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Draft (D): The deliverable is partially complete or complete but under review/revision before release.

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Acronyms and Abbreviations

API	Application Programming Interface
Bluetooth LE	Bluetooth Low Energy
CABIE	Context-aware Brokering and Inference Engine
HCP	Health Care Professional
PI	Personal Information
PIR(s)	Passive Infrared Sensor(s)
PwM(s)	Person(s) with Multimorbidity
RESTful	Representational State Transfer
SIMS	Subject Information Management System



Executive Summary

The **overall aim of ProACT** is to develop an open web application programming interface (API) ecosystem to integrate a wide variety of new and existing technologies to pull, aggregate and analyse data for the purposes of higher order inference, and to improve and advance integrated care for multimorbidity (including associated comorbidities). The ecosystem will connect four key care and support models central to understanding and implementing effective, continued and coordinated patient centric care (including self-management). These models are: 1) homecare (including informal care) 2) hospital care 3) community and social care and 4) social support networks.

The first release of the ProACT platform brings together component systems from ProACT consortium members, newly developed systems to support future development of a scalable and extendable platform, and early integration of user-driven development. This platform release will be tested in a friendly trial setting where members of the ProACT research team take on the role of persons with multimorbidity (PwMs), and other identified stakeholders, in a 12-week evaluation of system components and their interaction.

Development of the ProACT platform is an iterative process which will see updates to the system continue throughout the life of the project, with major release milestones in M9 (version for friendly trial), M24 (version for PoC trial), and M39 (version beyond the project's timeframe). For the first release of the platform, a focus has been put on the development of new core software technologies, and on system-wide integration of all component parts.

This document has been compiled to accompany the first release of the platform (D2.5) and associated demonstrations. As a public release in the early stages of a 4-year project, the purpose of this document is not to provide detailed technical descriptors of the system—these are available in other internal M9 deliverables—but is, instead, to give readers a high-level overview of the developed system, its component parts, its methods of operation, its current state of readiness, and the next planned development stages.

The first section of this document introduces the concept of a friendly trial. Section 2 describes the integrated ProACT platform. Section 3 provides details on each of the component parts. Section 4 presents a table of core components, listing their development and integration status, and any in-progress or planned updates to be delivered prior to the commencement of the friendly trial.



1 Friendly Trial Introduction

The first release of the ProACT platform will be evaluated in a friendly trial setting. ProACT defines a friendly trial as a trial to test the robustness of a technology ecosystem prior to its deployment to real end users.

The ProACT friendly trial will be undertaken at the project's two main trial sites (Ireland and Belgium), and to a smaller extent at the transfer feasibility site (Italy), over a period of 12 weeks (one action research cycle). For the purposes of the trial, participants will be members of the research team who will act as proxies for the persons with multimorbidity (PwM) and other stakeholders in their care networks. 5 participants will be recruited at the Irish and Belgian trial sites, each taking on multiple roles (PwMs, informal carers, clinicians, etc.), and 5 participants will be recruited at the Italian trial site, each taking on a single role.

The aim of the friendly trial is to deploy an integrated ProACT platform to pilot participants and determine any issues with deployment or connectivity during the pilot period. Outcomes will be fed directly into technical work packages to support the iterative development and improvement of the platform and its user-facing components.

Early evaluation of the ProACT platform in this setting, and validation of platform robustness, will allow us to produce a more trustworthy system for the main proof-of-concept trial, including PwMs and their formal and informal care networks. A full description of the friendly trial process and its objectives can be found in D1.4 (*Ecosystem Trial Strategic Plan—Friendly Trial*).



2 The ProACT Platform (1st Release)

The ProACT project brings together a multidisciplinary consortium of 12 European partners for the purpose of developing and evaluating an open application interface to empower home-based, patient-centric care and proactive self-management of conditions for Europe's 50 million PwMs.

To achieve these aims, the ProACT platform combines a wide range of both new and existing technologies to create a single, interoperable system which is sufficiently flexible to adapt to ever-evolving target-user requirements, and sufficiently open to allow for the incorporation of new components on an as-needed basis. On top of this technology infrastructure, the ProACT project will make use of innovative, person-centric modelling and analytics to inform and augment behavioural change techniques, and will deliver tools to educate and assist PwMs, and their wider care networks, in condition management.

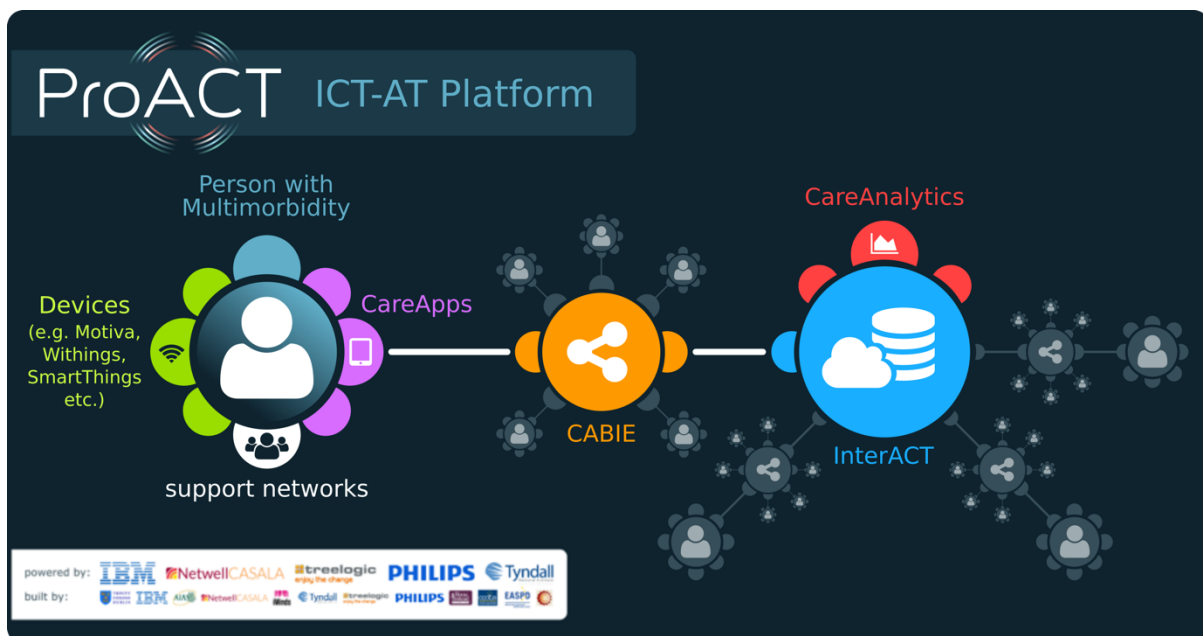


Figure 1: Overview of the ProACT ICT-AT Platform (1st Release)

The ProACT platform is comprised of the following technologies:

- **Measurement and Sensing Devices:** Suites of novel and “off-shelf” devices tailored to specific multimorbidities which are used to collect clinical, non-clinical, and ambient parameters from PwMs in their home. The full list of devices to be deployed in ProACT’s friendly trial can be found in section 3.1 of this document. In parallel to the friendly trial timeline, a range of devices and systems from partners Philips, including a modified version of their medical-grade Motiva platform, will be tested to better inform decisions on the most appropriate components to be employed for the project’s main proof of concept (PoC) trial.
- **CareApps:** Interactive dashboards which provide tailored interfaces and bidirectional feedback mechanisms for multiple ProACT ecosystem stakeholders. Used to deliver

scheduled surveys and behaviour change training and support to PwMs; to connect care network stakeholders; and to assist in everyday condition management tasks. A description of CareApps can be found in section 3.2 of this document.

- **CABIE:** A novel data collection and aggregation system which connects to a wide range of device manufacturer data stores through a mixture of both open and proprietary gateways and APIs. Employed for local data aggregation. A description of CABIE can be found in section 3.3 of this document.
- **InterACT:** A cloud-based platform for secure and scalable federated storage, mining, and analysis of anonymised PwM data. Employed for global data aggregation. A description of the InterACT cloud can be found in section 3.4 of this document.
- **CareAnalytics:** Contextually-aware procedures and algorithms which can detect and react to current or historic data in ProACT systems, to track and monitor clinical and non-clinical parameters for multimorbidities, condition management and condition status; and to inform learning, guidance, and care pathways for PwMs. A description of CareAnalytics can be found in section 3.5 of this document.

Functional technology components for the ProACT platform have been developed by, or are in development by, partners IBM, NetwellCASALA at DkIT (DkIT), Philips, Treelogic, and Tyndall National Institute.

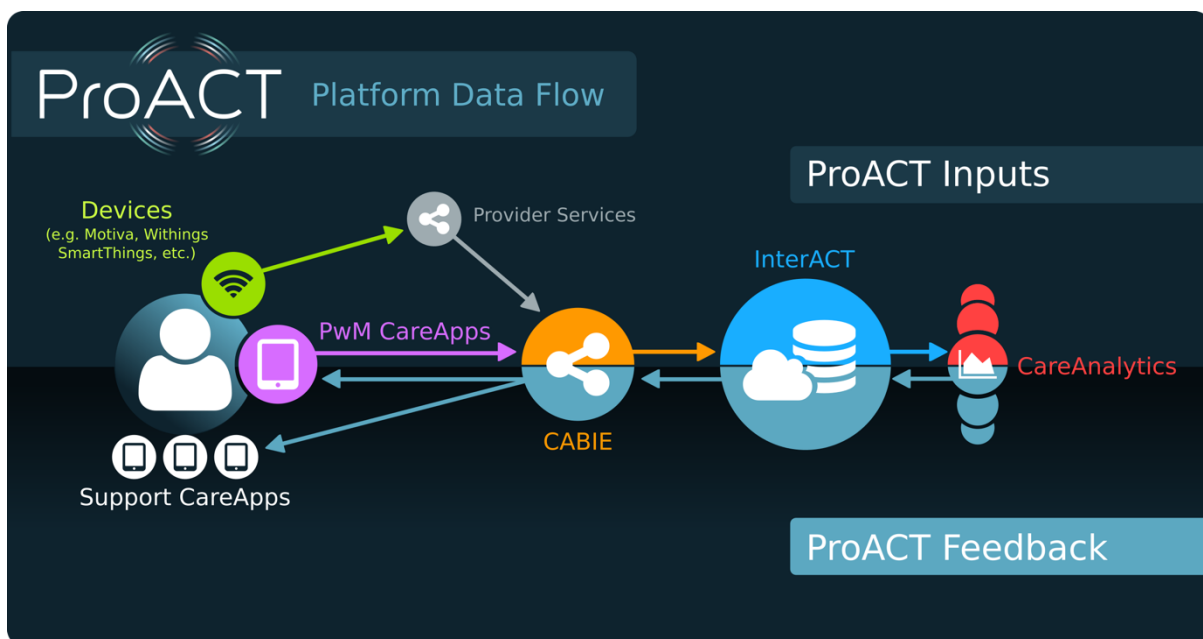


Figure 2: Data flow in the ProACT platform

The flow of data through the ProACT platform (Illustrated in Figure 2, above) starts and ends with the PwM and other relevant stakeholders. The following steps, each of which will be tested during the project's friendly trial, occur in the data transfer process:

- Measurement and sensing devices (e.g. SmartThings, Motiva, etc.) collect PwM data

- Data is stored by device providers (surveys go directly to CABIE)
- CABIE collects data from provider stores for local PwM clusters
- CABIE de-identifies data and forwards to the InterACT cloud
- Analytics operate on data in the InterACT cloud (global store read and write)
- CABIE retrieves analytics results from the InterACT cloud, and re-identifies results for local PwM clusters
- CareApps read data from local CABIE stores

From the PwM perspective, measurement and sensing devices and CareApps will be the only system technologies visible and interacted with on a regular basis. For other end-users (formal and informal carers, health care professionals (HCPs), etc.), CareApps tailored to their requirements will be their point of interaction with system technologies. Of course, these user-facing technologies cannot operate without the backing of a robust integration of the other platform components. Consequently, key test criteria for the ProACT friendly trial will be to evaluate the integrity of data as it passes through all platform components.



3 ProACT Platform Components

3.1 Measurement and Sensing Devices

Measurement and sensing devices in the ProACT platform are used to collect clinical, non-clinical, and ambient parameters from PwMs. Additionally, a dedicated interface device (a tablet) will be provided to PwMs participating in ProACT trials. Among other uses (see section 3.2, *CareApps*), this device will be used to collect scheduled survey responses.

The following device types have been identified in initial requirements gathering processes as being necessary for the monitoring of ProACT’s targeted multimorbidities (please also refer to D2.1 *Technical Report* (restricted access) and D2.2 *Deployment Plan for ICT-AT Interventions* (restricted access) for further details). For ProACT’s friendly trial phase, the full suite of identified devices will be deployed. For the main proof-of-concept trial, device suites will be tailored to an individual’s needs for their presented multimorbidities (inclusive of a subset of the below devices, and any additional devices identified at later dates). All devices identified as “connected” currently integrate with CABIE. Readings from devices marked as “manual input” must be manually entered through the primary PwM CareApp.

- **Smart Watch** (Third party / “Off Shelf”): *Withings Activite Pop Smart Watch*. Tracks the number of steps a wearer has taken in a day. This device can also be used to track stages of sleep, inclusive of time spent in light, and deep states. This is a connected device. When paired with an iOS tablet or phone which features Bluetooth LE (Low Energy), this device will automatically synchronise in the background. When paired with an Android tablet or phone, this device will synchronise each time the Withings HealthMate application is opened. This device is water resistant, and can store 38 hours of data before needing to synchronise with a paired tablet or phone.
- **Ambient Sensors** (Third party / “Off Shelf”): *SmartThings Ambient Sensing Kit*. This kit includes a network-connected “hub” to connect all ambient devices in a home, passive infrared sensors (PIRs) for a common set of rooms (living room, main bedroom, bathroom, kitchen, ensuite) and multi-use (contact) sensors for front and back doors. These are connected devices. PIR devices are activated on movement within their sensing zone. Contact sensors are activated on state changes (going from open to closed; closed to open). These devices automatically synchronise with the home-based SmartThings hub.
- **Blood Pressure Cuff** (Third party / “Off Shelf”): *Withings Wireless Blood Pressure Cuff*. Captures diastolic and systolic blood pressure, and heart rate. This is a connected device. This device does not feature an on-device interface for activation, the Withings HealthMate application on a paired tablet or phone must be opened to take a reading. This device is wireless, but can optionally be used with a micro-USB wired adapter. This device will synchronise each time it is used.
- **Digital Scales** (Third party / “Off Shelf”): *Withings WiFi Scales*. Captures weight readings. This is a connected device which can be paired directly through a WiFi network, or via Bluetooth to a tablet or phone (iOS or Android). When paired through



a WiFi network, this device will synchronise each time it is used. This device is activated when an individual steps onto it.

- **Blood Glucose Meter:** Provides blood glucose level readings. Manual input device. Readings from this device must be manually added to the system through a provided interface in the primary PwM CareApp. The possibility of integrating a connected device for these parameters will be investigated further prior to the PoC trial.
- **Pulse Oximeter:** Provides blood oxygen saturation levels (SpO₂). Manual input device. Readings from this device must be manually added to the system through a provided interface in the primary PwM CareApp. The possibility of integrating a connected device for these parameters will be investigated further prior to the PoC trial.
- **Tablet:** Android or iOS tablet or phone featuring Bluetooth or Bluetooth LE technology to pair connected devices. This device will host any required provider applications (e.g. the Withings HealthMate application). This device will also host the primary PwM CareApp which will deliver scheduled self-reporting surveys.

Data from the above devices is collected by the CABIE aggregation system (see section 3.3, CABIE / SIMS) at regular intervals throughout each day, or as data is received by provider systems (collection methods and frequency are provider- and device-dependent). Survey responses and manually-input readings will be sent directly to CABIE. For daily metrics (such as step counts, sleep summaries), collected data will be forwarded to the InterACT cloud when a finalised reading for each day has been collected. For point-in-time measurements (such as blood pressure readings) from connected devices, data will be forwarded to the InterACT cloud as it is received by CABIE. Raw readings data on CABIE will be available to CareApps as soon as it has been received by the system.

While every effort will be made to ensure all core ProACT devices to be deployed as part of the PoC trial are connected devices, this may not be possible for all device types. Additionally, stakeholder engagement has shown a desire from a subset of PwMs to use their existing, non-connected devices in place of ProACT-provided devices. To accommodate these requirements, the ProACT PwM Health and Wellbeing CareApp will feature a manual input feature for adding readings. Two devices (a Blood Glucose Meter and a Pulse Oximeter) are being used to evaluate this feature during the friendly trial.

3.2 CareApps

CareApps in ProACT are interactive dashboards which provide tailored interfaces for multiple ProACT ecosystem stakeholders, and facilitate all user-facing interactions with software components of the ProACT platform. An initial set of CareApps which focus on bidirectional feedback for PwMs and their formal and informal carers will be deployed for the purposes of evaluating data flow during the ProACT friendly trial. These initial CareApps are based on DKIT's YourWellness application, and use its underlying technology as their starting point (please see D3.5 *A Machine-Processable Catalogue of CareApps* (restricted access) for specific details).



Figure 3: DKIT's YourWellness Care App

The following CareApps will be available for evaluation during the friendly trial:

- **PwM Health and Wellbeing CareApp:** This application will be used by individual PwMs and will be delivered through a dedicated tablet (deployed as part of the PwM kit during ProACT trials). PwMs can use this CareApp to view their collected and generated ProACT data (sensor readings and analytics, respectively); to view condition-relevant and general wellness tips and training; and to engage with scheduled self-reporting surveys. Additionally, this application will allow PwMs to input readings from non-connected devices. This application will also be available, with some small functionality changes, within a web browser (device agnostic).

Support Actors:

- **Informal Carer CareApp:** This application will closely resemble the functionality of the PwM Health and Wellbeing CareApp, but with content tailored toward informal carers. Informal Carers can use this application to view data relating to the PwM in their care, and to view relevant training and tips material. In the first platform release, this application will not display a PwM's self-reported survey responses. A later revision (post friendly trial) will also allow informal carers to engage with scheduled surveys relating to the care process, and will also allow for configurable access to PwM survey responses. As with the PwM Health and Wellbeing CareApp, this application will only display data for a single PwM. This application will be available through a tablet or browser interface (device agnostic).
- **Formal Carer CareApp:** This application will be used by formal carers to view wellbeing data from multiple PwMs, and to view training materials relevant to the formal care process. PwM health data, survey responses, and training materials will not be

available for inspection. This application will be available through a tablet or browser interface (device agnostic).

- **Health Care Professional (HCP) CareApp:** This application will be used by health care professionals to view health and wellbeing data from multiple PwMs. In the first platform release, this application will not display a PwM's self-reported survey responses. A later revision (post friendly trial) will allow configurable access to PwM survey responses. Requirements gathering processes have not yet identified a need for this application to deliver training materials. This application will be available through a tablet or browser interface (device agnostic).

The set of CareApps to be deployed for the platform's first release, and evaluated during the friendly trial, focus on general categorisations within a PwM's care network. Works are currently ongoing to modify the YourWellness application to act as a technology template for ProACT use. Post friendly trial, works on CareApps will continue toward development of further tailored interfaces for relevant stakeholders, to augment the functionality of core CareApps based on stakeholder feedback, and to provide additional communication and condition management tools.

The development of core CareApps is being led by partners Treelogic and DkIT. As the project progresses toward the PoC trial stage, it is planned that additional partners, both within and external to the ProACT consortium, will contribute additional CareApps to the ecosystem's catalogue.



3.3 CABIE / SIMS

The Context-aware Brokering and Inference Engine (CABIE) is a data aggregation system developed by DkIT for the purposes of collecting, processing, and disseminating data from heterogeneous sources. Current deployments of the system process between 10 and 15 million distinct inputs per month and manage a historical data cache extending back to 2010. CABIE collects PwM measurement and sensing device data by interfacing with device manufacturers through a mixture of open and proprietary gateways and APIs. As part of its operation, CABIE performs normalization of incoming data (time formats, units of measurement, etc.) to simplify consumption by partner systems.

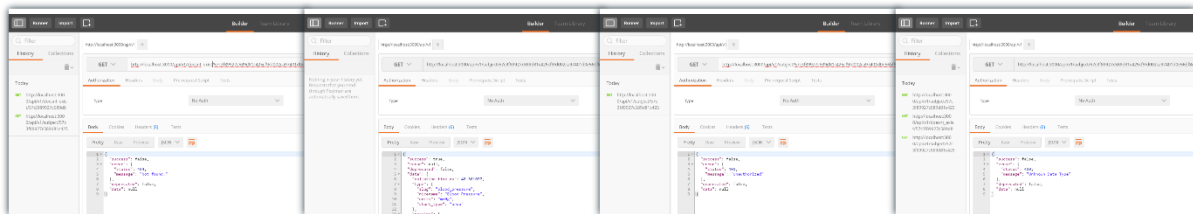


Figure 4: CABIE API Rendering a Variety of Success and Error Responses

To simplify management of trial site technologies and components for PwMs, and to provide ProACT research and technical personnel with a method of inspecting platform data, DkIT has developed a CABIE companion module for use in ProACT. The Subject Information Management System (SIMS) augments core CABIE functionalities and can be used to manage one or more CABIE deployments from a single location. This module uses a granular permissions system for access which can be used to limit the functionality of user interface or API users.

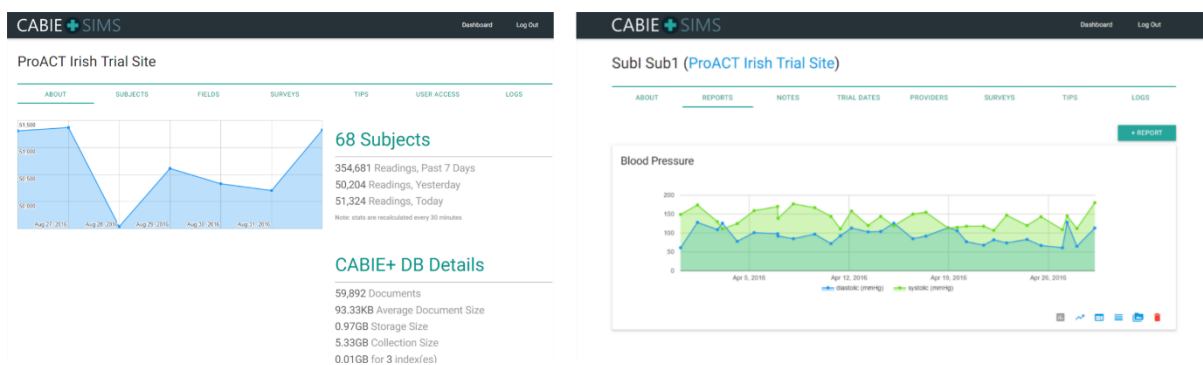


Figure 5: SIMS Dashboard and Report-generation Page

In addition to collecting PwM device data, and providing this data to partner systems, CABIE will act as the primary exchange conduit between all core ProACT technology components. CABIE will act as a data provider to the InterACT cloud and to CareApps, and will act as a data consumer from the InterACT cloud and from CareApps. By extension of its connection to the InterACT cloud, CABIE will also act as an indirect provider and consumer of analytics input and results, respectively (please see D2.1 (restricted access) for further details).



3.4 The InterACT Cloud

ProACT’s global data store, the InterACT cloud, has been developed by partners IBM to act as a secure platform for the storage, mining, and analysis of de-identified PwM data. The InterACT cloud acts as a nexus for local data aggregators (CABIE) and provides a platform for analytics services to make use of collected data in a secure and privacy-conscious manner.

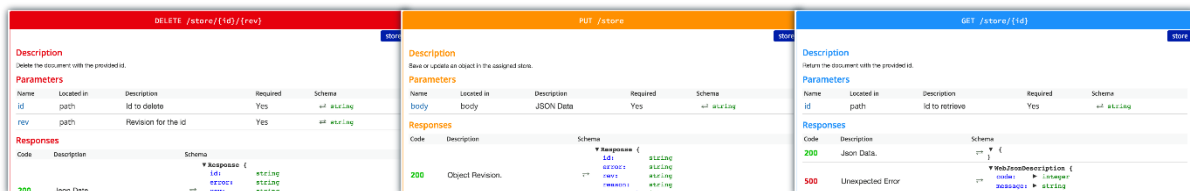


Figure 6: Rich Interactive InterACT API Documentation

The InterACT cloud has been designed to be easily extended, features dynamic storage allocation, and is exposed as a set of services to manage anonymised health data, and to coordinate collaboration between data provider services, data analytics services, and data consumer services. The platform features a role-based authentication system which controls access to various data stages, and can be interacted with through a Representational State Transfer (RESTful) API.

External systems (e.g. CABIE, CareAnalytics providers) which register with the InterACT cloud through the role-based access system will only have access to the data states their roles permit. PwM data stored in the InterACT cloud undergoes a de-identification process before reaching the service. This process ensures that data available to analytics providers (one of the available roles) does not contain personal information (PI), and also that it has been disassociated from programmatic identifiers which might be used to re-identify individuals through inference from access to public components of partner systems—for example, individual identifiers within the InterACT cloud are not the same identifiers used for a PwM within CABIE or CareApps.

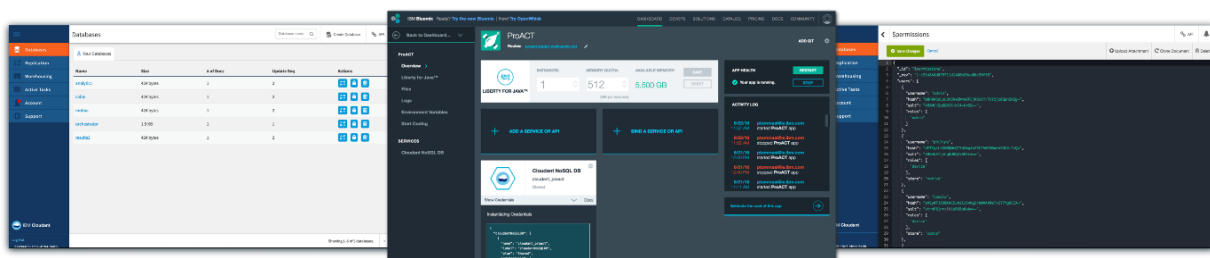


Figure 7: InterACT Hosted on IBM Bluemix

For ProACT’s friendly trial, the InterACT cloud will be deployed on IBM’s BlueMix platform backed by Cloudbant for scalable, reliable storage. The combination of these services ensure that the InterACT cloud is future-proofed for PoC trials at an early stage, and that CareAnalytics are tested against a production environment from their earliest stages of integration (please see D2.1 (restricted access) and D3.4 *The InterACT Cloud Infrastructure* (restricted access) for further details).



3.5 CareAnalytics

Analysis of person-centric data in ProACT will operate through the InterACT cloud platform in the form of *CareAnalytics*—contextually aware procedures or algorithms which can detect and react to patterns in current or historic data available to ProACT systems. These analytics will be employed to track and monitor clinical and non-clinical parameters for multimorbidities, condition management, and condition status; to inform learning, guidance, and care pathways for PwMs through the recognition of trends over time; and to generate alerts from incoming data which may indicate short- or long-term changes in general wellness. A variety of analytic methods to meet these goals are in active development by partners Treelogic and IBM.



Figure 8: Room Location Plotting (as displayed in DKIT’s YourWellness CareApp), and Predictive Analytics (as shown in Treelogic’s Arteriotarget Interface)

A small selection of CareAnalytics will be deployed for the ProACT friendly trial to test operation on the InterACT cloud, and data delivery pathways to CABIE and CareApps. Development of the full suite of CareAnalytics will continue throughout 2016/17 in preparation for the ProACT PoC trial. Examples of Care Analytics include:

- An adaptive model of the individual which combines and evaluates biological, physiological, psychological, and social dimensions through use of a dynamic Bayesian network (currently in development by IBM).
- Both simple and dynamic alert generation for contra-wellness indicators by programmatic inspection of incoming data streams. Currently available examples include the detection of night time wandering outside of the home, and detection of suspected falls in the home through inspection of ambient sensing data.
- Ambient assessment of frailty and changes in emotional wellbeing achieved through recognition of trend adherence and deviation over time.

CareAnalytics on the ProACT platform will also make use of system analytics data to evaluate and enhance stakeholder engagement with CareApps, and the wider platform. For example, proposals have been put forward by partners Treelogic to use system analytics to discover questionnaire responses which PwMs have difficulty in completing (please see D3.5 (restricted access) for further details).



4 Development Process and Progress

The ProACT platform has been, and will continue to be, developed in direct consultation with PwMs and key identified stakeholders in their care networks. Partners IBM, DkIT, Philips, Treelogic, and Tyndall National Institute will provide new technology components as needs are identified by the wider research team. As a first step in this process, extensive engagement with stakeholders has taken place in WP1 to identify and better understand care pathways and requirements. The findings from this process will be augmented throughout the life of the project by continued stakeholder engagement and feedback, all of which will directly influence future development and refinement of the ProACT platform. This first platform release has focused on the development of new core technologies, and on integration of core platform components. However, realisation of the full platform is an ongoing process where iterative updates and augmentation will continue throughout the project's lifetime. The first release of the platform is one step in a continuous process which will see major updates delivered in M24 (prior to the PoC trial) and in M39 (prior to the project's completion).

Table 1, below, lists the core components of the ProACT system, their current state of development and integration, and any works currently ongoing or planned in advance of the friendly trial:

Table 1: ProACT System Components Development and Integration Progress (early M9)

Component/System	Status	Integration Status	Roadmap
InterACT	PoC Complete	In progress.	Ongoing: CABIE integration in progress--expected M10. User management, testing, deployment.
CABIE	Existing	Point of integration (see other rows)	Ongoing: Misc. internal updates taking place M9/M10. Internal testing of updates through M10. External testing as part of friendly trial.
SIMS	PoC Complete	Integrated with CABIE. CareApp integration in progress.	Ongoing: Porting survey and training management from existing system. Due as part of next PoC revision, M11.
CareApps Platform	In progress	Integrated with CABIE. SIMS integration in progress. All other integrations through CABIE / SIMS.	Ongoing: Due in line with next SIMS PoC revision, M11.
CareAnalytics	In progress	Awaiting other components.	Basic test analytics operating on InterACT

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			data to be deployed for friendly trial testing.
Measurement and Sensing Devices	Friendly trial devices selected. Required parameters identified. Miscellaneous devices being tested in parallel to, and after, friendly trial.	Connected devices for friendly trial integrated with CABIE.	Incorporation of functionality to allow for manual input from non-connected devices due in line with CareApp platform, M11



5 Platform Demonstrations

Demonstrations of the ProACT platform (first release) will be available at trial sites in Ireland, Belgium, and in the transfer feasibility site in Italy throughout the project's friendly trial. Public demonstrators for the next iteration of the system (second release) will be available in advance of the PoC trials. Where appropriate, out-of-trial demonstrations of the system or component parts can be arranged on request to the Project Coordinator in Trinity College, Dublin.



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