 and the share of those aged over 80 is projected to more than double between 2017 and 2080, from 5.5% to 12.7% [1]. According to Eurostat's 2018 statistics report, good health is not only of value to the individual as a major determinant of quality of life, well-being and social participation, it also contributes to general social and economic growth. In 2017, nearly one fifth (19%) of the EU population was aged +65; the proportion of EU citizens who describe themselves as being in good or very good health has fallen since 2011 and varies greatly across EU MS: between 82.8% and 43.4%.

The evolution of digitisation of services and eHealth technologies is likely to empower the aged population to gain control of their own health and thereby contributing to the healthy ageing.

In particular, eHealth technologies can increase motivation and awareness and engage the individuals in self-education about their health conditions. In addition, the digital health solutions enable self-management of the condition with the use of IoT medical devices (blood pressure, weight scales, oximeters, glucose meters etc) and facilitate the remote monitoring and communication with the physicians.

This section describes in detail the Digital Solutions that contribute to the healthy ageing and will be used in the various pilots via the Shapes Platform.

4.1 *eHealthPass Mobile Application (GNO)*

eHealthPass is a platform for integrated care that provides its users with an overview of their daily health and care activities, their treatment plan, a self-assessment tool with personalised questionnaires (uses a text-based chatbot) and notifications. Within the treatment plan function, users can control the medication, register vital signs monitoring, manage diet and nutrition and regulate physical activity. Further, due to the interoperability with their healthcare service provider, the user may also book, manage and cancel medical appointments. The platform also includes educational content (e.g., virtual patients, stories and practical video tips) and a discussion forum, and it is able to synchronise with third-party devices (e.g., fitness tracker, heart rate device) and other Apps (e.g., Apple health). The platform supports eHealth standards (HL7 CDA, HL7 FHIR and IHE ITI profiles) and has therefore the capability to connect with existing clinical data repositories, master patient indexes (MPI) and patient management systems (PAS) to retrieve and to update user health and medical information. In addition, it connects to openNCP supporting its users to benefit from cross-border access and exchange of health-related data in Europe.

Features

- Treatment plan
- Medical history
- Appointments
- Questionnaires
- Video consultation
- Connection with IoT devices
- Virtual Community portal
- Education material and activities
- Reporting data to national registry (optional for COVID-19)

Application areas

- Chronic disease management: Diabetes, Chronic pain
- Teleconsultation
- Emergency scenarios and unplanned care
- Medical tourism
- COVID-19 self-management

4.1.1 Technical specifications

eHealthPass frontend is available via smartphone in two platforms, Android and iOS. The backend platform is built around the FHIR leading medical interoperability standards and utilizes a fully compatible FHIR server. In addition, a number of IOT devices are integrated either via Bluetooth with the mobile application or via 4g cellular network and cloud services directly with the FHIR server.

4.1.2 Interfaces and interoperability

The main interface for the user/patient and the caregiver is the mobile application. Additional technical interfaces and APIs are available to third party applications and IOT devices in order to enable exchange of information.

4.1.3 Pilot themes

Pilot Theme 1 - Smart Living Environment for healthy ageing at Home

Pilot Theme 2 - Improving In-Home and Community-based Care

Pilot Theme 3 - Medicine Control and Optimisation

Pilot Theme 5 - Caring for Older Individuals with Neurodegenerative Diseases

Pilot Theme 7 - Cross-border Health Data Exchange

4.1.4 Mock-ups

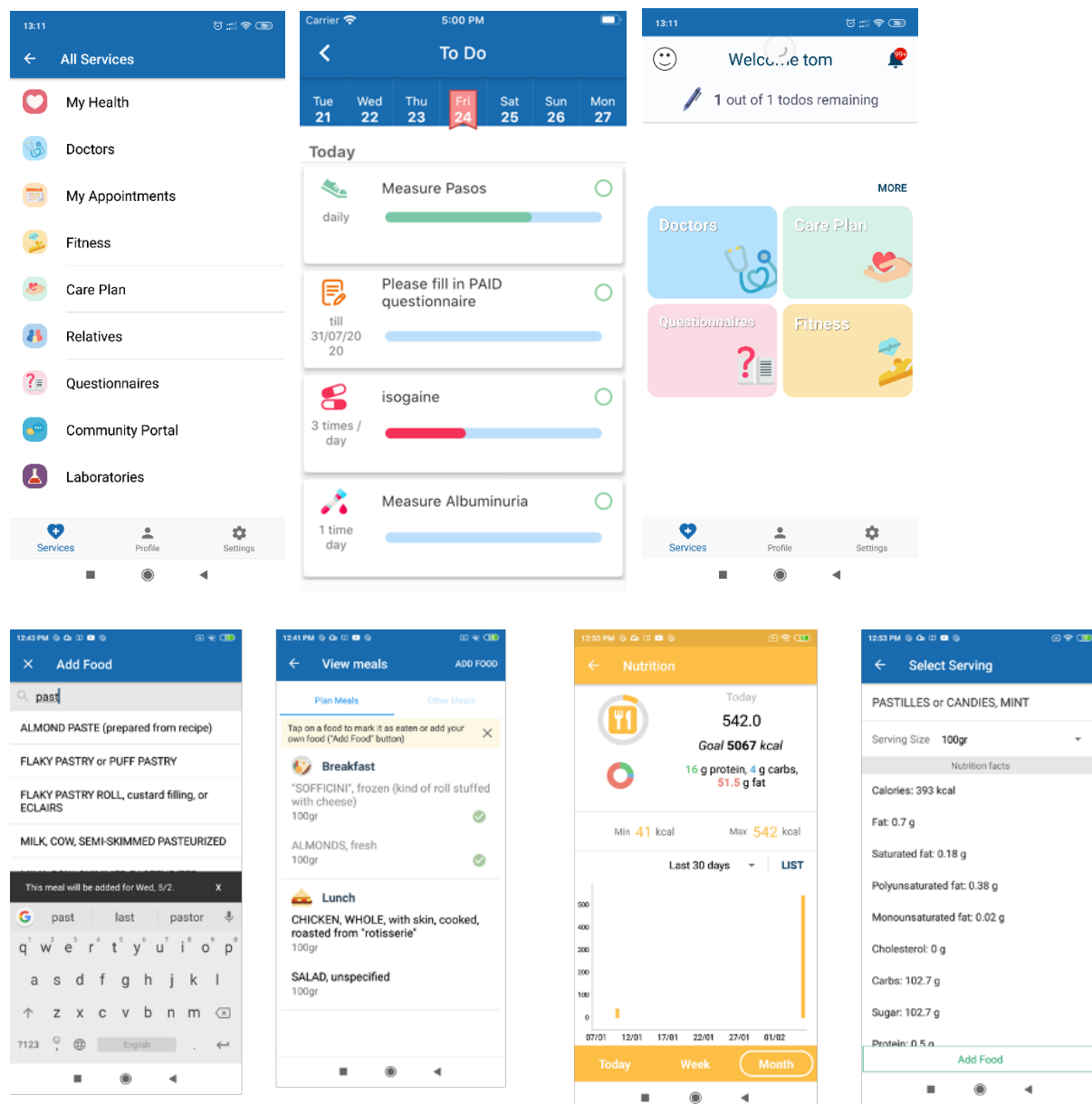


Figure 9 eHealthPass mock-ups.

4.2 diAnoia Mobile application and diAnoia marketplace online platform (SciFY)

diAnoia is a free smartphone application created by SciFY in collaboration with dementia professionals. It is aimed at the caregivers of people with mild cognitive impairment and at the early stages of dementia. diAnoia offers practical ways to help

people with dementia to improve their cognitive functions, their mood, functionality and quality of life. It offers cognitive exercises, ideas for spending quality time together, daily reminders, allows monitoring the frequency of mental stimulation. diAnoia is freely available for Android and iOS in Greek. In Greece, the beneficiaries are estimated to be around 5,500. SciFY will adapt its diAnoia app for people with mild cognitive impairment and early stage dementia. The adaptations will result in offering diAnoia in 4 languages (Greek, English, Spanish and Italian). SciFY will also adapt the code so that the app is easily translated in more languages. SciFY will create a marketplace that will allow experts in dementia to create exercises for people with dementia in various languages. We will then allow diAnoia to use the exercises created in the diAnoia Marketplace.

4.2.1 Technical specifications

diAnoia runs on mobile phones running Android or iOS operating systems. The application is built using the Ionic hybrid mobile framework.

4.2.2 Interfaces and interoperability

Interface for the diAnoia mobile application: Smartphone
Interface for the diAnoia marketplace online platform; Desktop Computer or Laptop
Stakeholders.

Family carers and health professionals have in hand an everyday helper that:

- Offers printable cognitive exercises to work on memory, attention skills, in a familiar way for the elderly (paper and pencil).
- Makes exercises more attractive using storytelling: mental stimulation exercises are incorporated into stories that make exercises fun.
- Every day suggests ways to spend quality time together, sending notifications on your smartphone.
- Reminds you what is important: key points we should not forget.
- Allows you to keep track of the exercises performed (history).

4.2.3 Pilot themes

Pilot 2 Improving In-Home and Community-based Care

Pilot 4 Psycho-social and Cognitive Stimulation Promoting Wellbeing.

4.3 *Memor-I videogame and Memor-I studio online platform (SciFY)*

Responding to the huge need for the creation of electronic games for the blind and/or visually impaired, SciFY has created Memor-i studio. Memor-i Studio is an online platform that allows users to easily create games for educational and recreational purposes, that are suitable for both persons with and without visual impairment. The user just uploads sounds and pictures, and the game is automatically created. Memory is a classic mental stimulation game, and the fact that it can be very easily customised to the interests of the individual, makes it an invaluable tool for achieving learning and mental stimulation objectives.

Schools for blind and visually impaired children have already started using it, creating their own games, with the contribution of the children themselves.

Memor-i is currently offered in 2 languages (English and Greek). The platform, initially aimed at people with blindness and visual impairments, has been populated with 30+ games already created by the community. It is used by teachers in EU, but also promoted by prominent schools in the US.

SciFY will adapt its platform. The adaptations will allow the use of the platform in 3 languages, easy expansion to other languages, easy creation of new games in many languages. It will also use the SHAPES Platform to suggest related content that is related to the user profile. SciFY will also create tutorials and offer easy-to-use resources for creators. SciFY will create a Memory Marketplace component so that it contributors can offer their games publicly.

4.3.1 Technical specifications

The videogame works as a desktop application. It needs the Java programming language installed and works in Windows and Linux operating systems. The online platform needs a modern Operating System and browser (Google Chrome, Mozilla Firefox) to work.

4.3.2 Interfaces and interoperability

Interface: Desktop Computer or Laptop

Stakeholders: The online platform allows users to:

- find free Memor-i games
- create new Memor-i game (the user uploads sounds and pictures)
- create a 'clone' of the game (make copy of the game and enrich it)
- play against a computer and against another player, online
- report a game

The desktop application (videogame) allows the users to play the Memory game.
Interfaces: Desktop Computer (or Laptop).

4.3.3 Pilot themes

Pilot 4 Psycho-social and Cognitive Stimulation Promoting Wellbeing.

4.4 *Talk & Play and Talk & Play marketplace (SciFY)*

Talk and Play is a software application created by SciFY application for people with simultaneous speech and motor disabilities (e.g. due to accident and/or cerebral palsy). It allows people with such disabilities to communicate, listen to music, watch movies, and practice to improve their cognitive functions with the help of a computer. It has been designed and developed in cooperation with special occupational therapists to make it very user-friendly.

In Greece, Talk and Play has exceeded 900+ beneficiaries, and is currently being used by most of the key Greek rehabilitation institutions.

SciFY will adapt Talk and Play to suit the SHAPES' objectives. The new Talk and Play (adapted version) will be available in 3 languages (Greek, English and German) and will allow full customization to the needs of the individual, automatically considering the user's profile. SciFY will create a marketplace component that will allow contributors (occupational therapists, psychologists, speech therapists etc.) to create mental stimulation exercises and new communication cards for Talk and Play.

4.4.1 Technical specifications

Talk & Play is a desktop application. It works on computers running Windows or Linux operating systems and needs the Java language installed.

Talk & Play marketplace will be an online application. It will require a modern operating system and a modern browser (Google Chrome, Mozilla Firefox).

4.4.2 Interfaces and interoperability

Interface: Desktop Computer or Laptop

Talk and Play is fully customisable: an occupational therapist / carer can:

- create multiple profiles
- customise the interaction mode for each profile (mouse / switch / keyboard)
- create new communication cards and customise the communication module
- create new variations of the cognitive stimulation games
- customise the difficulty of the stimulation games.

The user then is able to use the communication cards and the integrated games.

4.4.3 Pilot themes

Pilot 2 Improving In-Home and Community-based Care.

4.5 ICSee (SciFY)

ICSee is an application for android smartphones/tablets, which processes the image/video of the device's camera in real time, applies a series of filters and shows on screen a result that is easier to be read or recognized. This way, whoever owns an android smartphone or a tablet, can have a free solution for his/her problem. The users just point the camera of their smartphone/tablet towards where they want to have a better view of, and see on their screen a processed, clearer image for them. This way, they have the ability to read a small text (like the bill or a restaurant menu, the taximeter fare, a name on a doorbell). ICSee has exceeded 16,500 downloads worldwide.

4.5.1 Technical specifications

ICSee runs on mobile phones running Android operating system. The application is built using the Java programming language.

4.5.2 Interfaces and interoperability

Interface: Smartphone

The user holds the phone with the camera directed in the position of the text they would like to read. This can be done either by the user or their caregiver. They then can swipe their finger across the screen to change filters, and their finger on the screen to temporarily freeze the image.

The application offers an audio interface in order to be usable by users who cannot read a text written on a smartphone screen.

4.5.3 Pilot themes

Pilot 7 Cross-border Health Data Exchange – Supporting Mobility and Accessibility for Older Individuals.

4.6 Integrated Health and Social Care System Long Lasting Memories Care - LLM Care (AUTH)

The Integrated Health and Social Care System Long Lasting Memories Care - LLM Care (www.llmcare.gr), is an integrated ICT platform which combines state-of-the-art mental exercises against cognitive deterioration with physical activity in the structure of an advanced ambient assisted living environment (Figure 10). The empowerment of older people to improve their mental ability is enabled, while simultaneously boosting their physical well-being. This technological solution coincides with daily monitoring and helps to increase an older persons' overall feeling of safety and self-confidence.

The LLM Care aims at providing the vital cognitive and physical training to the older people aged above 50 [2]. It includes new technology platforms and software to improve or maintain the quality of their life. This integrated solution combines independent living solutions with cognitive and physical training, and it is based on recent research that claims the effectiveness of moto-sensory training on older people with cognitive problems or mild dementia.



Figure 10 Interfaces of webFitForAll and BrainHQ respectively

The LLM Care as a certified ICT platform was designed to incorporate two interoperable components:

The Cognitive Training System, based on the BrainHQ (www.brainhq.com), is a specialized software designed to support cognitive exercises. BrainHQ is a fully personalized, adaptable cognitive training platform. The stimuli are synthetically processed, enabling variations in duration and amplitude of rapid frequency modulations within sounds and speech to adapt difficulty. This software provides the opportunity to speed up and sharpen auditory and visual processing of the brain. The improvement of the quantity and quality of the inputs taken in through sound or image leads to an overall improvement in thinking, focus, and memory.

The Physical Training System, based on the webFitForAll (www.fitforall.gr), is an exergaming platform that provides the essential physical training to older people in

order to maintain their fitness and well-being, through the use of an innovative, low-cost and widely accepted technology platform (exploiting a motion detection device). webFitForAll was developed in the Aristotle University of Thessaloniki, within the European project called Long Lasting Memories (LLM) (www.longlastingmemories.eu). Different types of (gaming) exercises have been developed ranging from aerobic, muscle flexibility, endurance, and balance training with tailor-made (for older adults) interface.

4.6.1 Technical specifications

Cognitive Training System (BrainHQ)

- Operating System: Windows 7 / 8.1 / 10, Mac OS X Catalina (10.5)/ Mojave (10.4)
- Web browsers: Chrome, Firefox, Safari, and Microsoft Edge
- Internet connection

Physical Training System (webFitForAll)

- Operating System: Windows 7 / 8.1 / 10 64bit
- At least 4GB of RAM
- Internet connection

4.6.2 Interfaces and interoperability

Cognitive Training System (BrainHQ)

The cognitive training exercises are delivered through the BrainHQ, which is applicable to smartphones, tablets, laptops and computer devices.

User's interaction

1. User connects to the BrainHQ platform and logs in with his/her credentials
2. User interacts with the exercises
3. User logs out

Physical Training System (webFitForAll)

The physical training exercises are delivered through the webFitForAll, which is applicable to laptops and computer devices. A motion detection device is also needed to detect body skeletal and recognize gestures/movements in real-time.

User's interaction

1. User connects to the webFitForAll platform and logs in with his/her credentials
2. User makes sure the motion detection device is on
3. User performs the exercises displayed at the screen in distance of 1.5 m. from the motion detection device
4. User logs out

4.6.3 Pilot themes

PT2: Improving In-Home and Community-based Care (PT2-003: LLM CARE Healthcare System for Cognitive and Physical training).

4.7 Access Earth Platform (AELTD)

Access Earth is a global platform that uses smart and crowd sourced data gathering methods to provide the world with details on the levels of accessibility local bars, restaurants, shops and other businesses have.

The Access Earth mobile and progressive web application serves as a crowd sourced data gathering method for users to view and contribute to this growing data set, while the Access Galaxy system uses an AI image classifier to identify accessible assets (e.g. accessible parking spots) within an area from satellite image data. Both systems will be used to target participating partner sites for the gathering of the necessary data for the SHAPES project.

Recently COVID-19 related criteria have been added to the platform for users to also view and contribute to, what social distancing practices are being used by these local establishments, to keep their workers and customers safe during this global pandemic (more details are included in Section 10.7).

This information allows users with accessibility needs or who are immunocompromised the added confidence to engage within their local communities by viewing the information they require before they make their journey.

The information gathered using the Access Earth platform can be deployed and integrated with a live, real time connection in existing systems through an API or with an interactive plugin for users to view. Alternatively, users can always access the Access Earth application for free on their own personal devices.

4.7.1 Technical specifications

The Access Earth application is built using the ionic framework to allow for the ease of development and maintenance of the code base for the multi-platform application (iOS, Android, PWA).

The Access Galaxy system takes in satellite image data and passes it through an AI image classifier to identify key points for inclusion into the Access Earth platforms data set.

Access Earths data is stored on the cloud and can be accessed via APIs, interactive plugin that can be deployed on any website or platform required or through the Access Earth application itself.

4.7.2 Interfaces and interoperability

All stakeholders can either operate as data gathers or data viewers for the information that exists within the Access Earth system. Thus, empowering both caregivers and the cared for agency in viewing and providing insights on their local community.

Users of the application can interact and contribute to the data via their personal devices (iPhone, Android Mobile device, or PC browser) or through an interactive plugin.

The level of data gathering for each interested pilot site will be determined by all interested pilot leaders.

4.7.3 Pilot themes

- PT1-002 Digital Assistant to Support Older People to Live Independently and Remain Socially Connected
- PT2-002 Community interaction
- PT7-002 Foster older people's (with physical disabilities) independent living by identifying accessible locations and routes in other locations (domestic and abroad)
- PT1-003 Competent usage of digital technologies.

4.8 *Physical Activity Monitoring (UCLM)*

This Digital Solution will enable capturing parameters related to physical activity. These parameters will be provided by means of wearable devices such as bracelets or smart bands, equipped with Inertial Measurement Units (IMUs), that measure physical activity of an individual throughout the day. This information is particularly relevant for supervising the recovering process of a person and tracking their general

condition. The application areas include tracking recovery process and evolution of diseases with an impact on the physical activity and mobility including gait analysis. It can also provide valuable information for other application such as fall detection.

The system will be collecting data and storing it locally or streaming it through a gateway device to the cloud where it will be stored and processed using different data analytics techniques such as machine learning, to identify patterns and predict the evolution of certain conditions that have an impact in physical state and mobility.

The Physical Activity Monitoring solution currently integrates two different smart bands: The Xiaomi Mi Band 4 and the Mbientlab MetaMotionR MMR.



Figure 11 Mbientlab MetaMotionR MMR used in the Physical Activity Monitoring Solution.

4.8.1 Technical Specifications

Xiaomi Mi Band 4 features and technical specification:

- Functionalities: Step counting, Heart frequency, Sleep quality, Activity recognition and tracking (running, treadmill, walking, cycling, swimming).
- Autonomy: Battery lasts 20 days, approx.
- Connectivity: Bluetooth, NFC.
- Xiaomi API available (no need to use Xiaomi Cloud).

Mbientlab MetaMotionR MMR:

- Sensors: 9-axis IMU (Bosch BMI160 6-axis Accelerometer + Gyroscope, BMM150 3-axis Magnetometer) with environmental sensor (BMP280 Temperature, BMP280 Barometer/Pressure/Altimeter, LTR-329ALS Luminosity/Ambient Light).
- Battery: Lithium-ion Rechargeable battery.
- Memory: 8MB Memory.
- Actuators: Vibrating Coin motor.
- Connectivity: Bluetooth Low Energy 4.0, GPIOs, I2C, SPI interfaces.

- Real-time communication is achieved via Bluetooth. Data may also be logged in the 8MB NOR Flash memory, allowing recordings from 2 hours to 48 hours. All data is available in CSV format with a timestamp so you can sync multiple devices.
- License free open-source APIs.
- Wearable accessories: wristband, velcro sleeve, belt clip or body adhesive.

4.8.2 Interfaces and Interoperability

This Solution provides an API (Back-end) for integration with the SHAPES Platform, so that information can be stored and consumed by other Digital Solutions. An automated registration system is also provided for the user.

4.8.3 Pilot themes

The physical activity monitoring solution will be used in the following pilot themes and use cases of SHAPES:

- PT2 Improving In-Home & Community-based Care, use case PT2-001 Monitoring of Health Parameters.
- PT6 At-home Physical Rehabilitation, use case PT6-004 Wearable Motion Monitoring Devices.

4.9 *Phyx.io (UCLM)*

This solution provides a tool for monitoring physical rehabilitation processes without the need to rely on direct supervision by the physiotherapist. A system equipped with 3D depth camera analyses the movements made by the user during exercise routines and check that they are within the range of movement that can be considered safe. This tool also offers the possibility of capturing information during exercise sessions. In this way, the physiotherapist will be able to analyse the evolution of each patient, making an informed supervision. This system will also be equipped with a videoconference system so that the user and the physiotherapist can interact at any time. The system provides support for the supervision of exercise performance correcting wrong postures as well as tracking of exercise execution (number of repetitions, achievements, time required to complete the exercise, etc.)

The system will offer a version for nursing homes, gyms, or rehabilitation centres, which will take the form of a kiosk where all the hardware will form a single piece. Furthermore, a lighter version will be offered, for which we plan to use the TV at home.



Figure 12 Kiosk version of Phyx.io.

4.9.1 Technical Specifications

The Phyx.io tool provides a graphical interface for different user roles: therapists and individuals exercising. These interfaces are intended to navigate through the different exercises available both for being prescribed to an individual or to be executed. Graphical interface is also available for the video call. A data dashboard is also available for the therapist and other professionals involved in the supervision of the condition of a given individual.

The Phyx.io tool incorporates the Microsoft Axure Kinect 3D depth camera, that has the following features:

- 1 Megapixel Depth sensor with wide field.
- 12 Megapixel RGB video camera.
- Matrix with 7 microphones to capture voice and sounds.
- IMU sensor to orientate the camera.
- Matriz de 7 micrófonos para capturar sonidos y voz de campo lejano.
- Cámara de vídeo RGB de 12 MP para obtener una secuencia de colores adicional en línea con la secuencia de profundidad.
- Skeleton joints data provided by their SDK for body tracking.
- System Requirements: Windows® 10 PC or Ubuntu 18.04 LTS with 7th Generation Intel® Core™ i3 Processor (Dual Core 2.4 GHz with HD620 GPU or faster), USB 3.0 Port, 4 GB RAM. Skeletal/body tracking and other experiences may require more advanced PC hardware.

4.9.2 Interfaces and interoperability

The Pyx.io tool is provided through a PC application.

4.9.3 Pilot themes

The Pyx.io tool for physical rehabilitation will be used in the following pilot themes and use cases of SHAPES:

- PT6 At-home Physical Rehabilitation, use case PT6-001 Orofacial Musculature Training Tool, use case PT6-002 Gait Rehabilitation Robot and use case PT6-003 3D Depth Camera and software application for semi-supervised rehabilitation with data analytics.

4.10 ROSA (CH)

ROSA is a combination of inter-communicated technologies for the clinical management of users with heart failure as main condition (patients). The patient has 24/7 contact with a chatbot (virtual nurse) through a chat application. The virtual nurse asks the patient questions to gather data and establish a personalized health plan (frequency of questions, pieces of advice) and launch alerts. The patient may start the conversation (“I do not feel well”, “my blood pressure is high”). The technologies are:

- **Mobile app for patients:** It is a mobile App which serves as interface for instant messaging. The patient can communicate with the virtual nurse and the health professional.
- **Control Panel:** It is a web-based application for the health professional. The health professional can see the health plan of their patients, their alerts and the conversation history. Instant messaging has been embedded in the interface to interrupt the virtual-nurse/patient conversation and intervene (human-in-the-loop). The control panel also includes the database. The algorithm that determines the personalized health plan is in its code.
- **Conversational agent:** it is the chatbot technology.

4.10.1 Technical specifications

- Mobile app for patients: Hybrid application (IONIC v5), currently working on Android and iOS operating systems
- Control Panel: Application Server, Ruby on rails
 - Database: PostgreSQL
- Conversational agent: Dialogflow (external technology)
- Chat history: Firebase and FireStore (external technology)
- Notifications: OneSignal/Firebase (external technologies)
- Communications: Json

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

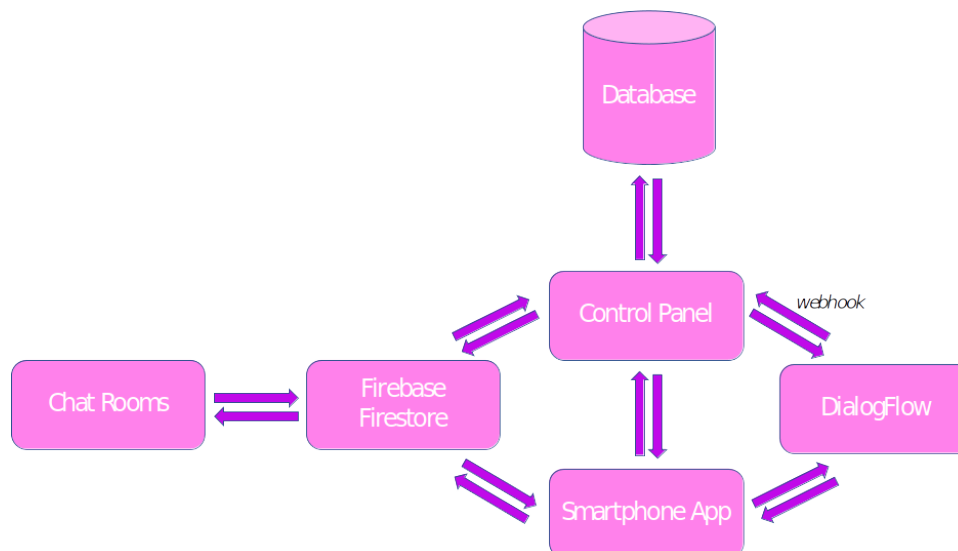


Figure 13 ROSA's components and data flows.

4.10.2 Interfaces and interoperability

Mobile Application, smartphone:

- Interface for patient interaction with chatbot and health professional, mobile application: Smartphone

Control Panel, web-based: Browser (preferably Chrome):

- Interface for the health professional interaction with the patient and health plan management system
- Interface for the system administrator

Stakeholders: patients, medical doctor, physician, system administrator (to add/delete users, to assign patients with health professionals).

4.10.3 Pilot themes

PT1 - Smart Living Environment for healthy ageing at Home

PT2 - Improving In-Home and Community-based Care

PT3 - Medicine Control and Optimisation

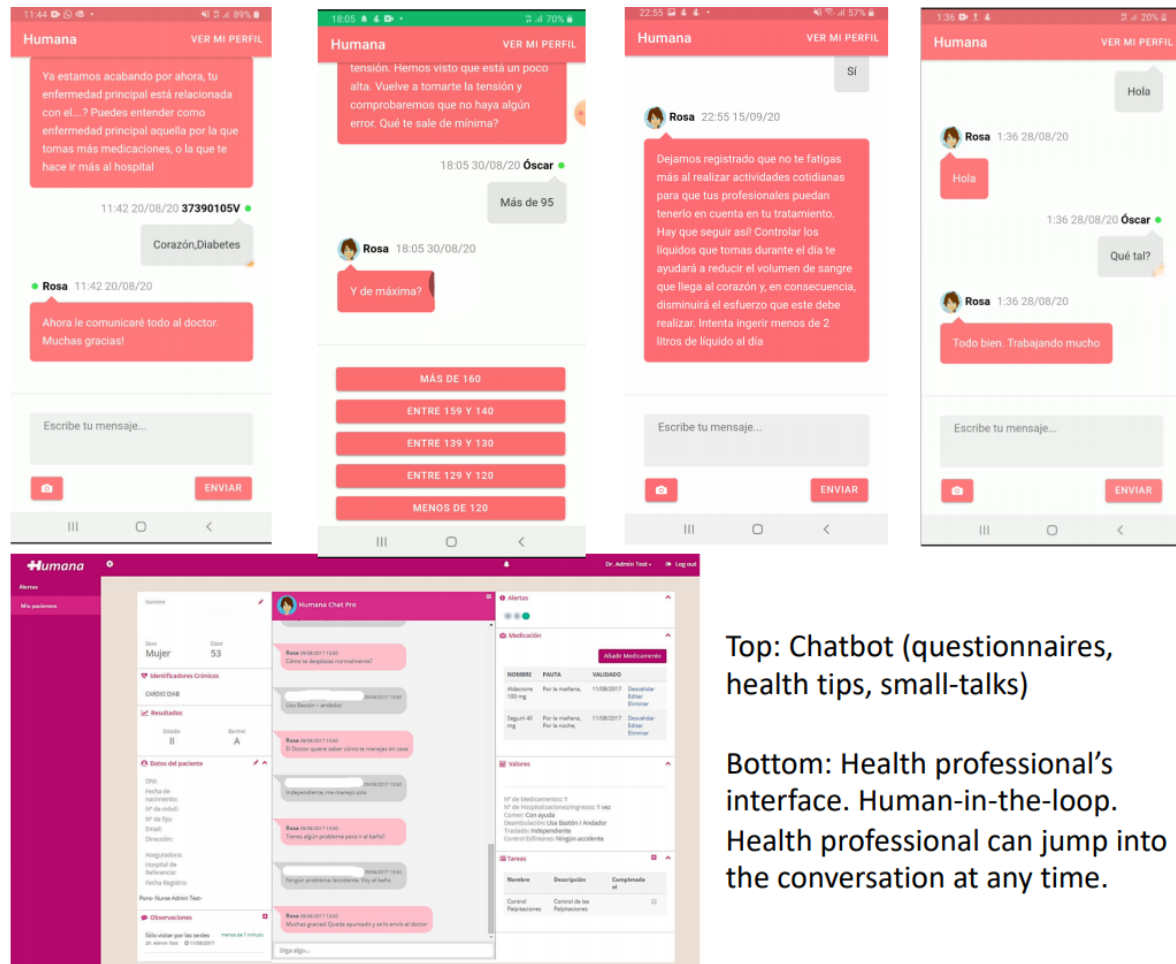
PT4 - Psycho-social and Cognitive Stimulation Promoting Wellbeing

PT5 - Caring for Older Individuals with Neurodegenerative Diseases

PT6 - Physical Rehabilitation at Home

PT7 - Cross-border Health Data Exchange

4.10.4 Mock-ups



Top: Chatbot (questionnaires, health tips, small-talks)

Bottom: Health professional's interface. Human-in-the-loop. Health professional can jump into the conversation at any time.

Figure 14 ROSA's mock-ups.

4.11 DigiRoom (OMN)

Omnitor DigiRoom is a digital meeting room based on WebRTC. DigiRoom is a generic meeting room built to be easy to integrate with digital solutions and platforms lacking that functionality. An Application Programming Interface (API) is provided to enable smooth integration with DigiRoom. The digital meeting room is encrypted end-to-end.



Figure 15 DigiRoom Solution, from OMN.

Data Category	Measurements Type	Collection Method
Internet Data	Room ID/link Settings DigiRoom connection & Calls Connection status	Automated (from connected devices)
Data to Industrial Devices	Can be connected to NOTiFY	Automated (from connected devices) or manual
Data from Industrial Devices	Join other DigiRoom meetings Meetings statistics	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances Service appliances	Automated (from connected devices)

4.11.1 Technical specifications

Omniator DigiRoom is based on WebRTC. WebRTC enables the creation of calls without a dedicated application. It can be run on almost all modern platforms thanks to the widespread adoption of WebRTC. Future enhancements can easily be deployed to all users without their involvement.

Technical requirements for the DigiRoom;

- Relatively modern smartphone/ tablet/ computer.
- A browser that supports WebRTC (any modern browser). The latest version of Chrome, Firefox, or Safari recommended.

4.11.2 Interfaces and interoperability

General Description	<ul style="list-style-type: none"> • Omnitor DigiRoom is a digital meeting room based on WebRTC. • DigiRoom is a generic meeting room that is built to be easy to integrate with digital solutions and platforms lacking that functionality. • Application Programming Interface (API) is provided to enable smooth integration with DigiRoom.
Features	<ul style="list-style-type: none"> • Integrated into platforms and services that need a digital video meeting room for two participants (could be more). Typical use cases; meetings between doctor-patient, veterinarian-pet owner, customer support-customer. • DigiRoom is a web-based meeting room that supports video, audio, and file sharing (soon chat). The meeting is accessed using a unique link. • No installation is required, only a web browser. It works on Windows 10, iOS, Android and Mac OS. • Built to be easy to integrate - An Application Programming Interface (API) is provided to make it easy to create meetings.
Application Areas	<ul style="list-style-type: none"> • Conversation tool • Instruction tool
TRL	From TRL7
Data Type	NoSQL
Inputs	Room start/close
Outputs	Room ID, Room start/close, Feedback
Actions to be performed	<ul style="list-style-type: none"> • User will be able to generate a link which creates a room where two participants can have a meeting.
Interface	PC, smartphone, tablet

4.11.3 Pilot themes

PT1-003 - Competent usage of digital technologies

PT2-001 - Monitoring of health parameters

PT2-002 - Community interaction

PT3-001c - Advanced telemonitoring of patients with heart failure in home environment

PT7-001 - Monitor older patient with chronic diseases when traveling abroad

PT7-002 - Foster older people's (with physical disabilities) independent living by identifying accessible locations and routes in other locations (domestic and abroad)

PT7-003 - Preventing and/or handling a medical emergency while visiting another country

4.12 StepMania (UAVR)

StepMania is a free dance and rhythm game for multiple platforms such as Windows and Linux. The game interface has 3D graphics and allows the player to use a keyboard or a dance pad to interact.

To play StepMania, the user should pay attention to the arrows that scroll upwards on the screen and when they meet a stationary set of target arrows, the player should press the corresponding arrows on their keyboard or dance mat.

The movement of the arrows is defined based on the beat of the song. The player performance is scored based upon how accurately he can trigger the arrows in time to the beat of the song. If the player has an excellent or poor performance, the software triggers motivation messages.

StepMania has multiple game modes divided into games and styles. The most recent version has the following styles available by default: Dance, Pump, kb7, kickbox, lights, para, beat, Ez2, pop, techno, ds3ddx, karaoke, Maniax. More information about game modes here (<https://github.com/stepmania/stepmania/wiki/Supported-Game-Modes>). The software interface as also an editor for creating music steps.

StepMania also allows for other input options like specialized adapters like PS2 and Xbox controllers or dance pads that connect to PC. The simplest way is using the keyboard to tap out the rhythms using arrows or other keys.

StepMania is (c) Chris Danford, the StepMania development team. Anyone can install and use it, free of charge, without limitation of copy, modify, merge, publish, distribute, and/or sell copies of the Software.

4.12.1 Technical specifications

The StepMania is Open Source and free software. The system requirements are:

- Windows 7; Linux; Mac OS X 10.6+,
- 512 MB of RAM (1 GB recommended)
- 700MHz minimum (Multi-core recommended)

- Video card with support for 16-bit color, 128MB video RAM and OpenGL 2.1 or higher.
- DirectX 9.0 or later (Windows only)
- Sound card

4.12.2 Interfaces and interoperability



StepMania software as the graphical user interface that allows the user to play. An XML file stores the player performance data. The data contained in this file can feed a third-party database enabling the exchange of information.


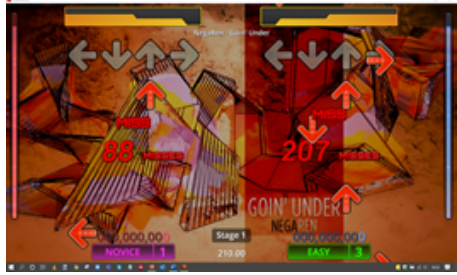
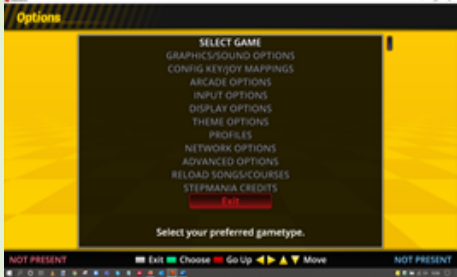


4.12.3 Pilot themes

UC-PT4-001 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

4.12.4 Mock-ups

Table 10 StepMania Mock-ups

Screen	Functionalities
Main Screen 	<p>Allow to start the game</p> <ul style="list-style-type: none"> • Allow to access game options • Allow to edit/share • Allow to access jukebox • Allow to select game • Allow to exit the game
Select style 	<p>Allow to select the style mode</p> <ul style="list-style-type: none"> • Single = 1 player • Versus = 2 players – versus • Double = 1 player • Couple = 2 players – versus • Solo = 1 player • Routine = 2 players – cooperative

<h3>Select Music</h3> 	<ul style="list-style-type: none"> Allow to select the music to play
<h3>Playing</h3> 	<p>Play screen</p>
<h3>Options</h3> 	<ul style="list-style-type: none"> Allow to select game (change the current game type with – dance, pump, kb7, para, beat, techno, lights, kickbox), graphics/sound Allow to configure key/joy mappings, Arcade options, input, display, theme options, profiles, network options
<h3>Display options</h3> 	<ul style="list-style-type: none"> Allow to set background fitting mode, appearance options (e.g., language), set user interface options (e.g., one player on the screen; percent or dance points; lyrics, instructions), set over scan correction (calibrate the screen)
<h3>Select game</h3> 	<ul style="list-style-type: none"> Allow to select the default game dance style (dance, pump, kb7, beat, techno, lights, kickbox)

5 Robotics and Assistive Technologies (Task 5.4)

The Task 5.4 presents the different digital solutions SHAPES project will integrate onto the robots provided by PAL Robotics and KOMPAÏ. It should be noted that additional solutions may also be integrated later on as the project evolves and if further requirements need to be met.

It is undeniable that the use of robots is gaining importance in the past years, and especially so in the health sector, in order to use personal assistive robots. These types of robots have navigation abilities that, unlike digital assistants, make them possible to approach people, move around the user's apartment or an area and prompt the user to interact with it in a socially engaging way by both verbal and non-verbal behaviours, like this also reducing loneliness. They can serve to remind people to do tasks, play games with them for entertainment or therapeutic purposes; carry out assessments, or monitor them through their cameras in order to detect anomalies. These robots have a set of sensors, such as cameras, to recognise and detect people and objects; map and navigate around an area; speech abilities, and, in the case of a manipulator, the ability to help in physical tasks like fetching objects. All in all, reducing the need of physical human-to-human contact.

In SHAPES, these robots will serve as communication means between other digital solutions such as speech recognition systems, vision-based systems, and the end-user, also adjusting the robot's behaviour and interaction to suit each use case. These solutions are presented from Section 2.3.3 to Section 2.3.10. In the next section, different solutions will be presented and the partner who is bringing the solution.

5.1 *ARI and TIAGo robots (PAL)*

PAL Robotics is offering two possible robots to SHAPES, the most suitable one of each user-case will be chosen based on the requirements of the pilot sites. In general:

- **TIAGo robot** for manipulation abilities and physical tasks
- **ARI robot** for cases where no manipulation is needed as it promotes further social interaction

Integration of SHAPES Digital Solutions onto the robot would be the same for both robots.

TIAGo (<http://pal-robotics.com/robots/tiago/>)



Figure 16 TIAGo robot, from PAL.

TIAGo (Figure 16) is provided with a mobile base, a lifting torso, a head, an articulated arm with a dexterous hand. TIAGo has a modular design and can be configured based on our customers' needs. The arm has a large manipulation workspace, being able to reach the ground as well as high shelves. The end effector can be a gripper or a humanoid hand and they can be quickly exchanged or substituted with a third-party development. TIAGo arm can be controlled in effort mode (Sensorless torque control) and if provided with the force/torque sensor it can be controlled with admittance control. The robot's arm has 7 degrees of freedom in total, including the 3 of the wrist. There is an option of 5 fingers underactuated hand or parallel gripper.

The robot can be used to provide a personal robot assistant that helps patients with a wide range of practical tasks, both in hospitals, rehabilitation centres and the patients' own home.

The robot can create a semantic map of the apartment to learn more about an object or a location. The robot can handle a set of known and unknown visitors, who will arrive individually at the home entrance and recognise people. The robot can provide general purpose requests of the person inside the apartment or day-care hospital, focusing on interaction as well as manipulation tasks, like fetching simple objects.

ARI Robot (<http://pal-robotics.com/robots/ari/>)



Figure 17 ARI robot, from PAL.

ARI is a high-performance robotic platform designed for a wide range of multimodal expressive gestures and behaviour, focused on social interaction. Its behaviour can be customized using the easy-to-use web interface provided.

ARI can be integrated with different speech recognizers like this enabling it to interact in many languages, recognize faces, make gestures, and show information/application on the touchscreen on its chest for user interaction and multimedia content, as well as being fitted with a voice and facial recognition system. It can locate itself inside a building and move around while avoiding obstacles in its path.

ARI is provided with a mobile base, torso with an integrated Linux-based tablet, two arms and a head with expressive gaze. It can be manufactured in different colours (e.g. orange, red, blue) and can be configured based on the needs of SHAPES - the touch-screen if needed can be positioned externally or with the option to remove it to facilitate its interaction. ARI's two arms are mainly to promote gesture-based communication.

ARI has navigation capabilities thanks to its Realsense D345 camera on its torso, using feature-based SLAM. ARI is also equipped with RGBD cameras and microphone array that can be used for vision and audio capabilities.

ARI comes with a comprehensive set of ROS software and documentation, specifically Ubuntu 18.04 and ROS Melodic, with the option to test the robot on simulation (Gazebo), like the TIAGo robot.

With an integrated NVIDIA Pascal GPU, it is a powerful platform that can be used to develop AI algorithms, and can be equipped with text-to-speech software and human face detection and tracking capabilities, to name a few examples.

As a social robot ARI can serve as a therapeutic assistant at hospitals, care-homes or end-user homes to foster social communication, reduce loneliness, stress, and

increase overall user entertainment. It can be connected to other AI systems, such as virtual assistants with robust natural language processing (NLP) systems, emotion and facial recognition systems, to engage in verbal communication and improve human-robot interaction. Thanks to facial recognition, the robot can authenticate the user and provide customized care.

Users can interact with ARI through its tablet, can use it to communicate with friends and family by video calls, and to play games such as cognitive games to improve their cognitive abilities. The caregiver can arrange an agenda for each user and input the user profile into the robot, so that the robot can provide personalized timely reminders -medical appointments, the need to play a specific game, and user-specific activities. ARI can help by creating a map of the user's apartment and locating different objects there, in order for instance to remind the user of their location and guide them around the house, or provide instructions on how to different activities that they may have trouble doing alone assistance in switching on new home devices, etc.

5.1.1 Technical specifications

TIAGo

- Mobile base has a Differential drive, Max speed of 1 m/s, operates in indoor environments.
- 15 Degrees of Freedom (without end-effectors), 7 DoF on each arm
- 64 cm diameter footprint
- 110-145 cm height
- 3 kg arm payload (without the end-effector)
- 87 cm arm reach (without end-effector)
- WiFi-Bluetooth connectivity
- 4-5h (1 battery) / 8-10 h (2 batteries) autonomy
- Sensors
 - Laser 5.6/10m / 25 m range, rear sonars 3x1 m range
 - Head RGB-D camera for perception
 - IMU
- Audio: 2-microphone array and 1 audio speaker
- Software: Ubuntu LTS 64-Bits, working on ROS (Robotics Operating System)
- Possible as add-on: different types of end-effectors, touch-screen, wrist sensoARI
- 165 cm height
- The mobile base with 2 differential drive wheels and 2 caster wheels, with maximum hardware velocity of 1.5 m/s, but due to the constraints of obstacle avoidance, for navigation it has a maximum speed of 0.5 m/s. Indoor environments, specifically flat ground

- 14 Degrees of freedom (Figure 18): 4 in each arm, 2 mobile base, 2 head, 1 each hand. Motion builder to create new robot motions and gestures to support its speech, touch-screen content and/or LED lights to improve interaction.

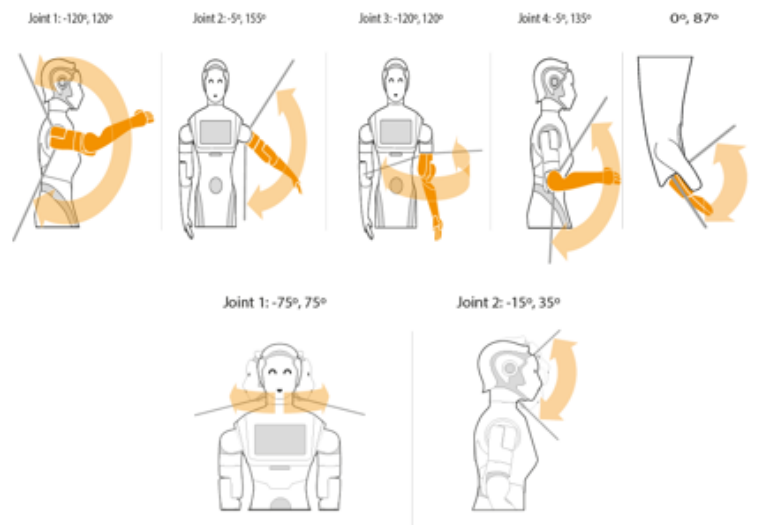


Figure 18 Degrees of freedom in TIAGo robot.

- Connectivity: WiFi, Bluetooth, Ethernet
- 0.5 kg arm payload
- 8-12 h autonomy
- Cameras
 - Head RGB camera: especially for perception
 - Torso RGB-D camera: used for autonomous navigation
 - Rear stereo-fisheye camera: Currently used for auto-charging behaviour and to be extended for navigation (localization).
- Audio: 4 microphone array, 2 speakers
- GPU: NVIDIA Jetson TX2, enabling the deployment of powerful AI algorithms
- Software: Ubuntu LTS, Robotics Operating System

Interfaces for interaction:

- Touch-screen: it has incorporated a 10.1" touch-screen working on Ubuntu, fixed on the torso. To display data:
 - HTML, CSS, Javascript or other Web-Technologies
 - Pictures loaded robot's WebGUI
- LEDs: 2 LED rings on each ear, and 1 at the back. Possible to adjust their intensity, colour
- LCD animated eyes: at the moment of writing, the eyes move randomly, but could be within scope of project to research how to combine with specific gaze behaviour



Figure 19 TIAGo robot: different components.

Set-up and input/output requirements for TIAGo/ARI:

- The robot can set up its own WiFi (access mode) but would need to be connected to an existing WiFi network (Client mode) like this interconnecting with other devices and SHAPES platform
- Charging area (room or protected small area)

Existing software implemented (TIAGo/ARI)

- Speech: right now, it is connected to an external TTS/ASR API: Google Speech API, and DeepSpeech. It uses Ubuntu's PulseAudio, with Acapela's TTS, to output speech. Possible to exchange to another speech assistant (e.g. digital solution of SHAPES)
- Auto-charging behaviour
- Perception: using the head RGB camera, default packages already installed include face recognition using Verilook Face SDK by Neurotechnology, people detection, basic object recognition, augmented reality marker detection.

5.1.2 Interfaces and interoperability

As input for this digital solution, it does not need anything to work off-the-shelf, as the robot is already equipped with some software packages that enable it to perceive people, objects, autonomously navigate, and speak. Its behaviour will be programmed for each particular user-case and based on the digital solutions that will be integrated in.

Integration with DS

The robots work on Robotics Operating System (ROS) and it is possible to code new programs using either Python or C++ as ROS packages. Digital solutions to be integrated onto the robot may be added as ROS nodes, specifying needed ROS messages and actions based on the required input from the sensors and output. For instance, in the case of a digital assistant, it will give as input the sound wave obtained from the robot's microphones (.wav format) and then output from the encapsulated ROS node, the text understood (string format).

The robot also has an extensive Rest API so that digital solutions may call its functions externally, enabling the use of other programming languages (e.g. Java, Android).

User interfaces

The functionality of the robot is dependent on the digital solutions to be integrated and the user-case, as it will be adapted to each case in particular. In general, users can interact with ARI/TIAGo through:

- Speech
- Touch-screen (for ARI)

In the case of ARI, the robot's behaviour can be customised so that it uses a combination of LED lights, gaze behaviour, arm gestures, and touch-screen to provide both verbal and non-verbal interaction behaviour.

The robot can approach the user in question or move around the house/common room using its autonomous navigation abilities.

5.1.3 Pilot themes

In bold are those confirmed to participate in.

PT1: Smart Living Environment for healthy ageing at home

PT2: Improving In-Home and Community-based Care

PT4: Psycho-social and Cognitive Stimulation Promoting Wellbeing

PT6: Physical Rehabilitation at home

5.1.4 Mock-ups

The robot's behaviour will be programmed to simulate different actions that they could perform as part of some user-cases and describes its own capabilities. For example,

in the case of PT1-002, the robot will be programmed to remind users to take medication, explain how to carry out a kitchen chore (e.g. make tea). It will not have other digital solutions integrated, and therefore will make use of its own text-to-speech system for speech production, and the conversations will be pre-organised, without including vision techniques. The goal will therefore be to show a sample output.

5.2 KOMPAÏ-3 robot (KOM)

KOMPAÏ robotics is offering its last generation of KOMPAÏ-3 robot to SHAPES in its two basic versions: EHPAD version and R&D version. The most suitable one of each user-case will be chosen based on the requirements of the pilot sites. In general:

- EHPAD version robot equipped with its walking assistance bars for physical tasks
- R&D version for cases where no physical tasks are required

Integration of SHAPES digital solutions onto the robot would be the same for both robots.

The Kompaï-3 robot is unique of its kind because it was designed with health organisations and only for them. It offers mobility assistance capacity, multiple functions, and numerous development possibilities.

Kompaï-3 robot was designed with two main objectives: to help care professionals in their repetitive daily tasks, but also to help patients, regardless of where they live.

5.2.1 Technical specifications

Figure 20 gives the main dimensions and volumes of the robot.

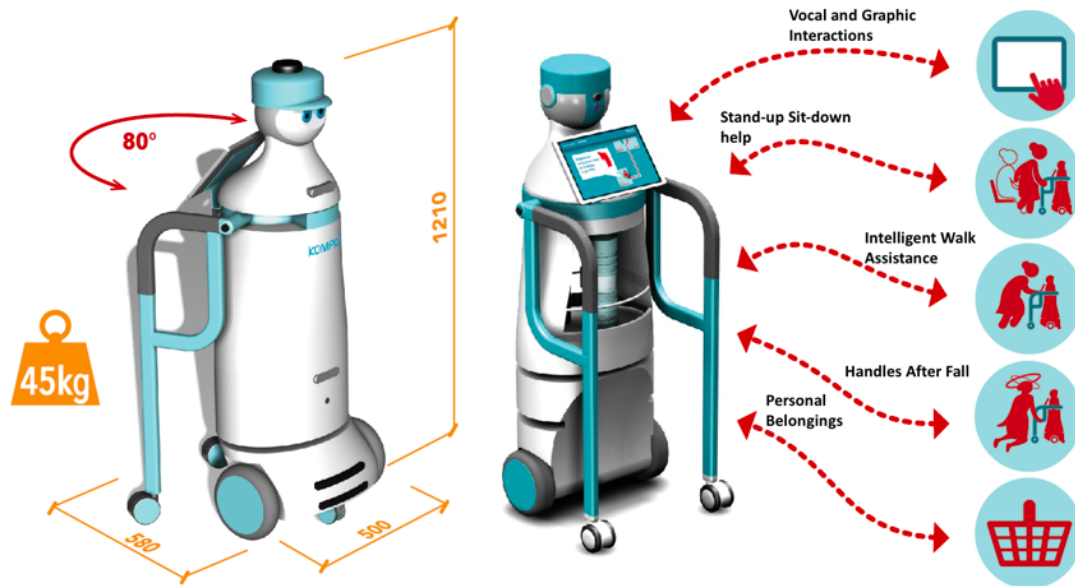


Figure 20 KOMPAĬ-3 robot: dimensions and volumes.

The main robotic components are:

- The rotating laser on the head, ensuring localization in a pre-recorded map
- Animated eyes, which can express many emotions, but also give indications such as malfunctions
- The call button emergency, which can send an SMS or an email to a remote assistance center
- The 3D camera, used among other things for obstacle detection
- The “fisheye” camera, used for taking control of the remote robot
- The low laser, which completes the 3D camera for obstacle management

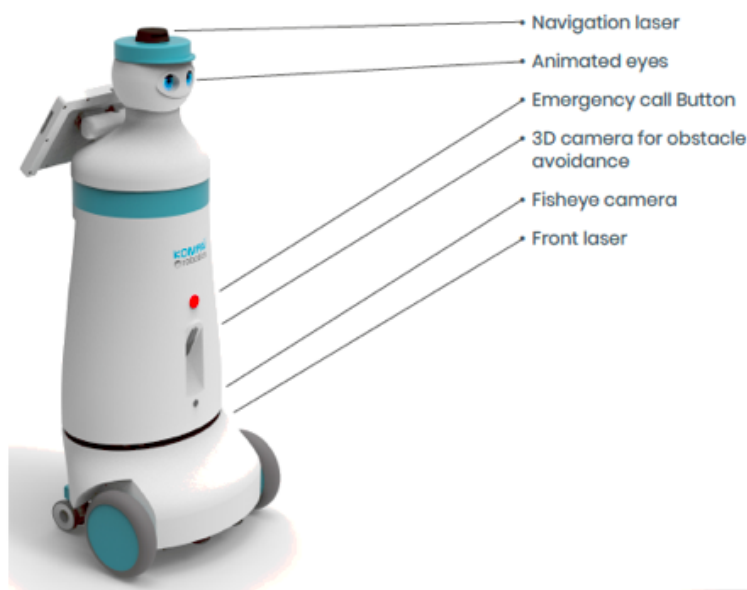


Figure 21 KOMPAĬ-3 robot components.

Table 11 Technical specifications

Functionality	Specifications Use
Cases	<ul style="list-style-type: none"> • Mobility aid with patented rotary bar • Individual and collective entertainment Animation, logistics, surveillance tours
Speed	From 0 to 2.3 m / s max, limited by software
Traction	2 AC motors (2x120W: continuous, 2 x 500W: at start-up)
Direction	By speed differential on the 2 motors
Dimensions	Height x Width x Length = 1210 x 500 x 580 mm
Clearance of obstacles (vertical step)	~ 2cm
Maximum slope	10%
Autonomy	Up to 6 h (depends on the use scenario)
Sensors	
navigation sensor	2D Laser above the head for mapping and localization
Obstacle detection	<ul style="list-style-type: none"> • The 2D laser above the head is used for the detection of high obstacles • A low 2D laser for the detection of low obstacles • A 3D camera that covers the entire front volume of the robot
Hole detection	2 at the front and 2 at the rear
Leg movement detection for walking	2D laser
Remote control assistance	Fisheye camera at the front
Assistance with automatic recharging	an IR locator at 180 ° placed on the docking station
Embedded	
Main controller	<ul style="list-style-type: none"> • computers NVIDIA Jetson TX2 card under Linux (256 core Pascal GPU @ 1.12GHz, ARMv8 Multi-Processor CPU @ 2GHz, 8GB LPDDR4, 32GB eMMC, WLAN) • Low level controller u PURE and software navigation
Human / Machine	<ul style="list-style-type: none"> • Tablet Size 13 "Windows 10 • Microphone • Speaker
Communication	<ul style="list-style-type: none"> • WIFI • 4G
Other	
Eye	<ul style="list-style-type: none"> • animated Eyes

The Kumpai robot is in accordance with the marking requirements of EC Machinery Directive 2006/42 / CE and ISO 13482-2014, basic standards for this type of product.

The two versions of the Kumpai robot are:

1) The R&D version

It is the modular version for all those who wish to customize their robot, whether mechanically or software:

- at the hardware level which through the walking assistance bar allows it to be entrusted with various missions (autonomous product transport, autonomous zone disinfection, etc.)
- at the software level thanks to the SDK which is supplied with the robot to develop any on-board or off-board application, in s 'pressing on http requests or URL access

Figure 22 shows the many possibilities offered to developers:

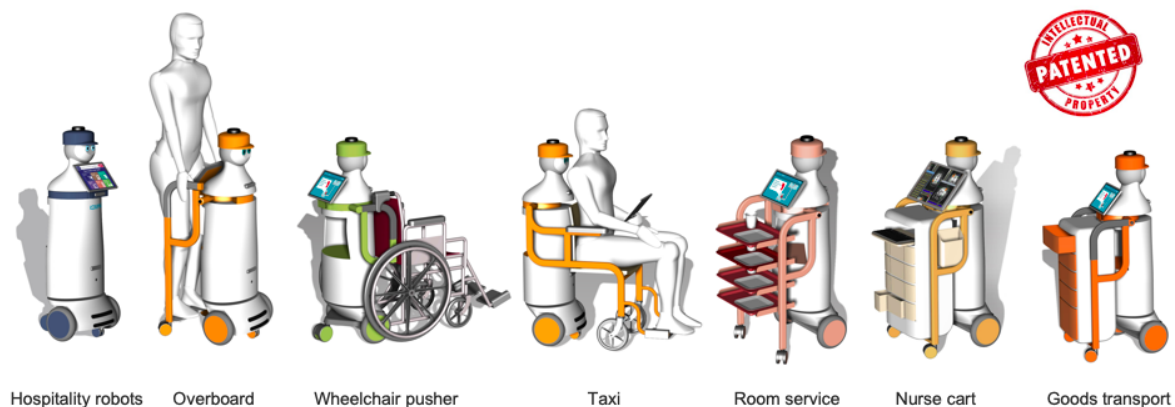


Figure 22 Different possibilities offered to developers.

Note that the R&D version can be delivered with or without assistance bar.

2) The EHPAD version

The version EHPAD is the same robot, but with application software specific to the needs of establishments.

These are the two basic functions of the EHPAD version:



Figure 23 Basic functions of the EHPAD version of Kompai.

- Mobility assistance to residents: Kompai can be used as an intelligent walker to help residents move around inside the building. It can adapt his speed to that of the user but also to assist him vocally and visually throughout his journey. Three assistance modes are available:
 - **Free mode**: allows a cognitively autonomous resident with slight physical difficulties to go where he wants with the help of the robot. Here the resident controls the speed of the stops as well as the trajectory. The number of steps taken is displayed on the robot to motivate residents to walk more regularly.
 - **Guided mode**: The robot takes the moderately autonomous resident physically and cognitively from a starting point to an ending point by following a trajectory established thanks to a map. It is the caregiver who sets the journey for the resident. The resident therefore has no control over the trajectory, but he/she can manage the speed and stops because the robot adapts to its walking. Like a GPS, the robot indicates the directions to take during the journey.
 - **Exercise mode**: to be used in the presence of a caregiver to do walking exercises. Several trajectories are possible (forward, backward, curves) and must be selected by the healthcare provider. The resident has no control over the trajectory, but he/she manages the speed and the stops because the robot adapts to its walking. The robot encourages users during their exercises.
- Rounds or tours: announcements, surveillance, animation: A tour is defined by a title and a launch time. It is a route from POIs to POIs (Points of Interest) to which the robot must go to take action. They can be:
 - **Announcements**: information given by hand beforehand by a caregiver
 - **Monitoring**: movement detection (ambulation of people), temperature controls, air quality control, doors open ... The idea is to patrol to detect possible anomalies and if so, send a screenshot to the guard to warn him.
 - **Activities**: broadcasting videos, music, audio stories, cooking recipes, etc.

Entertainment

The robot can be used to distract residents, individually or collectively.

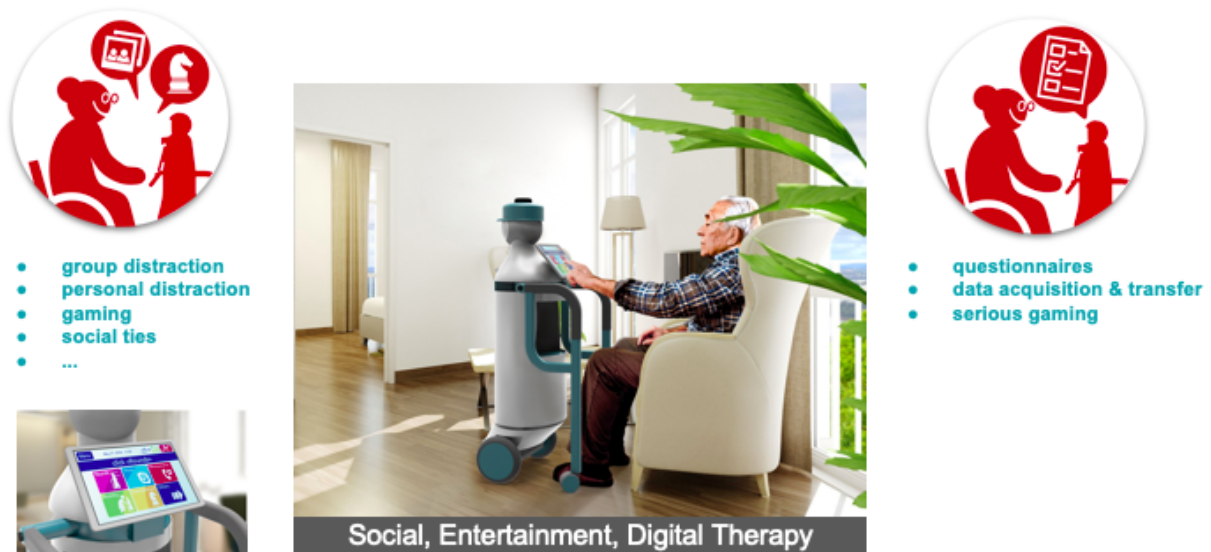


Figure 24 Kopaï as entertainment robot.

- **Individual:** entertainment Kopaï has a touch pad allowing the user to play games, see the weather, see the horoscope, talk to family via Skype, watch photos or videos, listen to music or audio stories. Thanks to facial recognition it is possible to offer personalized content for each resident. Thus, a resident will only see the horoscope and the photos that concern him. This scenario requires upstream work by caregivers to create content specific to each resident.
- **Collective entertainment:** Personalized content is not an obligation. Less personal photos and videos can be made available to all residents for collective use. Distraction sessions can be set up to entertain residents while the meal is being prepared, for example. Kopaï will be able to go around the common room and show videos / photos or read stories to residents. Similarly, collective games can be imagined and developed in partnership with caregivers. Kopaï can help organize quizzes, a Trivial Pursuit, a Bingo and even a gym class. Of course, the presence of another facilitator is essential for this scenario.

Operating interfaces

The EHPAD version, based on so-called “business” software, remains configurable by healthcare personnel, with simple and intuitive interfaces, requiring no IT skills. Figure 25, Figure 26 and Figure 27 are interface examples, while noting that these interfaces are constantly evolving.



Figure 25 Route monitoring interface.

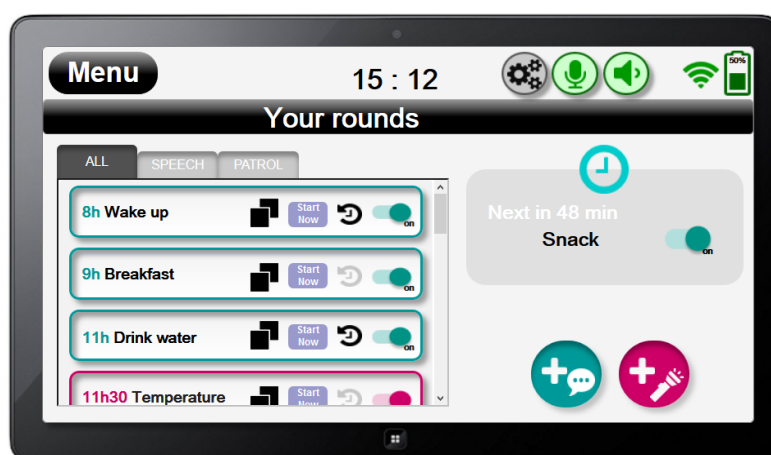


Figure 26 Route setting.



Figure 27 Emergency stop interface when the robot is in autonomous mode.

5.2.2 Interfaces and interoperability

Thanks to the SDK (Software Development Kit), the 2 versions (R&D and EHPAD) are customizable, directly by customers or by third parties. The robots are designed to be easily integrated into any IT architecture, thanks to the use of the latest web technologies. It is important to understand that these web technologies can also work on private local networks, without going through the internet.

All robot functionality is accessible by external applications via http requests. They also have an embedded web server that allows access to internal pages via URLs, from any browser (chrome, firefox, etc.).

The software architecture is summarized in Figure 28:

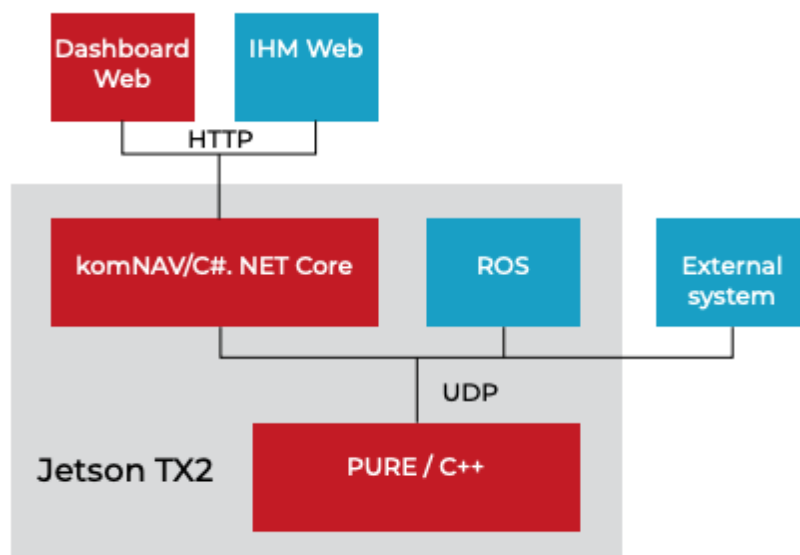


Figure 28 Software Architecture.

The technical interfaces are in the “Web Dashboard”, and the business interfaces in the “Web HMI”, the 2 accessible on the tablet equipping the robot (a Microsoft Surface).

It is also possible for developers to control the robot at its lowest level via the PURE UDP API (API provided).

5.2.3 Pilot themes

In bold are those confirmed to participate in.

PT1: Smart Living Environment for healthy ageing at home

PT2: Improving In-Home and Community-based Care

PT4: Psycho-social and Cognitive Stimulation Promoting Wellbeing

PT6: Physical Rehabilitation at home

5.3 *Sentiment Analysis (TREE)*

Non-verbal communication while doing activities is very important since it indicates the predisposition of the interlocutors or intention during a human interaction. A very representative part of this non-verbal communication is facial expression, and mainly, the expression of feelings (joy, sadness, etc.). However, the analysis of these sentiments by artificial systems (robots, apps) is complex due to the variability and subjectivity of these expressions. However, Tree Technology brings a digital solution for sentiment analysis which can detect the eight most representative facial expressions: joy, fear, disgust, sadness, anger, surprise and contempt.

As input for this digital solution, it needs videos of users interacting with the systems. These videos (or collection of images) must capture users from the front and a distance from the sensor (camera) that allows the visualization of facial details. This distance depends on the resolution of the camera so it cannot be defined a priori. As a reference, facial expression detection can be optimally performed with 720p resolution cameras from about two meters away.

There are two outputs from this solution: First, a file with information on the most probable facial expression (among 8 possible facial expressions) at each instant of the video (image). On the other hand, another file with temporal consistency (sliding window) of the expression made by the user.

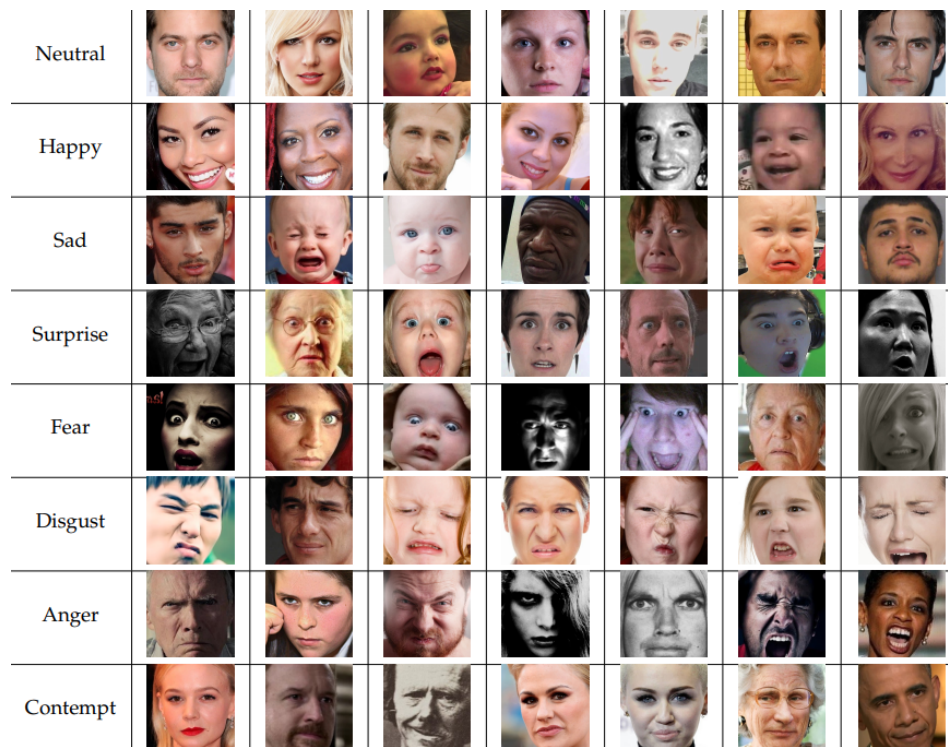


Figure 29 Sentiments detected by Sentiment Analysis Digital Solution.

5.3.1 Interfaces and interoperability

Two ways of communicating with the needed Digital Solutions are proposed. In the case of a robotic system, the encapsulation of the sentiment analysis system is performed as a ROS node, connectable by means of specific messages to the sensors (inputs) and the information managers (outputs).

In the case of an application, the system must present an API. This API must define the ingestion of data or how to introduce the images to the module, as well as the dump areas of information (processed data).



Figure 30 Sentiment analysis solution, from TREE.

5.3.2 Pilot themes

PT2-003 Cognitive and physical training

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

PT2-004a Night Surveillance Rounds at Community Care

PT2-004b Night Surveillance Rounds in the Home-Setting

PT4-002: Cognitive tasks

PT6: Physical Rehabilitation at Home, UC1 Training of orofacial musculature, UC2 Gait rehabilitation and UC3 3D Depth Camera Rehabilitation Tool.

5.4 *People detection and tracking (TREE)*

The detection and monitoring of individuals is a key piece for understanding the various activities and movements of people in certain environments. Naturally, these applications were widely embraced by video-security systems, as they allowed reducing the cost and effort of monitoring intrusions or other types of incidents, and health application as evaluation of performance during physical exercises. However, this technology which is very mature indoors and with favourable lighting conditions, has many applications beyond the detection of these events. For example, the control of patients in healthcare environments, market research (clients), etc.

The Digital Solution proposed aims to detect people and detection of the different performed activities in different supervised areas covert by CCTV and/or by integrated cameras in robotic platforms as well as their paths as long as they are visible by cameras. They can be used in video-surveillance and Health (Detection of daily routines, falls detection, to name some applications).

As input for this digital solution, it needs videos provided by the CCTV or video-surveillance system of the facilities or homes.

There are two outputs from this solution. First, the logs of detection of people, and second, the path of each detected person (tracking) (Figure 31).

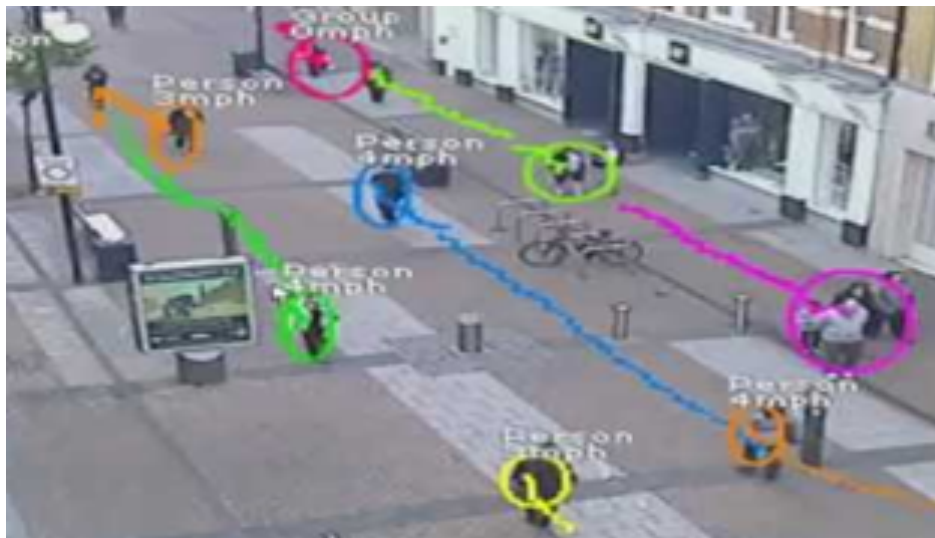


Figure 31 Example of people detection and tracking Solution.

5.4.1 Interfaces and interoperability

For the integration of these monitoring systems within video-surveillance systems, an API will be defined. This API must indicate the way to enter the images into the digital solution, as well as the storage areas for detection and monitoring logs of the detected people.

5.4.2 Pilots themes

PT2: Improving In-Home and Community-based Care, UC4a Night Surveillance Rounds at Community Care and UC4b Night Surveillance Rounds in the Home-Setting

PT4: Psycho-social and Cognitive Stimulation Promoting Wellbeing, UC2 Cognitive tasks.

5.5 User Engagement (TREE)

Knowing if users are engaged during activities or exercises performed at home has always been important for the supervisors of these activities. Currently, through the application of deep learning, we can make an objective quantification of commitment using various metrics. One metric is the attention. The attention is calculated by tracking the direction of the gaze during the activities and evaluate if it disperses outside the screen or area of attention. Other relevant metric is the drowsiness. This metric exploits the EAR (Eye Aspect Ratio) calculation to check when the user has their eyes open or closed, so we can realize if they are asleep or pre-sleep. Finally, the commitment is also relevant. The commitment exploits the valence and excitement metrics by classifying student expressions during class. The excitement represents

how happy/angry is the end-user while the valence indicates the interest during the activity. Merging these metrics, a level of real-time engagement while performing an activity is indicated.

The main objective is to study the users' engagement during the execution of different activities or exercises. This exercise is applied to education and health areas.

The inputs required for the digital solution are videos of users interacting with the systems. These videos (or collection of images) must capture users from the front and a distance from the sensor (camera) that allows the visualization of facial details. This distance depends on the resolution of the camera so it cannot be defined a priori. As a reference, facial expression detection can be optimally performed with 720p resolution cameras from about 2 meters away.

The outputs are three metrics to change how attentive and committed the user is during activities. These metrics are attention, sleepiness, and commitment.

5.5.1 Interfaces and interoperability

Two ways of communicating with the rest of the system are proposed. In the case of a robotic system, the encapsulation of the sentiment analysis system is performed as a ROS node, connectable employing specific messages to the sensors (inputs) and the information managers (outputs).

If we are in the case of an application, the system must present an API. Said API must define the ingestion of data or how to introduce the images to the module, as well as the dump areas of information (processed data/real-time engagement metrics).

5.5.2 Pilots themes

Two pilot themes were identified to use this DS:

PT4-002: Cognitive tasks

PT6: Physical Rehabilitation at Home, UC1 Training of orofacial musculature, UC2 Gait rehabilitation and UC3 3D Depth Camera Rehabilitation Tool.

5.5.3 Mock-up

The design of this solution will be shown as a dashboard (Figure 32). This dashboard will indicate, in real-time, the independently calculated metrics (at the top) and a summary of them on a timeline (at the bottom).

At the top, attention, engagement, and sleepiness will be indicated in this order. For attention, we will indicate the estimate of the point of attention (employing a bounding

box) on a heat map where the focus of the attention of the person who interacts with the system is represented.

In the case of engagement, the values of arousal and valence will be indicated. These combined values indicate the interest of the person during the interaction with the system and if said interaction is positive or negative.

Finally, for drowsiness, the frequency of the person's eye-opening is indicated. A person is drowsy when the opening frequency (blinking) falls or becomes zero (closed eyes).

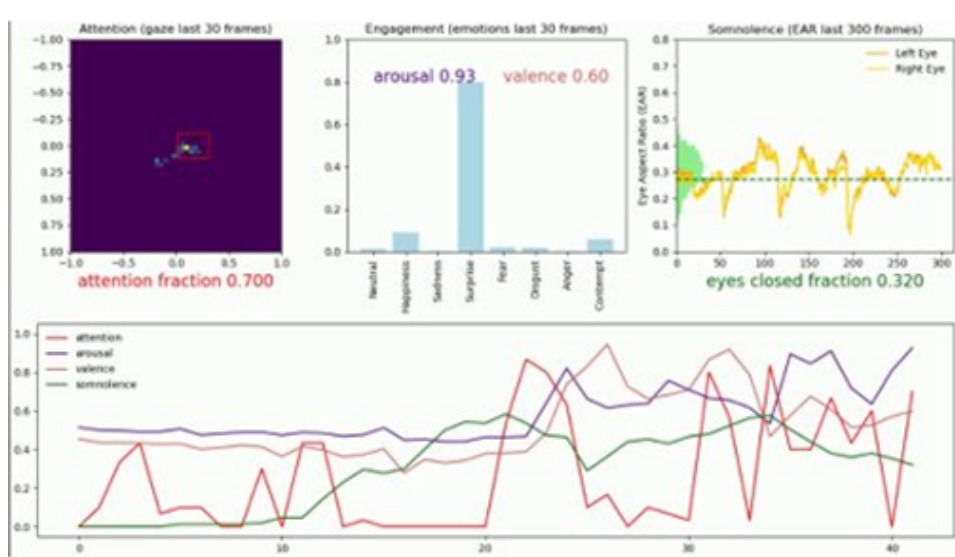


Figure 32 Example of the dashboard, resulting from the User Engagement Solution.

5.6 Emotion detection and gesture analysis (VICOM)

The most representative, “basic” facial expressions (joy, fear, disgust, sadness, anger, surprise and contempt) brought by TREE's digital solution for “sentiment analysis” (see Section 5.3) are suitable to check the predisposition of the interlocutors or intention during a human interaction or while using a specific Digital Solution. The digital solution brought by Vicomtech for “emotion detection and gesture analysis” focuses on detecting emotions and gestures from facial images beyond the “basic” facial expressions, i.e., more “fine-grained” dimensional emotions, following the Valence-Arousal-Dominance (VAD) model, and other kind of facial gestures that do not necessarily relate to facial emotions, usable for other kind of applications, such as rehabilitation. The VAD model maps emotional states to an orthogonal dimensional space, with measurable distances from one emotion to another. Since dimensional models pose an emotion as real-valued vector in the space, it is likely to account for subtle emotional expressions compared to categorical models which employ a finite number of “basic” emotions. With dimensional VAD models, capturing fine-grained emotions could benefit clinical natural language processing (NLP) researches,

emotion regulation as a psychotherapy research and other works in computational social science fields dealing with subtle emotion recognition.

It relies on multi-tasking of Deep Neural Networks (DNNs), i.e., several facial attributes are estimated from one forward pass of the DNN, which allows the efficient deployment of the digital solution in low-resource devices.

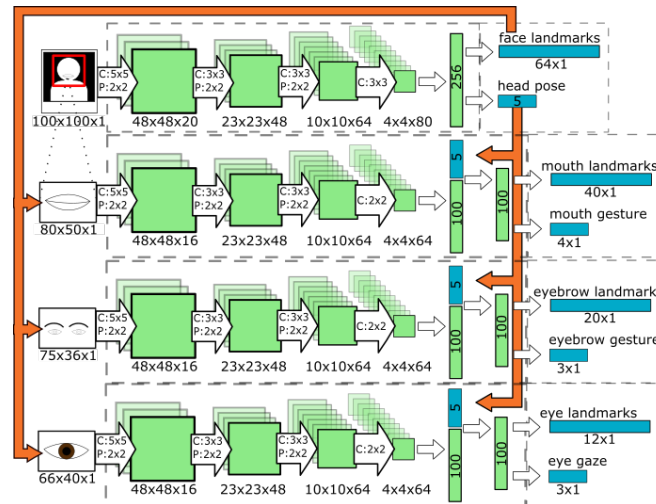


Figure 33 A depiction of the kind of DNN-based multi-tasking approach for emotion detection and gesture analysis of the digital solution.

5.6.1 Interfaces and interoperability

This digital solution is a functionality from Vicomtech's Viulib library (<http://www.viulib.org/>). It has C++ and Python APIs that allow building apps that would run this functionality locally (i.e., no cloud support required for the calculations).

The C++ API of the library is ready for the following computing platforms:

- Desktop and laptop PCs with Windows, Mac or Linux operating systems.
- iPhone and Android mobile phones and tablets.
- Embedded systems, such as NVIDIA Jetson boards.

The Python API is ready for PCs and NVIDIA Jetson boards.

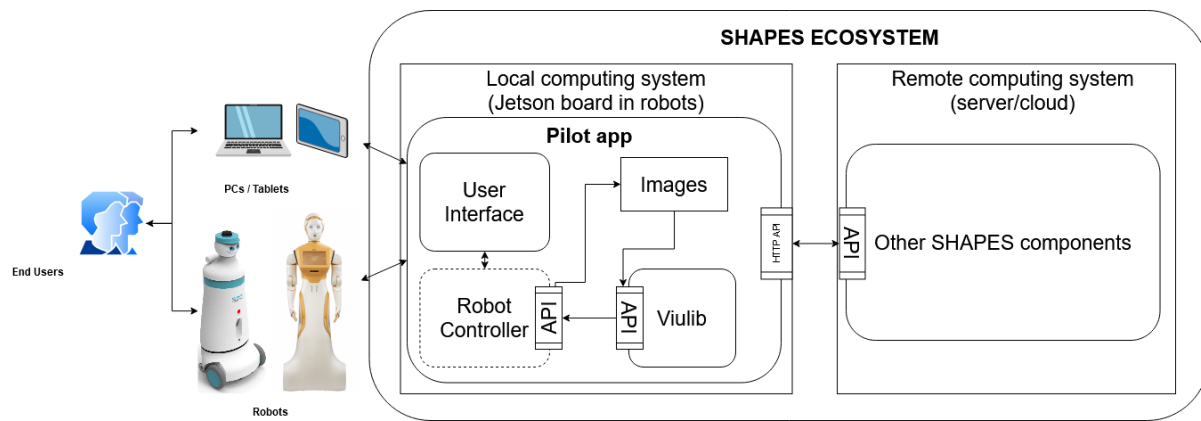


Figure 34 The proposed interoperability mechanisms to integrate Viulib functionalities in the SHAPES ecosystem.

5.6.2 Pilot themes

PT2-001: Monitoring of health parameters

PT6-001: Training of orofacial musculature

PT6-003: 3D depth camera rehabilitation tool

PT7-001: Monitor older patient with chronic disease when travelling abroad

PT7-003: Preventing and/or handling a medical emergency while visiting another country

5.6.3 Mock-ups

The pilot front ends are still to be designed, considering not only what output data the digital solution can provide, but also the expected interaction with the final users in each case, which might be different for each pilot. Nevertheless, here we show some examples of the kind of visual feedback that is used to analyse the results obtained by the digital solution.

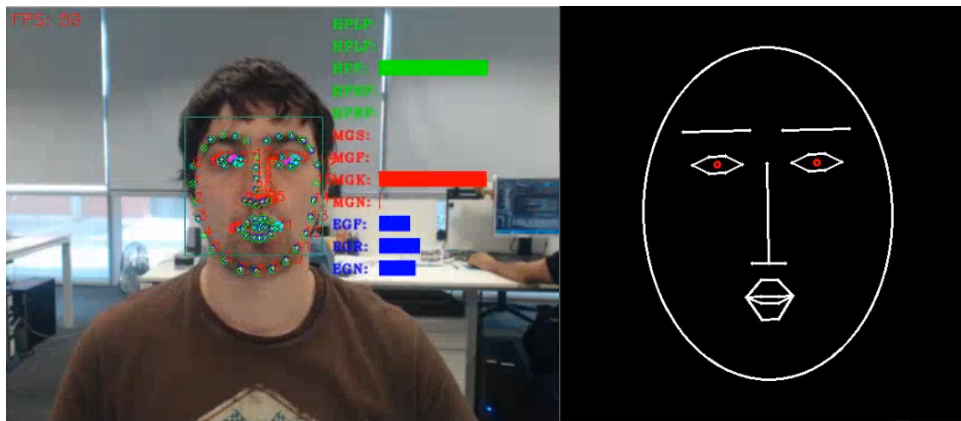


Figure 35 Example of visual feedback with the kind of data obtained from the digital solution to analyse the obtained results.

Here, the considered facial gestures are modelled as bars whose width change dynamically, in real time, depending on the intensity of the performed gesture. This dynamism allows animating in real time a parameterized generic avatar to show the resulting gesture without considering any other effect from the user's facial appearance. This allows us comparing better the user's gesture with respect to another one of reference not performed by the same user. This could be useful, for example, in applications for rehabilitation.

5.7 Facial recognition (authentication) (VICOM)

This digital solution allows recognizing user identities, based on their facial images, captured from video-cameras, image files or video files. It relies on a set of Deep Neural Networks (DNNs) that extract representative and privacy-preserving i-vectors from facial images. The involved image processing stages are the following:

1. Faces “in the wild” are detected in captured images.
2. Facial landmarks from the cropped facial images are detected to estimate the user's facial shape.
3. Facial image textures are normalized to minimize the impact of environmental and behavioural effects (illumination, image quality, distances from the camera, poses, expressions, etc).
4. Representative and privacy-preserving i-vectors are extracted.

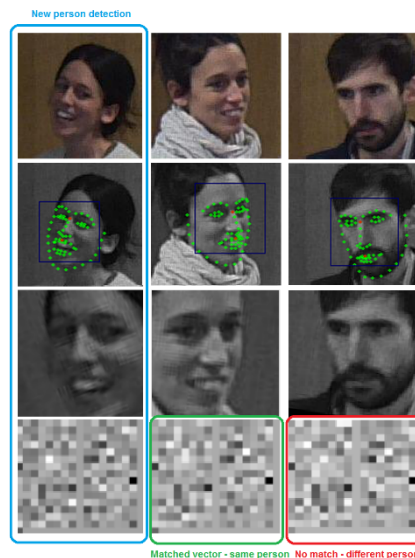


Figure 36 Examples of the image processing stages: From top to bottom rows: (1) face detection, (2) shape estimation, (3) facial texture normalization, and (4) i-vector extraction.

No facial images are stored, neither during the user registration process, nor during the surveillance/authentication process, only the extracted i-vectors are used. The user's facial images cannot be obtained from the extracted i-vectors, as these i-vectors are constructed by learning facial cues from facial image datasets built without any of the final users involved. Thus, the user's privacy is totally preserved.

5.7.1 Interfaces and interoperability

This digital solution is a functionality from Vicomtech's Viulib library, and therefore it can be integrated in the same way as the digital solution for "emotion detection and gesture analysis" described previously.

5.7.2 Pilot themes

PT2-001: Monitoring of health parameters

PT2-004a: Night surveillance rounds at community care

PT2-004b: Night surveillance rounds in the home-setting

PT4-002: Cognitive tasks

PT6-001: Training of orofacial musculature

PT6-002: Gait rehabilitation

PT6-003: 3D depth camera rehabilitation tool

PT7-001: Monitor older patient with chronic disease when travelling abroad

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

PT7-003: Preventing and/or handling a medical emergency while visiting another country

5.7.3 Mock-ups

The pilot front ends are still to be designed, considering not only what output data the digital solution can provide, but also the expected interaction with the final users in each case, which might be different for each pilot. Nevertheless, here we show some examples of the kind of visual feedback that is used to analyse the results obtained by the digital solution.

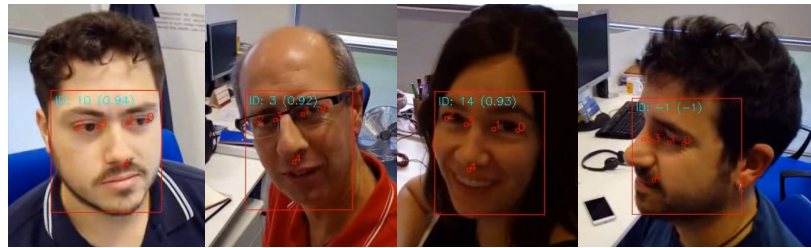


Figure 37 Examples of visual feedback with the kind of data obtained from the digital solution to analyse the obtained results.

Here, the output of the digital solution is depicted with a bounding box on the detected facial image, a few key facial landmarks and two numbers that indicate the detected identity number (an integer number) and the authentication score (a floating point number from 0 to 1). In case that the person is detected but not authenticated a -1 number is delivered (as shown in the last image of Figure 37).

5.8 Safe Digital Assistant and NLP (VICOM)

This section presents the Chatbot & NLP digital solution, its detailed technical description, the available interfaces, expected use cases, and an illustrative mock-up of two of the main skills: reminders and periodical follow-ups. Although this solution is being included under Task 5.4, it could be included under various tasks.

A chatbot is an interactive solution that can comprehend the end-user intention in natural language, plan the next response according to some domain knowledge and give the appropriate response. They are widely used due to their naturalness and frictionless communication with the end users.

The objective of the DS described here is to provide simple, transversal, modular and customizable solutions to satisfy the demands raised by the SHAPES consortium, lowering the gap of the technical skills required to build a chatbot as much as possible. To that end, a Skill based approach is selected.

A Skill is a specific functionality of the Chatbot, e.g. weather forecast, which allows to have a customizable “recipe” to adapt to each possible Chatbot, highly reducing the time and effort required to build these systems.

The skills that are identified are listed below, but due to the dynamic nature of the project they could be adjusted, changed or replaced by other ones:

- **Reminders:** be able to set different types of reminders by the caregivers (water intake, pill intake, cultural activities, ...) so the system can have the required initiative.
- **Periodic follow-up:** be able to make follow-ups periodically with a sort of pre-defined question types (evolution, scoring 1-5, and so on), setup alarms and register and store this information for further analysis.
- **Forms/Questionnaires:** be able to identify frequent questions and gave them the appropriate answer.
- **FAQs:** define frequently asked questions and their answers.
- **How-to:** gave the assistant the ability to guide the end users through a procedure of multiple steps.

5.8.1 Technical specifications

The technical information is summarized in the table below:

	Adilib Skills
Goal	Add a certain functionality to the Chatbot
Operating System	Ubuntu
Deploy method	Docker
Hardware requirements	TBD
Web Interface	Yes
HTTP Rest API for Developers	Yes
Connects via	API with Adilib Core
Persistence	MongoDB/Customizable
Data-dump	None/TBD
Requires SHAPES Ecosystem	Yes
Required Info from SHAPES	Bridge user identifiers Store information Skill configuration Personalization
Interfaces to add External Modules	Customizable (but HTTP REST APIs preferred)
Malleability¹	Very High
Scalability	Vertical

Overall, both Adilib Core and Adilib Skills work as a black box which communicates using JSON style messages following the REST properties. Note that they need to be

¹ Degree of possible adaptations/adjustments.

The communication with the Chatbot is done via WS, so any front-end type can interact with the Chatbot. Two persistence layers appear in the Adilib Core, the MongoDB where the dialogue sessions are stored and the ElasticSearch data-dump, where the information of the conversations and dialogues is stored.



The consumption of other services & Adilib will be done using HTTP REST API protocols, and the communication with the Skills will be handled by an internal Skill API. The whole Adilib Core and Adilib Skill is intended to be a black box.

As each Skill will be customizable for each individual (see Mock-up section), the skills will require to access certain information which can be stored in a MongoDB that each skill has or in other persistence layer in the SHAPES ecosystem. As illustrative example, the following items will be needed:

- **User profile and identifiers:** to determine its channel identifier, assigned follow-ups/reminders, and so on. For example, if a question arrives from “user10” the Chatbot has to retrieve if “user10” has any reminder or pending task.
- **Configurations:** of each skill, reminder types, questions to ask, follow-up templates and so on.

5.8.2 Interfaces and interoperability

Denoting as “interface” every mechanism that will allow external users to gain access/control or modify the behaviour of the Adilib Core/Skills, i.e. having a significant impact on the behaviour of the Chatbots, the following interfaces are identified:

- **WebSocket communication with Adilib:** Main communication channel to talk with the Chatbots deployed in production.
- **Adilib User Interface:** this web-interface allows to train the main technological modules of the chatbot, define interaction rules, deploy model, open channels such as the WebSocket and so on. This is intended to use by the Chatbot developers, as it requires a deep knowledge on the topic.
- **Skill User Interface:** this web-interface allows to modify the behaviour of the skill, adapting and personalizing it to each UC and, if it is necessary, to each user. This interface is intended to be used by the UC integrators, the caregivers and non-technical staff. See the Mock-up section for an illustrative example.
- **Skill HTTP REST API:** Optional. This API will be exposed for Skills that could require a programmatical integration with other services so the Skill could be configurable with automatisms.
- **Adilib Chatbot HTTP Client:** The Chatbots have a HTTP REST Client mechanism that allows to interact with external services and middleware to integrate information and knowledge into the Chatbot process. For example, to generate an adequate response for the question “What will the weather be in Sydney tomorrow?” the chatbot will have to communicate with a Weather API and provide it with the right information (location and time).

Voice Layer

The voice layer is the service which grants access to Speech Recognition and Text to Speech synthesis. The languages provided by Vicomtech are Spanish and English.

To access these services an HTTP REST API/Socket will be made available, integrating the following mechanisms:

- **Recognize:** send an audio file and receive the transcription.
- **Synthesize:** send a text and returns an audio

Other connection types/custom APIs/Bridges or mechanisms will be determined according to the needs expressed by the different UCs

5.8.3 Pilot themes

The summary of the UCs that have demonstrated interest on integration this DS are here:

- PT1: UC1 Remote In-Home Wellbeing Monitoring and Assessment, UC2 Digital Assistant to Support Older People to Live Independently and Remain Socially Connected
- PT2: UC 001 Monitoring of health parameters
- PT3: All use cases: general, UC1 In-home decompensation prediction for heart failure patients and UC1c Advanced telemonitoring of patients with heart failure in home environment
- PT4: UC2 Cognitive tasks
- PT5: UC2 Digital Assistant for Older People with Mild Cognitive Impairment
- PT6: UC2 Gait rehabilitation

Note that the goal of VICOM will be to provide as much coverage as possible to the several UCs that have shown interest on digital assistants.

5.8.4 Mock-ups

This section describes the ongoing work on the development of two principal skills:

1. Reminders: where the caregivers can set-up reminders of certain events (birthdays, social events, drug intakes, follow-ups etc.)
2. Follow-up: the caregiver can determine a set of questions to ask to the user personalizing to each one of them and set up alerts if some score is too low.

These two skills have been merged, so a follow-up can be set-up as a reminder. The initial screen shows a calendar where scheduled reminders and events are shown.

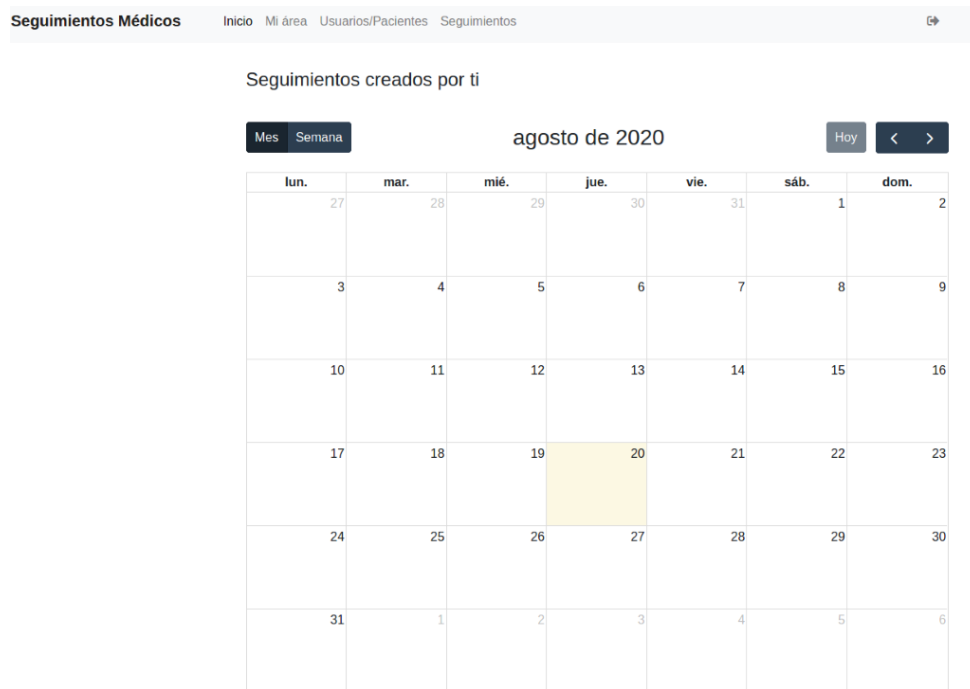


Figure 39 Reminders and Follow-up features in the Assistant Solution.

The users section provides a simple mechanism to log user profiles, with their name, surname(s) and nicknames (very common in Spain in older generations, where compound names like María Josefa tends to be called like Marijo or Josefina).

The current version needs to be adapted so it can handle real SHAPES users and their data-format. As an important note, as the chatbot/virtual assistant needs to link the user identifier that comes from the messaging channel (i.e. WhatsApp) with the user profile, some unique identifier is needed, in this mock-up the phone number is used. In other words, the Chatbot needs to know with who it is talking, if the received user identifier cannot be matched with the profiles that stored in our database; no personalized follow-up or reminder can be set.

Inicio Mi área Usuarios/Pacientes Seguimientos

Gestionar usuarios/pacientes

Añadir un nuevo perfil de usuario/paciente

Nombre* Dialogue

Apellido(s)* Systems

Vocativo Josema

Número de teléfono (asociado a Telegram)* +34666666666

Crear nuevo perfil

Figure 40 Management of users.

In Figure 41 a user is created, for the Dialogue Systems Research line of Vicomtech.

Inicio Mi área Usuarios/Pacientes Seguimientos

Gestionar usuarios/pacientes

Añadir un nuevo perfil de usuario/paciente

Dialogue Vicomtech

Figure 41 Creation of a new user.

Once that the user is created, we can build a personalized follow-up (Figure 42) by defining:

- Name: Name of the follow-up
- Associated patients: user profiles which will be asked
- Date beginning/end: days where the follow-up needs to be reminded.
- Hour: at this time the reminder will be started by the Chatbot.
- Alert criteria: if some response have a low value, send an alert.
- Questions: the questions to perform by the system in the follow up.
 - Question text: free text to be defined by the caregiver.

- Expected response: constrained expected response type to be selected
 - Dual: yes/no
 - Tripe: yes, no, I don't know/Maybe
 - Comparative: better/equal/worse
 - Scoring: 1,2,3,4,5
 - Free text: anything that the user wants to log.

Inicio Mi área Usuarios/Pacientes Seguimientos

Seguimientos

Crear nuevo seguimiento

Nombre del seguimiento e.j. seguimiento estándar covid

Pacientes asociados* Nothing selected

Fecha de comienzo*

Fecha de finalización*

Hora* --:--

Enviarme una alerta si una puntuación es baja ☐

Alertar si puntuación es igual o menor que:*

Lista de preguntas que hacer al paciente durante el seguimiento (mínimo una):

Pregunta #1

Texto de la pregunta*

En comparación al día de ayer, ¿hoy te encuentras mejor, peor o igual?

Tipo de respuesta esperada*

Puntuación: 1, 2, 3, 4, 5


Crear nuevo seguimiento

Figure 42 Personalised follow-up.

Once this is created and saved, it will be shown in the calendar (Figure 43). At the determined date and time, the Chatbot will start a conversation with the end user (here using Telegram).

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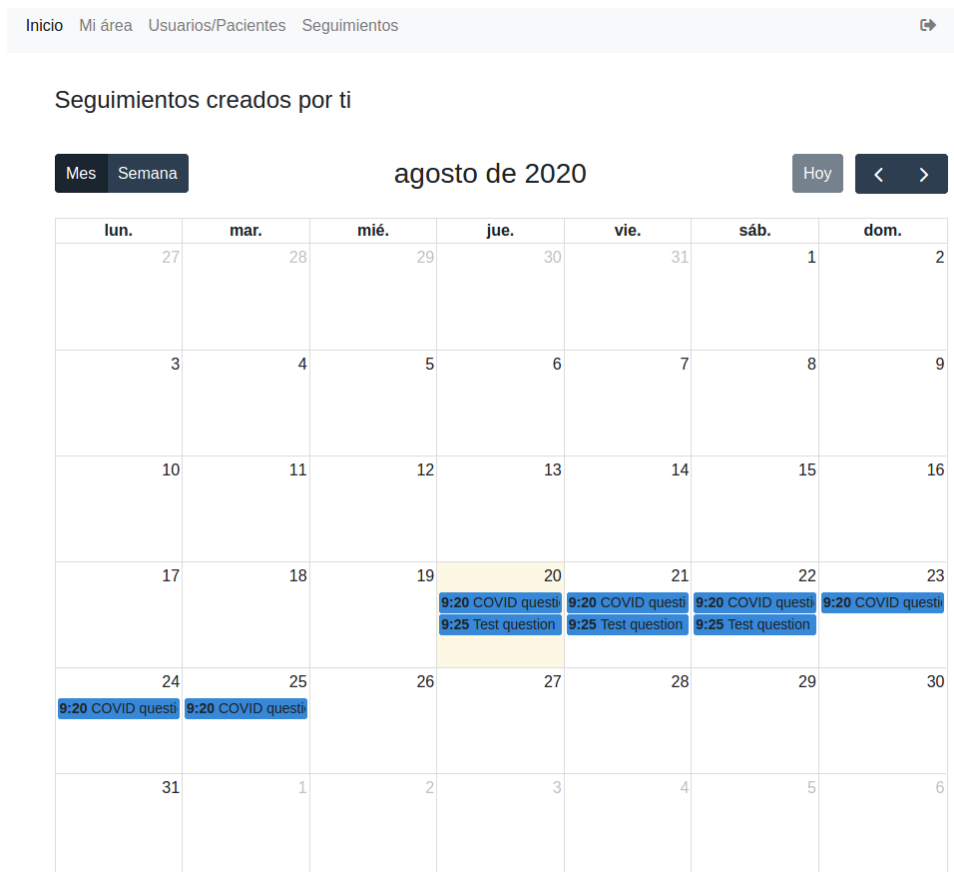


Figure 43 Calendar.

Chatbot greeting the user:

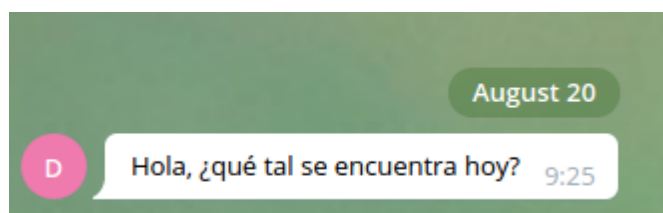


Figure 44 Interaction between the chatbot and the user.

Interacting with the user using the defined questions:

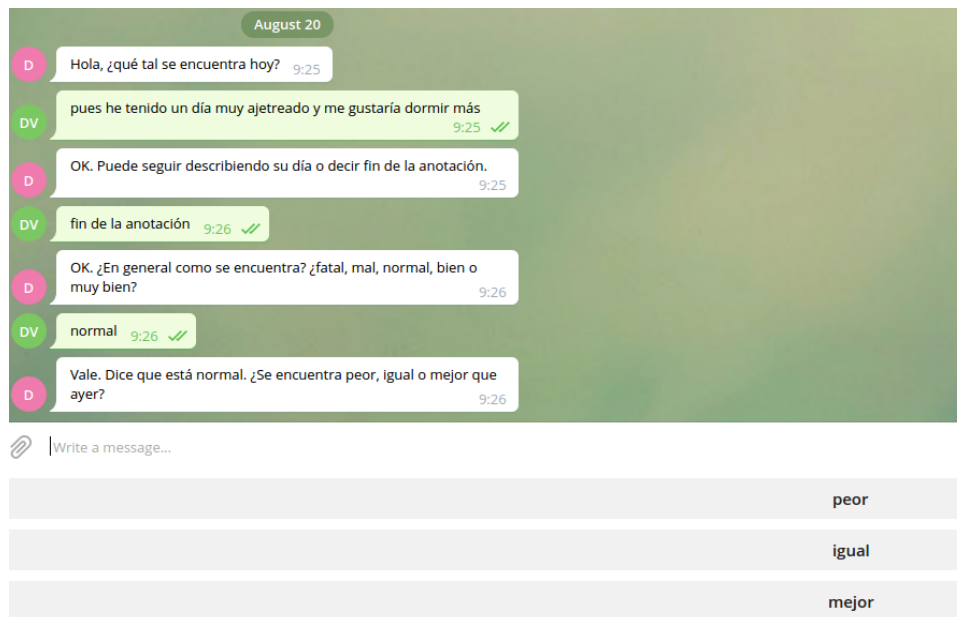


Figure 45 More examples of interactions between the chatbot and user.

When this is finished, the Chatbot will say goodbye to the user and exit the skill.

5.9 NewSum Mobile Application (SciFY)

NewSum automatically summarizes information from many sources and combines them in a single text. It gives you the main points of all the different information that you would get if you read all the articles from the sources you visit. With the use of artificial intelligence technology, news is summarized, and all repeated information is not duplicated. NewSum is an open source project and is offered for free without ads. The New Sum App will be adapted to incorporate elder-oriented content on local and national news feeds and social networking feeds and interactions.

NewSum is available in English and in Greek.

5.9.1 Technical specifications

NewSum runs on mobile phones running Android operating system. The application is built using the Java programming language.

5.9.2 Interfaces and interoperability

Interface: Smartphone

The user can:

- choose from a plethora of news categories

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- see news, for each category, that were gathered from multiple sources (like news websites, RSS feeds, etc) and summarized by AI
- click on an article and see the summary
- see the sources that were used for each news article
- share the summary on social media
- select favourite news categories
- select from which news sources they would like to receive news

5.9.3 Pilot themes

Pilot 2 Improving In-Home and Community-based Care

5.10 eCtouch (OMN)

Omnitor eCtouch app for computers, tablets and smartphones. eCtouch is an accessible Total Conversation communication software for Windows, iOS and Android. eCtouch supports assistive technologies such as screen magnifiers, screen readers and Braille devices.



Figure 46 eCtouch DS, from OMN

Data Category	Measurements Type	Collection Method
Internet Data	Contacts Settings SIP registration & calls Connection status	Automated (from connected devices)

Data to Industrial Devices	Can be connected to NOTiFY	Automated (from connected devices) or manual
Data from Industrial Devices	Calls from other SIP-based units	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances Service appliances	Automated (from connected devices)

5.10.1 Technical specifications

Omnitor eCtouch uses VoIP protocol (RFC 3261) to create a call session. During calls, the protocol dynamically allocates UDP ports for media. The ports range from 35000 and 40000 server sided.

A restrictive firewall rule could be achieved with limitation to communication with Omnitor's SIP server, which is located at a specific IP. The ports that are needed for the server are 35000 – 40000 UDP and 5060, 443, 80 TCP.

In summary, the technical requirements of eCtouch are:

- eCtouch Android

Minimum Android 6, 2,3 GHz quad-core processor and 3 GB RAM to handle HD-video.

The camera needs to support a resolution of QVGA, VGA, 720p with 25fps minimum.

A built-in speaker and microphone are recommended.

IP network Wi-Fi 802.11b, 802.11g or 3G/4G. At least 1000 kbit/s both upstream and downstream is recommended for good video quality. 2 MBIT/s is required to handle calls with HD video.

- eCtouch iOS

Minimum iOS 13 and up. The oldest supported hardware is iPad 2017 (gen 5) and iPhone 7.

The camera needs to support a resolution of QVGA, VGA, 720p with 25fps minimum.

A built-in speaker and microphone are recommended.

IP network Wi-Fi 802.11b, 802.11g or 3G/4G. At least 1000 kbit/s both upstream and downstream is recommended for good video quality. 2 MBIT/s is required to handle calls with HD video.

- eCtouch Windows

Minimum Intel i3 processor and 2 GB RAM to handle HD-video.

The camera needs to support a resolution of QVGA, VGA, 720p with 25fps minimum.

IP network Wi-Fi 802.11b, 802.11g or 3G/4G. At least 1000 kbit/s both upstream and downstream is recommended for good video quality. 2 MBIT/s is required to handle calls with HD video.

5.10.2 Interfaces and interoperability

General Description	<ul style="list-style-type: none"> • Omnitor eCtouch app for computers, tablets and smartphones, accessible Total Conversation communication software for Windows, iOS and Android • eCtouch support assistive technologies such as screen magnifiers, screen readers and Braille devices.
Features	<ul style="list-style-type: none"> • Citizens with disabilities (often elderly) that need an accessible remote communication solution. Used at work and home by the citizen with a disability for daily communication with friends, family, colleagues, authorities, customers. • eCtouch is an accessible Total Conversation (RTT, video, audio) app (Windows 10, Android, iOS) for deaf, hard of hearing, deafblind, vision impaired, speech impaired individuals. • Support assistive technology such as screen magnifiers, screen readers, braille devices. • Follows the SIP-standard and works together with remote interpretation services e.g. for sign language. • Independence and well-being, cost reduction for society – individuals with disabilities are able to work.
Application Areas	<ul style="list-style-type: none"> • Conversation tool (app)
TRL	From TRL9
Data Type	XML
Inputs	Contacts, App settings
Outputs	Call logs, Chat logs, App settings
Actions to be performed	<ul style="list-style-type: none"> • Users will be able to contact each other with the eCtouch app. • The user could also add a NOTiFY to their eCtouch which would enable them to have e.g. a flashing light when they have an incoming call.
Interface	PC, smartphone, tablet

5.10.3 Pilot themes

PT1-003 - Competent usage of digital technologies

PT2-001 - Monitoring of health parameters

PT7-001 - Monitor older patient with chronic diseases when traveling abroad

PT7-002 - Foster older people's (with physical disabilities) independent living by identifying accessible locations and routes in other locations (domestic and abroad)

PT7-003 - Preventing and/or handling a medical emergency while visiting another country.

6 Decision Support, Risk Assessment and Prediction Services (Task 5.5)

Although T5.5 has not officially started yet, some preliminary discussions were held around the different solutions SHAPES project will integrate related to Decision Support, Risk Assessment and Predictions, while designing the different use cases of the project. In this section, a summary of these different solutions is presented. It is important to stress these Digital Solutions are dependent on the data collected during the project, so this first approach can be modified as the project evolves.

Predictive systems have been used and continue to grow in use in healthcare systems for early identification of patients at high risk (or at the beginning) of suffering an adverse event or disease, allowing for a proactive approach by healthcare staff and patients. They can help predict the onset of diseases and adverse events for patients with long-term diseases, allowing for early treatment and prevention measures that could improve people's health and lower healthcare costs. Risk assessments can be used to determine the likelihood of a patient to contract a particular disease in the future, enabling the patient and medical staff to take measures early on for prevention. Decision support systems use clinical knowledge, patient and other health information to improve healthcare delivery and quality.

In situations of real-time monitoring of older adults, prediction and analytics services can detect abnormal signs, allowing doctors to know when to perform further tests and provide advice and support in relation to the results or even suggest medication.

In the next section, different Solutions will be presented as well as the partner who is bringing the Solution.

6.1 *Prediction of exacerbation/ chest infection in patients with COPD (TREE)*

Exacerbations in Chronic Obstructive Pulmonary Disease (COPD) are a worsening of the COPD symptoms commonly caused by an infection in the lungs or airways. Exacerbations can lead to physician and hospital visits and can cause long-term declines in lung function and health. The ability to predict an oncoming exacerbation could mitigate the impact of exacerbations on the health of the patient. Tree Technology can provide a predictive algorithm that can predict in advance the onset of an exacerbation of COPD (contingent on data availability for predictive model training).

The input for this digital solution would be the relevant daily vital signs of users that would be collected using sensors. The output would be an alarm for when an

exacerbation is predicted to occur in the next day(s) and the level of risk of an exacerbation in the next day(s).

6.1.1 Pilot themes

PT3: Medicine Control and Optimisation

6.2 *Prediction of Hypo/hyperglycaemic events in T2D patients (TREE)*

In type 2 diabetes (T2D) hyperglycemia and hypoglycemia occur when there is too much sugar or too little sugar in the bloodstream. Having high blood glucose levels can cause short and long-term complications, for example increases in the risk of organ damage. Low blood glucose levels if severe enough can also have serious health implications. Being able to predict in advance of a hypo- or hyperglycemic event allows the diabetic person to take in advance measures to prevent the event, improving health outcomes in the long and short term. Tree Technology can provide a predictive algorithm to predict hypo- and hyperglycemic events (contingent on data availability for predictive model training).

The input for this digital solution would be the self-monitored twice-daily glucose measurements along with other information over physical activity, diet, etc., if available. The output would be an alarm in the case of a predicted event and the risk level.

6.2.1 Pilot themes

PT3: Medicine Control and Optimisation UC general Supporting multi-morbid older patients

6.3 *Fall detection using wearable data (TREE)*

Falls can be critical to the health of older persons resulting in injuries, loss of autonomy and death. The rapidness of the medical response and first aid treatment when an older person falls can have a large impact on its severity. For this reason, having a fall detection system can be useful in reducing the negative impact when an older person falls. Tree Technology can provide a fall detection system to alert caretakers and/or medical staff when an older person has suffered a fall, so that they can take the needed actions.

The input for this digital solution would be the sensor data from wearable sensors (for example, a sensor placed on the waist). The output would be an alarm in the case of a fall.

6.3.1 Pilot themes

PT6-004 Wearable Motion Monitoring Device.

6.4 *Major Adverse Cardiovascular Events (MACE) risk prediction in T2D patients (TREE)*

Major adverse cardiovascular events (MACE) can include myocardial infarction, stroke, unstable angina, heart failure and cardiovascular death. Patients with type 2 diabetes have a two- to threefold higher risk of suffering from MACE than non-diabetic patients. In addition, the important indicators for predicting MACE can be different for patients without diabetes. For this reason, a specific prediction for these patients can be useful. Tree Technology (TREE) can provide a predictive algorithm to predict MACE in T2D patients.

The input for this digital solution would be the relevant daily vital signs of users that would be collected using sensors and patient information. The output would be an alarm for when MACE is predicted to occur and the level of risk of an exacerbation.

6.4.1 Pilot themes

PT3: Medicine Control and Optimisation UC general Supporting multi-morbid older patients

6.5 *Prediction of risk of Type 2 Diabetes (TREE)*

Type 2 Diabetes (T2D) is the most common type of diabetes and most often occurs in middle-aged and older adults. The prevalence of T2D is expected to increase as life expectancy increases. If not treated properly diabetes can cause serious health problems, such as heart disease, stroke, kidney disease and eye problems. Risk assessments for diabetes can be very helpful in giving people and medical staff an advanced warning such that the person can take preventive measures to try to decrease his/her risk. Tree Technology can provide a predictive algorithm to predict T2D.

The input for this digital solution would be the relevant vital signs of users that would be collected using sensors and patient information. The output would be the risk level for a person of T2D.

6.5.1 Pilot themes

PT3: Medicine Control and Optimisation.

6.6 *Visual Analytics (VICOM)*

Due to the limited time of clinicians to explore data, it is essential to give them intuitive and fast tools to interpret them. In this context, visual analytics (VA) is the science of displaying information through interactive interfaces focused on analytical reasoning [3]. Analytical reasoning is the ability to detect patterns within the data and to gain deep insights by looking at the representation of large amounts of data. One of the most widespread criteria for classifying the visualization types is the dimensionality of the visualization, that is, the number of attributes that allows to show. Univariate visualization -one dimension- is the simplest form of data analysis and its goal is to gain insight about the distribution, the central tendency and the spread of an attribute. On the other hand, the main objective of the multivariate visualization -two or more dimensions- is to allow the analysis of the relationship or interaction between attributes.

Thus, Vicomtech provides a VA tool to explore different metrics that provide the evolution of patients (Figure 47), statistical results of patient characteristics and patterns (Figure 48).

DESIREE - Visual Analytics Dashboard

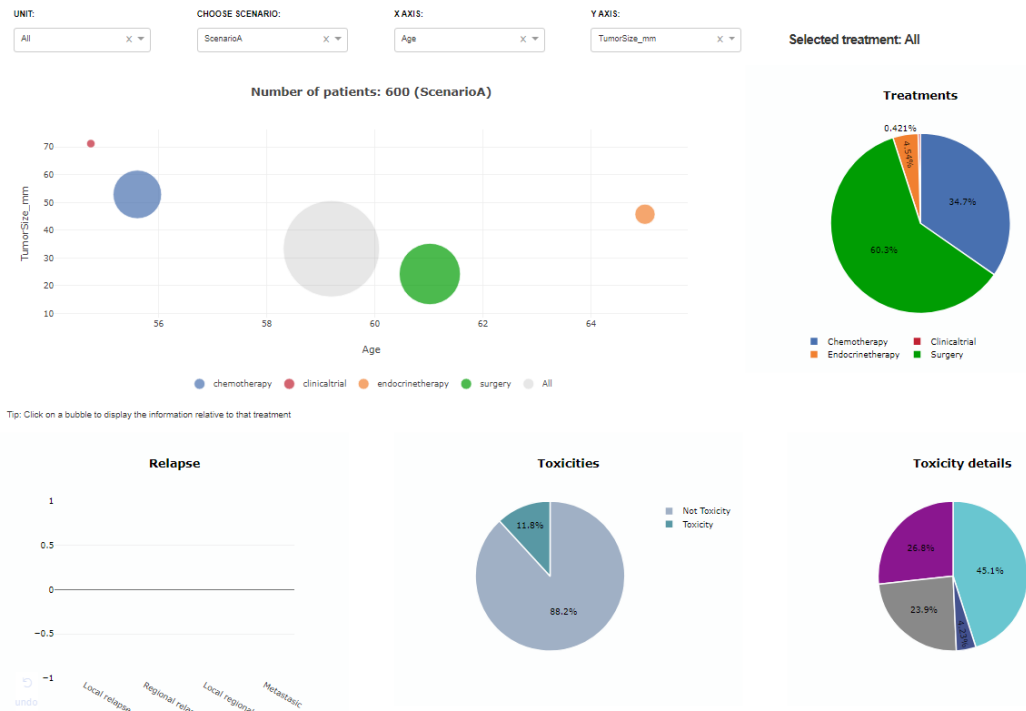
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Figure 47. Visual Analytics for Statistical Results

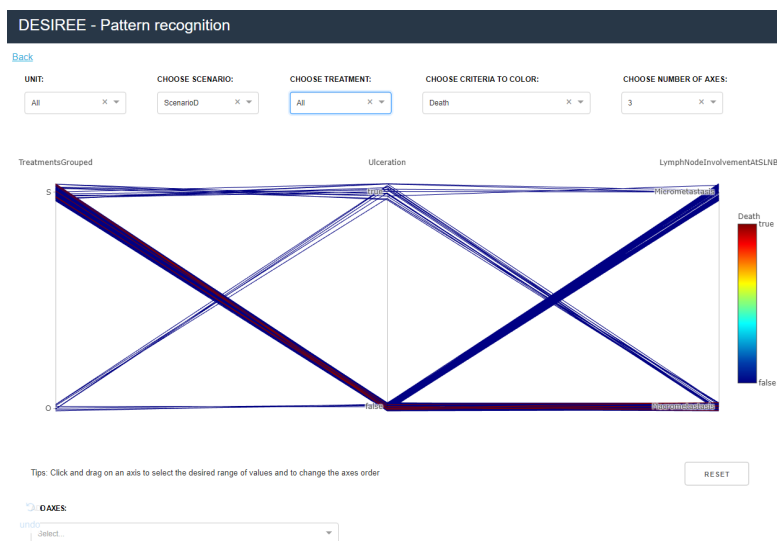


Figure 48. Visual Analytics for Patterns

6.6.1 Pilot themes

PT1: Smart Living Environment for healthy ageing at Home

PT2: Improving In-Home and Community-based Care

PT3: Medicine Control and Optimisation

PT4: Psycho-social and Cognitive Stimulation Promoting Wellbeing

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

PT6: Physical Rehabilitation at Home

PT7: Cross-border Health Data Exchange

6.7 Model-driven Decision Support System (VICOM)

Clinical Practice Guidelines (CPGs) are paper based documents reporting latest evidence-based recommendations in order to (i) support clinicians during decision making process, (ii) reduce clinical variability, (iii) improve clinical outcomes and (iv) reach a more efficient healthcare service. For their best implementation, Clinical Decision Support Systems (CDSS) are promoted which need from the digital version of the CPGs to be able to reason and provide the recommendations that best fits the studied patients. Nonetheless, this implementation process of transforming the paper-based guidelines into computer interpretable guidelines is tedious for the complexity of the medical language and the variability and complexity of the structuration of the clinical information. Moreover, it is capital to record the made decisions since the compliance of clinicians with the guidelines depends on a number of factors including their own experience and preferences but also patients' preferences.

Hence, taking into account all the identified difficulties for developing a CDSS based on modelled knowledge and independent from big quantities of clinical data, Vicomtech has developed a tool, named eHST, which provides an intuitive and easy-to-use authoring tool that helps clinicians, along with knowledge engineers in the process of digitalizing clinical protocols and maintaining them up-to-date with latest evidence (Figure 49).

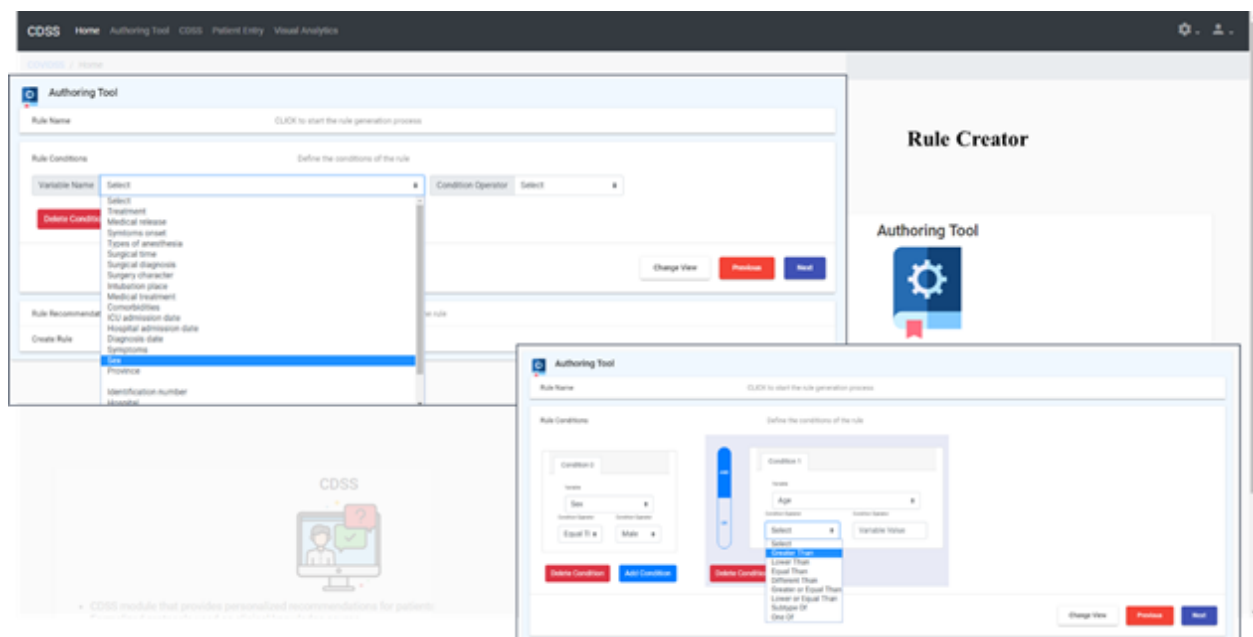


Figure 49 The authoring tool of the eHST from Vicomtech.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Moreover, a rule engine is integrated to make available instantly the formalized rules for any analysed patient.

Finally, a decisional event structure has been formalized too in order to register all made decisions and identify and justify guideline compliance deviations for generating new knowledge in rule form that will cover those gaps in the guidelines and also to study the impact of those decisions through clinical and patient-based outcomes.

6.7.1 Pilot themes

PT1: Smart Living Environment for healthy ageing at Home

PT2: Improving In-Home and Community-based Care

PT3: Medicine Control and Optimisation

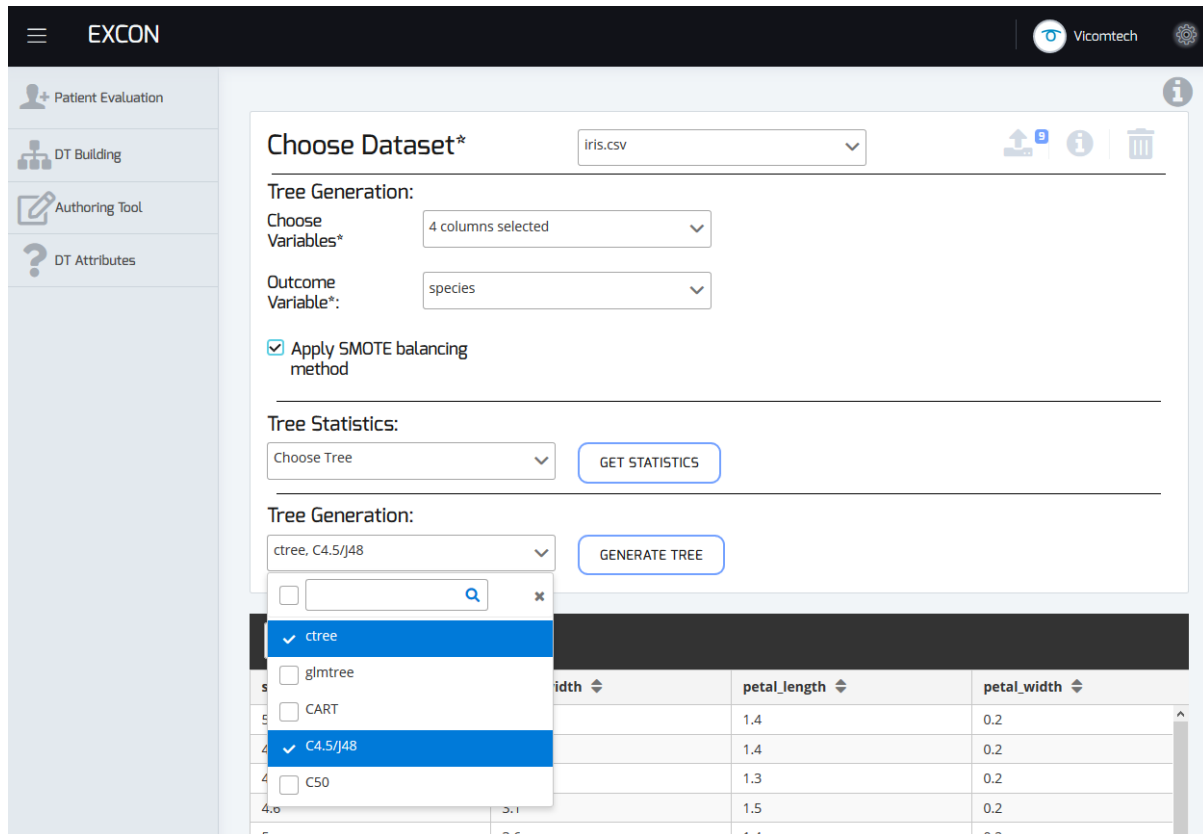
PT7: Cross-border Health Data Exchange

6.8 *Data-driven Recommendation system (VICOM)*

Advances on ICT have given a huge opportunity to telemedicine applications and new e-Health services. Along with this phenomenon is the large quantities of mobile data that are being collected and processed these days. The growth in these two areas are leading in advanced healthcare systems that not only provide continuous support to clinicians or informal care givers (e.g. family members), but also to patients. In this context, telemedicine systems that monitor ambulatory patients and guide them in their daily routine are emerging. Nevertheless, often all the potential of the health data is not sufficiently exploited. Other times the exploited clinical data, in the form of, for example predictive models to identify patients at high risk, is not applied in a real setting to support clinicians and patients.

Therefore, Vicomtech offers an automatic artificial intelligence tool by means of predictive models that can improve several pathologies. In particular, we can offer a tool for the automatic generation of decision trees automatically.

For this automatic generation of decision trees is necessary to load any set of structured data (see Figure 50).



width	petal_length	petal_width
1.4	1.4	0.2
1.4	1.4	0.2
1.3	1.3	0.2
1.5	1.5	0.2
1.4	1.4	0.2

Figure 50 Data-driven Recommendation System

Once the tree has been generated, clinicians can edit the tree according to their knowledge and patient characteristics. This way clinicians can prepare decision trees for those cases in which there are no protocols or elaborated guides, but we do have a considerable volume of data. To facilitate editing and taking into account its impact, the tree is visualized with colours, observing how the objective variable varies throughout the nodes (see Figure 51).

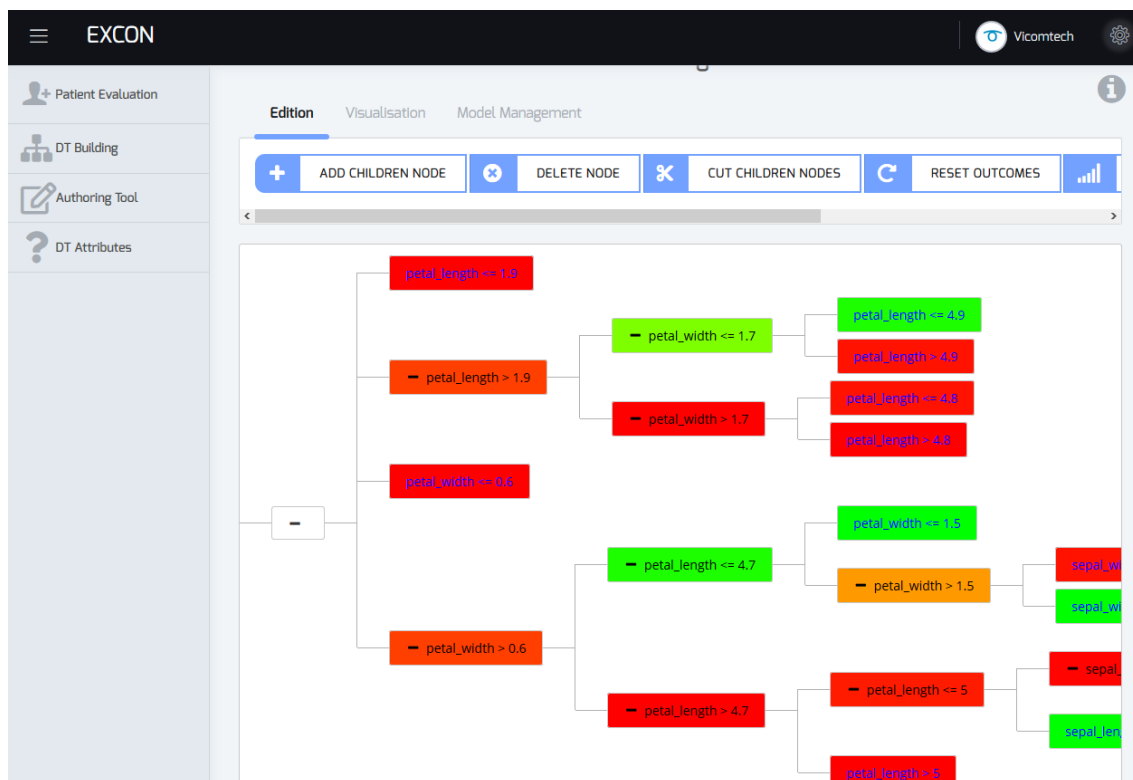


Figure 51 Authoring Tool for Data-driven Recommendation system.

6.8.1 Pilot themes

PT1: Smart Living Environment for healthy ageing at Home

PT2: Improving In-Home and Community-based Care

PT7: Cross-border Health Data Exchange

6.9 Heart failure decompensation predictive module (VICOM)

Heart failure (HF) is a clinical syndrome caused by a structural and/or functional cardiac abnormality. HF patients suffer decompensations, which is defined by Mangini et al.[4] as a clinical syndrome in which a structural or functional change in the heart leads to its inability to eject and/or accommodate blood within physiological pressure levels, thus causing a functional limitation and requiring immediate therapeutic intervention. Hence, decompensations may lead in hospital admissions, which in this study are defined as emergency admissions and hospital admissions, and home interventions. As Ponikowski et al. presented in a paper [5], the prevalence of HF depends on the definition applied, but it is approximately 1-2% of the adults in developed countries, rising to more than 10% among people >70 years of age. Hence, due to the aging population, an increase in the number of HF patients is expected in the future. Therefore, predicting the risk of a patient to suffer a decompensation may

prevent admissions and readmissions, improving both patient care and hospital management, which has a high impact on costs and clinical professionals' time. The first step to predict the risk of decompensation is to telemonitor ambulatory patients. Next, we need reliable systems to assess the risk. Most telemedicine systems apply alerts or rule-based systems to detect potential complications of ambulatory patients [6][7]. But these usually contain large number of false alerts, and hence, these systems are not trustworthy.

Therefore, it is key to use current AI solutions to develop predictive models in this context. Vicomtech, together with the public health service of Basque Country (Osakidetza), Hospital Universitario de Basurto from Bilbao (Spain) have developed a predictive model based on mobile clinical data of 242 heart failure (HF) patients collected for a period of 44 months [8].

The input for this digital solution is baseline data (i.e., information collected by a clinician when the patient is diagnosed (Table 12), ambulatory patient monitored data (i.e., information collected from three to seven times per week, Table 13 and Table 14), and patients' admissions information (i.e., emergency admissions, hospital admissions, and home care interventions that are associated to HF associated with a patient decompensation).

Table 12. Baseline Characteristics of the Study Population for HF Predictive Model

Characteristics	Description	Median \pm SD/ percentage
Age	The age of the patient (years)	78 \pm 10.9
Height	The height of the patient (mm)	162.37 \pm 10.34
Sex	The sex of the patient (men/women)	57% men
Smoker	If the patient smoke, did smoke and now do not or never has smoked	15.35% do smoke, 22% did smoke (not now)
LVEF	Left Ventricular Ejection Fraction (%)	42.4 \pm 15.21
First Diag	Years since first diagnosis	5.8 \pm 7.04
Implanted device	If implanted device (pacemaker, implanted cardioverter defibrillator, cardiac resynchronisation therapy)	22.7%
Need oxygen	If the patient needs oxygen	4.7%
Barthel	Barthel Scale	82.98 \pm 15.23
Gijón [25]	Socio-family assessment scale in the elderly that allows the detection of risk situations or social problems.	7.47 \pm 2.29
<i>Laboratory</i>		
Urea	Urea (mg/dl)	75.12 \pm 37.8
Creatinine	Creatinine (mg/dl)	1.3 \pm 0.54
Sodium	Sodium (mEq/L)	140.12 \pm 4.14
Potassium	Potassium (g/dl)	4.28 \pm 0.74
Haemoglobin	Haemoglobin (g/dl)	13 \pm 9.6
<i>Comorbidities</i>		
Rhythm	If sinus rhythm, AF or atrial flutter	Sinus: 37.1%
Atrial Fibrillation	If the patient has atrial fibrillation (AF)	57.4%
Pacemaker	If the patient has a pacemaker	14.5%

Table 13. Ambulatory Patients Monitored Characteristics of the Study Population for HF Predictive Model

Characteristics	Description
SBP	Systolic Blood Pressure (mmHg)
DBP	Diastolic Blood Pressure (mmHg)
O2Sat	Oxygen Saturation (%)
HR	Heart Rate (bpm)
Weight	Body weight (Kg)

Table 14. Ambulatory Patients Questionnaire for HF Predictive Model

n	Tag	Question	Possible Answer
1	<i>Well-being</i>	Comparing with the previous 3 days, I feel:	B/W/S*
2	<i>Medication</i>	Is the medication affecting me well?	Yes/No
3	<i>New Medication</i>	During the previous 3 days, did I take any medication without my clinicians' prescription?	Yes/No
4	<i>Diet and exercise</i>	Am I following the diet and exercise recommendations provided by my clinician and nurse?	Yes/No
5	<i>Ankle</i>	In the last 3 days, my ankles are:	B/W/S*
6	<i>Walks</i>	Can I go walking like previous days?	Yes/No
7	<i>Shortness of breath</i>	Do I have fatigue or shortness of breath when I lay down in the bed?	Yes/No
8	<i>Mucus</i>	Do I notice that I started coughing of with phlegm?	Yes/No

The predictive model obtained is a combination of alerts based on monitoring data and a questionnaire with a Naive Bayes classifier using Bernoulli distribution. This predictive model performs with an AUC= 67%, and reduces the false alerts per patient per year from 28.64 to 7.8. This way the system predicts the risk of admission of ambulatory patients with higher reliability than simple alerts. It provides a risk score from 0 to 100, divided in three terciles: from 0-33% low risk, from 34-66% medium risk, and from 67-100% high risk.

This HF predictive model service will be made available through an API to other SHAPES digital solutions that request the risk score from a patient.

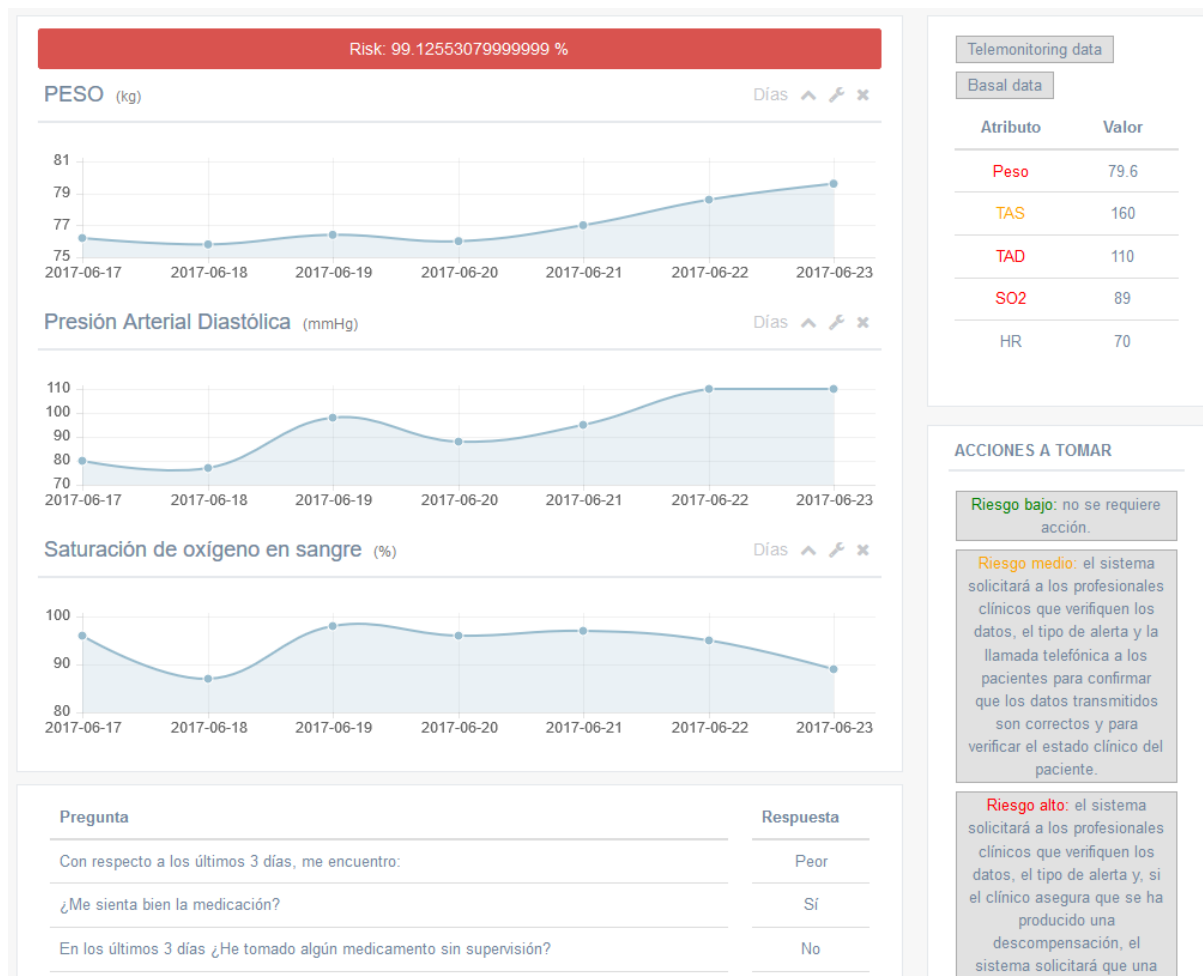


Figure 52 Visualization of HF Predictive Models.

6.9.1 Pilot themes

PT2: Improving In-Home and Community-based Care

PT3: Medicine Control and Optimisation

PT6: Physical Rehabilitation at Home

PT7: Cross-border Health Data Exchange

7 Solutions for Health and Care Service Providers (Task 5.6)

Aside from the obvious benefits for older individuals looking for digital support for an active and healthy ageing and independent living, SHAPES's digital solutions are also important for caregivers and health and care providers, who benefit from the connected SHAPES digital solutions to improve the delivery of health and care to older individuals whenever required, especially for those living in remote locations (e.g., rural areas).

In particular caregivers and health and care service providers can leverage digital solutions in order to:

- a) remote monitor the progress of the patients and alleviating the need of unnecessary physical visits,
- b) create and assign treatment plans to the patients and be alerted automatically when a critical condition occurs,
- c) schedule and carry out online appointments via the video consultation feature.

In the times of COVID-19, utilising such solutions becomes even more imperative since it can greatly reduce the physical visits to the hospital which increase the risk of infection and also the workload of the healthcare professionals.

This section lists the Digital solutions that the caregivers and health and care professionals and service providers will use via the SHAPES platform.

Some solutions that fit this category were already presented in a previous one. To avoid replicating content, a list of the solutions is presented below, together with the Section in this document where the information is available:

- eCare Platform: Section 3.2
- dianoia mobile application and dianoia marketplace online platform: Section 4.2

7.1 *eHealthPass – Web Application*

eHealthPass web application is used by clinicians and healthcare professionals, allowing them to directly connect with patients, to schedule appointments, to validate monitoring data, to review and update treatments as required and to follow up on patients' activities and progress. eHealthPass web application is used in conjunction with the eHealthPass mobile application which is the interface of the patients.

Features

- Treatment plan
- Appointments
- Questionnaires
- Medication prescription
- Video consultation
- Charts for visualising the patient's progress
- Personal notes
- Virtual Community portal
- Education material and activities
- Reporting data to national registry (optional for COVID-19)

Application areas

- Chronic disease management: Diabetes, Chronic pain
- Teleconsultation
- Patient's remote monitoring
- Emergency scenarios and unplanned care
- Medical tourism
- COVID-19 self-management

7.1.1 Technical Specifications

eHealthPass web application is available via all popular browsers such as Chrome, Safari and FireFox. The backend platform is built around the FHIR leading medical interoperability standards and utilizes a fully compatible FHIR server. In addition, several IOT devices are integrated either via Bluetooth with the mobile application or via 4g cellular network and cloud services directly with the FHIR server.

7.1.2 Interfaces and how stakeholders are placed

The main interface is the web application which is accessible via a browser. This interface is used by the physicians and nurses that monitor the progress of the patients.

7.1.3 Pilot themes

Pilot Theme 1 - Smart Living Environment for healthy ageing at Home

Pilot Theme 2 - Improving In-Home and Community-based Care

Pilot Theme 3 - Medicine Control and Optimisation

Pilot Theme 5 - Caring for Older Individuals with Neurodegenerative Diseases

Pilot Theme 7 - Cross-border Health Data Exchange

7.1.4 Mock-ups

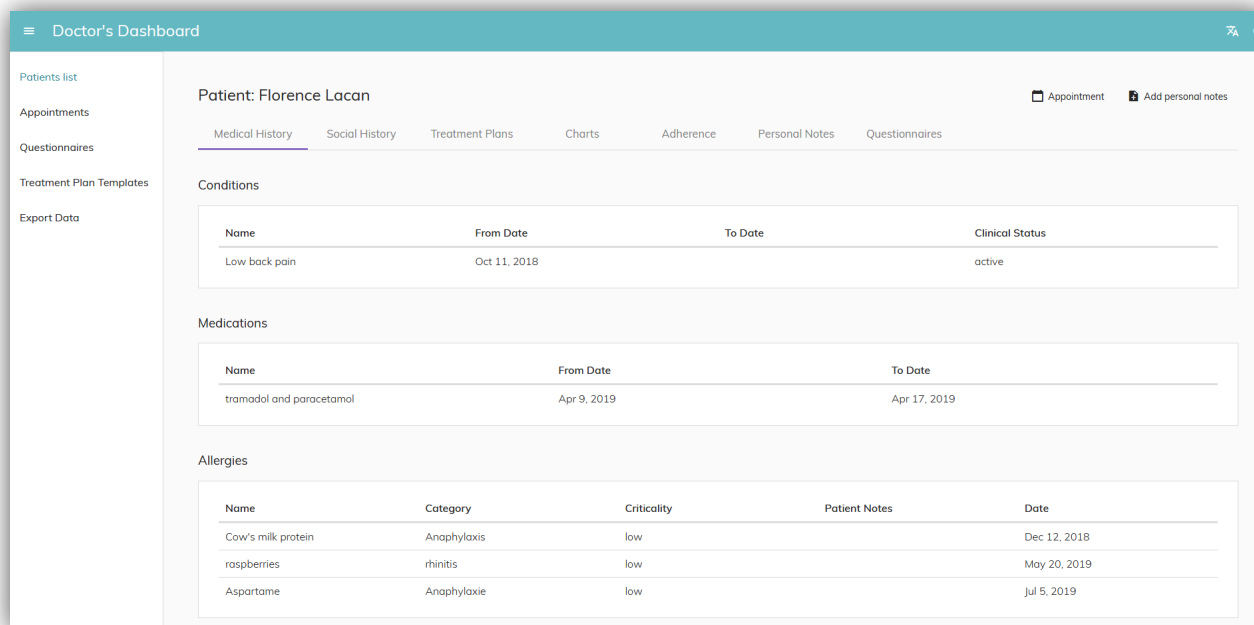


Figure 53 eHealth Pass web Application mock-up.

7.2 Virtual Patient Scenarios – Mobile Virtual Patients (AUTH)

Virtual Patient Scenarios (VPS) and Mobile Virtual Patients (MVP) have been increasingly used as educational resources in many medical educational institutions. More specifically, they are defined as specific types of computer-based programs that simulate real-life scenarios where learners emulate the roles of health care providers [9]. They can be deployed as problem-based learning activities [10] and are considered an innovative approach which may lead to effective outcomes in education [9][11][12]. VPS are developed using the OpenLabyrinth (<http://vp.med.auth.gr>) (Figure 54), an open-source platform for creating and playing virtual patients, while MVP using the Open Source Framework Drupal (Figure 55). They are considered effective learning tools that facilitates the transfer of real-life challenges in engaging scenarios which mimic the tensions, distractions and uneven issues that make real-life decisions more difficult. In particular, the methodology followed is to provoke the learner to think through a number of solutions or options in order to move forward in the scenario.

In this vein, caregivers have the opportunity to interact with diverse virtual cases through scenarios and therefore familiarize themselves with a range of Neurodegenerative diseases (including Alzheimer's, Parkinson's, dementia, stroke)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159



and other chronic diseases (diabetes, heart disease, etc.), aiming at enhancing their learning skills with regard to symptoms, diagnosis and treatment. Thus, they are considered as being valuable for caregivers in encouraging decision making, reasoning skills, as well as self-assessment.

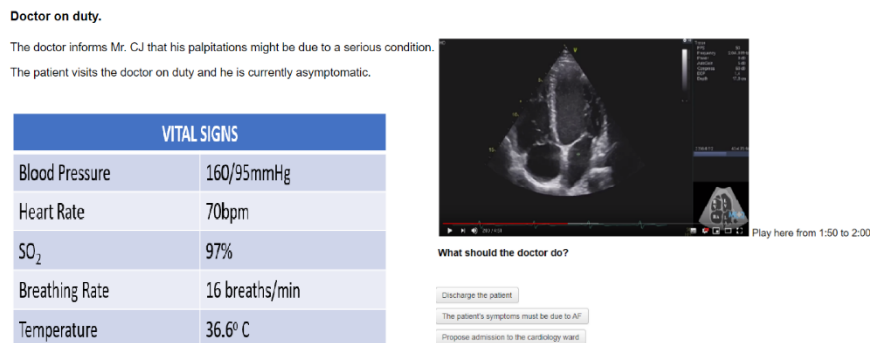


Figure 54 VPS's interface.

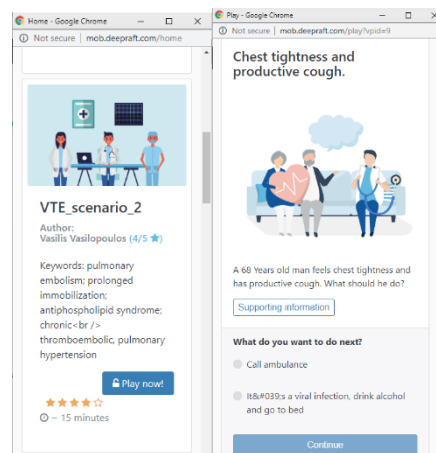


Figure 55 MVP's interface.

VPS and MVP can be used in many different learning activities and contain a wide range of features that make them fit for individual purposes.

- **Provision of different learning settings and learning activities:** (a) Large Group Teaching, (b) Small Group Teaching, (c) Self-Directed
- **Structure of Scenario:** VPS can differ in their structure. The three main structures are linear, semi-linear and branched (Figure 56).
- **Enrich with media:** extensive media enhancement, or just be simple text
- **Assessment steps or questions:** free text, multiple choice, list-based questions and others
- **Interactive Scenarios:** VPS can include many different types of interactivity
- **Disciplines:** VPS can be used in a range of different disciplines and there have been very popular within the medical and healthcare settings.
- **Languages:** VPS can be developed in many languages

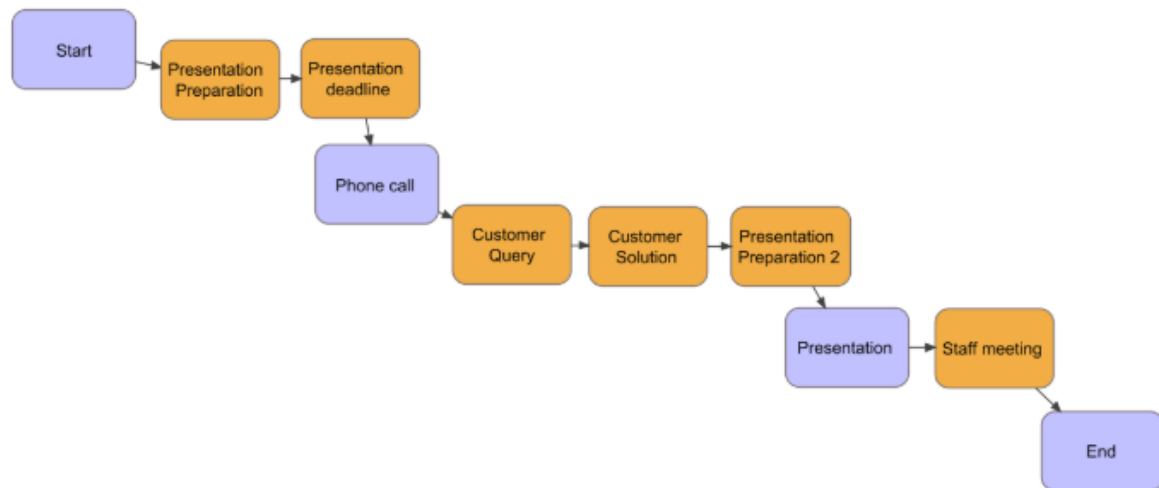


Figure 56 Simple scenario map showing the ideal route through a scenario with key nodes in purple and additional information notes in amber.

7.2.1 Technical specifications

Virtual Patient Scenarios (VPS) and Mobile Virtual Patients (MVP)

- Disk space

The total amount of disk space needed for your site is not a fixed amount, as it depends on your site. The base files for the core software take up about 100 MB on the web server. You will need more space if you install additional modules or themes, and you'll also need space for media, backups, and other files generated by and uploaded to your site. The database also uses disk space, although that is typically not in the same area (and in some cases, not even on the same server) as that used by the site files.

- PHP

PHP 7.2 or higher. PHP must be set up with a minimum memory size of 64MB; if you are running multiple modules on your site or using memory-intensive PHP-based command-line tools (such as Composer), considerably more memory than that may be needed.

Certain PHP extensions are also required; the exact list of required PHP extensions depends on how you install the core software and which modules you are using on your site. Generally, hosting service providers have installed all the PHP extensions you will need. If you are self-hosting or running your site on your local computer, you will get error messages during installation if any required PHP extensions are missing, and should be able to install them and continue.

- Web server

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Apache (Recommended). Apache is the most commonly used web server. The core software will work on Apache 2.x hosted on UNIX/Linux, OS X, or Windows that have the Apache mod_rewrite module installed and enabled. The Apache VirtualHost configuration must contain the directive AllowOverride All to allow the .htaccess file to be used.

- PHP

You can temporarily run a local demo site on your computer using just PHP, without installing web server software.

- Nginx

Nginx is a commonly used web server that focuses on high concurrency, performance and low memory usage. The core software will work on Nginx 1.1 or greater hosted on UNIX/Linux, OS X, or Windows. The ngx_http_rewrite_module must be installed and enabled.

- Microsoft IIS

Microsoft IIS is a web server and set of feature extension modules for use with Microsoft Windows. The core software will work with IIS 5, IIS 6, or IIS 7 if PHP is configured correctly. Because clean URLs are required, you may need to use a third-party product. For IIS 7, you can use the Microsoft URL Rewrite module or a third-party solution.

- Database

Use one of the following databases:

- MySQL - 5.5.3 (MariaDB 5.5.20, Percona 5.5.8) or higher with an InnoDB-compatible primary storage engine
- PostgreSQL - 9.1.2 or higher
- SQLite - 3.4.2 or higher. Temporary local demo sites use SQLite, which is distributed as part of PHP and does not require installing separate database software.

7.2.2 Interfaces and interoperability

Virtual Patient Scenarios (VPS) are developed and delivered through the OpenLabyrinth system (vp.med.auth.gr) that represents an open source authoring software. VPS are applicable to tablets, laptops and computer devices.

User's interaction

1. User logs in to the Open Labyrinth platform (<http://vp.med.auth.gr>) where a list of healthcare-related use case scenarios is available
2. User selects a VPS to perform
3. User interacts with diverse virtual cases and familiarizing him-/herself with issues that may be confronted with in real-life with care receivers
4. User responds to related questions aiming the selection of the right “pathway” and completes the VPS successfully aiming the acquisition of proper teaching skills regarding symptoms, diagnosis and treatment

Mobile Virtual Patients (MVP) are developed and delivered through the Open Source Framework Drupal that represents a free and open-source web content management framework. MVP are applicable to smartphones.

User’s interaction

1. User logs in to the <http://mob.deepraft.com/home>, where a list of healthcare-related use case scenarios is available
2. User selects an MVP to perform
3. User interacts with diverse virtual cases and familiarizing him-/herself with issues that may be confronted with in real-life with care receivers
4. User responds to related questions aiming the selection of the right “pathway” and completes the MVP successfully aiming the acquisition of proper teaching skills regarding symptoms, diagnosis and treatment.

7.2.3 Pilot themes

PT5: Caring for Older Individuals with Neurodegenerative Diseases (UC-PT5-004: Virtual Patient Scenarios - Mobile Virtual Patients)

7.3 Video Call Solution (MedSyn)

Especially in times of a corona pandemic, it can be advantageous for older people to be able to attend the next doctor's appointment not on site but via video consultation. In addition, there is growing evidence in Germany that the acceptance of video consultations among the elderly population has increased significantly during the Corona Pandemic.

For that reason, older people and care receivers as well as care givers shall be enabled to use a video consultation on a regular basis. To address the needs of elderly persons who live mostly alone and independently or with sporadic supervision in rural or urban environments the system is not only intended to be used between doctors and patients but also between older people and their relatives or care givers for example.

The video consultation of MedicalSyn works with a two-screen display for bidirectional communication. It offers a waiting room and an additional contact formular/chat with the option of encrypted transferring of documents. Access to the system will be kept very low-threshold in accordance with security and privacy regulations, to avoid potential barriers right from the beginning.

7.3.1 Technical specifications

The video consultation is a browser-based application. A concept for different roles and users with different rights and functionalities is implemented but can also be inactivated, if necessary. Same is valid for a login process, which is carried out anonymously via randomly generated PINs.

7.3.2 Interfaces and interoperability

The Video consultation will run in a responsive design for Desktop Computer, Tablet and Smartphone (Android and IOs). There is no App needed.

Possible Stakeholders are:

- Older people in general (65+)
- Elderly Care receivers
- Care givers (family members, friends, Health Care Professionals)

7.3.3 Pilot themes

Pilot 1 – Use case 3

Goal: overcoming the fear of digital technologies and easily getting in touch with family and friends while ensuring data protection rights

7.3.4 Mock-ups

The next three figures are of the previous system without addressing the intended use case.

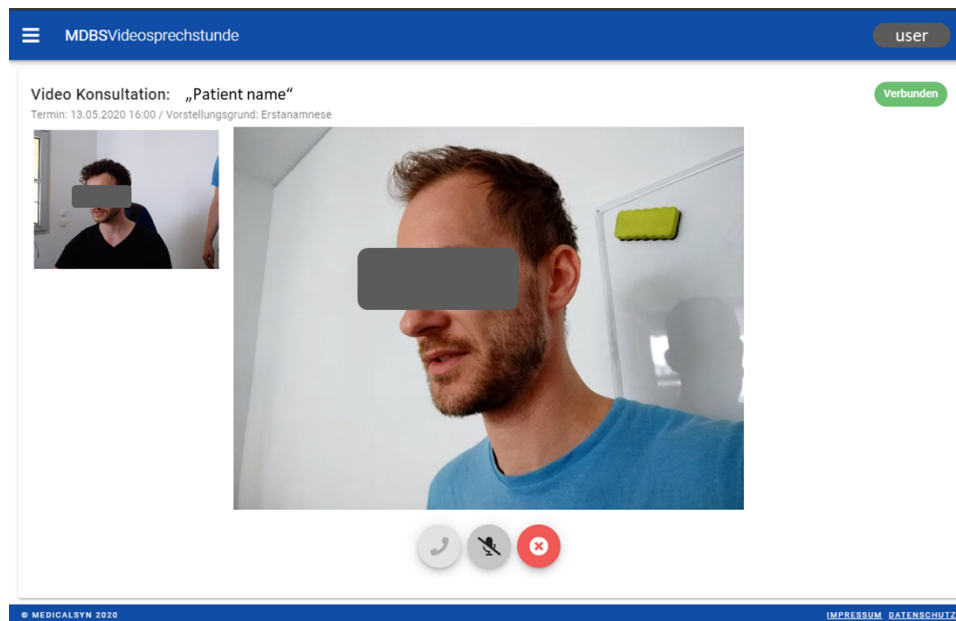


Figure 57 Two screen display for bidirectional communication.

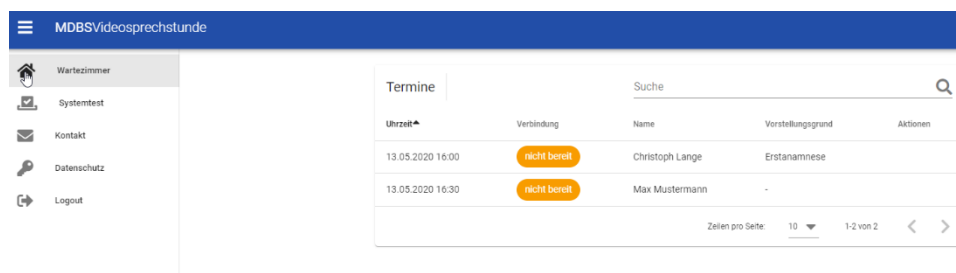


Figure 58 waiting room.

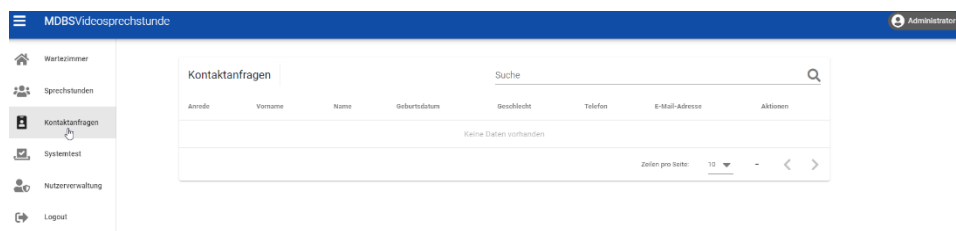


Figure 59 Chat and menu.

7.4 (Patient) Survey System (MedSyn)

To assess the satisfaction related to different digital solutions within pilot themes a digital survey system can be very useful. Moreover, wellbeing assessment via validated questionnaires e.g. addressing quality of life can be implemented regarding the requirements of the WP Leader.

The survey system of MedicalSyn can implement various surveys of interest into an easy to use interface to reach these goals, providing that all necessary licenses for using the questionnaires are existing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The system offers a personal survey view that lists all available surveys for the user and the specific progress. Surveys can be implemented in different timelines, e.g. in a visit scheme according to an observational study. For each participant, the surveys stored in the system can be selected or deselected according to the time schedule.

7.4.1 Technical specifications

The survey system is a browser-based application. A concept for different roles and users with different rights and functionalities is implemented but can also be inactivated, if necessary. Data can be exported in different formats to the pilot site.

7.4.2 Interfaces and interoperability

The survey system will run in a responsive design for Desktop Computer, Tablet and Smartphone (Android and IOs). There is no App needed.

Possible Stakeholders are:

- Older people in general (65+)
- Elderly Care receivers

7.4.3 Pilot themes

Pilot 1 – UC1 Remote In-Home Wellbeing Monitoring and Assessment and UC3 Competent usage of digital technologies.

Goal: assessing the satisfaction with digital solutions of interest within the use cases. Calculating a wellbeing assessment score.

7.4.4 Mock-ups

These are of the previous system without addressing the intended use case.

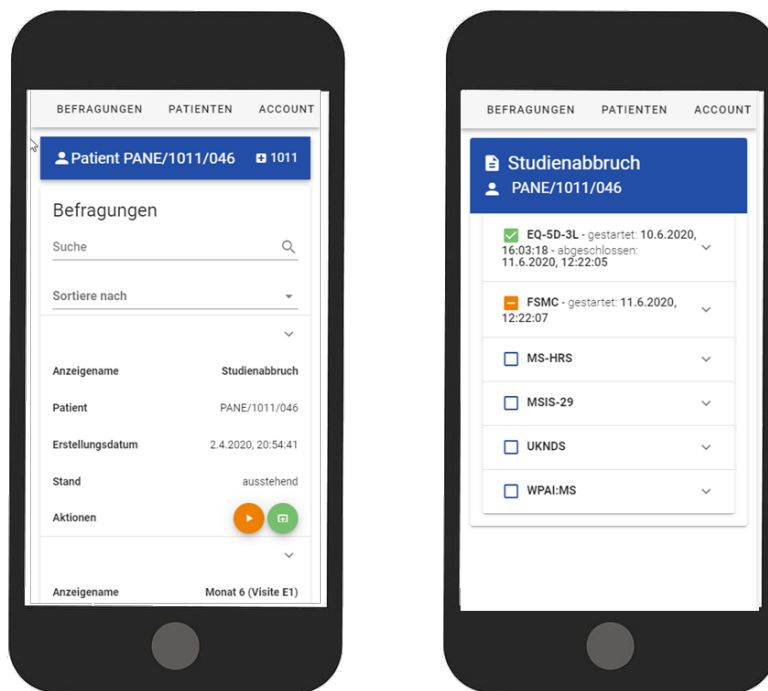


Figure 60 Patient view on iPhone 6/7/8.

SYNQUEST

BEFRAGUNGENPATIENTENACCOUNT

Logout

Neue Befragungen

Befragungen

Suche

Anzeigename	Stufe	Patient	Erstellungsdatum	Status	Aktionen
Studienabbruch	Evolution	PANE/1011/592	2.4.2020, 16:44:53	ausstehend	<div></div>
Monat 6 (Visite E1)	Evolution	PANE/1011/841	30.3.2020, 13:04:29	ausstehend	<div></div>
Monat 6 (Visite E1)	Evolution	PANE/4321/691	1.4.2020, 19:24:10	ausstehend	<div></div>
Evaluierung (Visite E0)	Evolution	PANE/1011/091	14.8.2019, 22:30:10	ausstehend	<div></div>
Studienabbruch	Evolution	PANE/1011/091	8.4.2020, 17:38:09	ausstehend	<div></div>
Pangaea 2.0 Monat 36	Pangaea 2.0	PANG/4321/004	9.6.2020, 08:49:25	ausstehend	<div></div>
Studienabbruch	Evolution	PANE/1011/142	30.3.2020, 17:49:48	ausstehend	<div></div>
Evaluierung (Visite E0)	Evolution	PANE/2222/756	4.3.2020, 15:26:37	ausstehend	<div></div>
Evaluierung (Visite E0)	Evolution	PANE/2222/707	1.4.2020, 07:58:05	ausstehend	<div></div>
Pangaea 2.0 Evaluierung Patientenstatus	Pangaea 2.0	PANG/2222/036	4.3.2020, 15:25:12	ausstehend	<div></div>

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Figure 61 Survey view on desktop (visit scheme).

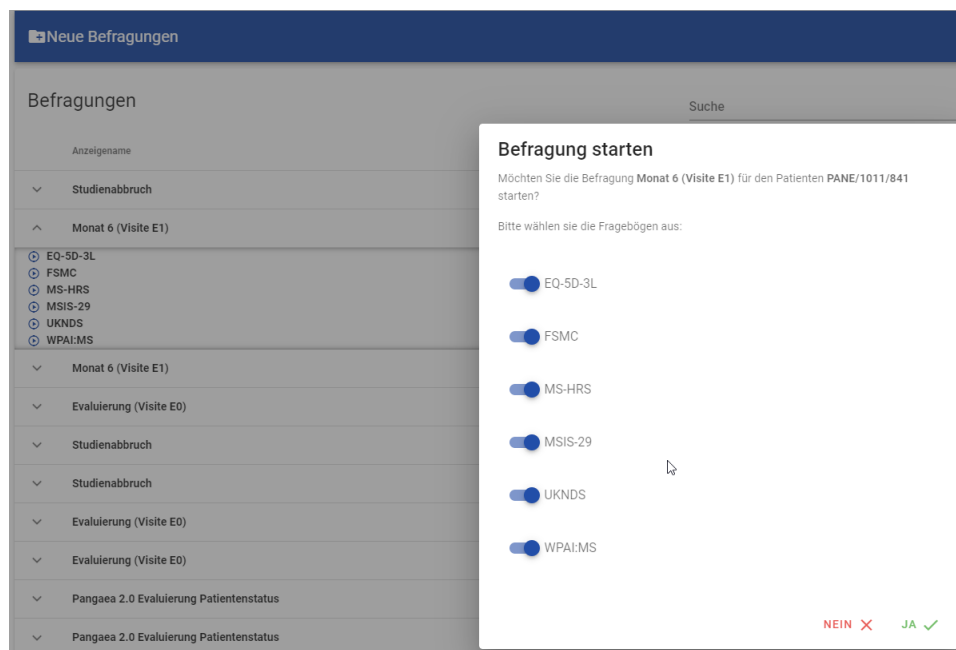


Figure 62 Listed surveys of interest.

7.5 IT Health Care platform (MedSyn)

The Health Care platform as medical EDC-systems and medical database solutions (MDBS) is a digital Service for medical-clinical care situations and for clinical trials. It was originally developed for the documentation of multiple sclerosis (MS) patient management (MSDS3D) as an electronic Case report form (eCRF).

Electronic case report form is adaptable on specific needs of SHAPES:

- Clinical parameters (e.g. patient anamnesis, clinical status, MS relapses)
- Treatments and pre-treatments
- Previous diseases
- Clinical investigations/ Clinical tests
- Laboratory results, automatic analysis of laboratory parameters and alarm functions
- Medication and concomitant medication
- Checklist for patients, physicians, and nurses
- Patient surveys
- Adverse event (AE) notifications (medications)
- User administration and user management (roles and rights)

health data, vital and physical signs as well as wellbeing and environmental parameters. The overall aim of the platform is to improve quality of patient's life and to empower and support him to adopt lifestyle reducing risk of deterioration. All the data and measurements are gathered through smartphones/tablets, sensors and devices (e.g. weight scales, blood pressure monitor, oximeter etc.) The platform provides to its users an overview of their daily health status, tasks and treatment plan assigned by medical staff, medication administration and requests, notifications, personalised questionnaires and it also offers the possibility to communicate with the medical staff and to manage medical appointments through videocall. Health care professionals can remotely monitor the health and wellbeing parameters of their patients, they are able to early identify deterioration signs and to intervene promptly.

The practice enabled screening of common population in the region with the disease; it provides tools for remote control of patients with advanced heart failure (NYHA class III-IV, it means patients that are markedly or severely limited during physical activity) on standard medical therapy (ESC guidelines), before and after heart transplantation. Further it covers population of patients with hemodynamic support (ventricular assist device - VAD) before orthotropic heart transplantation (OTS) or in long-term regimen. Until the service was introduced, there has not been method that would enable to collect relevant information about critical parameters development besides keeping the patient in hospital. The practice requires only minimum organizational changes in the hospital; its essential parts are under control of clinical staff (cardiologists and nurses) who make use of data (including weight, blood pressure, SpO2) received from patients at home.

The ICT system used for the practice has also several features that enable bidirectional communication between the medical personnel and patient; including distant ordering of medicaments.

Other features increase technical reliability of distant communication between patient's smartphone (gateway) and healthcare personnel (nurse, cardiologist with access to telehealth portal).

Patients with CHF can be discharged from the hospital and more regular information about their vital signs is available to the medical staff that care. If a decision is to be made the patient is called to come to the hospital as the practice introduces only informative elements and therefore medical protocols are not compromised. The practice enables to reduce routine status checks for which the patients must have stayed in or frequently to come to the hospital. Patients stay in the services for period

of time as necessary (e.g. 1 month) and then the equipment can be transferred to another patient.

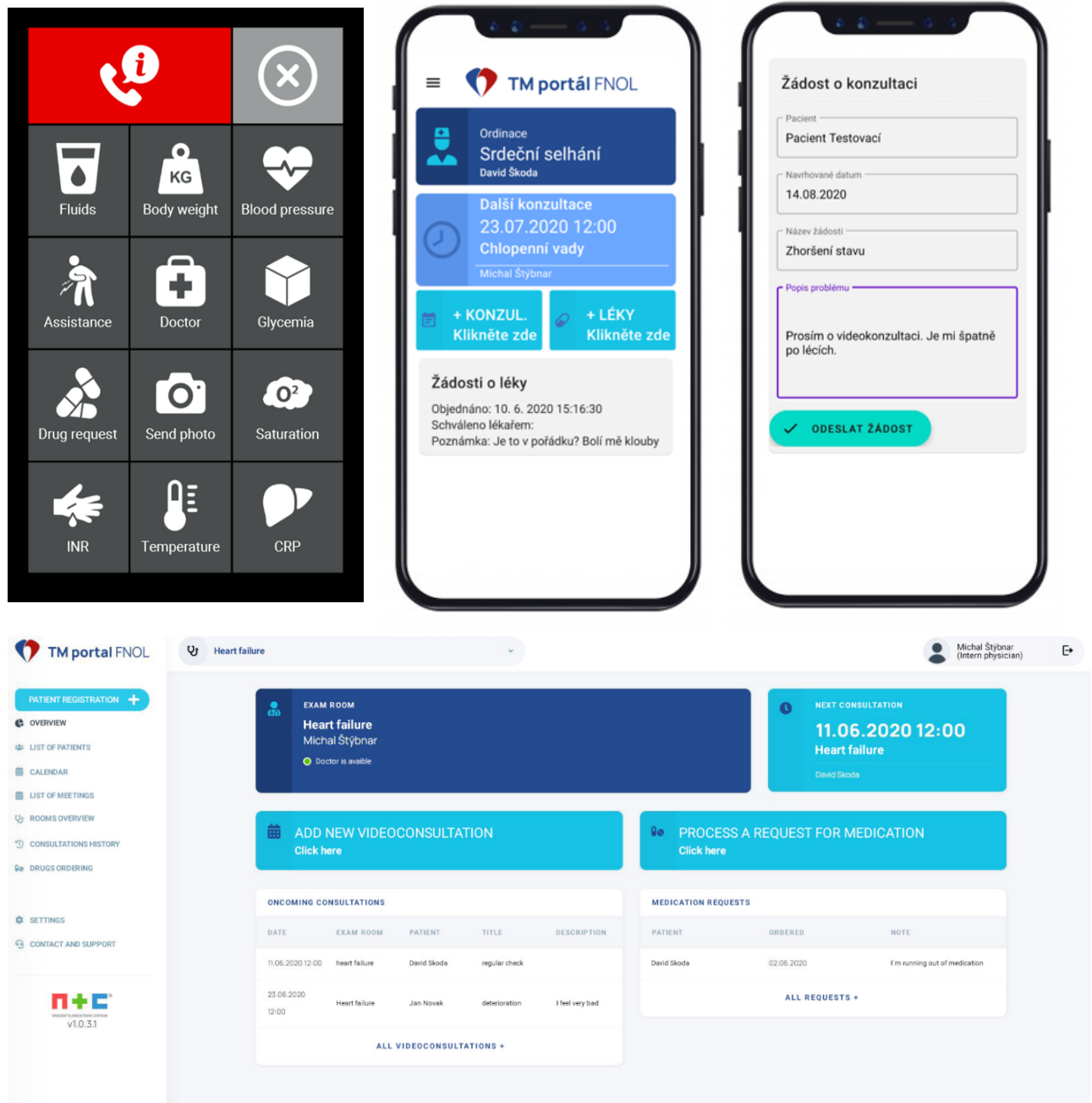


Figure 64 Medimonitor Solution.

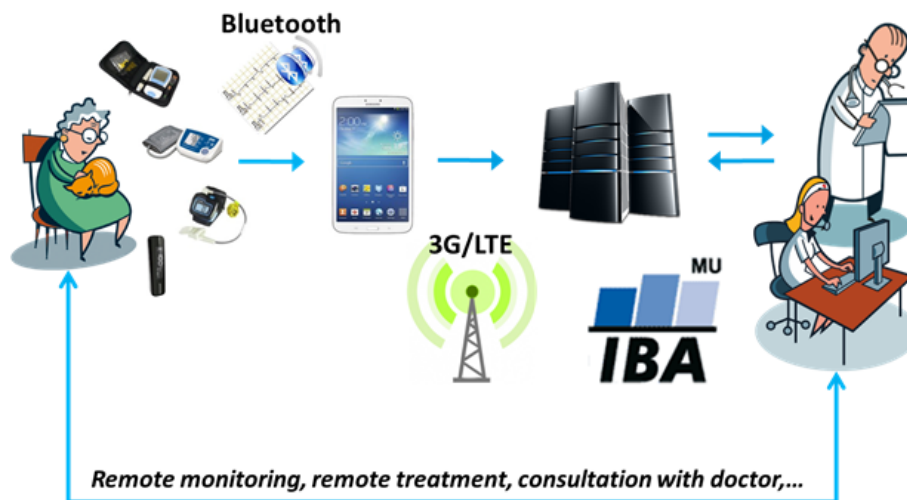


Figure 65 Medimonitor Solution: stakeholders, components and connectivity.

7.6.1 Technical specification

Patients are provided with a smartphone or tablet, blood pressure meter, pulse oximeter and weight scales and are given training to use software application called Medimonitor on the smartphone. The smartphone or tablet acts as a gateway to upload the vital signs readings daily to the telemonitoring centre located in the hospital's Cardiology Clinic. Doctors, specialist nurses and biomedical engineers can access the telehealth portal with collected data via internet using a web browser with secure login. The Medimonitor system generates alerts in response to:

- A patient's vital signs readings are outside their threshold parameters. Patients will be contacted by a specialist nurse who will assess the severity of the situation. If the patient's treatment and self-management plan needs adjusting, the cardiologist will contact the patient to make the necessary adjustments and/or invite the patient to attend an unscheduled outpatient appointment.
- If there is missing or incomplete measurement uploads twice in a row – either a biomedical engineer or nurse contacts the patient by telephone, SMS or Medimonitor message and provide additional training in the use of the smartphone or tablet if required.

The scheduled outpatient consultations are enhanced through the availability of the telemonitoring information which is also able to be accessed by hospital specialists in a patient's symptoms worsen and they are admitted to hospital. The system can also receive data from INR measurements (anticoagulation therapy) using the Medimonitor if required as part of the patient's care management.

Table 15 Technical specifications for Medimonitor

Data Category	Measurements Type	Collection Method
Vital signs	Heart rate Blood pressure (diastolic and systolic) Anticoagulation ECG Spirometer	Automated (from connected devices) or Manual
Physical	Height Weight Fluid intake	Automated (from connected devices) or Manual
Health	Medication Medical conditions Symptoms Side effects Pedometer	Manual (fill-in questionnaires)
Lifestyle and Wellbeing	Mood Physical activity	Manual (fill-in questionnaires or everyday tasks)
Ambient Living (in house)	Room humidity Air quality (e.g., PM levels)	Automated (from connected devices)
Environmental (outdoor)	Air quality	Automated (from existing open access databases)

Individuals interact with the **Medimonitor mobile app** that enables an easy manual or automatic collection of health and wellbeing parameters. Automated parameters are collected via health and medical devices and wearables mainly through Bluetooth connection. In case of medication adherence a solution which collects data and transfers it through USB port is used. Device – pill box is equipped with motion sensors and it will be compared with lab tests and with results from mobile app where the patients confirm that they took the medication.

Patients can communicate with the medical staff through video consulting solution which is based on Jitsi platform which is the open source solution, and it can be replaced by any other online video consulting platform. Jitsi runs on hospital servers and every session has its own dedicated URL link which expires after the meeting. There is also possibility to lock the virtual room by password and record the session. Patients can order medication online through the mobile app.

Also, the App allows individuals to answer to simple and short questionnaires and feedback forms on symptoms (SF-36, WHOQOL etc.), medication adherence (reminders), quality of life.

7.6.2 Interfaces and interoperability

Data collection is provided by a mobile application, which is available for Android devices where data can be transferred through Bluetooth and for Apple mobiles where the data are entered manually. All mobile devices have LTE mobile internet connection for data transportation or WIFI connection. Patients receive mobile phone or tablet

with downloaded app and with MDM system for distance support. In addition to mobile devices, patients receive portable devices defined by diagnosis. Patients with chronic heart failure use a personal weight, blood pressure monitor, and Coaguchek for INR range and ECG for daily measurements. All these devices are certified for medical use and have built-in wireless transmission using the Bluetooth 4.0 standard. The data is collected and stored on the hospital servers, from where they are accessible via the so-called Telehealth portal, which is used for access by doctors, medical staff and technicians. In the portal it is possible to set individual parameters of both measurement and uncompleted tasks, setting tasks in the calendar, checking measured values, compiling questionnaires, graphical display of measured values from a long-term perspective, medication settings, etc. used the program for Mobile data management, with which it was possible to update the application, track the patient using GPS, etc.

Mobile Application, smartphone:

- Interface for patient interaction with health professional, mobile application: Smartphone

Control Panel, web-based: Browser (preferably Chrome):

- Interface for the health professional interaction with the patient and health plan management system
- Interface for the system administrator

Telehealth portal

- Based on Microsoft technologies - .NET, SQL server
- Azure ready (cloud)
- Multitenant
- Data encryption

Security

- Auth 2 protocol for authorization
- Encrypted communication between server and device
- Encrypted data storage on device
- Ready for TeskaLabs SeaCat – another security layer (secured storage, user/device provisioning, communication with server)
- Mobile Device Management - MobileIron

Stakeholders: patients, medical doctor, physician, system administrator (to add/delete users, to assign patients with health professionals).

7.6.3 Pilot Themes

PT3: Medicine Control and Optimization.

8 Lifestyle Management and Wellbeing Assessment Solutions (Task 5.7)

The same as T5.5, although T5.7 has not officially started yet, some preliminary discussions were held around the different solutions SHAPES project will integrate related to Lifestyle Management and Wellbeing Assessment Solutions, while designing the different use cases of the project. These solutions are based on GNO eHealthPass and TREE Wellbeing analytics, enhanced with VICOM eHST and DSS, involving individual models to monitor various health and fitness parameters, provided by wearables, home devices, social activity apps, emotion readers, eHealth sensors, and incorporating intelligent data processing for the recognition of behavioural trends and specific services for personalised guidance on healthy lifestyle and disease prevention. As shown in the Figure 66, each of the partners' contribution is identified within the SHAPES platform, which is composed by 5 main modules of front and back-end elements.

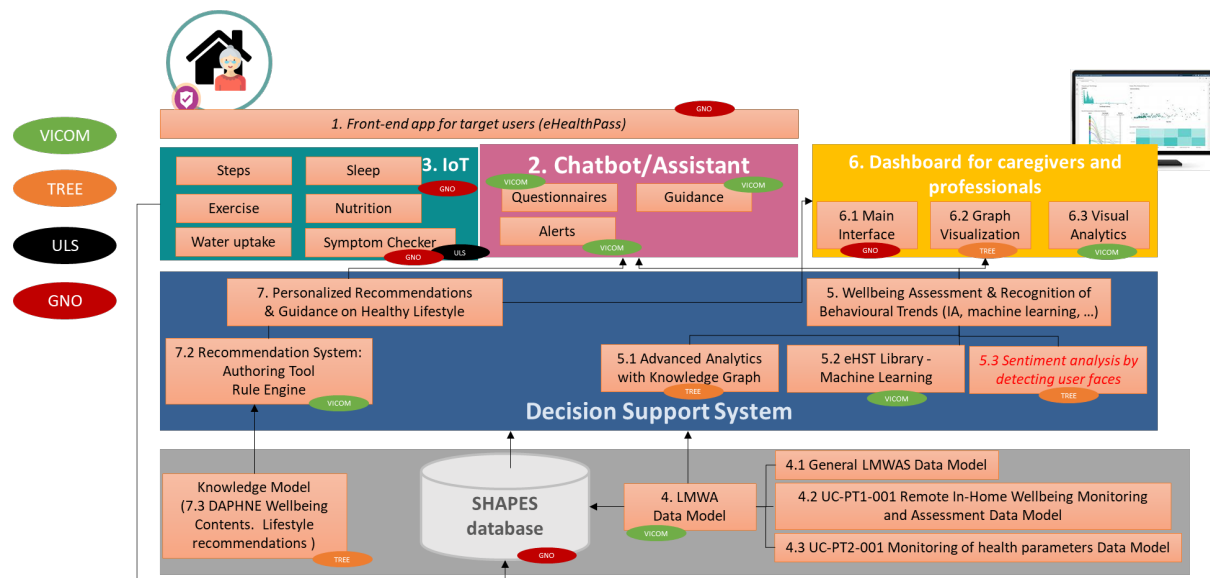


Figure 66 LMWAS (Lifestyle Management and Wellbeing Assessment Solution) architecture

In this section a summary of these different solutions is presented. It is important to stress that these Digital Solutions are dependent on the data collected during the project, so this first approach can be modified as the project evolves.

8.1 Anomaly detection (TREE)

Sensor-based smart home and the personal wearables/devices allow the collection of different information. This data collected can be cleaned and aggregated and different techniques can be applied to detect anomalous behaviour patterns. These anomalies can signal health problems and can be used to take preventive measures.

TREE can design anomaly detection for wearables to detect anomalies in sleep patterns or physical activity levels and also anomaly detection for home sensors to detect anomalies in Daily Living Activities (contingent on data availability for predictive model training).

The input would be the data from the wearable devices measuring sleep and physical activity metrics and/or the data from sensors placed in the home, for example sensors on electronics and room presence sensors. The output would be an alarm for when an anomaly has occurred.

8.1.1 Pilot themes

PT1: Smart Living Environment for healthy aging at Home, UC1 Remote In-Home Wellbeing Monitoring and Assessment

PT2: Improving In-Home and Community-based Care, UC1 Monitoring of health parameters

8.2 Lifestyle Recommendation System (TREE)

Personal wearables/devices allow the collection of different information over physical activity and sleep. Maintaining a healthy lifestyle in terms of physical activity and sleep is important for staying in good health. Reminders to exercise, avoid long periods of sitting, go outside and adopt behaviours to try to ensure good sleep can help older adults attain positive health benefits and ward off diseases.

Tree Technology can create a recommendation system to give recommendations over physical activity and sleep based on data acquired from wearables sensors (contingent on data availability for predictive model training), based in previous developments done in this field (mainly within FP7 DAPHNE project). The input would be the data from the wearable devices measuring sleep and physical activity metrics. The output would be recommendations over physical activity and sleep.

8.2.1 Pilot themes

PT1: Smart Living Environment for healthy aging at Home, UC1 Remote In-Home Wellbeing Monitoring and Assessment

PT2: Improving In-Home and Community-based Care, UC1 Monitoring of health parameters

PT6: Physical Rehabilitation at Home

PT7: Cross-border Health Data Exchange Supporting Mobility and Accessibility of Older Individuals

8.3 Wellbeing Assessment (VICOM)

The wellbeing assessment can be studied by the measurement and observation of changes in a previously predefined standard list of different Activities of the Daily Living (ADL) of the elderly people for an Ambient Assisted Living (AAL).

For this different temporal abstraction methods will be used to see whether the patient “normal” pattern is being changed over time or differs from the standard pattern.

8.3.1 Pilot themes

PT1: Smart Living Environment for healthy aging at Home

PT2: Improving In-Home and Community-based Care

PT5: Caring for Older Individuals with Neurodegenerative Diseases

PT6: Physical Rehabilitation at Home

PT7: Cross-border Health Data Exchange

9 Security Assessment as a Service (Task 5.8)

The Security Assessment as a Service (SAaaS) component is an authentication/Authorization framework for SHAPES. It continuously monitors the underlying network and detects existing and newly introduced network-enabled entities. It periodically assesses them against well-known vulnerabilities and certifies them against a CVSS score concerning their level of security (how vulnerable they are). These entities are assigned to the connectivity-appropriate network, according to their security level (CVSS score). After the assessment and certification of those entities, they are authenticated and authorized. This is achieved by utilizing the Authentication, Security and Privacy Assurance (ASaPA) component, developed in T4.6.

In more detail, the SAaaS component:

- Monitors the underlying network in real-time
- Is aware of the existing network-enabled entities
- Detects the newly introduced network-enabled entities
- Performs initial and periodical vulnerability assessments on each entity
- Certifies each entity against a CVSS score deriving from the vulnerability assessment
- Each entity is assigned to a connectivity-appropriate network (VLAN or slice)
- Certified entities are authenticated and authorized

9.1 Technical specifications

SAaaS runs on any Linux-Based platform and available to be deployed from the cloud. SAaaS will monitor the underlying network in real-time for any existing or newly introduced devices utilizing a software defined network (SDN) infrastructure on top of the legacy networks. These devices will be temporally separated in a neutral network environment (VLAN) with limited connectivity where SAaaS will test and assess the devices. Security assessment will be conducted using the OpenVas open source platform, which additionally certifies the devices in accordance to a standardized vulnerability scoring system (CVSS). Afterwards, certified devices will be assigned to a privilege appropriate VLAN where authentication and authorization takes place (ASaPA).

9.1.1 Interfaces and interoperability

SAaaS has a single interface (SAaaS.I.10) which communicates with ASaPA.I.10. This is required to decide if a device or service is allowed and secure to enter the SHAPES network.

9.1.2 Pilot themes

SAaaS is a SHAPES component, co-operating with ASaPA, required in most use cases that include a device/service requesting access to the internal network of SHAPES platform. Thus, SAaaS could be used in any pilot that includes devices or services requesting access.

10 COVID-19 response Digital Solutions

With the aim to support to the needs of the present times, SHAPES will bring some solutions to support on COVID-19 response. The different Solutions being analysed are detailed in the following sections.

10.1 System ONE – Observation of National Epidemics (EDGE)

ONE is EDGE's response to COVID-19, by providing a digital system allowing healthcare organisations and healthcare authorities to manage the progression of epidemics (specifically COVID-19) relying on citizens using Apps for reporting and sharing their health and wellbeing parameters.



Figure 67 EDGE's ONE System.

The **ONE** App allows citizens to insert their COVID-19 status (subject to validation by authorities), existing medical conditions and, on a periodic basis (e.g., once or twice per day), symptoms (e.g., cough intensity), health and wellbeing parameters (e.g., temperature) associated with the disease. The inserted information, after user consent, is sent to the **ONE** Server platform.



Figure 68 ONE App for Individuals at Home Environments.

Table 16 ONE Health and Wellbeing Data.

Data Category	Measurements Type	Collection Method
Vital signs	Body temperature Oxygen saturation	Automated (from connected devices) or Manual
Health	Medical conditions	Manual (fill-in questionnaires)
Symptoms	Fever Respiratory problems Cough Pain Headache Tiredness	Manual (fill-in questionnaires)
Wellbeing	How do you feel?	Manual (fill-in questionnaire)

Upon the patients' explicit consent, the data is shared with the healthcare professionals (care team) responsible for accompanying the patients, allowing them to remotely view the (self)reported health and wellbeing parameters, easily update the patients' health and wellbeing status during domiciliary visits or following telemedicine consults or phone calls, follow the evolution of the patients' condition and to act promptly if needed (e.g., adjustment of medication, change of treatment, immediate phone contact).

Through the **ONE System**, healthcare professionals are able to easily and efficiently monitor in a remote way the health and wellbeing parameters of a large number of patients under their care (significant high scalability is given to the one-to-many monitoring healthcare model), by means of intuitive dashboards and rich visualisation tools that highlight localised risks of relapse or hospitalisation, being aware of their condition at all times and receiving notifications or alerts in case any patient symptoms become severe and their condition worsens, thus warranting the patient's immediate hospitalisation.

ONE provides user friendly dashboards for health and care professionals, supporting large scale management and awareness of patient's health and wellbeing, clearly outlining situations requiring attention. **ONE** provides detailed information for carers concerning the patients' parameters evolution.



Figure 69 ONE System for Healthcare Professionals at Point-of-Care

Moreover, **ONE** provides tools for decision-makers concerning overall statistical data, trends and identification of clusters. The **ONE System** brings important insights for decision-makers that need to develop situational awareness concerning the progress of the COVID-19 disease and its impact on the population. Statistics (e.g., confirmed and deaths: total, rate over time, age distribution), correlation data (e.g., symptoms, medical conditions and wellbeing deterioration), trends and geospatial intelligence concerning the evolution of the COVID-19 pandemic are made available, leveraging on the vast amounts of data (the COVID-19 knowledge base) collected. **ONE** data services are thus able to generate statistical, stratification and clustering analyses adequate for strategic decision-making, signalling successful patient management options and identifying measures for the effective prevention and control of the COVID-19 contagion and the protection of the population. The data accessible to decision-makers is anonymised, protecting the privacy of individuals and the confidentiality of medical information. Decision-makers are able to access the data and visualise it through user-friendly data analytics and intuitive dashboards.

Data quality and security are also key concerns of the **ONE System** that uses advanced technologies to ensure an efficient access to trustworthy data. **ONE** deals with a high degree of personal and sensitive information pertaining to individuals, thus it is critical that high standards for security and privacy (fully adopting GDPR) are implemented, resulting in a highly trusted platform among its users and stakeholders. **ONE** adopts a privacy-by-design scheme to guarantee full compliance with EU and national legislation and regulations (e.g. GDPR) on data privacy, especially in regard to the use of personal and/or sensitive data. Likewise, security-by-design principles is assumed not only for the **ONE System** itself and security mechanisms, but also for the communication channels with external sources and components.

For any patient data to be sent, shared or anyway exchanged with the healthcare professional, it is required that the individual authorises, consents and enables the so-called data transfer. **Strict authentication, authorisation, and accounting security measures** are in place in the **ONE System** to guarantee the safeguard of the users' privacy and the protection of all personal data. Robust authentication mechanisms and secure access protocols are adopted and strong end-to-end encryption (e.g., transport layer encryption SSL/TLS) is used. Individuals or patients always retain the power to individually grant access to the different elements of their reported health and wellbeing information to healthcare professionals, thus remaining in control of their own data. Individuals have the option to delete all their data and their account with the **ONE System**, effectively leaving the System, in full compliance with GDPR's article 17 *Right to be forgotten*. The **ONE System** records in a secure log system all actions involving the data and information held within, that is, all access, creation, modification, archival and deletion actions concerning the System's data, including the identification of the user responsible for the action. Data access management is based on an Attribute-based Access Control (ABAC) approach, enabling finer grained data access control and a system better fitted to operational efficiency.

10.1.1 Interfaces and interoperability

The **ONE System** includes an Application Programming Interface (API) that supports the interoperability of the System with third-party applications or software. Following a pre-defined data model, the **ONE API** enables the exportation of anonymised data collected by the **ONE System** to third-party applications or software. The **ONE System** may also be extended to import data provided by external applications and devices.

Table 17 Summarised Technical Description of the ONE System.

General Description	Big data platform presenting the patients' symptoms and wellbeing data captured by health devices and wearables to support the monitoring of a population being treated at home and under active surveillance (quarantine for the diagnosed or suspected of being infected with a specific disease), in an epidemic scenario.
Features	<ul style="list-style-type: none"> Gathering and presentation of the patient's

	<ul style="list-style-type: none"> o temperature information, based on data captured by thermometers and oxymeters (automatic or manual input); o symptoms and wellbeing information, based on data provided by the individual in the eCare App (questionnaire). • Early detection of the deterioration of the patient's health and wellbeing conditions; • Statistics on the evolution of the patient's health and wellbeing conditions; • Remote monitoring of patient condition by healthcare professionals (workload reduction; faster action); • Delivery of recommendations.
Application Areas	<ul style="list-style-type: none"> • Remote monitoring of symptoms and wellbeing conditions of COVID-19 patients; • Patient empowerment (manage own care plan and adoption of preventative behaviours); • Management and control of the epidemic evolution and impact in population.
TRL	From TRL4 to TRL7
Data Type	JSON format. Used standards: <ul style="list-style-type: none"> • Openmhealth (https://www.openmhealth.org). EDGE extensions for specific fields.
Inputs	HTTP(S) REST, JSON messages.
Outputs	HTTP(S) REST, JSON messages.
Actions to be performed	<p>Older individuals use the ONE App or the ONE Portal to insert information to the ONE Platform.</p> <p>Professional and informal caregivers use the ONE Portal to insert information to the ONE Platform.</p> <p>Compatible smart devices (e.g., thermometer) provide automatic information to the ONE Platform.</p>
Interface	ONE App: Smartphone ONE Portal (front-end): Web browser ONE Portal (back-end): API for third-parties to access ONE information (using HTTP(S) REST) ONE Platform: API for third-party systems (e.g., data analytics) to insert automatic information in ONE (using HTTP(S) REST)

10.1.2 Pilot themes

In SHAPES, the **ONE System** will be adapted to a specific eCare COVID-19 module that will meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

- PT1: Smart Living Environment for Active Ageing at Home

- PT2: Improving In-Home and Community-based Care
- PT3: Medicine Control and Optimisation
- PT7: Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals



Figure 70 Application of the ONE System in SHAPES Pilot Themes.

10.1.3 Mock-ups

The following mock-ups of the ONE System are the basis for the adaptation work to be conducted in SHAPES, taking into consideration the applicable SHAPES users' needs and requirements and the functional specifications of the SHAPES Technological Platform.

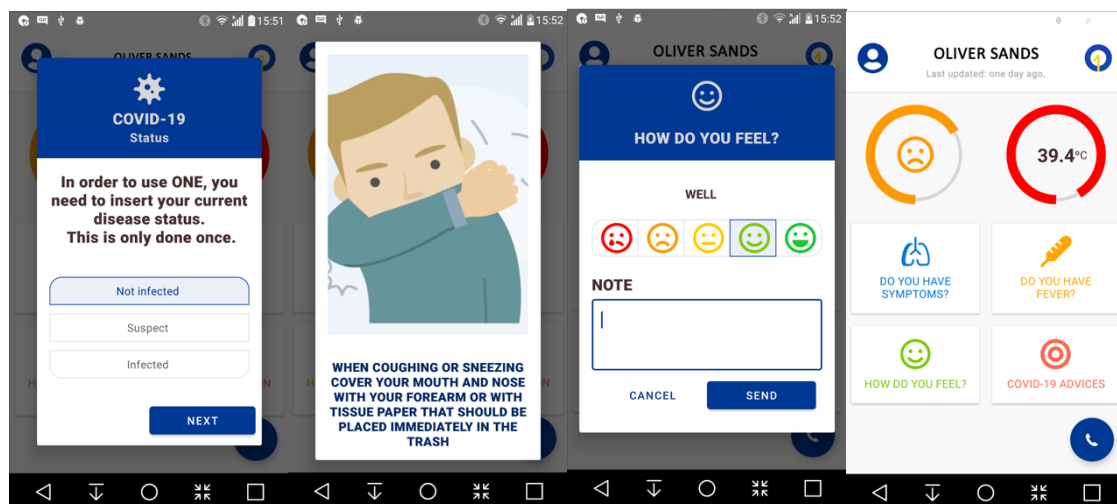


Figure 71 ONE System Mock-ups.

10.2 CovidShield (GNO)

COVIDshield is a post lockdown solution to manage patients in quarantine, chronic disease patients and the general public during and after the pandemic. Patient management is done using wearables, International Patient Summary data and shared care plan data to identify (using Machine Learning algorithms) relevant digital biomarkers that aid the treatment process.

In particular COVIDshield covers the following COVID-19 related scenarios:

1. Reporting epidemic data and managing patient remotely
2. EU cross border scenario & eHDSI National Contact Point (NCP) Integration
3. COVID-19 and Chronic diseases management
4. Emergency and unplanned care

The functionality is centered around the following pillars:

A. Case Detection and COV containment

- Advanced privacy by design including GPS contact tracing enablement, detailed patient consent and revocation, automated audit logs, standard based data portability and GDPR Compliance
- Automated clinical, quality of life and personalised smart questionnaire on COVID-19 symptoms
- Automated reporting to COVID-19 registries based on international HL7 FHIR resources

B. COVID-19 Patient Self-management

- Personalised Treatment Plans assigned by the doctors
- Automated reminders, alerts and to-dos
- IoT and medical devices connectivity, automated measurements collection
- Personalised Care and education information
- Panic Button features for emergency and COVID-19 request for testing
- Validated Questionnaires and PROMS
- Educational material to increase awareness and motivation

C. Remote patient monitoring

- First encounter (visit or remote visit) support
- Treatment plans among patients-doctor
- Video consultation and chat tools integrated for direct communication
- Appointment management for regular and online visits
- Integration with ePrescription system if existing

- Remote monitoring of the patients' progress via real-time analytics and visualisations
- Automatic detection of medical conditions and alerts notifications
- Automatic patient clustering based on the risk and their condition as well as discovery of digital biomarkers using Machine learning algorithms.

D. Interoperability

- Leading healthcare interoperability standards to ensure frictionless exchange of medical data
- Compliance with International Patient Summary Specifications (CEN PrEN17269)
- HL7 FHIR messaging and document sharing by design
- IHE profiles for Cross Enterprise Document Sharing (XDS) architecture in place to ensure seamless exchange of health documents across Healthcare Information Systems (HIS, LIS, RIS, etc)
- Compliance with IHE MHD integration profile for document sharing via mobile applications
- Integration with National or Regional ePrescription systems and Personal or other Electronic Health Records (PHR/EHR) if existing

E. Safe Cross-border travelling via

- A European Vaccination card to record upcoming EU regulation for upcoming travelling guidelines and prove conformance to EU and other countries relevant legislation
- Full patient summary with COVID-19 related data to be displayed at an unplanned care, compliant with the EU eHealth Digital Service Infrastructure (eHDSI) openNCP for cross border health care

10.3 RAPID (VICOM)

RAPID is a contacts traceability app that makes a log of the contacts made by the user through the day. It has a centralized and non-anonymous architecture that allows the analysis of the contacts maintained. While activated, the application detects nearby devices (that have the app installed) and sends the information to a server every 4 hours (as long as there is an Internet connection).

Regarding the contact tracking developed within the app, smartphone's Bluetooth Low Energy (BLE) service is used to scan for nearby devices identified by a universally unique identifier UUID. It advertises and searches for users' *PublicKeys* also working as a background app. Whenever a contact is detected both *PublicKeys*, timestamp and RSSI (signal strength) are saved into an internal database with the contact information and then transferred to the RAPID server. The personal data stored in the

Rapid database is the following: email address, nickname, contacts trace, health status and the answers to a risk assessment questionnaire composed by two questions (Are you part of the vulnerable population? (Yes/No); Are you in close contact with anyone part of the vulnerable population? (Yes/No)).



For a safe user registration assessment into RAPID, Keycloak authentication system is used, which grants the needed usage rights. Moreover, all state-of-the-art cybersecurity measures have been implemented both at smartphone and server and the application has been developed GDPR compliant, being the consent signed once the app is installed in the users' device. Actually, there is no IOS app available, but the Android version will be offered through Google play in a short period of time and the application is being validated in VICOMTECH as part of their quality and security policies.

Apart from the described, RAPID also provides several additional features:

- The user can update the health status when changes are detected
- It updates the potential risk in relation to the vulnerable population
- The app can scan QRs for Locations (Meeting rooms, office ...) and shows the number of devices and the last scanned QR

Within Shapes, Rapid could be applied for several functions:

- To log the contacts made in a nursing home or in-home care.
- To support the creation and the implementation of preventive policies at healthcare institutions.
- To facilitate the management of health issues related to persons with positive COVID19 test.

10.3.1 Pilot themes

In SHAPES, **Rapid System** will be adapted to a specific eCare COVID-19 module that will meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

- PT1: Smart Living Environment for Active Ageing at Home
- PT2: Improving In-Home and Community-based Care
- PT3: Medicine Control and Optimisation
- PT7: Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals

10.3.1.1 Mock-ups

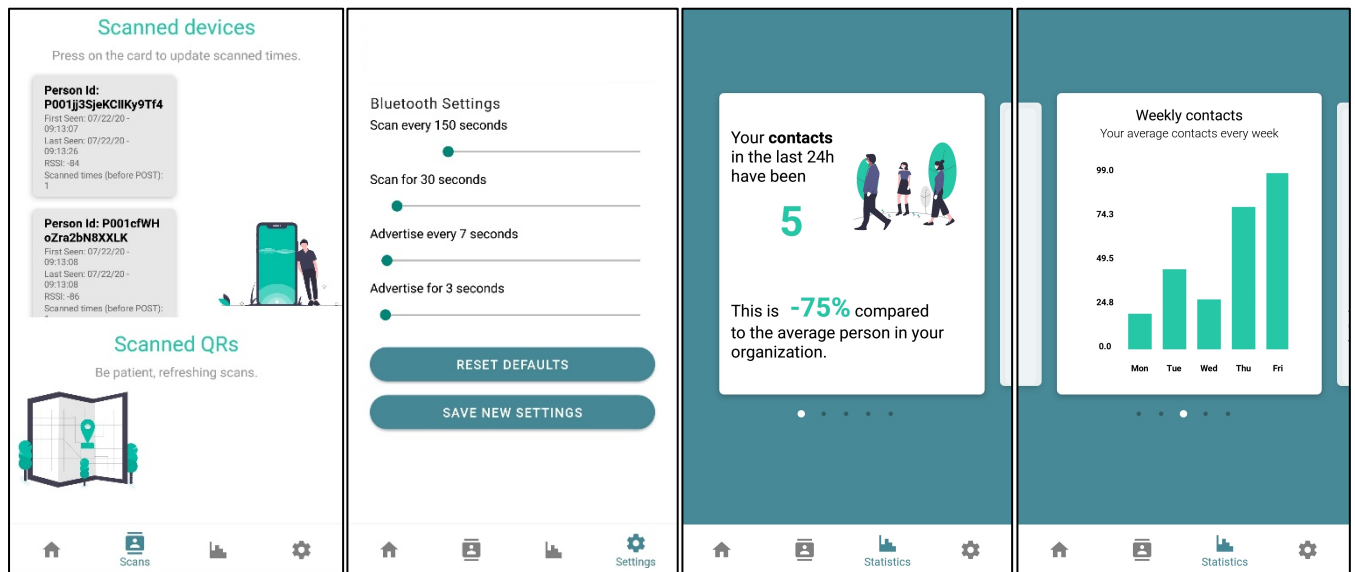


Figure 72 RAPID system.

10.4 Robotics (PAL)

Two issues are addressed by PAL Robotics solutions:

- the contamination rates of the medical and front line personnel fighting directly with COVID 19 by automating some of the front line activities and reducing their social interactions, providing a safer environment and support for the ones directly facing a risk of contamination due to the need of social interaction.
- Provide emotional support to isolated users through entertainment and facilitating remote communication with medical personnel and family

Secondly, due to COVID-19, an enormous amount of personal protective equipment (PPE) is needed in hospitals to protect medical staff against the virus. Doctors and nurses have to wear gowns, face masks, gloves and face shields to be able to attempt patients that are suffering the virus, as well as family visitors.



Figure 73 Personal protective equipment (PPE)

Robots can visit patients without risk of infection, increasing staff acceptability of the robots, and saving an enormous number of PPEs as well the time for its disinfection.

Overall, they can help reduce infection rates and provide better attention and care.

ARI and TIAGo robots, already described in Section 5.1, could be used for a range of roles targeting COVID-19 based on their skills, in order to reduce infection rates, provide better attention and care and for emotional support:

10.4.1 Receptionist

- Welcome, carry out administrative procedures in common areas or receive visitors to an elderly person's home, including triage by providing an initial health assessment
- Provide information on COVID-19 symptoms, hospital centres that are close-by to the user, as well as reminders (e.g. to take specific parameters, appointment reminders)
- Enforce protective measurements: remind users to keep social distance, to wear masks or apply gel, as example.



Figure 74 Robot as receptionist.

10.4.2 Entertainment and engagement with community

ARI/TIAGo can provide emotional support to users isolated due to COVID-19 by providing entertainment and promoting remote social interaction with caregivers/medical personnel as well as family and friends.



Figure 75 ARI/TIAGo for entertainment and engagement with community.

Some tasks that the robot could be adapted to do for entertainment are:

- Play songs requested by the user, or personalised to each person
- Play games using a mixture of touchscreen and speech (TicTacToe, solitaire) as well as motivate upper-limb physical exercise (ARI) through imitating gestures
- Provide daily news

Through the robot's calling functionality and touchscreen, the nurse can enter the room or connect with the end-users virtually. Moreover, another critical situation in this context is the impossibility of family visits. The isolation and stress situations for both, patient and family, has increased with the COVID pandemic. The contact with family has been restricted to "end life" situations. However, with this functionality on the robot, the contact between family and patient could increase drastically being more frequent during the hospitalization or confinement at home.

10.4.3 COVID-19 health monitoring

The robots can monitor the health status of the users through a variety of ways and alert medical personnel, either at individual apartments or to new visitors to a common room/apartment to screen for potential COVID-19 infected users.

- Temperature screening with a **thermal camera** that can be added to either of the robots
- **COVID-19 health assessments:** by asking a series of questions to detect potential symptoms

The robots can then notify medical personnel or family members through SMS or phone call, informing about results and other dynamic information.



Figure 76 Robot supporting COVID-19 health monitoring.

10.4.4 SHAPES integration

Integration of additional Digital Solutions

The robotic system may be substantially improved by a combination of digital solutions of SHAPES Platform. Examples include, but are not limited to:

- Virtual assistant ROSA (CH)
- Speech recognition and face recognition system (VICOM)
- Emotion recognition, fall detection (TREE)

TREE's emotion recognition system can be used by the robot to detect mood and approach users to initiate interaction, including answering questions and addressing doubts regarding their health. Fall detection would be another means of monitoring users that are isolated and alerting medical personnel through SMS/call.

VICOM's and CH's systems would be used for improved speech interaction and interconnection with the medical system and VICOM's face recognition for uniquely identifying each user and linking health measurements with the right person.

Additional development

Additional hardware to be integrated:

- Thermal camera

Additional software development:

- Design of new games based on pilot site requirements
- Video-call functionality
- Any desired adaptation to COVID-19 assessments or monitoring specific to the user-case

Pilot themes

Any of these functionalities can be integrated in a set of SHAPES pilot themes

- PT1: Smart Living Environment for Active Ageing at Home
- PT2: Improving In-Home and Community-based Care
- PT4: Psycho-social and Cognitive Stimulation Promoting Wellbeing.

10.5 Robotics for COVID-19 response support (KOM)

The outbreak of COVID-19 has continued to seriously affect the daily lives of citizens and the economies of every country around the globe. To prevent the spread of the virus KOMPAL offers 2 optional modules on the robots that will be used in SHAPES: a module for the disinfection of areas (rooms, common rooms, etc.) and a wireless temperature measurement module.

10.5.1 Disinfection module

This module consists of transforming the Kompai robot into a disinfection robot. Thanks to the walking assistance bar, this module is plugged into the standard robot in plug and play mode. We offer two disinfection technologies for this module:

UV-C technology

This technology, proven for decades, can destroy 99.99% of pathogens by exposing surfaces to be disinfected to radiation for a period of time

Disinfection capability of the proposed module: 13 min to disinfect a room of 20 square meter



Spraying of EC approved chemicals product

This system consists of spraying a chemical product through a nebulizer. This product complies with European standards and is widely used in crisis situations such as COVID-19. Compared to the UV system above, it is suitable for large surfaces and

also faster since it is enough to spray and continue on your way. to disinfect an area of 20 square meters it takes less than a minute. Same as the UV technology, this disinfection system can destroy 99.99% of pathogens.



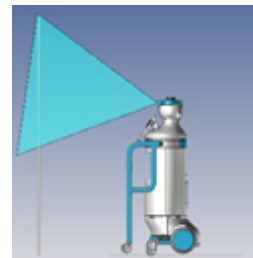
The usage scenario for this disinfection option is as follows:

- Mapping of the area (rooms, corridors, etc...) to be disinfected. This mapping is performed by driving manually the robot through the area to be disinfected),
- Construction of the robot path (a set of predefined points of interest) covering the complete disinfection of the area. This construction is made by a dedicated algorithm considering the embedded disinfection capability and the size of this area.
- Automatic disinfection task. This task consists of making the robot navigate autonomously through this path while stopping at each point of interest for the time necessary to ensure the disinfection of each elementary for the UV technology.

10.5.2 Body temperature measurement

To answer this function, we propose to add a thermal camera module on the KOMPAI robot for non-contact body temperature measurement. This assessment may be used:

- as part of an initial check at entry points (of hospitals, nursing homes, etc...) to identify and triage people who may have elevated temperatures,
- continues monitoring inside a nursing homes, hospitals, etc.. during robot patrol



Additionally, new features must be integrated in the robot such as:

1. Person identification via facial recognition. It is very important that the robot authenticates the user, so that the measured temperature is affected to the right person.
2. Integrate Speech-enabled ROSA in the robot so that ROSA can inform person having high temperature to take the necessary preventive measures (keep distance form others, get in contact with doctors, ...)

10.5.3 Pilot themes

In SHAPES, these plugs and play functions will be adapted to a specific COVID-19 module that will meet the pilot specifications associated with the following pilot themes:

- PT1: Smart Living Environment for Active Ageing at Home
- PT2: Improving In-Home and Community-based Care

10.6 Symptom Checker (ULS)

The SHAPES team from Ulster University have a long track record in the development of healthcare technology. One particular aspect of this has been the development of diagnostic algorithms and related m-health platforms. A notable example of this work was in Ulster participation in the Qualcomm Tricorder Xprize competition. This competition involved the development of a platform capable of accurately diagnosing a set of 13 medical conditions. The platform was based on a smartphone that could be capable of monitoring 5 vital signs and receiving input of symptoms from the user [13][14][15].

In response to the current COVID-19 pandemic Ulster have used their expertise based on previous activity such as the xPrize competition to develop a Covid Symptom checker app.

This app is under continual development currently. In its current form it collects information, checks for symptoms, helps perform diagnostics and provides advice. Data from the app can also be used to aid contact tracing and inform policy and decision makers in their overall recovery strategy. A novel add-on/peripheral functionality to improve overall result accuracy is the ability to read an antibody test result that is performed in the home setting.

10.6.1 Current App Functionality

As outlined above the app has a range of functionality that includes peripherals such as the addition blood diagnostics. The proposal for SHAPES is that the symptom checker component of the App be trialled at SHAPES pilot sites(s). In its current form the Symptom checker can be operated based on basic information entered by the user. The app asks questions about the users' age, gender, postcode, and involvement in the general flu vaccine programme. And checks for symptoms: fever, continuous cough, sore throat, muscle/joint pain, loss of sense of smell or taste, and exhaustion. The presence of any of these symptoms triggers additional questions: the duration of the symptoms, if there are difficulties in breathing, problems with the immune system, difficulty in doing normal activities, and if s/he lives with other people or not. Advice is then given accordingly depending on the severity of the symptoms and risk factors. Clear instructions are then provided. These instructions are currently tailored for the Northern Ireland context and are based on guidelines from HSC NI and NICE. Emphasis is given in staying at home when possible and in severe cases hospitalisation procedures are detailed. The user can opt-in to send anonymous

collected data to a server including current and historical GPS locations via the user's smartphone. A number of screen shots of the app in its current form are illustrated in Figure 77.

10.6.2 SHAPES integration

It should be noted that the app has been developed in the spirit of 'rapid prototyping' in response to the current and evolving COVID-19 situation and associated need for an expedited response. With this in mind there are many functionality and user experience aspects of the app that are necessitate ongoing development. Current limitations also include the fact that the app is currently is not support on any devices that are not Android based (e.g. no Apple iPhone support currently). If the app is to be utilised in the SHAPES project future developments will be required to include: refinement of the User interface, substantial debugging of the device platform, customisation for integration to the broader SHAPES platform, consideration of local constraints in app functionality (ranging from language support to consideration of integration with healthcare advice in different regions). It is not envisaged at this point that peripheral add-ons to the app will be include in SHAPES (e.g. Blood diagnostics).

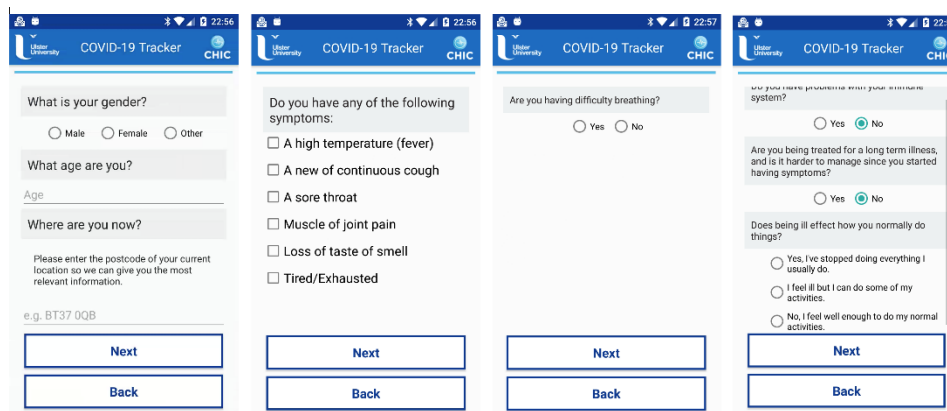


Figure 77 Selection of screen shots taken during interaction with app.

10.6.3 Technical Architecture – Brief Summary

The app is currently a standalone Android based app which has been developed in Java. All internal data structures are currently proprietary. The app has the potential to be re-developed to use a web services-based architecture based on HTTP and JSON. This will allow for multiplatform support of the app and would see algorithm logic migrated to the cloud. The current symptom checking functionality is based on a probability/rule-based algorithm. Future functionality is at the prototype stage that includes Bluetooth Low Energy (BLE) beacon-based contact tracing.

10.6.4 Pilot Themes

Potentially:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

PT1 Smart Living Environment for healthy ageing at Home - All use cases

PT3 Medicine Control and Optimisation -All use cases

10.7 AccessEarth (AELTD)

Access Earth are building the world's largest database of accessibility information through crowd sourcing and deep tech data collection technologies. Part of Access Earth's role within the SHAPES platform is to provide insights into the accessible landscape for designated pilot sites while also providing this information to participants in an intuitive and interactive manner.

Due to the global pandemic of COVID-19, how businesses, restaurants, shops and other venues operate, with regards to their social distancing procedures, can be a barrier to entry for those within the SHAPES project scope. In essence, COVID-19 information is now accessibility information and therefore falls under the remit of data to be gathered by the Access Earth data gathering tool.

10.7.1 App Integration

Thanks to the modular manner in which the Access Earth data gathering tool has been designed, adding social distancing criteria to complement the already existing accessibility criteria was able to be integrated seamlessly, from the user's perspective, without requiring an extensive UI layout redesign.

The app now shows accessibility information and COVID-19 information options when selecting a desired location and will prompt the user to begin answering questions if a desired spot does not have one or both of the criteria already answered.

This data is then fed directly into the Access Earth platform's database, ready for further adaption with the standard plugin/API integration offerings provided by Access Earth.

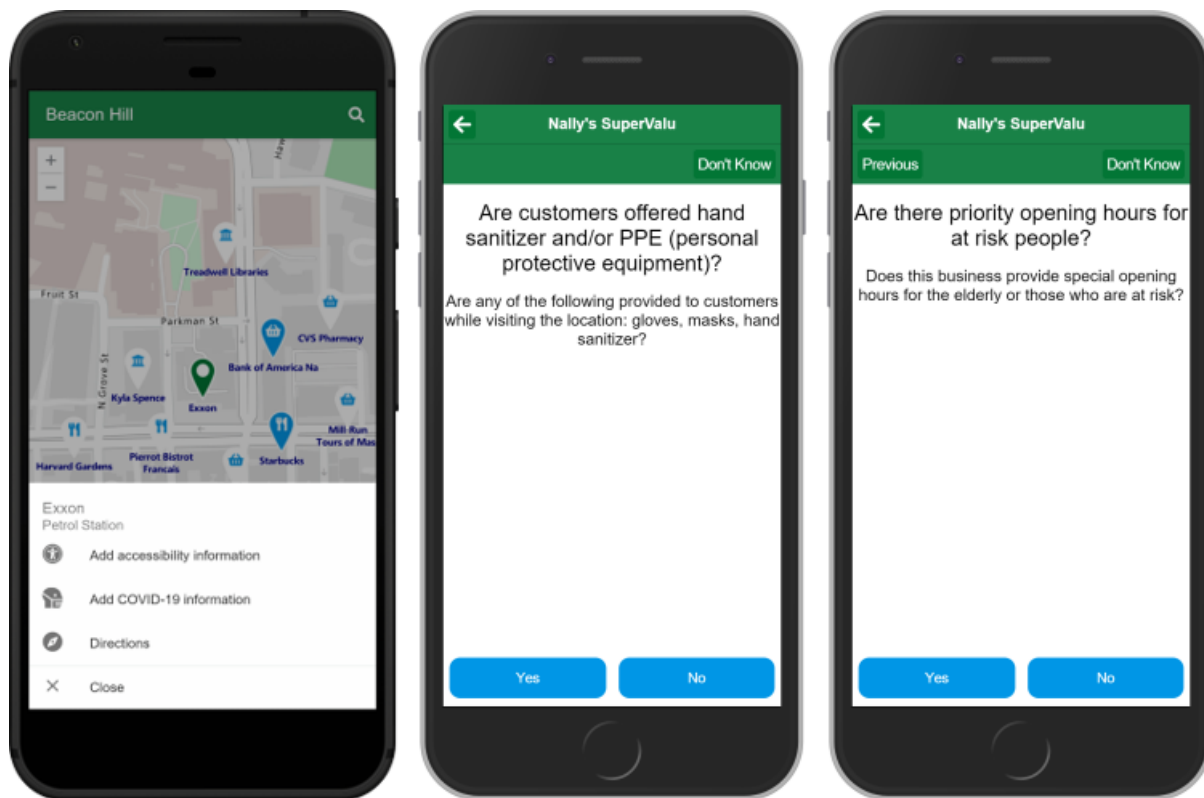


Figure 78 Access Earth Digital Solution for COVID-19 response.

10.7.2 Pilot Themes

- PT1-002 Digital Assistant to Support Older People to Live Independently and Remain Socially Connected
- PT2-002 Community interaction
- PT7-002 Foster older people's (with physical disabilities) independent living by identifying accessible locations and routes in other locations (domestic and abroad)
- PT1-003 Competent usage of digital technologies.

11 Conclusion

This report presents the different Digital Solutions that are available to be used in the SHAPES project, to be adapted to the SHAPES user requirements and needs and to be integrated according to the pilot themes and associated use cases defined in the project (WP2, described in *D2.5 SHAPES Personas and Use Cases V1*). The Solutions will be adapted within T5.2 to T5.8 and this is a summary of the solutions for all the areas targeted (Health and Wellbeing Platforms, online communication and Accessibility Tools, Robots, Analytics and Predictive models, conversational assistants and chatbot, cognitive stimulation and rehabilitation, multimodal biometrics, IoT and Big Data Platforms, between others). Regarding the analytics-related solutions, they are dependant from the data available within the project, which means the Solutions identified as relevant are included in this report, but if the right devices or historical data are not available, some of them may be not possible to be developed for the SHAPES Pilots.

The outputs of this deliverable are instrumental for the overall project, but in particular to WP4, where the different Solutions will need to be accommodated with the SHAPES TP Architecture, and to WP6, where the Solutions will be validated.

This is the first version of the deliverable, which will have two updates in the future (D5.3 SHAPES Digital Solutions v2, due to M24, and D5.4 SHAPES Digital Solutions v3, due to month 36). In the upcoming versions, relevant details concerning the adaptation work of the different solutions described in this report will be included.

12 Ethical Requirements Check

The focus of this compliance check is on the ethical requirements defined in D8.4 and having impact on the SHAPES solution (technology and related digital services, user processes and support, governance-, business- and ecosystem models). In the left column there are ethical issues identified and discussed in D8.4 (corresponding D8.4 subsection in parenthesis). For this deliverable, relevant requirements have been identified. For the requirement not relevant for the deliverable, N/A was entered in the right-hand column.

Ethical issue (corresponding number of D8.4 subsection in parenthesis)	How we have taken this into account in this deliverable (if relevant)
Fundamental Rights (3.1)	Fundamental Rights are part of the requirements of the SHAPES Digital Solutions.
Biomedical Ethics and Ethics of Care (3.2)	Biomedical Ethics and Ethics of Care were considered when defining SHAPES Digital Solutions.
CRPD and supported decision-making (3.3)	N/A
Capabilities approach (3.4)	N/A
Sustainable Development and CSR (4.1)	N/A
Customer logic approach (4.2)	N/A
Artificial intelligence (4.3)	Relevant for the Digital Solutions
Digital transformation (4.4)	Relevant for the Digital Solutions
Privacy and data protection (5)	Part of the project's requirements
Cyber security and resilience (6)	Relevant for the Digital Solutions
Digital inclusion (7.1)	Relevant for the Digital Solutions
The moral division of labor (7.2)	N/A
Care givers and welfare technology (7.3)	Relevant for the Digital Solutions
Movement of caregivers across Europe (7.4)	Relevant for the Digital Solutions

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