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Executive Summary

The aim of this deliverable is to provide a detailed specification of the PRECIOUS system integration process. In this case integration is considered in a broader scope that is not only limited to technical integration activities carried out at component, subsystem or system level. In addition to that, this integration report also considers system integration, verification and validation in the context of a complete and iterative lifecycle that brings together activities from the project's system analysis, design, implementation, integration and user testing phases. The objective of these processes integration, verification and validation processes is to ensure that PRECIOUS system is free from defects and acceptable for use. as well as, to verify that PRECIOUS system is able to fulfil the requirements.

The PRECIOUS system integration is constituted within iterative and incremental development approach, whereby, simple implementations of parts of the system (or implementation of some of the requirements) is carried out in each iteration until complete system (or subsystems) are ready to be deployed and tested by the users. Each, successive iteration provides lessons and insights that are useful for the continued design and implementation of the system and constituent components.

The deliverable is organised in two main parts. Part one provides an overview of the PRECIOUS architecture, include a summary of the architectural viewpoints with aim of utilising some of the viewpoints illustrate the overall integrated PRECIOUS system. Furthermore, the first part also presents a survey of tools, with a specific focus of food intake monitoring tools. The second part of the deliverable presents the PRECIOUS integration approach and also provides an extended description of the phases prior to and after the actual integration process.

The PRECIOUS system integration approach is part of an overall iterative and incremental development process. This agile approach has enabled continuous integration and deployment of PRECIOUS subsystems or systems for internal verification within the consortium or validation through user testing and feedback.

Background

1. Glossary

1.1 Acronyms

ADM	Automatic Dietary Monitoring
API	Application Programming Interface
BCT	Behavioural Change Technique
BIT	Behavioural Intervention Technologies
BMI	Body Mass Index
BP	Blood Pressure
CVD	Cardiovascular Disease
ECG	Electrocardiogram
EEG	Electroencephalography
EGG	Electrogastrography
EMG	Electromyography
FCDB	Food Composition Databases
GPS	Global Positioning System
GSM	Global System for Mobile communication
HIPAA	Health Insurance Portability and Accountability Act
HL7	Healthcare Layer 7
HRV	Heart Rate Variability
HSPA	High Speed Downlink/Uplink Packet Access
HTTP	Hypertext Transfer Protocol
HU	Helsinki University
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineering
IMT	Institut Mines-Télécom

IoT	Internet-of-Things
IP	Internet Protocol
ISO	International Standards Organisation
IT	Information Technology
ITU	International Telecommunications Union
JSON	JavaScript Object Notation
LAN	Local Area Network
LTE	Long Term Evolution
M2M	Machine-to-Machine
MI	Motivation Interviewing
MQTT	formerly acronym for *Message Queue Telemetry Transport*
N/A	Not Applicable
NCD	Non-Communicable Disease
OS	Operating System
PAN	Personal Area Network
PC	Personal Computer
PMBOK	Project Managers Book of Knowledge
PRECIOUS	PREventive Care Infrastructure based On Ubiquitous Sensing
QoS	Quality of Service
REST	Representational State Transfer
RM-ODP	Reference Model Open Distribution Processing
SDO	Standards Development Organisation
T2D	Type II diabetes
TB	Telecome Bretagne
TCP	Transport Control Protocol
TLS	Transport Layer Security
UDP	User Datagram Protocol
UI	User Interface

UNIVIE	University of Vienna
UX	User Experience
VHIR	Vall d'Hebron Research Institute
VIM	Virtual Individual Model
WAN	Wide Area Network
WHO	World Health Organization
XML	Extensible Markup Language

1.2 Terms and definitions

Architecture (of a system): Set of rules to define the structure of a system and the interrelationships between its parts (ISO/IEC 10746-2).

- A means for describing the elements and interactions of a complete system including its hardware elements and its software elements (SEI)
- The conceptual model that defines the structure, behaviour, and more views of a system (Wikipedia)

Interface: Named set of operations that characterize the behaviour of an entity. The aggregation of operations in an interface, and the definition of interface, shall be for the purpose of software reusability. The specification of an interface shall include a static portion that includes definition of the operations. The specification of an interface shall include a dynamic portion that includes any restrictions on the order of invoking the operations (ISO 19119:2005).

Interoperability: Capability to communicate, execute programs, or transfer data among various functional units in a manner that require the user to have little or no knowledge of the unique characteristics of those units (ISO 19119, ISO 2382-1).

Open Architecture: An architecture whose specifications are public. This includes officially approved standards as well as privately designed architectures whose specifications are made public by the designers (Wikipedia).

Reference Model: Framework for understanding significant relationships among the entities of some environment, and for the development of consistent standards or specifications supporting that environment. A reference model is based on a small number of unifying concepts and may be used as a basis for education and explaining standards to a non-specialist (ISO).

Service: Distinct part of the functionality that is provided by an entity through interfaces (ISO 19119).

System: Something of interest as a whole or as comprised of parts. Therefore a system may be referred to as an entity. A component of a system may itself be a system, in which case it may be called a subsystem (ISO/IEC 10746-2).

Validation: The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders (PMBOK/IEEE).

Verification: The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition (PMBOK/IEEE).

Viewpoint: Subdivision of the specification of a complete system, established to bring together those particular pieces of information relevant to some particular area of concern during the design of the system (ISO/IEC 10746).

2. Introduction

2.1 General PRECIOUS objectives

The PRECIOUS project aims to develop a preventive care system to promote healthy lifestyles with a particular focus on the environmental, socio-psychological and physiological factors linked to two common non-communicable diseases: Type 2 Diabetes (T2D) and cardiovascular diseases (CVD). Each of these conditions has individually modifiable risk factors that include, for example, physical activity level, stress, sleep quality, food intake and substance use, as well as living environment (see Figure 1). As such behavioural interventions and motivation for lifestyle changes play a major role in reducing an individual risk to T2D and CVD.

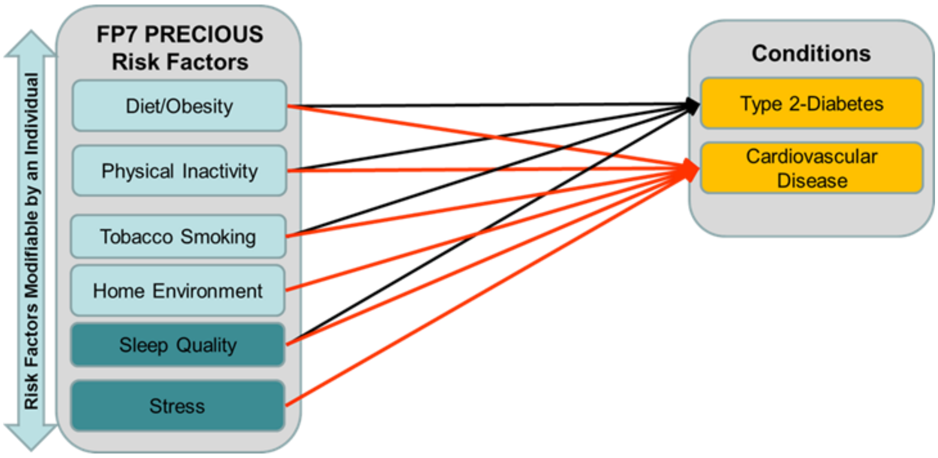

Figure 1 Risk factors considered in PRECIOUS

Therefore, the PRECIOUS project aims to provide new innovations in preventive health care that include:

- A new automated service that analyses user health and ambient data to identify present and future risk factors
- A novel motivational system that boosts the required user actions to reduce unhealthy habits and promote healthy ones
- An innovative gamified user interface, including key motivation elements from the gaming industry to trigger and maintain behavioral change

2.2 Specific objectives, context and scope of this deliverable

The overall PRECIOUS project objectives described above point to the requirement for system (consisting of subsystems and components) capable of monitoring risk factors associated with those two non-communicable diseases and provide feedback to the monitored end user and other relevant health stakeholders. In actual sense this implies implementation and realisation of system that includes the deployment and interconnection of physical and software (user applications, cloud-based components etc.), as well as, consideration the communication channels, protocols and interface standards utilised to achieve that.

The objective of deliverable D4.2 is to specify in detail the PRECIOUS system integration approach. In this case integration is considered in the broader that is not only limited to technical integration activities carried out at component, subsystem or system level. Therefore, this integration report also considers system integration, verification and validation in the context of a complete and iterative lifecycle that brings together activities from the project's system analysis, design, implementation, integration and user testing phases.

Therefore, this deliverable provides a detailed wide-raging description of the aforementioned PRECIOUS system integration aspects (both technical and non-technical). To that end, PRECIOUS system integration reports ties together activities across different phases project (specifically from WP2 to WP5) towards a fully integrated PRECIOUS system.

3. Overview of PRECIOUS Architecture

3.1 High-level specification

The PRECIOUS system architecture was specified in *D4.1 System architecture and design specification* to provide a framework for the many design and implementation activities carried from the second year of the project. To that end, the PRECIOUS system architecture specification is based on an architectural framework known as the Reference Model Open Distribution Processing (RM-ODP) which found use in many research projects and health enterprise IT design processes [9]. The benefit of RM-ODP is that it allows us to paint this 'big picture' with different perspectives or viewpoints that provide viewing angles for mixed set of system users (e.g. software developers, health practitioners, network engineers, etc.). Such diversity of expertise is event evident within the multidisciplinary PRECIOUS consortium.

The definition of each PRECIOUS architectural viewpoint is further complemented by the so called Behavioural Intervention Technologies (BIT) model, which provides conceptual and technological definitions from clinical aim to technological delivery for behavioural change interventions [2]. The BITs generally constitute a subset of m/e-Health interventions, utilise a broad range of technologies (smartphones, Internet, sensors, data analytics etc.) to support users in changing behaviours and cognitions related to health and wellness. Typically BITs have larger treatment goals which are built on a number of smaller interventions for the user. These interventions may include, promotion or elimination of particular behaviours and the related behavioural change strategies (monitoring of health risk factors, motivation methods, personalised guidance etc.).

The big picture describing the five viewpoints of the PRECIOUS system architecture that will guide us further in the project's ongoing work is illustrated in Figure 2.

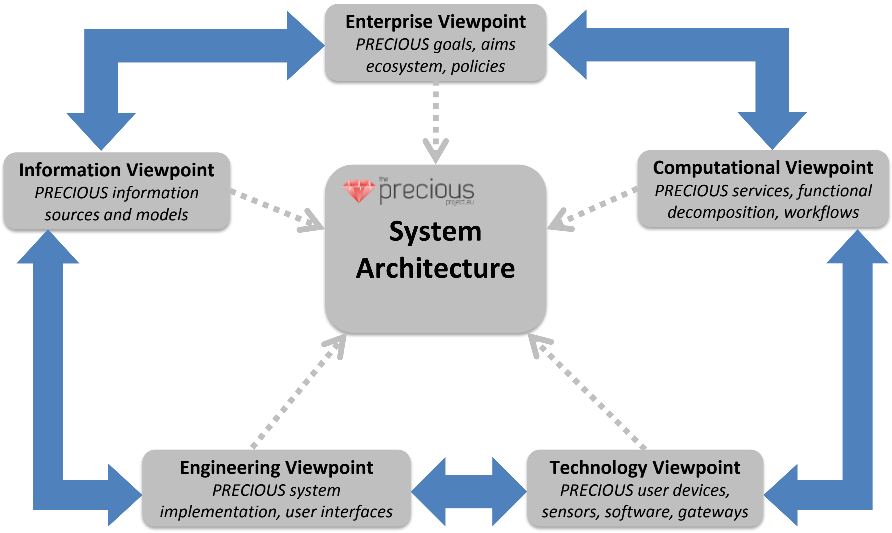

Figure 2 Representation of PRECIOUS architecture using the RM-ODP framework

The augmentation of the RM-ODP viewpoints with elements of BIT model adds more relevance to the mapping of the standard RM-ODP viewpoints to the PRECIOUS system architecture. This mapping of the augmented RM-ODP viewpoints to the PRECIOUS architecture is summarised below:

- *Enterprise viewpoint*: Focused on the PRECIOUS overall treatment goal is prevention of two non-communicable diseases: CVD and T2D. The clinical aims include behavioural changes to improve diet, physical activity, sleep quality and reduce stress level. Usage aims target acceptance/adoption of PRECIOUS intervention tools, including: PRECIOUS apps on smartphone, tablets etc. and sensors for monitoring user's physiology, activities, context, sleep quality, food intake and environment. Also the description PRECIOUS behavioural change strategies, including: behavioural change and motivation techniques; gamified feedback; goal setting and goal achievement mechanism. This viewpoint also provides overview PRECIOUS service ecosystem and main actors therein. It presents the PRECIOUS governance framework in the form of ethical and privacy guidelines. *Information viewpoint*: This PRECIOUS viewpoint lists the parameters for the building the virtual individual model (VIM) provides an up-to-date representation of user's risk to CVD and T2D. Furthermore, it defines the approach of semantic interoperability and processing of the aforementioned user data.
- *Computational viewpoint*: This PRECIOUS viewpoint illustrates the high-level functional decomposition of the PRECIOUS system and the interrelationship between different components. Furthermore, it describes the workflows of different PRECIOUS intervention services (initiation, push, pull, etc.)
- *Engineering viewpoint*: This PRECIOUS viewpoint presents the actual implementation and realisation of the PRECIOUS system. This includes the deployment and interconnection of physical and cloud based components, as well as, the *communication channel*s, protocols and standards utilised. The viewpoint also summarises the PRECIOUS user interface and user experience (UI/UX) design approach for customisation (complexity, aesthetic and personalisation) according to user profile and service or intervention.
- *Technology viewpoint*: This PRECIOUS viewpoint specifies the technological choices (hardware, software, middleware etc.) for implementing the PRECIOUS system, and for each, summarises their characteristics.

3.2 Summary description of implemented system

The PRECIOUS project aims to develop a preventive care system to promote healthy lifestyles with a particular focus on the environmental, socio-psychological and physiological factors linked T2D and CVD. To that end, this required implementation of a system capable monitoring risk factors associated with those two non-communicable diseases and provide feedback to the monitored end user and other relevant health stakeholders.

Table 1 describes how the risk factors for T2D or CVDs could be monitored (that is, the monitoring or sensing technologies for each risk factor) and summarises some of the related parameters of interest for the PRECIOUS system. A more detailed discussion on the parameters is provided in deliverable *D3.1 Interim report on behavioral representation and virtual individual modeling*.

Table 1 Risk factors that could be monitored and corresponding sensing technologies considered in PRECIOUS

PRECIOUS Risk Factor	Risk Factor Attributes Monitored in PRECIOUS	Monitoring/sensoring implemented in PRECIOUS (revised)
Diet/Obesity	• Body weight, body mass index BMI • Food intake and food composition	• Connected weight scale • Food intake monitoring (apps)
Physical Inactivity	• Indoor activity or movement • Outdoor movement or mode of transport car, bicycle, etc • Exercise (distance, elapsed time, etc.)	• Heart rate sensor (wearable) • GPS device (smartphone, wearable) • 3D accelerometer (smartphone, wearable) • Indoor activity sensor (infrared camera)
Home (or office) Environment	• Indoor thermal comfort (temperature + relative humidity) • Indoor air quality • Indoor lighting quality • Noise pollution	• Thermal sensor (indoor) • Humidity sensor (indoor) • Air quality sensor (indoor) • Light quality sensor (indoor) • Sound/noise sensor (indoor)
Stress	• Stress levels, recovery from stress • Mood/emotions	• Heart rate variability sensor (wearable) • Online (social media) mood detection
Sleep Quality	• Sleep posture, body movement, etc. • Sleep disturbances, interuptions • Sleep duration	• Heart rate variability sensor (wearable) • 3D accelerometer (wearable)

This engineering viewpoint of the PRECIOUS architecture specification describes the actual implementation and realisation of the PRECIOUS system. This included the deployment and interconnection of physical and cloud based components, as well as, the communication channels, protocols and standards utilised. A high-level diagram of the current PRECIOUS system implementation is depicted in Figure 3.

The system implementation constitutes distribution system components deployed by different partners at their respective sites. These include:

- PRECIOUS cloud server deployed at UNIVIE (initially deployed at AALTO)
- Ambient sensor and smart home network test-bed deployed at a living lab TB/IMT
- HRV data analytics server deployed at FB
- Development sandbox deployed at UNIVIE
- Mobile clients utilised at various locations and running the PRECIOUS apps

An additional ambient sensor network test-bed deployed was also deployed at AALTO but later decommissioned as the focus on home environment monitoring was limited to TB/IMT testbed. The integration aspects of the various PRECIOUS subsystems are described further in Section 5.

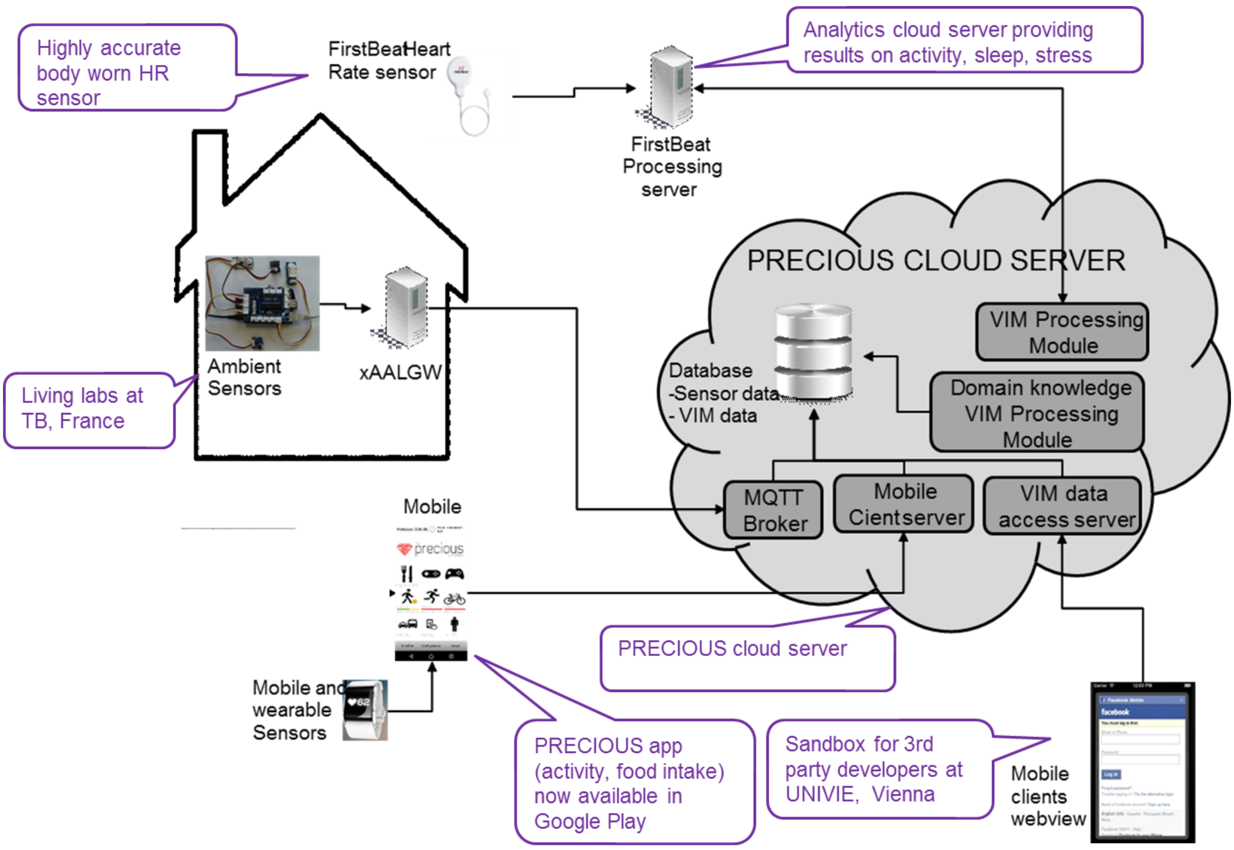

Figure 3 High-level diagram of PRECIOUS system implementation

4. Review of Food Intake Monitoring Tools

In this chapter an assessment is carried out from some of the most well-known tools for monitoring of food intake. This is part of the technology assessment process that was started in D4.1 where the focus was on assessing personal health systems and smart home solutions. Furthermore, monitoring tools for physical activity, sleep and stress where assessed to do different degree in D3.4, D4.1 and D4.4. Therefore, in addition to providing a complementary technology assessment to those previous assessment studies, this chapter also provides useful background information for the system integration discussion in the upcoming chapters. More detailed survey results are presented in Annex Section 8, in addition to the summary report of this chapter.

4.1 Introduction

Within PRECIOUS the term ‘food intake’ should be considered to include the intake of both foods and beverages. Food intake is known to impact on health, and a poor diet (e.g. excess energy intake, high fat, sugar and salt intake and low fibre and micronutrient intake) is associated with increased risk of obesity, type II diabetes and other metabolic disorders. Self-monitoring of food intake may help individuals to make dietary improvements; however food intake monitoring is not without error. Monitoring tools should ideally provide an overview of habitual dietary intake for key nutrients. However, collecting accurate data on habitual intake is a key challenge in food intake monitoring.

Records of food intake may be prospective (current intake) or retrospective. Prospective methods (e.g. weighed record, household measures, and checklist) are typically only collected for a short period of time (a few days) and are therefore unlikely to represent long-term habitual food intake. Furthermore, these methods can be burdensome for the user, who is required to record all food and drink items consumed, usually including weights/portion sizes of each item. Access to high quality data is also required to provide the energy and nutritional content of each item.

Retrospective methods (e.g. 24 hour recall, diet history, food frequency questionnaire) collect past data about diet, and, in the case of a diet history and food frequency questionnaire (FFQ), can provide an indication of habitual intake. Unfortunately, the diet history method is limited due to expert interviewers being required to collect information. FFQ’s are much simpler, and designed for the user to complete independently. However, this method is generally intended to determine the dietary patterns of a large cohort of people (i.e. in epidemiological studies), rather than individuals.

Since current retrospective methods are not suitable for self-monitoring purposes, users are required to rely on day-to-day diary recordings of food intake to predict typical intake. Traditionally such recordings were paper-based, and had to be entered manually into dietary analysis software by a suitable health professional, who then fed information back to the individual. This approach is still valid in some situations, for example in a clinical research setting or a one-to-one patient consultation; however for the general population a more transparent, user-friendly system is required.

Mobile technology has provided this opportunity, and a number of applications can provide instant nutritional information about foods entered by the user. Additional features, such as 'previously entered items' and barcode scanners, try to reduce the burden on the user over time. Other emerging tools include software that can process photographs of foods, load sensing tables and motion sensors in clothing. These emerging tools offer greater transparency than manual data entry via a mobile application; however may provide less detail and accuracy.

Additionally, there is evidence to suggest that healthy eating interventions which use self-monitoring in combination with self-regulation techniques from control theory (for example feedback, goal setting, action planning, prompt review of goals and setting of graded tasks) are more successful than self-monitoring alone [4],[6]. Encouraging behavioural change through a combination of goal setting, monitoring, feedback and other motivational tools is a key feature of PRECIOUS. Importantly, users should gradually internalise changes and adopt these as routine. Furthermore, individualised feedback has been linked with improved adherence to online interventions designed to promote healthy lifestyles [1],[5]. PRECIOUS aims to provide individualised feedback through adaptation of Firstbeat's Virtual Individual Model (VIM). The rest of this section will identify and review tools available for monitoring food intake, in order to understand the current state-of-the-art. The data collected in this task will help to develop a food intake tool for PRECIOUS.

4.2 Types of technology available and their corresponding pro's/cons

A wide range of approaches are being taken across the EU to tackle NCDs, including policy making, public campaigns and the reduction of inequalities in health. There is an increasing focus on these approaches being more patient centric, so that individuals become more empowered and responsible for their own health. As part of this more patient centric approach, Information and Communications Technologies (ICT) have a significant role to play, with a particular focus on the use of mobile technologies. The use of ICT in healthcare is characterised by two key definitions: i) *e-Health* is used to describe the use of ICT in health (WHO define e-Health as the transfer of health resources and health care by electronic means [7]) and ii) *m-Health* is used to describe the use of mobile technologies to deliver e-Health. m-Health has the potential to target large and diverse audiences and address the specific needs of individuals, because smart phones are intelligent, personal, portable and virtually always connected. With 67.6% of adults worldwide owning a mobile phone, there is a huge potential for using this technology, especially as it is already in the public domain [8]. The use of mobile computing and communication technologies in health care and public health is continuously expanding and evolving [8]. A recent report from the EU assessed the socio-economic impact of m-Health solutions and found that they offer potential for the EU to achieve a cost saving of €76 billion, with the technology assisting 54 million patients in avoiding the risk of developing a lifestyle disorder [8].

Based on the potential for cost saving in public health services, there are increasing investigations into the potential uses and role of technology in helping consumers make healthier choices, these range from wearable and novel technology to apps and games.

Self-reporting methods, whether paper based but more commonly now technology based, are still the main source of information gathered from technological food intake based tools, and hence the sole source of information for any personalised feedback/coaching. This self-reporting can lead to a high level of inaccuracy in the data collected from the user, due to lack of commitment/motivation, lack of understanding and awareness, along with memory issues and the setting of over ambitious goals, leading to early failure [9]. This is why experts are now looking to other approaches to data collection, including automatic dietary monitoring (ADM). O. Amft and G. Troster (2009) investigated the use of both ambient embedded sensors and on body sensing approaches as ADM solutions to monitoring eating behaviours [9].

This area of investigation, whilst showing promise is still very much in the early stages of development, and looks to be a rapidly developing area in the near future. The benefits of using ADM, means there is significantly fewer burdens on the user, and it can provide more robust data on eating behaviours. It simplifies the interaction with user, which in turn is believed to increase length of interaction. Examples of current ambient embedded sensors include the use of image collection, whether it is from a wristband or shirt pin, to dining tables that can detect changes in weight when eating food from specific bowls that also allow the identification of foods [9]. One of the major challenges currently facing ADM technologies is ensuring that robust data is collected in a way that is both easy and practical to use. Also these technologies need to be able to tackle the difficult challenge of identifying the food and amount eaten and be able of capturing and interpreting additional information like; alteration of food (addition of additional ingredients, post data capture, be able to interpret non-homogenous food and servings, and understand the how the environmental and physiological are impacting the users food intake.

In terms of on-body sensing they identified that swallowing, thermic effect, intake gestures, body composition, chewing, cardiac response, gastric activity and body weight, were the main body behaviours relating to food intake. O. Amft and G. Troster (2009) trialled various possible technologies to measure some these behaviours. This included using 3D acceleration, gyroscope and compass sensors to monitor intake gestures, surface electromyography (EMG) and microphones for chewing, the use of collars to detect textile elongation, EMG and a stethoscope like microphone to monitor swallowing patterns [9]. They also reviewed current technologies being researched to monitor gastric activity, the thermic effect of food, body weight, cardiac response and body composition. They identified that researchers are currently looking at the use of electrogastrography (EGG) and stethoscopes to monitor gastric activity, however there are a number of factors that affect the data recorded and this approach is not currently accepted clinically. Researchers are also currently investigating the thermic effect of food intake, however currently this requires the use of a respiratory chamber, and hence do not provide an easy portable solution for monitoring food intake. The intake of food results in an immediate increase on body weight. To capture these changes in weight requires continuous monitoring of weight of the body. Current shoe based weighing systems are unable to capture the robust data as they require the users to stand still whilst measurements are taken. The results also can be influenced by uneven surfaces. In terms of cardiac responses, they reported that research is currently on-going into the use of less novel approaches for monitoring cardiac responses, however the relationship between food intake and cardiac response is still not clearly defined and is easily influenced by physical activity, fasting and time of day.

As well as considering novel ADM systems being researched, currently available ADM systems and those in development were reviewed. The review highlighted that these technologies can range from the popular wristbands like FitBit® to sensors integrated into everyday clothing items like Hexoskin® tops. They use sophisticated algorithms and ubiquitous sensors to gather accurate health related data, without disrupting the individual's daily routine. This enables individuals to become more engaged and active in managing their health, by providing information and feedback on their current choices. The downside to these wearable tools is that there is still considerable variation in their accuracy; however as technology evolves there is no doubt that in the future they will play a critical role in managing the health of individuals.

A number of other technologies are being developed to help consumers monitor their diets. These include scales that connect to a smart-phone device via Bluetooth to enable the user to accurately record the weight of food they are consuming. This allows the user to more precisely log the nutritional intake. However, as the device requires the user to weigh individual dietary components, it may not be suitable for all environments (e.g. a restaurant). Another area currently being investigated is the use of spectroscopic analysis to determine the chemical makeup of food consumed, however there is currently limited scientific validation of this approach. An alternative approach is the HAPIfork®, which claims to help the user slow down while eating, as it tracks eating speed and alerts the user during use by shaking when eating is too quick. The down side to this is that it only controls one element of food intake providing no guidance on nutritional content. These novel technologies are, however, continuously evolving and they will have a part to play in helping consumers to manage their health in the future. It is crucial to ensure that the needs of the user and scientific validity are kept central to the design of such tools to maximise uptake.

Whilst ADM have a huge potential in food intake monitoring in the future the most popular and used technique for food/health monitoring by individual users is m-Health. Currently a huge range of apps/games are available for users to download on to their mobile devices. For example a search of the Google Play Store on the 19/07/16 using the term 'food tracker' resulted in 248 separate results. In this review 57 web/mobile based apps/games/quizzes have been reviewed as part of this review. These tools were identified by completing systematic search, using the search terms dietary intake tools, ways of measuring dietary intake, app to track food intake, games for recording food intake, games healthy eating, electronic ways of monitoring food intake, and healthy eating quizzes. Of the 57 apps/games/quizzes reviewed, 1 was a solely web based tool, 18 where apps, 36 were games or quizzes and 2 were both web and app based. All the apps and the web based tool were targeted at adult users, whereas 77.1% of the games/quizzes were aimed at children. All the apps/games/quizzes were free to use, however, Lose it did charge $40/year for additional features. On the 10.09.14, a review was completed to identify the top app store results. These are presented below;

Table 2 Review of various dietary apps from different app stores

App store	Website	Date	Diet app 1	Diet app 2	Diet app 3	Diet app 4	Diet app 5
Google Play (health and fitness top selling free)	https://play.google.com/store/apps/category/HEALTH_AND_FITNESS/collection/topselling_free	10.9.14	**MyFitnessPal**	A taste of Slimming World 2.0	**Weight Watchers Mobile UK**	**Weight Watchers Simple Start U**	Change4Life Smart Recipes
Windows (diet & nutrition free)	http://www.windowsphone.com/en-gb/store/top-free-apps/diet-nutrition/dietandnutrition	10.9.14	**MyFitnessPal**	All Diets	Weight Challenge	Flatten Your Belly	Calorie Counter
Windows (diet & nutrition best rated)	http://www.windowsphone.com/en-gb/store/top-rated-apps/diet-nutrition/dietandnutrition	10.9.14	przepisy.pl	My Food Diary	Recipes 4 Everyone	Fat Burning Abs & Diet	My Weight Diary
Windows (diet & nutrition paid)	http://www.windowsphone.com/en-gb/store/top-paid-apps/diet-nutrition/dietandnutrition	10.9.14	Flat Belly in a Week	Fat Burning Abs & Diet	Control Your Weight	Flat Belly Diet	Livescape

App store	Website	Date	Diet app 1	Diet app 2	Diet app 3	Diet app 4	Diet app 5
Apple US (healthcare & fitness free)	http://www.topappcharts.com/search.php?show=category&price=free&category=Healthcare+%26+Fitness&platform=iphone&start=0	10.9.14	**MyFitnessPal**	**Weight Watchers Mobile**	**Weight Watchers Simple Start US**	**MyPlate Calorie Tracker LITE**	My Diet Coach
Apple US (healthcare & fitness paid)	http://www.topappcharts.com/search.php?show=category&category=Healthcare+%26+Fitness	10.9.14	The Fast Metabolism Diet App	Paleo Central	Calorie Counter PRO by MyNetDiary	**MyPlate Calorie Tracker**	Paleo.io
Apple UK (Top 100 paid)	https://www.apple.com/uk/itunes/charts/paid-apps/	11.9.14	3 day detox	Carbs & cals	n/a	n/a	n/a
Apple UK (Top 100 free)	https://www.apple.com/uk/itunes/charts/free-apps/	11.9.14	**MyFitnessPal**	n/a	n/a	n/a	n/a

From this can be seen that My Fitnesspal™ is the most popular tool for users to self-monitor their food intake and physical activity. The review also identified that Noom coach provided the most tailored coaching to users. The review also identified that gaming approaches are not widely used currently to increase the engagement or motivation of adult users, and instead the majority of games/quizzes relating to food intake and intended to educate children on healthier choices. Of the apps reviewed the significant majority are reliant on the self-reporting by users into a food journal, which then calculate nutritional value of the diet based on a database. Some of the apps now also incorporated a barcode scanning feature to speed up the process on logging ideas, however the majority rely on the user inputting a correct portion size. This is known to be a major source of error in self-reporting of the diet. The Weightwatchers incorporates a function that allows users to photograph food to aid memory recall when logging intake at a later point in time.

Mobile based diet tracking tools, provide one solution for individuals to track their food intake, and be able to understand the dietary value of the foods they eat, however it is well understood the levels of error that can occur when using these methods, due to incorrect estimation of portion size, and incorrect memory recall. Level of usage of these tools is also found to wane over time due to the cumbersome nature of logging each item individually.

4.3 Summary

Classic dietary monitoring techniques require users to manually record their food intake; however, low adherence and accuracy reduce the robustness of the data captured. There are currently a wide range of electronic tools available for users to log their food intake using mobile devices. These offer an increased convenience as it allows logging of data in any location and as they often work from a nutritional database, they can provide real-time nutritional information to users, however like traditional food intake monitoring methods, the electronic tools are also based on self-reporting, resulting in similar levels of errors being seen. ADMs could potentially provide a novel solution but many of the approaches being developed are not commercially available yet and do not have sufficient supporting data to validate the robustness of the information they capture. As technology continues to develop it is clear novel solutions will be created, enabling users to better manage their diet and health. It is important to note that any product that is developed, need to maintain the user at the centre of its design, to ensure it meets the user’s needs and is suitable for purpose.

System Integration Aspects

5. PRECIOUS System Integration

5.1 Background

The PRECIOUS system integration, verification and validation is guided by the following primary objectives:

- To ensure that PRECIOUS system is free from defects and acceptable for use;
- To verify that PRECIOUS system is able to fulfil the requirements.

The integration process of PRECIOUS has combined separately produced components or subsystems to address problems in their interactions. A PRECIOUS subsystem can be identified as a set of interdependent elements built to achieve a given objective by performing a specified function, but which does not, on its own, satisfy the complete end-user needs. Within the context of the PRECIOUS project, the integration activities have been carried out at various levels components (e.g. sensors), subsystem to full system level.

5.2 PRECIOUS Integration Approach

The PRECIOUS system integration is constituted within iterative and incremental development approach, whereby, simple implementations of parts of the system or some of the requirements carried out in each iteration until complete system (modular and deployable subsystems) are ready to be deployed and tested by the users. Each iteration includes a number of key phases, such as: analysis, design, implementation, integration (and deployment) and user testing (acceptance) phases. Furthermore, successive iteration provides lessons and insights that are useful for the continued design and implementation of the system and constituent components.

The iterative and incremental development approach has gained significant preference over the classical waterfall model, which lacks the flexibility for intermediate verification and/or validation points [10]. Among the considered benefits within PRECIOUS for iterative and incremental approach includes:

- Ability to develop and release some working system or subsystem functional even early in the project lifecycle which facilitates user testing and feedback even at this early stage.
- Possibility to plan and implement parallel developments, which is particularly key for PRECIOUS as some of the subsystem developments and deployments have occurred in different partner sites.
- Progress, issues, challenges and risks are identified and in most cases resolved during each development iteration.

- Identifying design flaws or other development issues at an early stage of development enables to take corrective measures and thus minimise waste of project resources.

In the context of the PRECIOUS project, a mapping of the project's iterative lifecycle activities (represented here by the different deliverables) to a simplified version of the iterative model is shown in Figure 4. The model also points strongly towards verification and validation, whereby, verification is the internal process of evaluating of whether PRECIOUS system or services comply with system requirements and design specification, whereas, validation is an externalised process for identifying whether PRECIOUS service or system meets the needs of end users and other identified stakeholders.

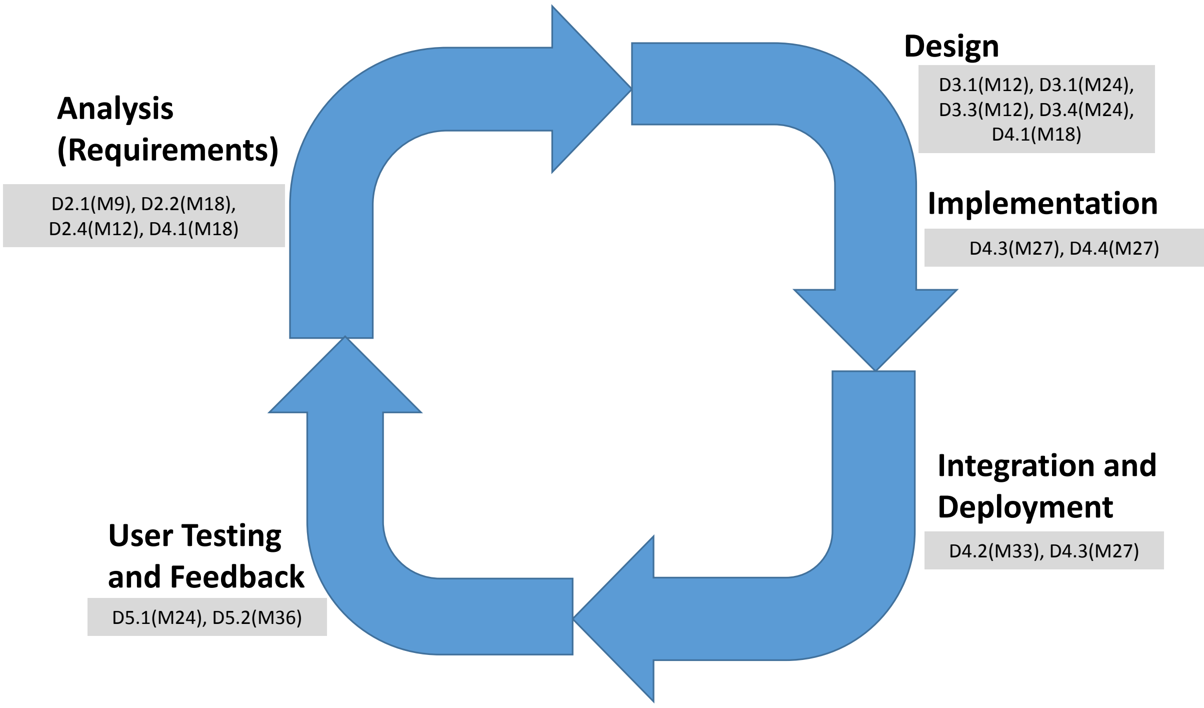

Figure 4 PRECIOUS iterations and mapping of deliverables to different phases

As noted above, the iterative development process of the PRECIOUS system has allowed for components or subsystems to be enhanced with incremental design features and/or functional capabilities (see illustration of Figure 5). The rationale for this approach to iteratively enhance the successive versions of the PRECIOUS system (or subsystems) towards the versions deployed for the various user trials.

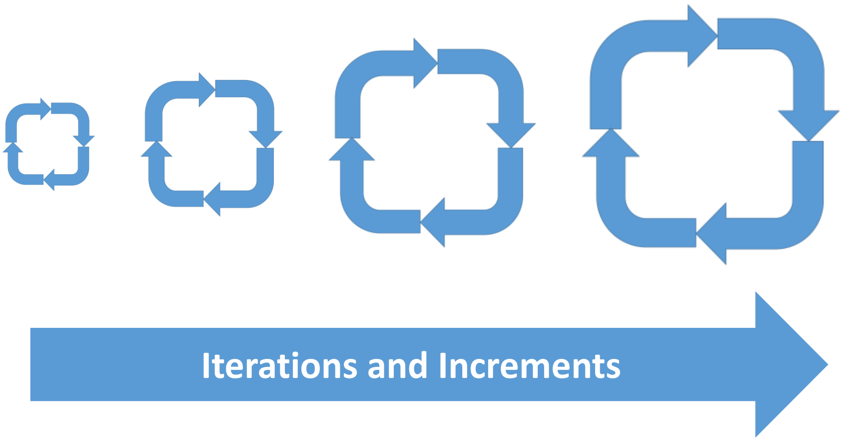

Figure 5 Increments in system functionality for successive iterations

5.3 Analysis Phase

The analysis phase was conducted mostly in the first half of the project lifetime. The initial part of this phase was to create an understanding of the user requirements for the PRECIOUS system and specify the usage scenarios that form the basis for subsequent design phase. The user requirements incorporate all aspects that users of the PRECIOUS system expect to see reflected in personal preventive health and wellness system. Moreover, the analysis phase identified the profile of end users targeted by the envisioned system and identified other key stakeholders (health care providers, technology developers, etc.) that are key to the system fulfilling intended intervention aims. The user requirements and scenario definition processes are described further in deliverable *D2.1 List of usage scenarios and user requirements*.

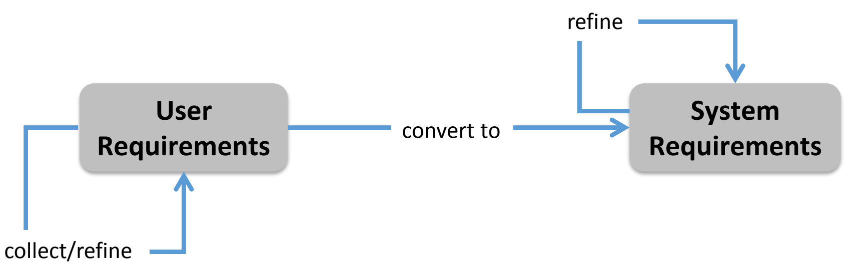

Figure 6 Mapping of user to system requirements

The effective adoption and usage of the PRECIOUS system is dependent on the system implementation meeting the PRECIOUS user requirements. Therefore, the user requirements where used to derive a set of system requirements to the PRECIOUS system requirements (see flow of Figure 6) as reported in deliverable *D4.1 System architecture and design specification*. The system requirements encompass all functional and non-functional aspects that need to be factored in order to reflect the user requirements on the system design. To that end, two types of system requirements were formulated

- *Functional requirements*: Requirements intended to define specific system behaviour or functions.

- *Non-functional requirements*: Requirements that define criteria that can be utilised for judging the operation of the PRECIOUS system

These system requirements have outlined useful characteristics for verification and validation of the systems.

Technology assessment was also done in parallel with system requirements specification. The iterative technology assessment process provided means for ensuring that the system requirements can be fulfilled with the current available technology, based as much as possible in interoperable and open standards. Moreover, it allows for incorporation of any emerging technology developments to impact on the design process. In D4.1 a detailed assessment was reported focused on standardisation, initiative and projects for personal health system and smart homes for health-conscious users. The assessment of technologies is updated in this deliverable with a survey on tools for monitoring of food intake (see Section 4).

In addition to analysis of user aspects (scenarios and requirements) and technological aspects, the analysis phase also considered market and socio-economic dimensions of PRECIOUS in deliverable *D2.2 Interim report on socio-economic factors and business models*. In particular, analysis was done to define prospective business models and business ecosystems (value networks) around preventive care and wellbeing marketplaces. Additionally, there is ongoing work to development of business models for specific PRECIOUS innovations which will be reported in deliverable *D2.3 Final report on socio-economic factors and business models*.

5.4 Design Phase

The design phase constituted the design of a number of aspects of the PRECIOUS system. This included:

- Design of the PRECIOUS system architecture described briefly in Section 3 and in more detail in deliverable 4.1;
- Development of the behavioural representation in the virtual individual model (VIM) as described in deliverables *D3.1 Interim report on behavioural representation and virtual individual modelling* and *D3.2 Final report on behavioural representation and virtual individual modelling*;
- Design of the motivational service as described in deliverables *D3.3 Interim motivational service design document* and *D3.4 Final motivational service design document*;

The PRECIOUS system architecture is designed in a way that allows for iterations so as to take into account any evolving user and system requirements as well as the ongoing technological progress in the personal health and wellness market and standardisation. Such changes require a dynamic architecture design that cannot be captured in one a step design.

The architectural design links together with the activities of the analysis phases as the design processes collectively informed by the requirements specifications and technology assessments of the analysis phase (see Figure 7).

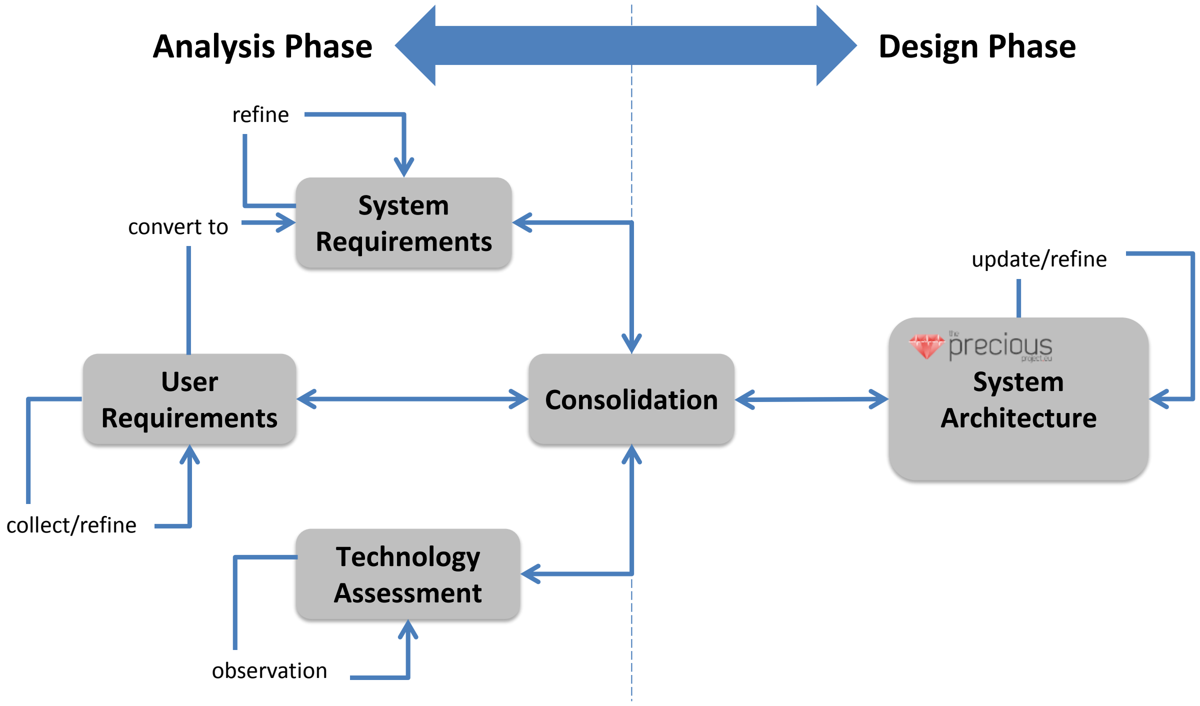

Figure 7 Linkages between the PRECIOUS system analysis and design phases

As PRECIOUS is considered a behavioural intervention technology the parametrization of the user behaviour is key element for the system design. To that end, the work reported in D3.1 and D3.2 provided a detailed description of the variables included in the VIM and an initial set of rules that will govern its function and guide individualised user interactions with the system. The development also considered user interactions with PRECIOUS by providing a through number of more specific use cases describing how the system will behave differently for various types of users.

The PRECIOUS system ultimately targets to support a motivational service framework that is promotes understanding of user motivation, preferences, values and interests; supports or motivates behaviour change and motivational status; and promotes autonomy and choice. The design of this PRECIOUS service has been grounded behavioural change theories as articulated in D3.3 and D3.4. The service design process included specification of the functionality of the user-facing content in each PRECIOUS sub-app, producing applied examples of the main service concepts and principles and development of mock-ups (see example of Figure 8) to guide the iterative design and implementation of the PRECIOUS apps. The iterative design of the app has included the user interface (UI) and user experience (UX) design processes. This process has involved periodic development meetings bringing together partners with expertise in UI/UX development, behavioural science and app development/coding. These periodic development meetings where carried out as frequent as once per week during the more critical development phases.

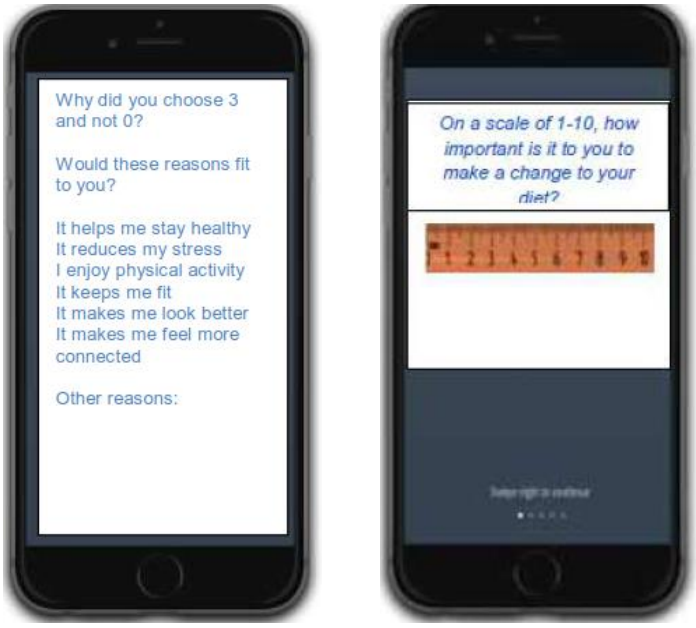

Figure 8 Example mock-ups of the PRECIOUS app utilised in later designs

5.5 Implementation Phase

The implementation of the PRECIOUS system has constituted two key primary components, namely the PRECIOUS apps (clients) and PRECIOUS cloud server (or backend) which are used to communicate with the clients. The PRECIOUS mobile smartphone apps are the primary interfaces for the user in interacting with the PRECIOUS system. The apps implemented in Android and iOS environments provide a modular environment for native modules which give the app basic functionality from the motivational service design, including goal setting, choosing targeted behaviours or statistics on achievements and so on (see example Figure 9). Moreover, the app provides the means for communicating with the PRECIOUS server.

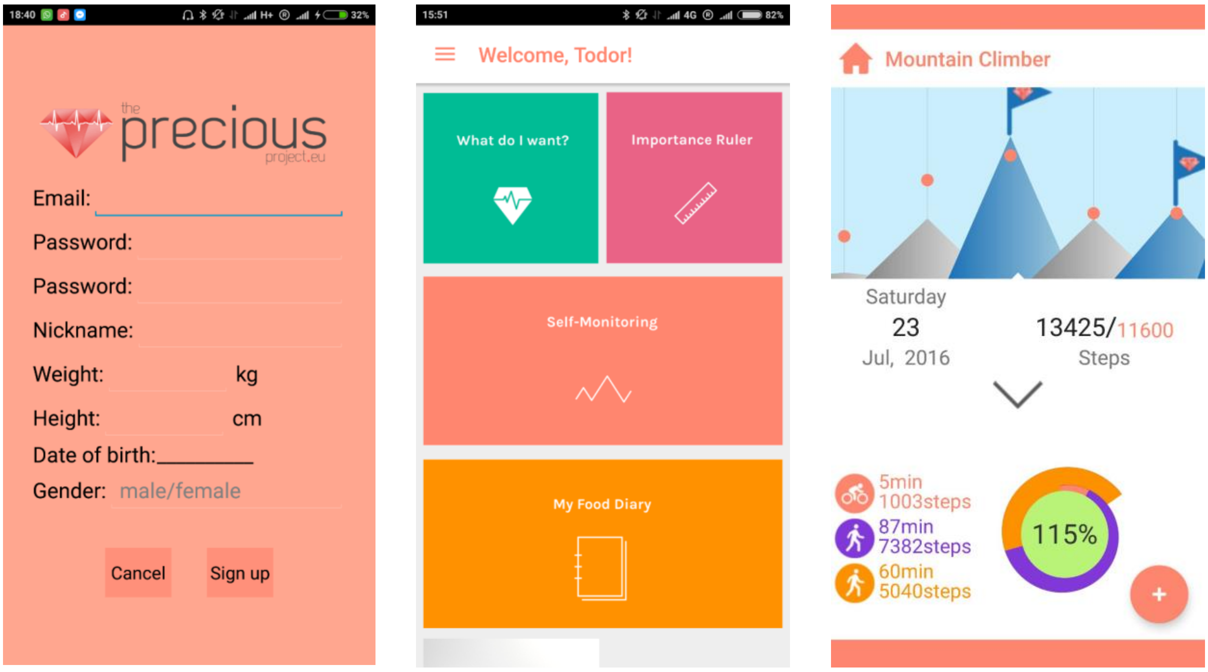

Figure 9 Example screenshots of the PRECIOUS app

Additional the PRECIOUS environments implement a sandbox (based HTML5 and Javascript) for running apps from developers external to the project. The sandbox concept allows PRECIOUS system to leverage the creativity and innovation inherent within the developer community for creating even more effective interventions.

The PRECIOUS cloud server is implemented based on NodeJS and has functionality for storage, analysis and processing of information sent to/from PRECIOUS apps. Furthermore, the server exposes APIs for accessing system-wide functionality, secure interaction with external entities (e.g. servers) and so on. Moreover, the server runs the rule-engine which is designed to also allow third-parties (e.g. health professionals) to simply and conveniently create rules for user(s) within their care domain. The server also facilitates the gathering and processing of the rules (e.g. based on monitored physical activity data). A detailed description of client and server-side implementations is provided in deliverable *D4.3 Development report of mobile applications and feedback tools*.

The implementation of the PRECIOUS system also considers the diverse data types from the multitude of modifiable risk factors that are considered for the system (recall Table 1 in Section 3). This data heterogeneity underlines the need for create an understanding of the different data types to all stakeholders (users, developers, experts, health staff). Moreover, it requires the monitoring and maintaining of semantic quality of the vocabulary and usage of a standardized data model for the entire project. These semantic aspects have described in deliverable *D4.4 Data fusions, analysis and semantic quality solutions*.

5.6 Integration and Deployment Phase

In the integration phase the various PRECIOUS subsystems or components are put together to constitute the overall PRECIOUS system and support the motivational services designed previously. The building of the PRECIOUS subsystems, integration and delivery has been carried out on a continuous basis. This has simplified the process of developers integrating changes to the system and making it easier for the end users to obtain an updated of the system applications. The use of automated and continuous building tools enabled increased productivity in the development and deployment of the applications.

Additionally, integration testing is performed whenever each of the PRECIOUS individual components or subsystems (apps, sensors, backend etc.) is integrated to the overall system. The integration testing and internal verification of the system within the project consortium seeks to expose and highlight problems between different interfaces among the components or subsystems before complications occur in the system validation with real end users.

Some of the main component/subsystem integration activities have been described in some of the previous deliverables. This includes the integration of the PRECIOUS server (backend) components and client-server integration in D4.3, and integration of the components and subsystems at the PRECIOUS xAAL living lab in D4.1.

A more detailed description of the integration of other subsystems and components (not described in previous deliverables) is presented below.

5.6.1 Integration of food composition databases

For software developers providing programmes and tools to work with nutritional information on food, high quality, and official food composition data are essential to underpin these products. Ultimately, the outputs of the product will only be as good as the data used by the software.

Many recipe, diet or menu planning software tools are based in a particular country and so use the national food composition data from that country. However, for any particular country's dataset it is likely that there will be some products that are not included, for which data is out of date, or that some nutritional values may be missing. In addition, with an increasingly global food supply it may be that those who are using food composition-based software may be looking for information on products outside their own country.

In the PRECIOUS app EuroFIR standardised food composition data was included with the most up to date, official data from across Europe and beyond. EuroFIR AISBL is a single and unique food information resource that allows users to simultaneously search more than 28 national and specialised food composition databases. The provision of high quality data in the food composition databases (FCDBs) linked with EuroFIR is one of the most important goals of its network. Therefore, skilled and experienced technical experts are continuously working towards improving the content and quality of the data in their national FCDBs. The data are thoroughly documented for best possible transparency, aggregated, validated and compiled following strict and standardised quality evaluation procedures before it can be published in the national FCDBs and be available for all data users.

For the PRECIOUS implementation the FCDBs (from three countries: Great Britain, Finland and Spain) are integrated directly into the PRECIOUS app. This approach enables rapid responses food composition queries by the user and also enables offline operation. FCDB integration in the app has been enabled by utilising only the mandatory food composition information for food labelling as specified by The European Food Information Council (EUFIC)[1]. The EUFIC guidelines specify labelling format (throughout the EU) that should include mandatory information on amounts of the macro nutrients per 100g or 100ml of food portions (listed in this order):

- energy value (in both kilojoules (kJ) and kilocalories (kcal)); and
- the amounts (in grams (g)) of fat, saturates, carbohydrate, sugars, protein and salt.

Nutritional labelling is originally associated with the labelling on packaged food products. However, the requirements on how food nutritional information is displayed on digital devices like smartphones should in principle adhere to the EUFIC guidelines. Therefore, the approach for displaying food info within the PRECIOUS diet sub-app follows EUFIC guidelines as shown in Figure 10.

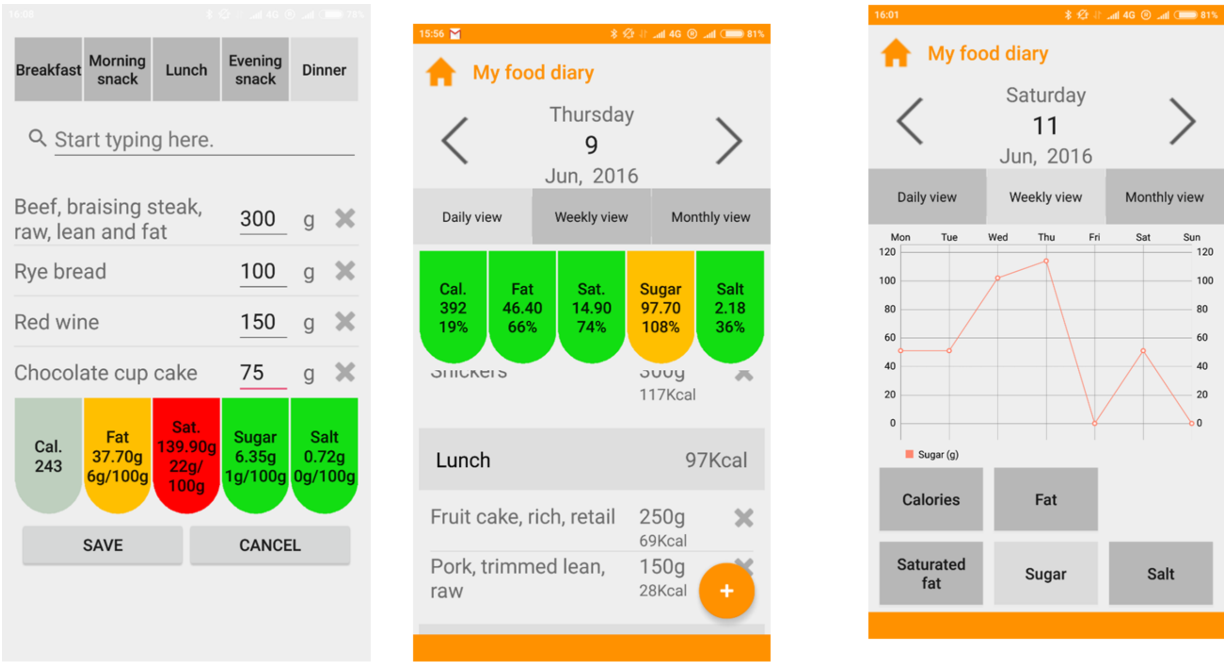

Figure 10 Different screenshots of the PRECIOUS diet sub-app

It is further noted in Figure 10 that food composition display info uses the UK Health Department colour coding scheme (Green=High, Amber=Medium, Red=Low)[2] for Front of Package (FoP) labelling to further facilitate the users' understanding on where a food product

[1] http://www.eufic.org/

[2] UK Government Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300886/2902158_FoP_Nutrition_2014.pdf

is positioned in terms of recommended minimum amounts of fat, saturates, sugar and salt. Further background on the representation of food composition information in PRECIOUS system is provided in D4.4.

5.6.2 Integration to physiological analysis (Firstbeat)

Firstbeat provides the PRECIOUS framework with detailed and accurate physiological reactions analysis through HRV and 3D acceleration measurement. The analysis provides information on user's physiological stress and recovery, physical activity, steps, energy expenditure, and sleeping periods based on sensor data. For acquiring the most accurate physiological analysis a device developed specifically for 24h HRV measurement based on measuring the electrical activity of the heart was used (Bodyguard2) instead of less accurate optical wrist sensors. In order to allow as convenient use of the device as possible and the device communication, an application was created allowing users to upload their data, analyse and receive their lifestyle reports between the days of measurement. The HRV analysis service is provided by the Firstbeat as a Web API. A desktop application utilizes this service by reading the measurements from the device and sending them to this service for analysis. Afterwards, the results are collected by the application and a customized Lifestyle Assessment report is drawn. The PRECIOUS framework also receives quick and regular analysis updates.

Functionality and Components

The functionality of the PC application, called the "Lifestyle assessment", can be broken down into two main parts of account management and measurement analysis. Figure 11 Integration of the PRECIOUS to Firstbeat shows the functionality breakdown of Lifestyle Assessment software.

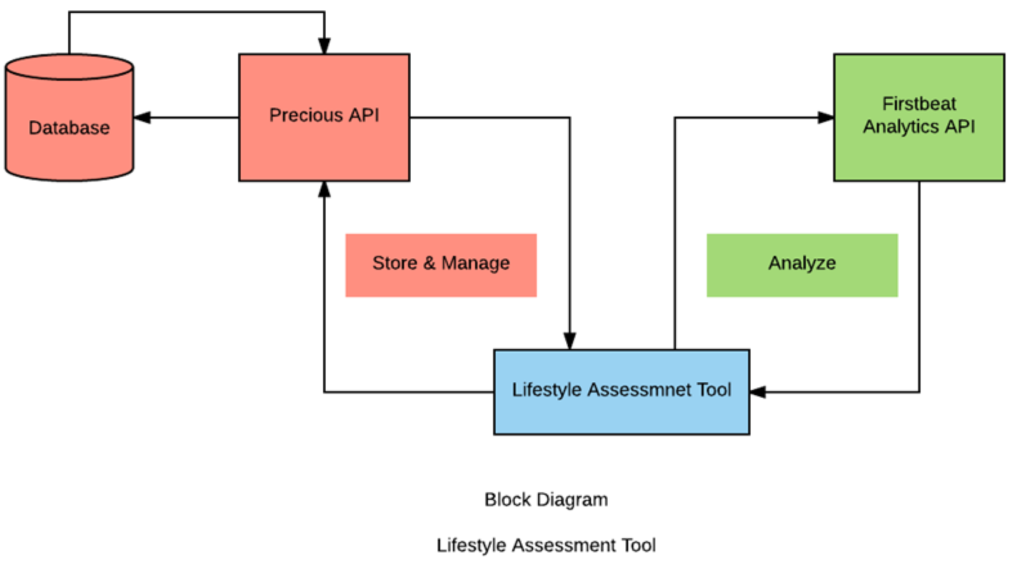

Figure 11 Integration of the PRECIOUS to Firstbeat Lifestyle Assessment Tool

The application uses two different Web APIs.

- The Firstbeat Analytics API is provided by Firstbeat and is used to analyze beat-by-beat heart rate and 3D acceleration measurements taken through the Firstbeat's Bodyguard2 devices.
- The PRECIOUS API performs account management and data storage/retrieval functions. Reports are uploaded by the Lifestyle assessment application to the backend servers using the PRECIOUS API. It is the common API used by different PRECIOUS subsystems and acts as point of integration for the PRECIOUS framework.

Table 3 and Table 4 show the various parameters used in the analysis request and response messages of Firstbeat analysis service

Table 3 Analysis Request Parameters

Parameter	***Unit***	***Range***	***Description***
Age	y	8-110	Person's age in years
Weight	kg	35 – 250	Person's weight
Height	cm	100 – 250	Person's Height
Gender	boolean	0, 1	Person's gender
ActivityClass	plain value	0-10	Person's activity class
RRVector	ms	1 - ∞	Vector consists of values indicating time in milliseconds between consecutive R peaks.
Acceleration (X,Y,Z)	plain value	127 – (-127)	Vectors consisting the acceleration information in three dimensions (optional)
Measurement start time	date and time		Start time as date and time of the day
AnalysisID			Unique identifier

Table 4 Analysis Response Parameters

Analysis Response	*Unit*	*Range*	*Description*
AnalysisId			Unique identifier
SessionTotalTime	min	0 - ∞	The duration of measurement period
DetectedArtifactPercentage	%	0 – 100	Grade of detected and corrected artifacts in RRVector.
AverageRMSSDSleep	ms	0 - ~100	Average of the RMSSDVector values during sleep periods.
EETotal	kcal	0 - ∞	Measurement period total energy expenditure.
EEPredictHealth	kcal	0 - ∞	An estimate of energy expenditure for 24 hours based on measurement.
RelaxationPercentage	%	0 - 100	Percentage of relaxation in measurement period.
RelaxationTime	s	0 - ∞	Total time of relaxation in measurement period.
StressPercentage	%	0 - 100	Percentage of stress in measurement period.
StressTime	s	0 - ∞	Total time of stress in measurement period.
RelaxationSleepTime	min	0 - ∞	Time spent in relaxation state while asleep.
RelaxationSleepTimePercentage	percent	0 - 100	Percentage of relaxation during sleep
SportsTime	s	0 - ∞	Total time of sports states
LightPhysicalActivityTime	s	0 - ∞	Total time of light physical activity
HardPhysicalActivityTime	s	0 - ∞	Total time of hard physical activity
HealthIndex	index	0 – 100	Health index revealing the health enhancing effects of physical activity
EEVector	kcal/min	0.5 – 45	Vector of instantaneous energy expenditure in measurement period.
ScaledRelaxationVector	index	0 – 1	Relative vector of relaxation, revealing the momentary proportional level of relaxation
ScaledStressVector	index	0 – 1	Relative vector of stress, revealing the momentary proportional level of stress
StateVector	plain value	0 - 10	Vector of states indicating which Firstbeat determined state is currently on at each respective moment

SleepPeriodsVector	s	0 - ∞	Consequent start and end seconds of detected sleep periods since the start of the measurement

Software Operation

The Lifestyle Assessment software provides a single click solution for searching new measurements on the Bodyguard2 device, analysing the new measurements and uploading the reports to the PRECIOUS server. The software is compatible with Windows 7 and subsequent later versions of Windows OS. The operational steps of the software are discussed below.

Login

To use the software, user must have a valid PRECIOUS account. The PRECIOUS account is created when a user registers his/her credentials on the PRECIOUS mobile application. The software is currently available in English and Spanish languages with plans for Finnish language support in the future. Figure 12 shows the login screen for Lifestyle assessment software.

Figure 12 Screenshot of the PRECIOUS desktop app for interacting with Firstbeat servers

Analysis and Upload

To simplify and automatize the usage of the application, a single click solution has been adopted to search, analyze and upload measurements on a BG2 device. The software searches for new measurements on the device by comparing the historic measurements of the user with the current measurements on the device.

Once a new measurement has been identified, the software performs the RR interval and 3D acceleration analysis using the analytics API provided by the Firstbeat. If the analysis is successful, a lifestyle assessment report is generated from the analysis results and made available to the user. This report is also uploaded to the user's profile on the precious servers. The same steps are repeated for all new measurements found on the BG2 device. Figure 13 shows the analysis and upload screen of the Lifestyle assessment software. Previously analysed reports are also viewable in this section.

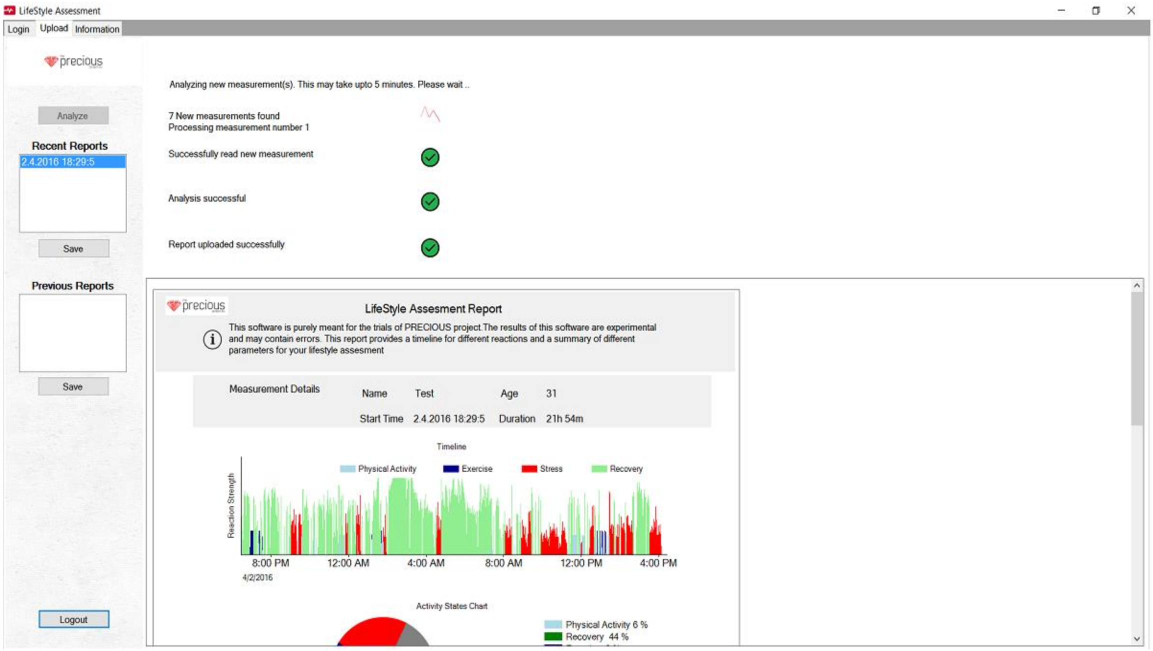

Figure 13 Screenshot of the Lifestyle Assessment Report on the desktop app

Lifestyle Assessment Report

The lifestyle assessment report shows stress/recovery reactions, exercise and light physical activity of a user during the measurement period. It also provides feedback on other measured parameters including the share and quality of recovery during sleep, the energy expenditure, physical activity points and step count. The report is tailored for the user's age and gender according to the recommendations provided by the Firstbeat. Figure 13 shows a sample Lifestyle Assessment report.

A help section is also included in the software to provide relevant information about various measured parameters. Figure 14 shows the help screen.

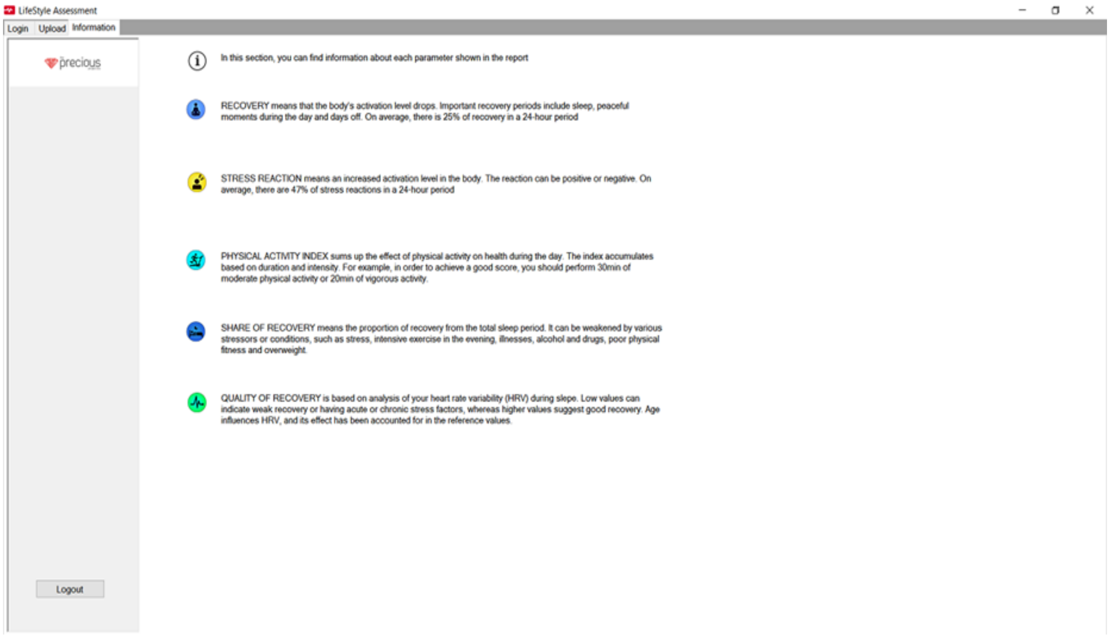

Figure 14 Screenshot of the Help screen for the desktop app

Firstbeat Integration with the PRECIOUS Mobile Application

The Lifestyle Assessment tool uses the same user profile storage and backend servers as the PRECIOUS app. Thus reports analysed with the PC application are also available on the PRECIOUS app. Figure 15 shows the Firstbeat section and report in the mobile application.

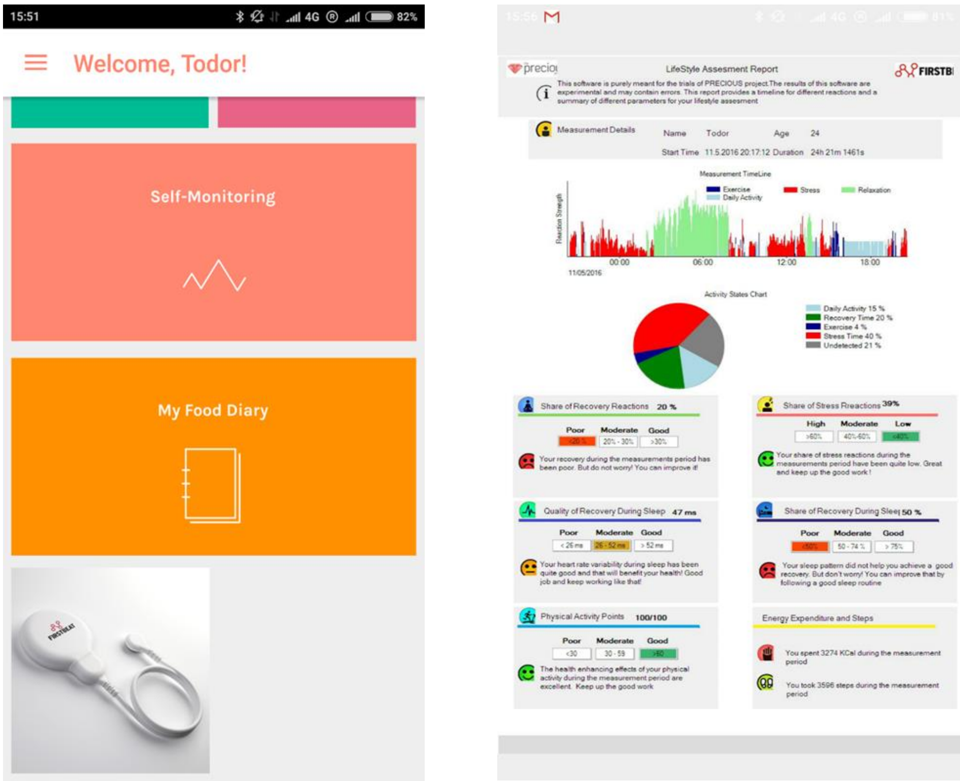

Figure 15 Integration of the Firstbeat as a PRECIOUS subapp

5.6.3 Integration of wearable device

The Xiaomi Mi Band wrist wearable is a low cost (around 15 USD), low power (at least 30 days of autonomy) and lightweight device. It is capable of step counting, including distance and burned calories estimation, and sleep quality and duration tracking. It also integrates a vibrator and three LED lights which can be used to get the attention of the user under the desired circumstance.

The wearable communicates with a smartphone via Bluetooth Low Energy (BLE) protocol. The communication protocol is available online and the integration of the device in the PRECIOUS app is stringboard, making it a very suitable device for the trials, not only because of the ease of development but also because of the 30-days standby power.

After linking the Xiaomi Mi Band with the smartphone using the PRECIOUS app, the physical activity data will be uploaded to the smartphone and then to the PRECIOUS server.

Mi band key specifications include:

- Connectivity: Bluetooth 4.0 / BLE
- Sensors: 3D accelerometer

- Monitored parameters: Steps, Calories Burned, Distance, Sleep Quality and Duration
- Battery: 30-day standby power
- Low cost (<15 USD)

Figure 16 Mi Band wearable device

5.7 User Testing and Evaluation Phase

The testing and evaluation phase represent the point the different version of the complete system or subsystems are presented to ("real-world") users for testing and determining whether the requirements in the analysis phase are met.

In the PRECIOUS project the user testing of the subsystem/system have been conducted from Year 2 onwards. The preliminary user tests in Year 2 have provided useful input for the evaluation and iterative developments towards the trial version of the system in Year 3. The rest of this subsection provides further details of the preliminary user testing in form of usability study in Year 2 (see Section 5.7.1) and summary of ongoing system validation activities in Year 3 (see Section 5.7.2).

5.7.1 Summary of the usability study in Year 2

Aim/Objectives

This study investigated the usability of two freely available mobile applications currently on the market, and the preliminary version of the mobile application being developed through the PRECIOUS project. The study examined factors that affect the usability of each mobile health tool for different user groups.

The four usability factors under investigation are:

Effectiveness: The ease with which a user is able to use the application to achieve specified goals.

Efficiency: The time taken and effort expended using the application to achieve the user's specified goals.

Satisfaction: The identification of challenges, barriers and positive aspects of the system from the users' perspective.

Learnability: The ease with which a user can learn to use the system.

Overall, the study measures and presents findings on:

- The ease of use for each application in terms of download and operation.
- The ability to set personal data, e.g. goals for achievement in each of the designated areas: food intake and physical activity.
- The level of participants' motivation in using the application to achieve their goals.
- The performance of each application in assisting participants to monitor their progress in relation to food intake and physical activity goals.
- The likely frequency and reasons for continuing to use the applications once the study is over.
- Participants' overall enjoyment of using the application in achieving their food intake and physical activity goals.

Method

The study examined the usability of three different mobile food intake and physical activity applications (MyFitnessPal®, My Diet Diary® and an application developed by PRECIOUS) for different user groups, with the view to improving the design of the PRECIOUS mobile app.

Each participant was assigned a single application to use for a period of seven days. At the end of the period, participants were asked to complete an on-line usability survey. In total the study involved 250 participants (82-85 per mobile health tool). The participants were in four user groups; age 18 to 35 years, with no children living at home, age 18 to 60 years, with at least one child under 18 years living at home, age 36 to 60 years, with no children living at home, age 61 to 75 years, with no children living at home.

Table 1 Sample matrix of participants for the on-line survey

Life stage subgroups	MyFitnessPal®	My Diet Diary	PRECIOUS	Total number of

		Calorie Counter®		participants by age range
Group 1: Age 18 to 35 years, with no children living at home.	*25 participants*	*25 participants*	*25 participants*	***75 participants***
Group 2: Age 18 to 60 years, with at least one child under 18 years living at home.	*25 participants*	*25 participants*	*25 participants*	***75 participants***
Group 3: Age 36 to 60 years, with no children living at home.	*25 participants*	*25 participants*	*25 participants*	***75 participants***
Group 4: Age 61 to 75 years, with no children living at home.	*25 participants*	*25 participants*	*25 participants*	***75 participants***
Total number of participants	*100 participants*	*100 participants*	*100 participants*	***300 participants***

Findings from the preliminary usability study

Overall the preliminary version of the PRECIOUS app (see screenshot of Figure 17) did not perform as well as the other two commercially available applications. However, this study highlighted several ways in which the PRECIOUS team could improve the usability of the tool.

Figure 17 Screenshot of the preliminary version of the PRECIOUS app

The study found the PRECIOUS app to be significantly harder to use than the others. This was reflected in the slightly higher percentage of users not using the PRECIOUS app every day, with the key reasons given being that 'It was too difficult to use' and participants could not see the benefit to themselves. Almost half of the participants who used the PRECIOUS app (49%) indicated that they would never use this application again. This was a higher percentage than for the My Diet Diary Calorie Counter® application (29%) and the MyFitnessPal® application (17%). Comments for both the MyFitnessPal® and My Diet Diary Calorie Counter® indicated them as being easier to use with an intuitive layout as opposed to the PRECIOUS app, where fewer respondents found the application easy to use or self-explanatory, with the majority finding the application challenging.

In terms of downloading the data and getting started, the results indicated that it was less easy to do this with the PRECIOUS app (46% of the PRECIOUS app users indicated that they had to look up or download additional information, as opposed to only 7% of the MyFitnessPal® users). In addition to this 81% of PRECIOUS users disagreed that there was clear guidance on how to use the application; this was significantly higher in terms of levels of disagreement than both the other applications; in contrast, MyFitnessPal® showed the highest agreement levels as indicated by 58% of users. This was reflected in fewer PRECIOUS users (39%) agreeing that they could use the application straightaway as opposed to 67% and 77% for the other two applications.

The PRECIOUS app did not perform particularly well against the other applications regarding food intake, recording a significant higher level of disagreement than the two other applications, across all statements. The MyFitnessPal® application had the highest levels of agreement for all the statements pertaining to food intake. The PRECIOUS app showed a high level of disagreement for being able to input the correct food eaten, with 71% of users disagreeing; this was significantly lower in agreement than both the other two applications. For all applications the food lists contained American products, therefore requiring participants to manually input data as they did for homemade meals, which become frustrating over the course of seven days. When entering data in the PRECIOUS app, the food items were weighed and measured in grams, which became time consuming and heightened participants' frustration over time. In contrast, within the MyFitnessPal® and My Diet Diary Calorie Counter® application, once a food item had been selected, the application 'remembered' the item, which made data entry far quicker.

The PRECIOUS app users also indicated a high level of disagreement with the statements 'The application motivated me to improve the quality of my food intake' and 'The application helped me clearly understand my food intake'. Significant differences were shown between all applications, with a significantly higher agreement shown for the MyFitnessPal®, whereas the PRECIOUS app showed a significantly lower level of agreement. PRECIOUS app users showed lower levels of agreement with 'Being able to change food intake targets easily' and 'Monitor food intake frequently', being significantly lower than both other applications. These findings were reflected by 72% of the participants indicating they did not enjoy using the PRECIOUS app to monitor their food intake. This high disagreement was significantly higher than for either of the other applications. Conversely, MyFitnessPal® application indicated a high level of agreement (74%) with this statement and was recorded as being significantly higher than both other applications.

For physical activity the PRECIOUS app performed better for 'The application motivated me to improve the quality of my physical activity' and 'The application helped me clearly understand my physical activity', than for the food intake, recording more similar agreement levels to the other two applications, with no significant differences between any of the applications for these statements.

The MyFitnessPal application users had the highest level of agreement for the remaining physical activity statements with the PRECIOUS app users having the lowest levels of agreement.

The PRECIOUS app users recorded a particularly high disagreement level with 'The application allowed me to input the correct physical activity I had completed' recording a mean of 3.7, a significantly lower agreement than for the other two applications. With regard to being able to input physical activity quickly and easily, the PRECIOUS app users again showed disagreement with these statements, with the users of the other two applications showing significantly higher agreement. The PRECIOUS app users also showed a significant lower agreement with being able to 'Change targets easily' in comparison to the MyFitnessPal® application. These findings were reflected in the outcome of participants enjoying using the PRECIOUS app significantly less to monitor their physical activity than users of both other applications.

Unfortunately, users of the PRECIOUS app did not see it as being effective in helping them reach their goals. It was also significantly the least liked overall. In contrast users of the MyFitnessPal® application had significantly higher levels of agreement with it being perceived as effective in helping them reach their goals through continued use and it was also significantly liked the most overall.

These results suggest that there is scope for improvement of the PRECIOUS app. In particular, there is a need for additional information to assist download and set up of personal data. The programming functions to assist users with managing their food intake and physical activity need to be improved, particularly the speed and ease with which to input data. Overall the application needs to be more intuitive, and easier to navigate. The open comments suggest that none of these applications are geared for home cooked foods, with all the applications using American style listed products. The PRECIOUS app also needs to look at ways of improving users' motivation and enjoyment of using the application in order to encourage more participants to initiate and maintain usage.

The objective of the PRECIOUS team is to use these findings to further develop and improve the application currently being developed and trialled as part of the PRECIOUS system. The study has highlighted that there are several key aspects that affect the perceived usability of these types of applications, and that there are several opportunities for the PRECIOUS app to increase its usability.

5.7.2 System validation activities in Year 3

The system validation activities for Year 3 are conducted on a number of aspects and functionalities of the PRECIOUS system in five out of the six countries participating in the PRECIOUS consortium. These include user tests to assess PRECIOUS components and subsystems to monitor: physical activity, sleep, stress, food intake and environmental factors. The objective of these user tests to assess the final PRECIOUS usability and effectiveness as a behavioural intervention technology. The Year 3 test plan includes:

- Field trial on the effectiveness of the PRECIOUS motivational and self-regulation components on physical activity and diet.
- Motivational interviewing (MI) field test is to assess users' overall satisfaction and adherence to the PRECIOUS system and user acceptance.
- Field trial to assess users' overall satisfaction and adherence to the PRECIOUS system and the validity of the data recording of the PRECIOUS diet application compared to the gold standard paper-based food diary method.
- Usability tests for heart rate (HR) sensors and their respective linked apps, so as to further inform on how the HR data should be presented to the user (dashboard, notifications, etc.) to design a system as usable as possible.
- User-interactions testing with the PRECIOUS apps will be assessed in order to provide immediate feedback to the design of the motivational framework and especially to the development team.
- Living-lab based investigation on how to present the environmental sensors (thermometer, hygrometer, air quality sensor, sound sensor and light sensor) should be collected, notified and presented to improve usability of home living quality monitoring.

- Study on how weight monitoring system should be designed to be as usable as possible will be described. This will aim at identifying how users want to access their weight data (notifications, type of display, frequency, etc.).

A more detailed planning description of the aforementioned user tests is presented in deliverable *D5.1 End-to-end valuation plan*. The actual implementations, results and findings from these test activities will be presented in *D5.2 System validation report* at the end of the project.

6. Conclusions

Deliverable *D4.2 System Integration Report* has presented an extended view of the PRECIOUS system integration aspects. The PRECIOUS system targets to meet a number of different needs and use cases for monitoring of risks factors associated with CVD and T2D, as well as, to provide feedback to the monitored user and support behavioural change. These objectives require design and implementation of a carefully integrated system constituting a number of typically distributed subsystems and components. Moreover, the system has to be acceptable to the user and comply with their requirements so as to sustain their motivation for both use of the system, as well as, for maintaining or adopting health promoting behaviours.

The deliverable was structured in two main parts. The first part contains background section describing the PRECIOUS system from a number of architectural viewpoints (relevant to system integration aspects) and also providing a technological assessment of legacy monitoring tools with a focus on food intake monitoring. The second part of the deliverable presents the PRECIOUS system integration approach that is part of an overall iterative and incremental development process. The agile approach has enabled continuous integration and deployment of PRECIOUS subsystems or systems for internal verification within the consortium or validation through user testing and feedback.

7. References

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8. Annexes for review of monitoring tools

8.1 Annex 1. Table reviewing technological tools for measuring food intake/physical activity/health either commercially available or currently being researched

Name	Type	*Description*	Further Information
SCiO	Technology - tool	A NIR spectroscopy based pocket molecular sensor to scan foods. The SCiO device then communicates the spectrum of the sample to a smartphone wirelessly, which in turn forwards it to a cloud-based service for review. Advanced algorithms utilize an updatable database to analyze the spectrum within milliseconds and deliver information about the analyzed sample back to the user's smartphone in real time.	https://www.consumerphysics.com/myscio/scio/
SITU	Technology - tool	Wireless scale to calculate nutrition content. SITU has been designed to be a learning tool for calorie counters, diabetics, hypertensives, athletes, and anyone who wants to lead a healthier life. It enables people to understand the nutritional content of the food they are consuming.	http://situscale.com/
Tell Spec	Technology - tool	A hand-held consumer device that can analyze the chemical composition of any food in less than 20 seconds. Uses spectroscopy, nanophotonics, and a unique algorithm. Information about the allergens, chemicals, nutrients, calories, and ingredients in the food is then downloaded and displayed on your smart phone.	http://tellspec.com/en/
Airo Wrist band	Technology - tool	Wristband that uses spectroscopic analysis through the skin to monitor nutrients in the body. Also monitors stress, sleep and exercise. Stress measurement based on heart rate, vibrates when too high. Linked to a pp, which provides feedback to the user. Not currently available and lack of data demonstrating validity.	http://www.getairo.com/index.html

Scientific intake	Technology - tool	The SMART™ Device is an oral device that is placed in the upper palate while eating. SMART™ states it reduces bite size, reducing food intake, it encourages through chewing of food, and helps stop eating too quickly, preventing over eating. The SMART™ Device contains a small sensor that records usage every day. Following use the SMART Device in its reader and attach the USB cord and the data can be downloaded onto a PC. Does not provide data on nutritional content of food eaten.	http://www.scientificintake.com/how-it-works/how-it-works
Smart Fork	Technology - tool	The HAPIfork, is an electronic fork that helps monitor and track eating habits. It also alerts the user by an indicator lights and gentle vibrations to when they are eating too fast. The HAPIfork also measures: how long it took to eat a meal, the amount of "fork servings" taken per minute, and intervals between "fork servings". This information is then uploaded via USB or Bluetooth to your Online Dashboard to track progress.	https://www.hapi.com/product/hapifork
Jaw Bone UP	Technology - app	The Jawbone UP is a flexible wristband with vibration and motion sensors that monitor and analyze exercise, diet, and sleep data. The motion sensors track your daily calories burned, physical activity, including time, distance, and intensity, and sync it to the UP app on any Apple smart device .Users log food intake on the Up App using barcode scanner or food gallery (can score points for good food choices). Also inbuilt coach provides personalised health tips and helps users achieve the goals. Can share progress on social media. Users have to plug in device to transfer data from wristband to app. Cost: $130	https://jawbone.com/up
Nike Fuel Band	Technology	A wristband that logs daily activity and collects data about habits, the Nike Fuelband helps track and improve activity level over time. The Fuelband wirelessly syncs data using Bluetooth to the Nike+ website or can use a USB to a computer or Smartphone. Can monitor stats; compare them with other members of the Nike+ community, set personal goals, and share progress with social networks. The more activity recorded on the band, the more “Nike fuel” can be won and users can compete with the Nike+ Community online. The band and app does not track sleep. Food intake or heat rate. It does not make tailored recommendations and can only be used on IOS devices. Cost: $149	https://secure-nikeplus.nike.com/plus/what_is_fuel/

FITBIT	Technology	FITBIT offers a range of wireless activity trackers and an app. The range includes a Zip. One, Flex, Charge, Alta, Charge HR, Blaze, Surge and Aria, with the zip offering the lowest cost option. The Zip (a clip on activity tracker) tracks steps, distance calories burned and active minutes. It uses wireless syncing to connect to the FITBIT app. It is weather proof and reports to have a long battery life. The One is also a clip on activity tracker with the same functions as the Zip plus it monitors sleep length and quality. The Flex, Charge, Alta, Charge HR, Blaze and Surge are all wristbands. The Flex has the same function as the Zip, but also uses LED lights to demonstrate progress. The Charge, has the same functions as the Flex, but also logs amount of time spent stationary and has a OLED display, allowing users to review daily stats and call notifications, with compatible mobile devices. The Alta offers all day activity monitoring, reminders to move. It can automatically recognise the type of exercise being completed and auto tracks sleeping. Like the Charge it has an OLED display, allowing users to review daily stats and call notifications/calendar alerts, with compatible mobile devices The Charge HR, allows users to get continuous automatic wrist based heart rate measurements. It also tracks steps, distance, calories burned, active minutes, hourly activity and stationary time. It automatically recognises types of exercise and users can get real time stats and post work out summaries from the app, which the device automatically syncs with. It also automatically tracks sleep and has a long battery life. The Blaze is a fitness watch that has a PurePulse™ heart rate sensor, along with connected GPS, on screen workouts and a colour touch screen, along with all the standard functions offered by the Charge HR. The Surge has the same functions as the Blaze but is sleeker in size. It also lets you control music on your mobile playlist and offers multisport+SMARTTRACK with automatic exercise recognition. The Aria is smart scales that can help multiusers track their weight, body mass index, lean mass and body fat percentage. It wirelessly syncs with an app which displays weight stats and progress in easy to read charts and graphs. It is compatible with the FITBIT trackers, and you can set goals and use the calorie coaching function of the app to help achieve them. Users can earn digital badges,	http://www.fitbit.com/uk/home

		and can share exercise progress on social media. Users can also share challenges and encouragement on the Fitbit Web site by creating groups or joining public ones. The app includes the food tracking element, in the form of a food diary. Cost: £49.99 - £199.99	
eButton	Technology	The eButton fastens to a person's shirt and contains a miniature camera, accelerometer, GPS, and other sensors -- captures data and information of health activities, eliminating the need for daily self-reporting. The eButton prototype was the result of research from a four-year NIH Genes, Environment, and Health Initiative grant that ended in 2011. Only requires Email, user name and create a password to sign up. Cost: Not currently available still in prototype phase.	http://www.sciencenewsline.com/news/2011110919200039.html
Wifi tooth	Technology	An artificial tooth that monitors eating, drinking and smoking habits along with how often someone coughs and even spends speaking has been developed.	http://www.telegraph.co.uk/technology/news/10213154/Wifi-tooth-to-monitor-eating-and-speaking-habits.html
Melon	Technology	Melon is a headband and mobile app duo that tracks and helps you improve your focus in relation to your activity, your environment, your emotions, and any other behaviour you want to track.	http://www.kickstarter.com/projects/806146824/melon-a-headband-and-mobile-app-to-measure-your-fo
Valencell	Technology	Powers popular wearable devices (earbuds, smart watches, armbands and wristbands) with the ability to accurately measure numerous biometrics. It continuously measures heart rate, VO_2 , calories burned and cadence with unmatched, scientifically validated accuracy. PerformTek® sensor technology gives	http://www.valencell.com/products

		wearable devices the ability to continuously and accurately measure weak blood flow signals even during extreme physical activity. PerformTek achieves this with a state-of-the-art, ultra-miniaturized optomechanical sensor module small enough to fit within an audio earbud, smartwatch, or other wearable device. The sensor module includes an optical emitter, an optical detector, specialized optomechanics and an accelerometer.	
“Sensogram”	Technology	A mobile, wearable (ear), non-invasive health monitoring device that reads, transmits, and stores vital signs and other biomedical parameters, like blood pressure, respiration rate, and heart rate and oxygen saturation. The data is stored on the device, and then it is sent to SensoSCAN’s proprietary app using any phone, tablet, or laptop device.	http://www.sensogram.com/sensogram-product.html
Septimu	Technology	Microsoft research team is working to redesign the *earphone* that can be a *sensing* and controlling device by integrating; activities, heart rate, and location. With this sensory earphone, they can demonstrate a number of applications, including posture detection, health diary, exercise patterns and coaching and remote doctoring. Not currently commercially available at time of writing.	http://www.wearabletechworld.com/topics/wearable-tech/articles/356989-microsoft-septimu-generates-mood-earbud-technology.htm **Error! Hyperlink reference not valid.**
Bra Sensors Could Monitor Overeating	Technology	Researchers from Microsoft Research invented a stress monitoring bra that keeps ‘en eye” on the wearers moods and helps regulate stress eating. The sensors are powered by a 3.7-volt battery; feature an EKG analyzer that captures heart rate and respiration, electro-dermal activity, skin conductance and even general movement via an accelerometer and gyroscope. The collected data is streamed to a smart phone app and PC software where it’s analyzed to predict physiology changes that accompany eating and stress, including whether the subjects were happy or angry. Not currently commercially available at time of writing.	http://mashable.com/2013/11/27/bra-monitors-overeating/

Athos	Technology	Athos clothing contains EMG (Electromyography) biosensor which can detect electrical activity produced by your skeletal muscles which can measure muscle activity, heart rate, and respiration. The data is passé to the Athos App Live View in real time enable users to see real time stats and imagery of how hard different muscles are working.	https://www.liveathos.com/
Hekoskin	Technology	Hexoskin's biometric shirt that can monitor cardiac, respiratory, and activity data. It monitors; heart rate, HRV (allowing to estimate stress and fatigue), Heart Rate Recovery, ECG. Breathing Rate (RPM), Minute Ventilation (L/min), Activity intensity, peak acceleration, steps, and sleep positions. It has a open data API allows you to download raw data and use your own analytics software. Costs; $169-$579	http://www.hexoskin.com/
Heddoko	Technology	Heddoko smartshirt and garment is an article of clothing that keeps information in 3D. Some of the other information that the Heddoko and its apps does is it shows a person if they are putting too much pressure on a certain part of their body. The Heddoko keeps track of performance and it allows users to keep track of goals. It provides real time feedback and help through the Heddoko app helps users understand why they are getting injured while training.	http://www.heddoko.com/
Cityzen Sciences	Technology	The D-Shirt has microsensors embedded all throughout the shirt and it tracks information such as keeping track of temperature, heart beat and heart rate, and the speed and intensity of workouts.	http://www.cityzensciences.fr/en/
OMsignal		The biometric smartwear from OMsignal has fitness tracking abilities and can track heartbeat and breathing. It has a compatible app in enabling users to track their health and fitness information. The OMsignal has moisture control, odor control, and is also machine washable. It also has the compression feature which helps with circulation and muscle recovery. Cost; $249	https://www.omsignal.com/

Spun Utensils	Technology	This is a smart utensil that promises to count calories with each bite and let the user know if they need to slow down when eating. Users use the Spün's app to take a picture of their meal, and then the app uses technology similar to face recognition to identify the food. Once the user has confirmed it has identified the correct food, the user uses the Bluetooth-connected Spün utensil to eat the food. The app then feedbacks o the user the nutritional content of each fork/spoonful, based on sensors that measure the weight of each bite. The device is currently unavailable for ordering.	http://spunutensils.com/
Food intake monitoring: an acoustical approach to automated food intake activity detection and classification of consumed food .(2012 Institute of Physics and Engineering in Medicine Physiological Measurement, Volume	Research paper	Abstract: Obesity and nutrition-related diseases are currently growing challenges for medicine. A precise and timesaving method for food intake monitoring is needed. For this purpose, an approach based on the classification of sounds produced during food intake is presented. Sounds are recorded non-invasively by miniature microphones in the outer ear canal. A database of 51 participants eating seven types of food and consuming one drink has been developed for algorithm development and model training. The database is labelled manually using a protocol with introductions for annotation. The annotation procedure is evaluated using Cohen's kappa coefficient. The food intake activity is detected by the comparison of the signal energy of in-ear sounds to environmental sounds recorded by a reference microphone. Hidden Markov models are used for the recognition of single chew or swallowing events. Intake cycles are modelled as event sequences in finite-state grammars. Classification of consumed food is realized by a finite-state grammar decoder based on the Viterbi algorithm. We achieved a detection accuracy of 83% and a food classification accuracy of 79% on a test set of 10% of all records. Our approach faces the need of monitoring the time and occurrence of eating. With differentiation of consumed food, a first step toward the goal of meal weight estimation is taken.	http://www.ncbi.nlm.nih.gov/pubmed/22621915 **Error! Hyperlink reference not valid.**

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Examining the Utility of a Bite-Count-Based Measure of Eating Activity in Free-Living Human Beings.	Research paper	*Abstract: The obesity epidemic has triggered a need for novel methods for measuring eating activity in free-living settings. Here, we introduce a bite-count method that has the potential to be used in long-term investigations of eating activity. The purpose of our observational study was to describe the relationship between bite count and energy intake and determine whether there are sex and body mass index group differences in kilocalories per bite in free-living human beings. From October 2011 to February 2012, 77 participants used a wrist-worn device for 2 weeks to measure bite count during 2,975 eating activities. An automated self-administered 24-hour recall was completed daily to provide kilocalorie estimates for each eating activity. Pearson's correlation indicated a moderate, positive correlation between bite count and kilocalories (r=0.44; P<0.001) across all 2,975 eating activities. The average per-individual correlation was 0.53. A 2 (sex)×3 (body mass index group: normal, overweight, obese) analysis of variance indicated that men consumed 6 kcal more per bite than women on average. However, there were no body mass index group differences in kilocalories per bite. This was the longest study of a body-worn sensor for monitoring eating activity of free-living human beings to date, which highlights the strong potential for this method to be used in future, long-term investigations.*	J Acad Nutr Diet. 2013 Nov 12. pii: S2212-2672(13)01425-1. Examining the Utility of a Bite-Count-Based Measure of Eating Activity in Free-Living Human Beings.
Measuring food intake with digital photography	Research paper	*Abstract: The Digital Photography of Foods Method accurately estimates the food intake of adults and children in cafeterias. When using this method, images of food selection and leftovers are quickly captured in the cafeteria. These images are later compared with images of 'standard' portions of food using computer software. The amount of food selected and discarded is estimated based upon this comparison, and the application automatically calculates energy and nutrient intake. In the present review, we describe this method, as well as a related method called the Remote Food Photography Method (RFPM), which relies on smartphones to estimate food intake in near real-time in free-living conditions. When using the*	http://onlinelibrary.wiley.com/doi/10.1111/jhn.12014/abstract

		RFPM, participants capture images of food selection and leftovers using a smartphone and these images are wirelessly transmitted in near real-time to a server for analysis. Because data are transferred and analysed in near real-time, the RFPM provides a platform for participants to quickly receive feedback about their food intake behaviour and to receive dietary recommendations for achieving weight loss and health promotion goals. The reliability and validity of measuring food intake with the RFPM in adults and children is also reviewed. In sum, the body of research reviewed demonstrates that digital imaging accurately estimates food intake in many environments and it has many advantages over other methods, including reduced participant burden, elimination of the need for participants to estimate portion size, and the incorporation of computer automation to improve the accuracy, efficiency and cost-effectiveness of the method.	
New technology in dietary assessment: a review of digital methods in improving food record accuracy.	Research paper	Methods for conducting dietary assessment in the United States date back to the early twentieth century. Methods of assessment encompassed dietary records, written and spoken dietary recalls, FFQ using pencil and paper and more recently computer and internet applications. Emerging innovations involve camera and mobile telephone technology to capture food and meal images. This paper describes six projects sponsored by the United States National Institutes of Health that use digital methods to improve food records and two mobile phone applications using crowd sourcing. The techniques under development show promise for improving accuracy of food records.	Proc Nutr Soc. 2013 Feb;72(1):70-6. doi: 10.1017/S0029665112002911.
Trial of a mobile phone method for recording dietary	Research Paper	We evaluated a mobile phone application (Nutricam) for recording dietary intake. It allowed users to capture a photograph of food items before consumption and store a voice recording to explain the contents of the photograph. This information was then sent to a website where it was analysed by a dietician. Ten adults with type 2 diabetes (BMI 24.1-47.9 kg/m(2)) recorded their intake over a three-day period using both Nutricam and a written food diary. Compared to the food diary, energy intake	J Telemed Telecare. 2011;17(6):318-23. doi: 10.1258/jtt.2011.100906.

intake in adults with type 2 diabetes: evaluation and implications for future applications.		was under-recorded by 649 kJ (SD 810) using the mobile phone method. However, there was no trend in the difference between dietary assessment methods at levels of low or high energy intake. All subjects reported that the mobile phone system was easy to use. Six subjects found that the time taken to record using Nutricam was shorter than recording using the written diary, while two reported that it was about the same. The level of detail provided in the voice recording and food items obscured in photographs reduced the quality of the mobile phone records. Although some modifications to the mobile phone method will be necessary to improve the accuracy of self-reported intake, the system was considered an acceptable alternative to written records and has the potential to be used by adults with type 2 diabetes for monitoring dietary intake by a dietician.	
Nutrition Monitor: A Food Purchase and Consumption Monitoring Mobile System	Research paper	The challenge of monitoring food intake can be facilitated by the truly transformational power of mobile phones. Mobile phones provide a pervasive and fairly ubiquitous infrastructure, which we leverage to provide cost-effective, high quality aids to behaviour monitoring and modification. Additionally, the technology allows public health messages to reach certain target groups, such as youth and members of low-income communities, which may not otherwise be practical. Our system leverages the existing mobile phone infrastructure. We use the highly capable computational and data-gathering platform of mobile phones to facilitate the collection, transmission and processing of data for purposes of monitoring in the field, behaviour and activity classification, and timely behavioural cuing. The nature of mobile phones coupled with a web-interface also allow for customization and personalization, retrieval of nutrition information on demand, as well as the ability to truly monitor the user's consumption trends.	http://link.springer.com/chapter/10.1007/978-3-642-12607-9_1
RE-DEFINING THE ROLES OF	Research paper	As physical activity researchers are increasingly using objective portable devices, this review describes current state of the technology to assess physical activity, with a focus on specific sensors and sensor properties currently used in monitors and their strengths and weakness. Additional sensors and sensor properties desirable	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3245644/

SENSORS IN OBJECTIVE PHYSICAL ACTIVITY MONITORING		for activity measurement and best practices for users and developers also are discussed.	
Validity of the Remote Food Photography Method (RFPM) for estimating energy and nutrient intake in near real-time.(Obesity (Silver Spring). 2012 Apr;20(4):891-9. doi: 10.1038/oby.2011.344.	Research paper	*Abstract; Two studies are reported; a pilot study to demonstrate feasibility followed by a larger validity study. Study 1's objective was to test the effect of two ecological momentary assessment (EMA) approaches that varied in intensity on the validity/accuracy of estimating energy intake (EI) with the Remote Food Photography Method (RFPM) over 6 days in free-living conditions. When using the RFPM, Smartphones are used to capture images of food selection and plate waste and to send the images to a server for food intake estimation. Consistent with EMA, prompts are sent to the Smartphones reminding participants to capture food images. During Study 1, EI estimated with the RFPM and the gold standard, doubly labeled water (DLW), were compared. Participants were assigned to receive Standard EMA Prompts (n = 24) or Customized Prompts (n = 16) (the latter received more reminders delivered at personalized meal times). The RFPM differed significantly from DLW at estimating EI when Standard (mean ± s.d. = -895 ± 770 kcal/day, P < 0.0001), but not Customized Prompts (-270 ± 748 kcal/day, P = 0.22) were used. Error (EI from the RFPM minus that from DLW) was significantly smaller with Customized vs. Standard Prompts. The objectives of Study 2 included testing the RFPM's ability to accurately estimate EI in free-living adults (N = 50) over 6 days, and energy and nutrient intake in laboratory-based meals. The RFPM did not differ significantly from DLW at estimating free-living EI (-152 ± 694 kcal/day, P = 0.16). During laboratory-based meals, estimating energy and macronutrient intake with the RFPM did not differ significantly compared to directly weighed intake.*	http://onlinelibrary.wiley.com/doi/10.1038/oby.2011.344/full

Epub 2011 Dec 1.)			
A novel method to remotely measure food intake of free-living individualsin real time: the remote food photography method (British Journal of Nutrition (2009), 101, 446–456)	Research paper	*The aim of the present study was to report the first reliability and validity tests of the remote food photography method (RFPM), which consists of camera-enabled cell phones with data transfer capability. Participants take and transmit photographs of food selection and plate waste to researchers/ clinicians for analysis. Following two pilot studies, adult participants (n 52; BMI 20–35 kg/m2 inclusive) were randomly assigned to the dine-in or take-out group. Energy intake (EI) was measured for 3 d. The dine-in group ate lunch and dinner in the laboratory. The take-out group ate lunch in the laboratory and dinner in free-living conditions (participants received a cooler with pre-weighed food that they returned the following morning). EI was measured with the RFPM and by directly weighing foods. The RFPM was tested in laboratory and free-living conditions. Reliability was tested over 3 d and validity was tested by comparing directly weighed EI to EI estimated with the RFPM using Bland–Altman analysis. The RFPM produced reliable EI estimates over 3 d in laboratory (r 0·62; P,0·0001) and free-living (r 0·68; P,0·0001) conditions. Weighed EI correlated highly with EI estimated with the RFPM in laboratory and free-living conditions (r . 0·93; P,0·0001). In two laboratory- based validity tests, the RFPM underestimated EI by 24·7% (P¼0·046) and 25·5% (P¼0·076). In free-living conditions, the RFPM underestimated EI by 26·6% (P¼0·017). Bias did not differ by body weight or age. The RFPM is a promising new method for accurately measuring the EI of free-living individuals. Error associated with the method is small compared with self-report methods.*	http://journals.cambridge.org/download.php?file=%2FBJN%2FBJN101_03%2FS0007114508027438a.pdf&code=717db1e05f0e983e5e74d9e8bd98cb77
DietCam: Automatic dietary assessment	Research paper	*Abstract: Obesity has become a severe health problem in developed countries, and a healthy food intake has been recognized as the key factor for obesity prevention. This paper presents a mobile phone based system, DietCam, to help assess food intakes with few human interventions. DietCam only requires users to take three*	http://www.sciencedirect.com/science/article/pii/S1574119211001131

with mobile camera phones (Pervasive and Mobile Computing *Volume 8, Issue 1, February 2012, Pages 147–163)*		*images or a short video around the meal, then it will do the rest. The experiments of DietCam in real restaurants verify the possibility of food recognition with vision techniques.*	

8.2 Annex 2. Summary of apps/games and quizzes reviewed relating to Food intake.						
Name	**Source**	**Type**	**Website**	**Description**	**Target Audience**	**Cost**
Healthy eating self-assessment- NHS	NHS	Quiz	http://www.nhs.uk/Tools/Pages/HealthyEating.aspx	A questionnaire to determine: how much users know what eating healthily.	Adults	Free
Change4Life Meal Planner	NHS	App	http://www.nhs.uk/Tools/Pages/Change4Life-meal-planner-and-recipe-finder.aspx	Meal mixer to help plan a day of healthier meals. You can download recipes and email yourself a shopping list. You can also search for recipes via the recipe finder feature.	Adults	Free
Nutrition Quiz	BUPA	Quiz	http://www.bupa.co.uk/health-information/tools-calculators/nutrition-quiz	A 10 question healthy eating quiz - multiple choice questions and gives correct answers + explanation after each question	Adults	Free
Healthy Eating Quiz	Healthy Eating Quiz	Quiz	http://www.bbc.co.uk/northernireland/schools/4_11/uptoyou/healthy/quiz.shtml	A range of activities and information for school children. Amongst other activities is a 10 question healthy eating & exercise quiz	Teachers & Children	Free
Healthy eating planner (not a game)	Dairy Council of California	App	http://www.healthyeating.org/Healthy-Eating/Healthy-Eating-Tools/Healthy-Eating-Planner.aspx	Healthy eating planner - personal information is filled out to create a healthy eating plan	Adults	Free
My plate match game	Dairy Council of California	Game	http://www.healthyeating.org/Healthy-Kids/Kids-Games-Activities.aspx	Learn about the 5 food groups and how much is needed from each	Children	Free
Power up your breakfast	Dairy Council of California	Game	http://www.healthyeating.org/Healthy-Kids/Kids-Games-Activities/Power-Up-Your-Breakfast.aspx	How to eat a healthy breakfast	Children	Free
My very own Pizza	Dairy Council of California	Game	http://www.healthyeating.org/Healthy-Kids/Kids-Games-Activities/My-Very-Own-Pizza.aspx	Create a virtual pizza whilst learning about the history & nutrition of a pizza	Children	Free

Energy balance	Food a Fact of Life	Games/ Quiz	http://www.foodafactoflife.org.uk/QuickLinks.aspx?contentType=2	Free resources about healthy eating, cooking, food and farming for children and young people aged 3 to 18 years. The resources are progressive, stimulate learning and support the curriculum throughout the UK. All resources are designed to ensure that consistent and up-to-date messages are delivered.	Teachers & Children	Free
Smart Food Choices Quiz	Seventeen magazine - online	Quiz	http://www.seventeen.com/health/health-quizzes/a27306/smart-food-choices-quiz/	5 questions which then puts users respondents into a group to define 'how food smart' they are	Teens	Free
Nutritional Quiz	North Carolina Department of Agriculture and Consumer Services (NCDACS)	Quiz	http://www.ncagr.gov/cyber/kidswrld/nutrition/nutritionQuiz.html	Multiple choice quiz	Children (7-15 yrs?)	Free
Healthy eating (activities)	Hwb - Digital Learning for Wales	Game	http://resources.hwb.wales.gov.uk/VTC/healthy_eating/eng/Introduction/default.htm	A series of short games, all very basic	Children / Teachers	Free
Nutrition Test	NetDoctor	Quiz	http://www.netdoctor.co.uk/interactive/interactivetests/nutritionquiz.php	24 multiple choice questions on respondents diet to determine how they are eating	Adults	Free
Nutrition Sudoku	Academy of Nutrition and Dietetics	Game	http://www.nationalnutritionmonth.org/nnm/games/sudoku/kids/index.html	No nutritional info, not sure what the point is!	Children	Free
Food hero – Food and exercise	HealthySocial	Game	http://healthysocial.org/foodherogame.html	Choose balanced meals to have enough energy for activities	Children	Free
Dining decision game	Cenres of Disease control and Prevention	Game	http://www.cdc.gov/bam/nutrition/game.html	Not really a game, info on good choices	Children	Free

Track and field	The Food and Nutrition Service (FNS) and Center for Nutrition Policy and Promotion (CNPP) are agencies of USDA's Food, Nutrition, and Consumer Services.	Game	http://www.fns.usda.gov/multimedia/games/trackandfield/index.html	Nutrition questions to move along	Children	Free
Kevin's build a meal game- building meals	Nourish Interactive	Game	http://www.nourishinteractive.com/kids/flash/games/build-a-meal/en/6-kevins-build-a-meal-game-balanced-meals	Make meals from ingredients around the kitchen – although not clear what the ingredients are!	Children	Free
Smash your food	FoodMe	Game	http://www.foodnme.com/smash-your-food/	Guess the sugar/salt/ oil content of foods. Doesn't work very well	All ages	Free
Blast off – Choose food categories and exercise	The Food and Nutrition Service (FNS) and Centre for Nutrition Policy and Promotion (CNPP) are agencies of USDA's Food, Nutrition, and Consumer Services.	Game	http://www.fns.usda.gov/multimedia/Games/Blastoff/BlastOff_Game.html	Gather food fuel to take off	Children	Free
My plate – Food groups and exercise	Dairy Council of California	Game	http://www.healthyeating.org/Healthy-Kids/Kids-Games-Activities/My-Plate-Match-Game.aspx	Food categories and exercise	Children	Free

Falling food fun	Nourish Interactive	Game	http://www.nourishinteractive.com/kids/flash/games/falling-food/en/17-falling-food-groups-nutrition-game	Required to 'catch' the particular food groups. More of a game, no information	Children	Free
Yummy Drops	Nourish Interactive	Game	http://www.nourishinteractive.com/kids/flash/games/yummy-drops/en/8-play-fun-kids-online-food-games	Dropping fruit from plane- no nutrition info. Quite hard too!	Children	Free
Whack a snack	Nourish Interactive	Game	http://www.nourishinteractive.com/kids/flash/games/whack-a-snack/en/16-whack-a-snack-food-group-game	no information, just have to click on the snack	Children	Free
Healthy harvest maze –	Nourish Interactive	Game	http://www.nourishinteractive.com/kids/flash/games/healthy-harvest-maze/en/12-healthy-harvest-maze-fruits-vegetables-farm-game	Maze but no info – basic	Children	Free
Nutrition machine – vitamin and minerals in different foods	Nourish Interactive	Game	http://www.nourishinteractive.com/kids/healthy-games/22-nutrient-machine-vitamins-minerals-game-children	Put the groups of food containing certain information into machine.	Children	Free
Healthy food hunt – very basic, just find foods from list	Fisher-Price	Game	http://www.fisher-price.com/en_US/gamesandactivities/onlinegames/healthyfoodhunt.html	Find foods from cupboard/shop etc. Quite pointless!	Children	Free
BBC NI	BBC	Quiz	http://www.bbc.co.uk/northernireland/schools/4_11/uptoyou/healthy/quiz.shtml	Quiz	Children	Free
British Council – Healthy eating	Learn English Kids	Quiz	http://learnenglishkids.britishcouncil.org/en/node/1233/by_subject/1352	Questionnaire style again-Gives result and recommendations depending on your diet is	Children	Free
Kids health quiz	Kids Health	Quiz	http://kh.polldaddy.com/s/health-q-quiz	More child friendly quiz-Good questions	Unsure	Free
Sorting healthy and unhealthy foods	Park Field	Game	http://www.parkfieldict.co.uk/infant/body/sort.html	Sorting healthy and unhealthy foods- very simple	Children	Free

Mix-up Match up	Learning Games for Kids	Game	http://www.learninggamesforkids.com/health_games/staying_fit/staying-fit-healthy-snack-separation.html	Sorting healthy and unhealthy foods- very simple	Children	Free
Healthy food game	ESOL Help	Game	http://www.esolhelp.com/healthy-food-game.html	Fun idea but they don't tell you if you win or what the foods are	Children	Free
Change4Life Sugar Swaps app	NHS	App	http://www.nhs.uk/Tools/Pages/Change4Life-SugarSwaps.aspx	App that allows you to scan the barcode of a product and find out how many sugar cubes are in it.	All ages	Free
The Big food quiz	Salford City council	Quiz	http://services.salford.gov.uk/Tapestry/HealthImprovement/TheBigFoodQuiz.aspx	Learn about food myths relating to health	Adults	Free
Test Your Fats IQ- 2 Quizzes	American Heat association	Quiz	http://www.heart.org/HEARTORG/quizTemplate.jsp?pid=ahaweb.quiz.quizintro&quizId=600004	Quiz about facts on fat	Adults	Free
Healthy Eating Quiz- Who wants to be a millionaire?	TES- the world's largest online network of teachers	Quiz	https://www.tes.com/teaching-resource/healthy-eating-quiz-6033844	Healthy Eating Quiz- Who wants to be a millionaire?- has to be downloaded a PowerPoint presentation	Children- used by teachers	Free
Healthy Eating Quiz (true or false)	Food for Life Partnership	Quiz	http://www.foodafactoflife.org.uk/	Healthy Eating Quiz (true or false) on range of topics	Unsure	Free
MyFitnessPal®	MyFitnessPal	App	https://www.myfitnesspal.com/	MyFitnessPal® is a website that helps people counts their calories by entering it into an online diary. The counter allows members to set daily goals, and the app can add multiple foods at once. It also automatically stores food and meals that members eat often, which makes them easy to find when they eat them again and need to log them.	Adults	Free

				It also keeps track of exercise, with more than 350 exercises stored in its database, and it shows how much each person burns during each activity, based on their specific height, weight, and gender. It can be tailored to fit the needs of anyone with specific and/or doctor/dietician-recommended requirements. It also provides an online community where users can exchange tips and advice, as well as to create relationships through sharing personal experiences or struggles.		
My Diet Diary Calorie Counter®	My Diet Diary Calorie Counter®	App		My Diet Diary calorie counter enables users to track food, exercise, weight, water consumption and keeps track of whether the user keeps track of weight goals.	Adults	Free
Cronometer	Cronometer	Website/ App	http://cronometer.com/	CRON-O-Meter is designed to be a simple online tool that can help users track their diet and exercise. The online diet diary, which like others provides a nutritional breakdown of a users diet. Users can track progress against goals and add custom recipes. Progress can not be shared on social media directly from the tool.	Adults	Free
Lose It	Lose It	Website/ App	https://www.loseit.com/	LoseIt is a combination food and activity tracker, It specifically aims to help people with their portion sizes, daily caloric goals and intake,. The android app has a barcode scanning option that can quickly scan and add servings of packaged food. Personalised recipes can also be added. LoseIt syncs with a number of activity trackers and smart scales and external apps and services to import activity data. It also has a active community to support users and the app includes a "challenge" function to encourage users to challenge their goals. The basic app is free however a Premium version has been released for $40/yr that extends the service's nutrition and activity tracking features, and more reporting tools	Adult	Free/ $40/yr
My Diet Coach	My Diet Coach	App	http://www.mydietcoachapp.com/	As well as offering diet and exercise tracking Diet Coach offers motivational and lifestyle tools to encourage users to lose weight. These tools include: Customized reminders, motivation pop ups, before and after photos, exercise reminders, reminders to drink water, a visual weight tracker, daily challenges, Inspirational quotes and tips arranged by common weight loss challenges, point reward system, a avatar that can be personalised and the PRO version get a coach function.	Adult	
Fat Secret	Fat Secret	App	http://www.fatsecret.co.uk/	FatSecret is another Online food diary and exercise tracking tool. It allows user to keep a personal journal then allowing users to match up what they eat with their mood. The App also has a strong community in which regular community challenges are run, to motivate users even more. Over time users can get tools to track habits and performance to enable them to see performance against goals	Adult	Free

Tap & Track -Calorie Counter (Diets & Exercises)	nanobitsoftware.com	App	http://www.tapandtrack.com/home/index	Online/Offline nutritional database for foods. Allows you to track food intake and apply different dietary plans. The Tap & Track users to track calorie intake vs needs by calculating their Basal Metabolic Rate (BMR) based on your gender, age, weight and height. The application features can be divided into 4 parts; Food, Exercise, Weight and Reports.	Adult	Free
Fast Food Calories	nanobitsoftware.com	App	http://www.tapandtrack.com/home/index	Fast Food Calories is a nutrition guide, which provides over 108 most popular restaurants with their full menus and nutritional information and the database is offline.	Adult	Free
Muscle Gainer	nanobitsoftware.com	App	http://www.tapandtrack.com/home/index	An app designed to help users gain weight from protein sources, by providing a specific dietary plan to follow	Adult	Free
Low Carb Diet Assistant	nanobitsoftware.com	App	http://www.tapandtrack.com/home/index	Low Carb Diet Assistant is easy-to-use carb counter, that aims to assist dieters with following a low carb diet plan (e.g. Atkins and South Beach). It provides daily info for Net Carbs, calories, fat, saturated fat, protein, sugars, sodium & fiber, water tracking, daily weight and BMI tracking, pictorial summaries of nutrition breakdown. The database is offline, allowing use anywhere. It has similar features to most other online food intake trackers.	Adult	Free
Good Food-Bad Food, food advisor & calorie tracker	nanobitsoftware.com	App	http://www.tapandtrack.com/home/index	Good Food – Bad Food shows the users the positive and negative aspects of each food they selects, whilst acting as a food diary, allowing users to track calorie intake. It also makes activity recommendations and tracks the user's stats. The information and values of all listed foods are based on scientific nutritional formulas and recommendations provided by the FDA.	Adult	Free
My Meal Mate App	X-Lab Ltd	App	https://itunes.apple.com/gb/app/my-meal-mate/id834966614?mt=8	"My Meal Mate" (MMM) is an app for weight management which has been designed by nutrition scientists at the University of Leeds, UK, based on scientific evidence. MMM helps users set realistic goals for weight loss based on their needs and contains a food and activity tracker.	Adult	Free
Noom Weight Loss Coach	Noom Inc	App	https://www.noom.com/	Noom provides users with a in-built fitness programme, a diet tracker and an intelligent coaching system. Noom focuses on habit-changing, to achieve the users goals. The app coaches users (data is fed to expert coaches that provide advice back to users) by providing support and motivation via daily personalised fitness challenges, meal logging, calorie tracking, and a simple traffic-light food-logging system. Noom have a dedicated team of dieticians, exercise scientists, personal trainers, and behaviour experts.(16 week course)	Adult	Free
Noom Diabetes prevention program	Noom Inc	App	https://www.noom.com/diabetes-prevention-program/	Similar to the Noom Weight Loss Coach in function, but specifically targets aspects to prevent Diabetes. (16 week course)	Adult	Free

Super Tracker **(USDA)**	United States Department of Agriculture	Web based tool	https://www.supertracker.usda.gov/foodtracker.aspx	Web based food intake tracking tool.	Adult	Free
Weight Watchers Mobile	Weight Watchers™	App	http://www.weightwatchers.com/templates/marketing/marketing_utool_1col.aspx?pageid=1191351	The app allows users to track food, weight and activity in any location. It also has a barcode scanner function and allows users to take a photo of their food to aid logging it at a later point in time. Also allows users to look up pro-point value of different food.	Adult	Free
A taste of Slimming World 2.0	Slimming World	App	https://play.google.com/store/apps/details?id=com.slimmingworld.app&hl=en_GB	This app allows members of Slimming world to share their stories and videos. App also provides meal plans, helps the user to find a local group and includes a food search element enabling members to search for Free Food, Healthy Extras and Syns	Adult	Free, additional benefits for members of Slimming World

*this is a review of only some of the most popular apps, currently available to track Food intake/physical activity/health. A search on the 19/07/16, of Google play store using the term "Food Tracker" resulted in 248 results, demonstrating the huge range of tools available for users to monitor their food intake.

8.3 Annex 3. Other Apps relating to PRECIOUS

Tactiohealth	NHS choices Health app library	App	http://apps.nhs.uk/app/tactiohealth/	Lose Weight. Stay Fit. Track your Hypertension. Manage Glucose and Lipids. Look no further. TactioHealth has it all for you and your family. Weight Tracking - TactioHealth tracks Height, Body Weight, Body Fat %, Waist Size, Body Mass Index and Waist-to-Height Ratio from manual data entry or automated eHealth sync from connected scales. Daily Steps Tracking - Tracks Daily Steps from manual entry or automated eHealth sync from connected Activity Trackers. Cholesterol Tracking - TactioHealth tracks LDL, HDL and Total Cholesterol by manual entry into the app. Glucose Tracking - TactioHealth tracks Fasting Glucose and Triglycerides by manual data entry into the app. Multi-User (Family) - TactioHealth supports up to 8 users for tracking supporting entire families. CDC growth data and percentiles are included from 2 to 75 years old. Blood Pressure Tracking - TactioHealth tracks Systolic, Diastolic and Resting Pulse from manual data entry or automated eHealth sync from connected BP Cuffs.
Diabetik	NHS choices Health app library	App	http://apps.nhs.uk/app/diabetik/	Diabetik allows users to keep a detailed diary of their diabetes and visualise the data they enter in interesting ways.

Diabetes Risk Tool	NHS choices Health app library	App	http://apps.nhs.uk/app/diabetes-risk-tool/	Find out your risk of developing type 2 diabetes with this tool. Based on a clinically validated questionnaire, it will give you the information you need to know about your diabetes risk in under a minute. The application will also provide you with statistics regarding how many people with your survey results become diagnosed with diabetes within the next 5 years. Once you have your risk, why not try improving it and doing the test in a few weeks?
Diabetes Key Tips	NHS choices Health app library	App	http://apps.nhs.uk/app/diabetes-key-tips/	Take control of your diabetes with the Diabetes Key Tips app suitable for adults with type 1 or type 2 diabetes. The app, developed by a practising UK Consultant Diabetologist with more than 10 years specialist experience, is based on up to date UK clinical practice and guidelines, and works alongside the advice of your diabetes healthcare professionals. The app is for general use only and is not intended to provide personal medical advice or substitute for the advice of your physician.
Diabetes Risk	NHS choices Health app library	App	http://apps.nhs.uk/app/diabetes-risk/	With this App you can know your diabetes risk in the next years using the Finnish Diabetes Risk Score
Diabetes Risk Checker	NHS choices Health app library	App	http://apps.nhs.uk/app/diabetes-risk-checker/	The Diabetes Risk Checker app asks some simple questions, and then performs calculations based on the open source ClinRisk Diabetes algorithm to determine the % risk of developing Type 2 Diabetes over the next 10 years.
Diabetes Manager	NHS choices Health app library	App	http://apps.nhs.uk/app/diabetes-manager/	Diabetes Manager from Patient.co.uk allows you to track your essential diabetes data and tailors the app whether you are type 1 or type 2 diabetic. Record your blood glucose, blood pressure, bolus and basal insulin doses, diet, activity levels, weight and more!
Hearts and Minds	NHS choices Health app library	App	http://apps.nhs.uk/app/hearts-and-minds/	This app calculates your 10 year risk of having a heart attack or stroke using the QRisk algorithm, available under license. It is relevant to anyone 25 to 84 years of age who has not had a diagnosis of heart attack, stroke, or mini stroke (TIA). Simply fill out the question screen and discover your risk, then use the app's help screens to find what is available to enable you improve things. If your risk is high try altering some of your entries to find what strategy reduces your risk the most, stopping smoking for example.