COMMIT

PROJECT PLAN

WORKPACKAGES

DELIVERABLES

BUDGET

SENSOR DRIVEN COACHING FOR HEALTHY LIVING (P3)

Project Leader: Vikas Kannav, Infosys

1. Background

The current welfare states face serious medical issues as a growing number of the population is at risk for developing health problems related to excessive food intake in combination with lack of exercise. These medical issues include obesity, diabetes and high blood pressure. An ageing society exacerbates this trend and millions worldwide are suffering or are about to suffer from the health problems in question. Current preventive healthcare mainly centers around exercise and to a lesser degree nutrition. The target user group that suffers from welfare diseases forms a new type of patient where the focus must be on the primary prevention of the aforementioned health problems and of secondary medical conditions that need extensive treatment.

Thus, preventive and recuperative health care has become extremely important in our society. A key problem in this area is how to motivate people to not only start, but also stick to a healthy life style, including sufficient physical exercise through sports or otherwise. Many researchers have looked at how to improve adherence to a healthy life style using ICT, for example through advisory web sites or data collection from sensors.

In this project, we take an integrated approach to the urgent adherence problem. Our goal is to improve health through behavioural change and compliance, by improving the personal motivation of people, using behavioural intervention technology based on modern ICT, especially smartphones, off-the-shelf sensors and clouds. The project differs from existing work in several ways:

- Combining *all three aspects* of health: physical, mental and social, and their interactions.
- Providing *real-time feedback* to users while they are exercising, using a smartphone based sensor network in combination with cloud technology; we thus provide a complete sense-model-action loop.
- Providing *personalized feedback* based on individual goals, but also exploiting *aggregated information* from groups of users to enhance the feedback.

To achieve these goals, we bring together a unique consortium with all required expertise, in particular in human movement, sensors, clouds, privacy, human-computer interaction, and complex pattern analysis.

We will be integrating technology to sense, analyse, interpret and motivate people who take part in sports and exercises towards a better wellbeing. This data will be used to provide intelligent coaching to improve sports and exercise related well-being on 3 dimensions: Physical, Mental and Social. The focus will be on people who partake or wish to partake in sports or exercise activities (like walking, running, cycling) as part of a work/life routine.

The project will deliver scientific results in the detection of exercise and health patterns from bio-physical and mobile sensor data as well as intelligent motivational support and will produce a series of business oriented inspirational demonstrations.

2. Problem description

Initial attempts have been made to use ICT to improve health, and several so-called sports coaching applications are available. Experts in health and human movement emphasize that a personalized and contextualized approach to coaching is crucial, as different users have widely different initial conditions and goals, such as getting fitter, losing weight, and running or biking long distances. ICT can indeed help with achieving individualized goals. Current sports coaching applications, however, focus on only one aspect of health, often physical health, while studies show that human health is the resultant of a complex interaction between physical, social and mental aspects. In particular the physical and mental aspects change during exercises and therefore should be monitored in real-time. Many personalized coaching applications only give advice before the exercise and feedback afterwards. For social health, it is often very encouraging to give advice to groups of people (e.g. teams of runners or bikers) in their particular situational contexts, but most existing coaching applications lack such functionality.

In this project, we investigate how smartphone and cloud technology can be used to achieve the following breakthrough in health coaching: real-time advice based on all the three aspects of health (i.e., physical, mental and social). A key idea is to build a sensing framework for both individual amateur athletes and groups of people. Since we explicitly aim at the 'masses', the sensing framework should use off-the-shelf components as much as possible and be scalable to huge numbers of users.

Therefore, we will use smartphones as the primary sensing device. Smartphones are now widely deployed: they already have a wide variety of useful sensors and networks, they can easily be extended with specialized external sensors, and they provide the computing capacity to do basic real-time analysis, modeling and feedback. For more large-scale computations and data-aggregation, we will use cloud technology. The combination of hybrid processing on smartphones and clouds is particularly powerful and flexible, yet also complicated and still in its infancy. Therefore, it is essential to study this technology hand-in-hand with domain experts and human-computer interaction experts.

3. Challenges

P3 is a large-scale project; the challenges envisaged to execute the same both in research and application space are as follows:

- Enhanced detection of human physical, mental and social state through aggregated sensor data (collected via off-the-shelf sensors and smartphone).

- Enhanced computation on device and in the cloud to provide real-time feedback to users.
- Context-based and personalized information/knowledge on exercising based on scientifically validated findings from human movement sciences.
- Planning, executing and adapting the multimodal agent behaviour (i.e. a virtual human) on-the-fly based on the sensor output and in temporal coordination with the user's behaviour.
- Personalized and contextual coaching strategies through social network pattern analysis of increasingly growing amount of physical, social and mental data, and related coaching data of both, individuals and masses.
- Exploring which useful (long-term) physical and social network pattern analysis (relating to both, individuals and masses) can be performed in the cloud and how would the analysis scale to large numbers of users.
- Identify long term and emerging patterns for sharing, recommending, and switching or adapting coaching strategies.
- Analysing and addressing the challenges of ensuring the availability, security and privacy of the sensor data collected on the cloud.

4. Objectives

This project aims to develop an engaging and motivational exercise coach for people who partake in amateur sports activities. To achieve this, the following objectives need to be realized:

Human activity detection to identify the physical, mental and social state of the user in real-time: By fusing data from multiple off-the-shelf sensors on the body and in mobile smart devices, user behaviour needs to be deduced (e.g. if the user is running, what is the heart rate, are any other people nearby). An interpretation of this data is needed to assess the current physical, social and mental state (e.g. the user has just started running and is talking to another person at the same time).

Based on the human activity detected, user-specific intervention programs aimed at improving the user's health should be developed.

Human mental and social state assessment and modeling to infer from low-level movement and voice data higher-level user states such as engagement, stress, and other emotion-related states.

Development of user-specific lifestyle programs to support and improve the health of the individual in question by incorporating information about the user's physical, mental and social states. Not only the current state of the user is of importance, but also the user's state over a span of time needs to be taken into account.

Analyzing human activities over time to assess lifestyle patterns in users' behaviour (e.g. analyse person's weekly or fortnightly patterns and deduce if the person needs to exercise a little extra on weekdays too).

Real-time motivational coaching and feedback in response to exercise or sport activities (e.g. to avoid damage to the muscles, a person who is running after a gap of 3 months should walk for 3 minutes every 15 minutes). The user interaction should be motivating and engaging in order for the user to comply with the lifestyle program and feedback as proposed by the system.

Validation and evaluation to gain insight into the effectiveness of the methods and the application developed**.**

The new knowledge that has to be developed:

To optimize computation, the trade-offs between implementing functionality on the smartphones versus implementing it in the cloud need to be assessed. In addition, it needs to be researched which expression language is needed to monitor context conditions on the phone, finding the right trade-off between expressivity and performance. We also need to understand which useful analysis can be done in the cloud on information aggregated among groups of users. We will need to understand how to perform real-time analysis on constantly changing big sensor data and find out how to deduce long-term patterns that emerge from collections of sensor data on sport activities.

To optimize interaction, we need to understand what the most effective way is to communicate motivational feedback to the user in a real-time and contextualized manner. After detection, interpretation of the data is needed to assess the users' social and emotional context. Therefore, it is important which parameters (e.g. voice) change under influence of the user's mental state (stress), social situation and/or physical activities. The engine that drives the agents behaviour (i.e. sends messages to the user, provides overviews, motivates) needs to plan and execute system behaviour in real-time response to the user's behaviour as captured by sensor data.

It is also important to understand how quantitative and qualitative information on performance of physical activity, and qualitative information on the mental state can be derived from data obtained from sensor data processed on a smartphone.

To analyse the success of the solution, long-term evaluation of users' behaviour and health is needed. This will also include studying the effectiveness of interventions translated to autonomous system behaviour.

Deliverable Impact and Valorisation

- Report on user studies on compliance, consumer satisfaction, perceived app performance and post market evaluation.
- Evangelizing the project scope and research effort.
- Build leads with prospective collaborators. This includes piloting the mid-term demonstrator and gathering the feedback on experience.
- Software libraries for user behaviour assessment.
- Software libraries for mental and emotional state assessment.

Deliverable Dissemination

- Opening speech of digitale zorg event, jaarbeurs utrecht 21 Juni 2013 (http://event.digitalezorggids.nl/)
- Prototypes will be advertised and made available to participants of regular large walking and running events in the Netherlands like the Dam tot Damloop, de Batavierenrace and Nijmeegse Vierdaagse.
- Prototypes will also be advertised and made available to members of chains of fitness clubs and health spas, such as Basic Fit, David Lloyd and Splash.
- Presentations about the app, its workings and the philosophy behind it will be given to organizations concerned with lifestyle improvement, such as the Netherlands Institute for Sport & Physical Activity (NISB), and investigations of their effects, e.g. the Netherlands Institute for Health Services (NIVEL).
- Sense and Almende are well-connected in the communities for open data and “self-quantification”, which touch on the subject matter of the project. We will demonstrate the application at international conferences such as the International Open Data Day, or the annual Quantified Self conference.
- We will participate in the annual ICTDelta conference at least through poster presentations/demos.
- Demonstration and presentations during international conferences as European Conference on Complex Systems; International Conference on Ambient Intelligence.
- Specialist and 'lay' publications in newspapers, news letters from specialized groups and professional journals (e.g. 'on assets that people motivate, facilitate and encourage to sport and exercise')
- Certification: the intervention can be included in the database of ''Effectief Actief' of the Netherlands Institute for Sport and Physical Activity (NISB) and the i-database of the Centre for Healthy Living of the National Public Health Institute (RIVM).
- Web articles at sporters' websites like www.runnersworld.com, www.losseveter.nl, www.runinfo.nl, www.hardlopen.nl, www.duursportersweb.nl, etcetera; and at public health/lifestyle news sites such

as www.nu.nl/gezondheid, www.nu.nl/lifestyle www.personalizedprevention.com

- Social media: start a twitter account on the project; develop a Facebook community with our test group on the golden demo
- Prototype presentation at big events: marathons, triathlons, championships, health markets, etc.
- Education and training (addressing the human capital agenda): guest lectures at universities of (applied) sciences: e.g. sport and movement science, physical education, media and IT studies, public health, health promotion, life style and fitness etc. At initial and post graduate education.
- Inform health insurers and occupational health services
- Inform and interest big companies and local government with specific health/physical activity policy

Deliverable Synergy

- **P4/P5**: Collaboration with P4/5 on Virtual Worlds for Well-being will concern the exchange of knowledge on sensor fusion and sensor-data analysis. Also, the project involves emotion detection from music and images that is complimentary to the detection of user emotional state for vocal analysis in P3.
- **P7**: Collaboration with user centered reasoning for well-working, this project concerns the detection of stress from bio-physical signals for instance from a wearable device. P7 is most interested in our work on vocal analysis of voice data retrieved from mobile phone use. There will be an exchange of knowledge and sharing of recourses possible on the level of sensors used and data analysis and fusion modules.
- **P8**: Synergy with P08 SWELL happens in WP1 where we analyse user mood from vocal feature analysis. We will exchange our learning with SWELL; they wish to collaborate by comparing such data with data they receive from external sensors on a smart vest.
- **P9** looks at very large sensor networks with many small inexpensive sensors. P3 uses smartphones as sensing nodes, which have much more general computing functionality, richer sensing capabilities, and more power. The proximity detection sensors and resulting proximity graph from P9 could become a relevant building block for P3. P3 applications will also be interesting showcases to demonstrate the potential of proximity information for promotion of an active lifestyle. P3 will also be an interesting use case for the crowd detection algorithms developed in P9.

International Embedding

- Collaboration with WUR/Health and Society and Glasgow Centre of Population Health: Asset based approaches for health improvement).

- Collaboration with National Institute for Public Health and the Environment: Health monitors and population data.
- Collaboration on monitoring of physical activity and determining qualitative aspects of physical activity using inertial sensing data within the FARAO project (the Netherlands Organisation for Health Research and Development) and within the ITN programme ‘Moving Beyond’ (FP7, Marie Curie) with McRoberts bv and within the project ‘From Lab to Life’ with XSens and the Harvard School of Public Health (Liberty Mutual-Harvard School of Public Health postdoctoral program).
- Collaboration with EU CONTRAIL project on Clouds.
- Collaboration with Active2Gether (EMGO/VU/Philips collaboration).
- Collaboration with ARTEMIS SIMPLE project.

5. Scientific Question

The main scientific question the project addresses is:

"How can a personalized behavioural intervention technology be built that effectively motivates people to comply with exercise goals thereby enhancing their physical, mental, and social health?"

For the ICT research, this requires to:

- Understand which sensor data can be collected from the smartphone and how it should be interpreted with respect to physical, mental and social contexts.
- Study how to build a scalable and power efficient framework that can do real-time context evaluation for social (group) applications by coordinating tasks between individual smartphones and a cloud platform.
- Research and develop a cloud service that interacts with the sensor collection/evaluation framework to increase the scalability of the entire system and enable (secure) data sharing. Big-data and analytics in real-time will also be researched and implemented.
- Explore and implement encryption, searching and access control of sensor data on the cloud.

6. Scientific Approach

	Sense	Model (interpret)	Action (Feedback)
Physical	Sensing of physical activity (e.g. detect running with an accelerometer)	Understand the physical state of the user (e.g. the user is running but getting fatigued)	Feedback on physical state and exercise goals (i.e. switch to a lower pace or frequency, or this is the third time you are running this week, this is excellent)
Mental	Sensing of mental state (i.e. stress or emotion through voice or GSR analysis)	Understand the mental state of the user (e.g. the user is no longer enjoying the run)	Feedback on mental state (e.g. try to switch to a lower pace and enjoy the environment)
Social	Sensing of social activity (e.g. data-mine facebook or twitter, or analyse phone or dialogue activity)	Understand the social state of the user (i.e. user is running alone)	Feedback on social state (e.g. try running with your team [real or virtual] at least once a week)

7. Economic and Social relevance

Sports, exercise and a healthy population have important economic and societal added value.

Healthy people with healthy lifestyles need less health-care. This saves money on the public budget and private costs on less absenteeism and incapacity to work. Sufficient exercise is also positively associated with health-related quality of life. People who get enough exercise live longer.

The National Public Health Institute (RIVM) estimated that, in the Netherlands, 1.4 percent of expenditure on health is a consequence of too little exercise. Sufficient physical activity reduces various health risks e.g. heart disease, early death, stroke, type 2 diabetes and high blood pressure, obesity and depression.

Sports also contributes to bonding (between people of the same group) and bridging (between people of different backgrounds) social capital. Bridging social capital can be a resource for social advancement. Binding social capital can be positive for the wellbeing of people and provides opportunities for exploiting social contacts, support and skills development.

An obvious observation is that the school children and adolescents who play sports and regularly engage in exercise do better at school.

It has been estimated that in a big city like Rotterdam, sport benefits for nearly 0.5 billion € per year. Slightly more than half (54 percent) is the result of a healthier population, almost a quarter is due to less absenteeism at work, 12 percent to a greater quality of life, 9 percent increase in real estate value and 3 percent to less school absenteeism.

8. Indicative use cases

1. Joanna is running, has the app and her mobile headset on to listen to music and to hear the virtual coach motivating and instructing her during her run. The virtual coach tells Joanna that she is almost breaking her own record in length and speed of running and to keep the current pace for another 5 minutes to beat it. The system notices that Joanna is slowing down and coming to a halt, probably because of a traffic light. The system takes this into account and explains to Joanna that to beat her record she needs to speed up from the current pace and run another 3 minutes longer. Joanna is having a tough time, she is breathing heavily and the system indicates that her heart rate is very high. It is better for her to slow down but extend the run. The virtual coach proposes this and explains that beating the record on speed is perhaps not a good idea today but that she has definitely improved on endurance from previous times. After the run, the system asks Joanna a few questions (Was the run a good experience? Did you have fun? On a scale from 1-10, how exhausted do you feel? How active do you feel now? How positive do you feel now?); Joanna responds by speaking into the microphone.

2. Mary has decided to go cycling. She starts the app and wears her mobile headset to receive calls and feedback from the virtual coach. At some point, she is alerted by the app that a friend of hers is also cycling nearby. She decides to give her a call (while cycling) and speaks into the headset: "call Cindy". Mary and Cindy meet up and decide to cycle and chat together. They establish a connection on their phones so that they can talk to each other through the headset (in a walkie-talkie manner) and so that they can monitor each other's current performance. Meanwhile, the system is monitoring the conversation and the activities of both cyclists. The system is sensing that Cindy is getting tired and that she is doing too much workout and gives feedback to both of them. Mary hears that and slows down, adjusting her pace to that of Cindy's.

3. A group of 12 runners is doing an intensive 20km run. After a while, the system discovers (by exchanging the runner's heart beats over WiFi) that 5 of them have a heart beat high in their individual anaerobic zone (close to 90%) while the other runners are still in their aerobic zone. The system advises the runners to split up into 2 groups, and instructs the 5 runners to slow down to 80%.

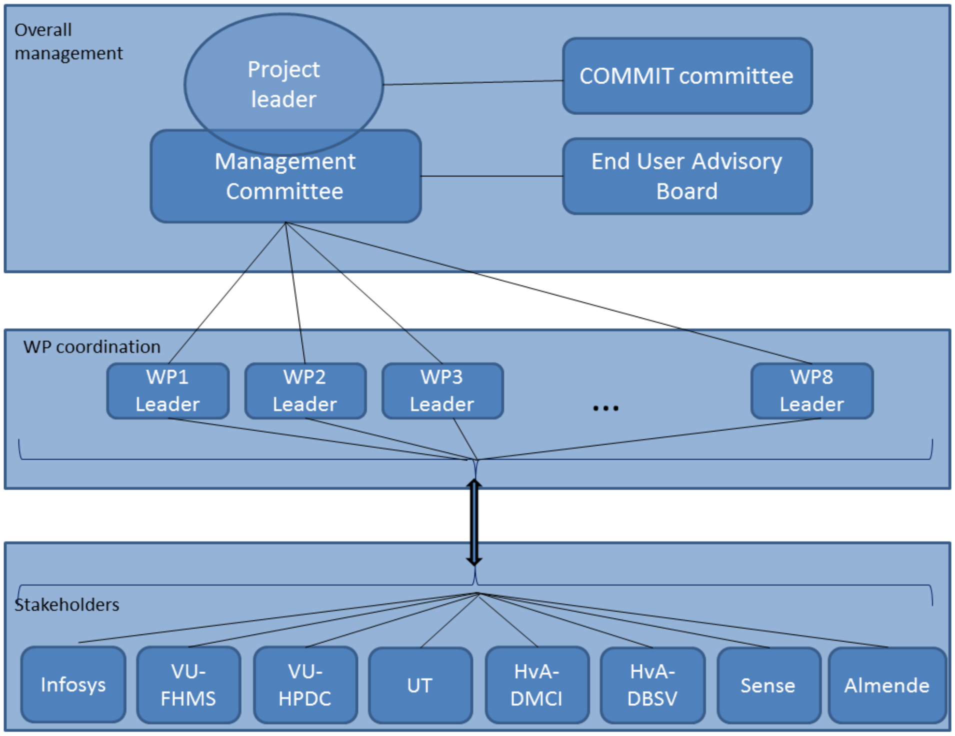
9. Consortia and contribution

The initiating partners are knowledge institutes, two SMEs and an international technology company:

- Infosys
- Vrije Universiteit Amsterdam
    - Faculty of Human Movement Sciences (FHMS)
    - Faculty of Sciences, High Performance Distributed Computing (HPDC)
- University of Twente
- Hogeschool van Amsterdam
    - School of Design and Communication (DMCI)
    - School of Sports and Nutrition (DBSV)
- Sense
- Almende

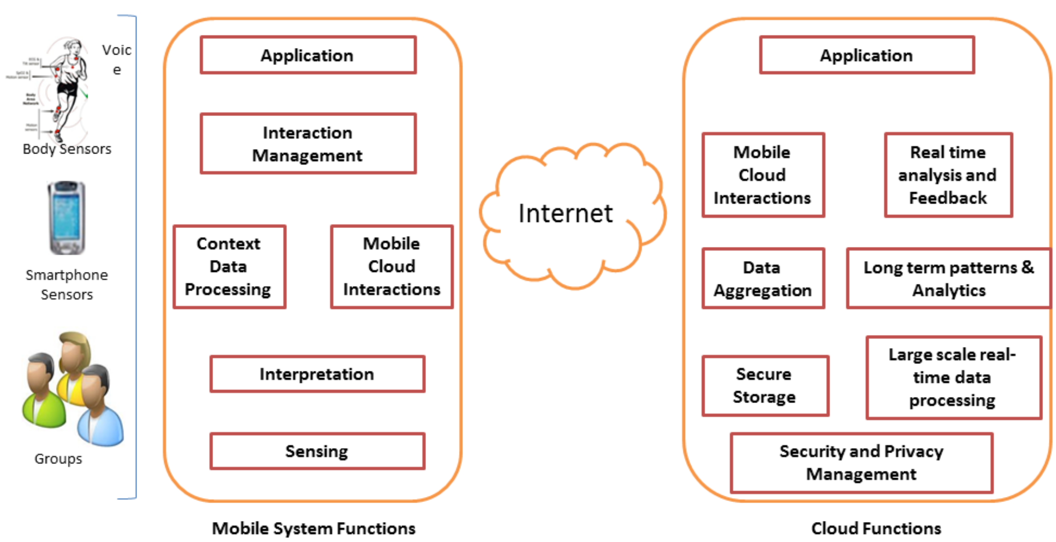
10. Management structure

The management structure will be in line with rest of the COMMIT programs. The figure below depicts the hierarchy and coordination among different entities/parties.

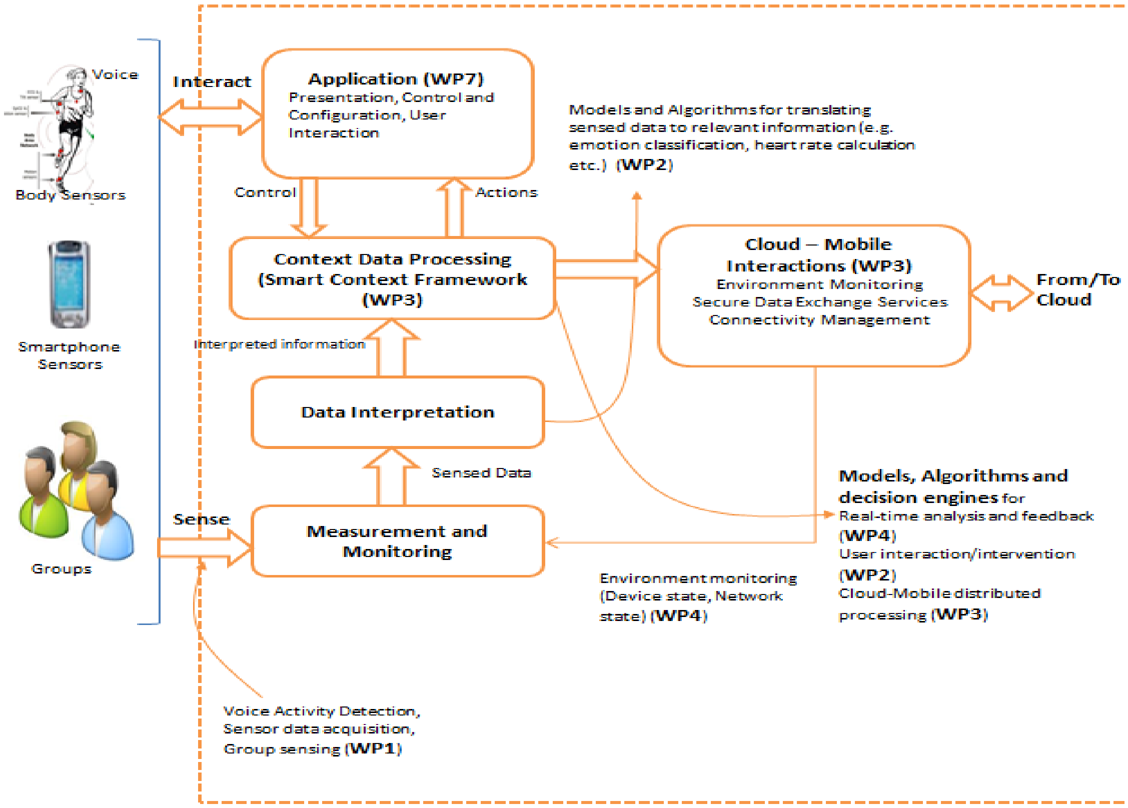


11. System Design

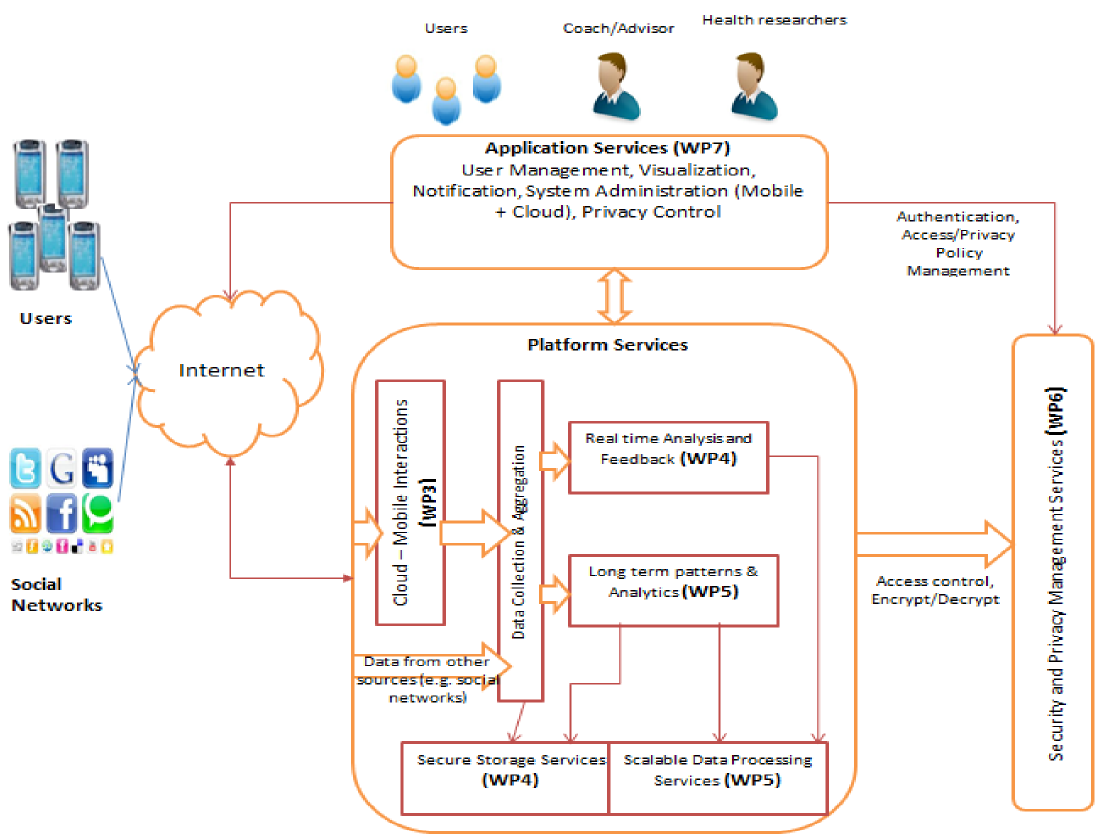
The figure below is the depiction of the high-level system design, and shows the components/functional-blocks/modules on mobile side and on the Cloud.



Mobile side functions:

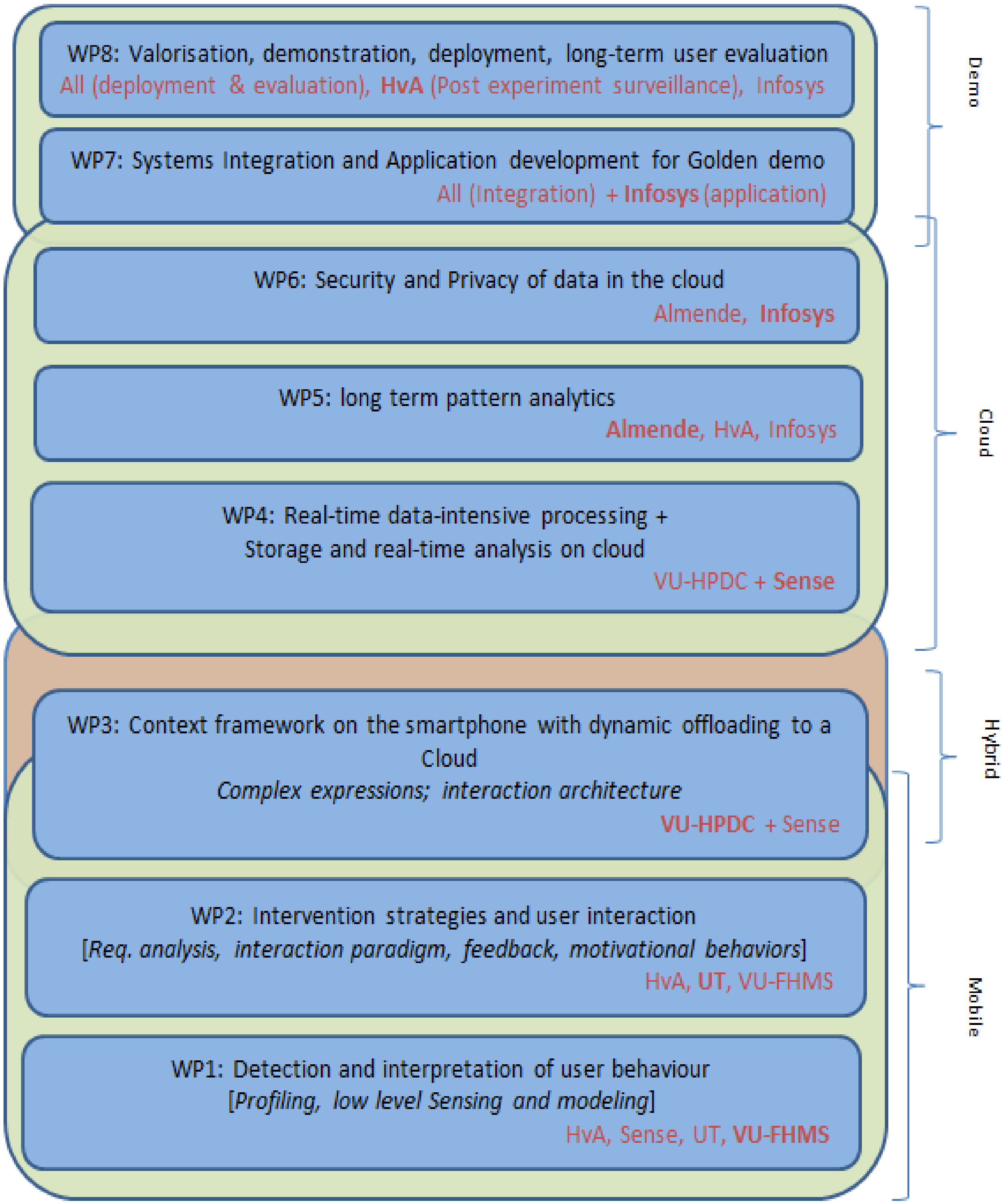


Cloud side functions:



12. Work Packages

The figure below is an abstracted representation of different WPs and logical sub-groupings at a high level.



WP1: Detection and interpretation of user behaviour

WP leader	Peter Beek (VU-FHMS) p.j.beek@vu.nl			
Participant	VU-FHMS	UT	HvA-DMCI	Sense
Person-months	38 + 24	See VU-FHMS	6	6
Type of job	AiO 36PM, senior researcher 2PM, postdoc 24PM	Post doc.	Researcher	Researcher

Description/Objectives:

WP1 is concerned with the low-level detection of user's physical, mental and social behaviours from low-level sensing data and the identification of higher-level physical, mental/emotional, and social states of the user, like fitness, objective and subjective fatigue, arousal, stress and social inclinations. WP1 consists of three main subprojects.

Assessment of Physical Aspects of Exercise: Algorithms for monitoring the ambulatory activity of the user based (mainly) on smartphone data will be developed for assessing both exercise type (categorization) and physical load, as well as for assessing the quality of specific exercise (notably walking and running).

Assessment of Mental/Emotional/Social Aspects of Exercise: Mental, emotional and social user states will be assessed via the smartphone through explicit verbal prompts from the user about how he or she feels (VU-FHMS), and by extracting the implicit information contained in the voice (UT). Social states and inclinations will be gleaned from (accelerometer and voice) data obtained from other users with whom the user interacts or doesn't interact (HvA-DCMI). Models for mental, emotional and social state assessment will be developed and implemented on the smartphone for further testing and training. VU-FHMS, UT, and HvA-DCMI will collaborate extensively in integrating data from explicit and implicit verbal responses as well as accelerometer data in order to obtain a comprehensive assessment of the user's mental and emotional state.

Low level sensor implementation: The aim of the present project is to create the processing environment for assessing the physical, mental and social state of the user. Initially, we will use the existing Sense platform on the phone to access local sensor data. This platform will be extended with additional sensor implementations for sport applications. This includes extra audio sensing, support for external sensors such as heart rate monitors and additional sensing modes for the motion sensors.

WP2: Intervention strategies and user interaction

WP leader	Prof.dr. Vanessa Evers (UT) v.evers@utwente.nl			
Participant	UT	VU-FHMS	HvA-DBSV	
Person-months	24	15.5	6	
Type of job	AiO	AiO 12PM, Sen.Res. 2PM, Prof. 1.5PM	Researcher	

<u>Description/Objectives:</u>

WP2 concerns a) the development of intervention strategies based on the physical, mental and social state assessment (WP1) and a user's health profile, and b) the communication and display of health-related exercise advices that are relevant for the user in the specific real-time context of exercising. User-specific intervention programs will be designed based on the user's amount and type of exercise and the user's mental and social state.

Community health profiling: The community health profiling provides a snap shot of the health status of the population involved, focusing on the life style aspects targeted in the project. A framework for this health profile will be produced based on the RIVM model of health. Health data will be systematically gathered through The Amsterdam Health Monitor in cooperation with the RIVM and CBS.

Subgroup health profiling: For profiling the subgroups, we follow the asset-based approach (Morgan & Ziglio, 2007). Assets are any resource, skill or knowledge that enhances the ability of individuals, families and neighborhoods to get and sustain an active and healthy lifestyle. Specifically, we will use the Motivational Interviewing and Structured Interview Matrix (SIM; O'Sullivan et al, 2012), which includes contextual evaluation, identification of effective motivational strategies, inventory of the needs, wishes, habits, knowledge, expectations and app-experience of our set of target (sub)groups.

Evaluation and design of overall interaction paradigm and motivational agent behaviour: We will evaluate and design the human-agent interaction by identifying the user requirements for interaction through context analysis of the target users' lifestyle, exercise routines, rituals and habits around exercising and smart-phone usage patterns. A limited set of main interaction paradigms are evaluated and compared to identify one or two effective system roles (for instance should the system act as a buddy, information provider, game, or coach). Based on the intervention programs developed by VU-FHMS, UT will evaluate and design persuasive system behaviours to optimise user compliance and habit-formation as well as satisfaction in using the system.

Physical, mental/emotional and social feedback: The output of the algorithms developed in WP1 to detect physical (i.e., quantity and quality of exercise), mental (i.e., emotion-related user states such as stress and fatigue) and social aspects of exercising will be used to determine the intervention strategies. Based on the *quantity* of exercise in relation to the individual user's aims and objectives, we will develop intervention programs aimed at improving the health status of the individual in question. Based on the *quality* of exercise in relation to the individual user's aims and objectives, we will develop intervention programs aimed at improving the quality of movement (e.g., cadence, economy, fluency etc. of walking and running). In addition, based on the explicit verbal report data and the implicit voice data (UT and HvA-DCMI), guidelines for specific individualized interventions with regard to attention, mood/emotion and subjective fatigue, will be implemented.

WP3: Context framework on the smartphone with dynamic offloading to a Cloud

WP leader	Prof.dr.ir. H.E. Bal (VU-HPDC) h.e.bal@vu.nl			
Participant	VU-HPDC	Sense		
Person-months	42	6		
Type of job	AiO	Researcher		

Description/Objectives:

WP3 addresses the following research questions:

- How to build a scalable and power efficient context evaluation framework on smartphones that can continuously evaluate a high number of context conditions to effectively support social (group) applications?
- How to coordinate computational tasks between individual smartphones and a cloud platform?

WP3 will build a framework that enables capturing of a wide variety of sensor data from on-phone sensors (e.g., accelerometers, magnetometers, and GPS), from nearby Bluetooth sensors (e.g., activity and heart rate monitors like the new MIO ALPHA watch), or user interaction sensors (e.g. graphical user interface and speech input from WP1), or proximity information from COMMIT-P9. We will use the SWAN system of the VU and Sense's CommonSense platform as starting points and extend their expressivity and scalability. SWAN allows for continuous monitoring of context conditions based on sensor data.

We will investigate ways to combine SWAN with Sense's CommonSense platform, for example using sensors in SWAN to push to CommonSense or using "features" extracted using CommonSense to feed back into SWAN as local context.

We will study the scalability of the framework to a large numbers of sensor types and instances, context conditions, and users.

Smartphones and cloud platforms have very different characteristics that are continuously changing. It is important to use the capabilities of all resources in this hybrid system optimally.

WP4: Real-time data-intensive processing

WP leader	Steven Mulder (Sense) steven@sense-os.nl			
Participant	Sense	VU-HDPC		
Person-months	42	6		
Type of job	Researcher	AiO		

Description/Objectives:

This WP studies the question of how to build a framework for real-time parallel and distributed processing of large-scale sensor fine-grained data in the cloud. This way, WP4 provides the cloud counterpart to the mobile framework that is built in WP3. This unique approach will give us the best of both worlds: low-cost analysis can be done quickly on the phone, but the system is still able to offload to the cloud when circumstances require it, e.g. in case of low battery level, or when the information from a single device is not enough. The end result is an open, cloud-based platform, based on open-source tools and frameworks.

State of the art solutions with respect to large scale distributed processing are suitable for batch-type handling of large datasets and calculating transformations on these datasets in a distributed way. What we aim for, however, is large scale *real time* processing. This is an issue not resolved yet. It means a shift from a batch-oriented approach towards a streaming approach. We will create a scalable topology of interconnected sensor data streams and processes that analyse these streams. When the static structure of real-time analysis is in place, we will make the system dynamic and so it can be adapted to the context. Algorithms will be dynamic so the system does not have to be restarted when algorithms are updated.

Additionally, we will study how all the information collected in the cloud can be usefully combined, integrated with external sources on the Internet, and fed back to the athletes, in order to increase their performance or adherence to a training scheme. Given the richness of sensor data, many scenarios are feasible here. Based on requirements from the application scientists, a small selection will have to be made that offers effective motivating feedback. A few illustrative examples are: comparing performance against other athletes or advising groups of athletes how to split up into subgroups with similar performance.

WP5: Long Term Pattern Analytics

WP leader	Alfons Salden (Almende) alfons@almende.org			
Participant	Almende	HvA	Infosys Labs	
Person-months	33	6	36	
Type of job	0.25 Senior Researcher + 0.75 Researcher	Researcher	0.5 Senior Researcher + 0.5 Technology Analyst	

This work package investigates and develops a long-term cloud data pattern analytics framework that is capable of providing intelligent feedback towards the coaching application layer. The key objectives are estimating personal mood, social network analytics and context-dependent recommendation for adapting and recommending or automatically switching coaching application strategies on the basis of the huge amount and diversity of historic data streams that are acquired about the contexts, physical, mental and social well-being of individual people but also masses – possibly stored and shared across different social media networks.

Estimating personal mood from social media to adapt coaching application: This task will focus on the development of a social media-based personal mood estimator to implicitly evaluate the exercise and adapt coaching application flow by grounding emotional states acquired through cross correlating data both from sensors on the mobile platform and analysis of social media.

Contextual personalised recommendation to adapt coaching application: This task will focus on the development of a recommender system that generates alternative sport programmes of different lengths for different types of users (e.g. male, female, age groups) that each are heading given their contexts for their own typical goals in terms of physical, mental and social well-being.

Social networks analytics to adapt coaching application: This task will focus on the development of a social networks analytics tool that provides 'intelligent' feedback towards the coaching application in the sense that the end-users can be made aware of potentially novel and viable coaching strategies with and/or of others.

In the first phase the basic methods, techniques and modules for adapting the coaching application are developed, whereas in the second phase they are further advanced and corroborated by the large-scale social media network, context and coaching application related data available.

WP 6: Security and privacy of data in the cloud

WP leader	Vijayaraghavan Varadharajan Vijayaraghavan_V01@infosys.com			
Participant	Infosys	Almende		
Person-months	36	1.5		
Type of job	0.5 Senior Researcher + 0.5 Researcher	Researcher		

Description/Objectives:

Sensor driven coaching involves a huge volume of diverse data collection, transportation, storage and analysis at the Cloud. Personal, healthcare and coaching data are sensitive information. They need to be protected and only specified users shall have access to different parts of data on a need to know basis. The existing encryption and access control schemes provide data security and privacy but they limit usability. WP6 analyses and addresses the challenges in ensuring the availability, security and privacy of the data collected. This work package studies the following questions:

- Encryption of diverse set of data in distributed environment
- Search over the encrypted data
- Fine grained access control to the data

The goal of this work package is to propose a novel security solution that eliminates potential security threats on health and related personal data hosted in public cloud, assures privacy and also supports fine grained access control. In particular, we will propose techniques for search in encrypted data that would allow different participating entities to access data privileged to them, while preserving the users' privacy. The existing systems support single user search on encrypted data or multi-user setting by sharing common encryption key between different users. These schemes introduce burden in key management and entire data needs to be re- encrypted with new key if any user leaves the group. Our objective is to develop a system that addresses the above mentioned challenges while considering the diversity of coaching sensor data in distributed environment.

The healthcare and coaching data are collected from different users and sources and hence each dataset must be accessible only by a specific group of users. The researchers will also propose fine grained need-based access control, which will allow the participating entities to search and access the encrypted data based on their roles. We provide mechanism for dynamic classification of the healthcare / coaching data under different categories and also assign role for different participating entities. We define access policy that associates each dataset with the roles that can access the data. This facilitates search over the encrypted data within the scope of the participating entity, while preserving the users' privacy.

WP7: Systems Integration and Application development for Golden demo

WP leader	Vikas Kannav (Infosys) Vikas_kannav@infosys.com			
Participant	Infosys	Infosys	All partners	
Person-months	36 Software engineer	12 Researcher	Person months to be utilized from those quoted in other WPs	
Type of job	Engineering	Research	Integration of respective modules	

Description/Objectives:

The golden demo is targeted towards effectively showcasing the innovations coming out of COMMIT-P3 project. The key objectives are:

a) Act as an effective demonstrator of innovations coming out of P3 by integrating all the research outputs into a cohesive and relevant application
b) Enable easy evaluation of various research deliverables
c) To be robust enough to enable pilot and early trials with the general user population
d) Demonstrate outcomes of P3 in 2 phases (end of year 2 and year 4) enabling mid-term assessment of the project

The golden demo (hence forth referred to as application) will span both mobile and cloud spaces and the targeted users of the application will be:

a) Users seeking to effectively achieve their health goals by using sensor driven personalized coaching capabilities provided by P3 project
b) Experts who look at user data and suggest post-facto interventions
c) Healthcare researchers who can access aggregated training data to detect health patterns of national significance

WP8: Valorisation, demonstration, deployment, long-term user evaluation

WP leader	Prof. Dr. Ir. Ben Krose (HvA) b.j.a.krose@hva.nl				
Participant	HvA	UT	ALM	Sense	Infosys
Person-months	18	26.5	1.5	5	2
Type of job	researcher	24 PhD student + 2.5 S. Researcher	researcher	researcher	Project Leader (valorisation)

Description/Objectives:

Objectives:

- Deployment of intermediate prototypes built in WP7
- Long-term user evaluation of application and post experiment surveillance

Deployment of intermediate prototypes: During the research intermediate prototypes will be made available that are suited for user studies. Starting from a paper prototype we will work to a functional prototype that will be tested with end users. Results will be discussed with stakeholders in a series of workshops that lead to the definition of the golden demo.

Long-term user evaluation of application and post experiment surveillance: A random selection of the student population (2350) of the School of Sports and Nutrition can test the beta releases of the app. We evaluate the consumer satisfaction and impact of the app in facilitating and motivating sports and exercise in three different groups: 1.sustainable user groups, 2.dropouts and 3. Non-users (but potential users).

Validation studies to evaluate causal relationships between system intervention and motivational behaviours and user activity, health and experience: This task builds upon the task on identification of motivational behaviour in WP2. The task will involve 2-4 controlled experiments with users 'in the wild' where we expose participants with alternative conditions for the system to assess causal effects of the system's motivational behaviour on user activity and experience.

Dissemination among prospective user communities: To maximize the potential of the platform, the project partners will spread the word about the system, also outside of scientific circles. Sense and Almende are well-connected in the communities for open data and "self-quantification", which touch on the subject matter of the project. We will demonstrate the application at international conferences such as the International Open Data Day, or the annual Quantified Self conference.

13. Deliverables

Journal papers: 11

Conference contributions: 14

Software/Products:
Year 1 (Q1-Q4):

- R1.1: Method for assessment of mental states (e.g., mood/emotion state, exertion, attentional focus) through the smartphone (Q3)
- R1.5: Low level sensing implementation (Q4)
- R2.1: Report on health profiles of the target communities and subgroup profiles on health, lifestyle, (enabling) assets, expectations on abilities and performance of the app (Q4)
- R2.2: Report with specifications of demands and requirements for app (Q4)
- R2.3: Report on User studies identifying main interaction paradigm (Q4)
- R3.1: First implementation of the sensing framework (Q-4)
- R3.2: Design of awareness modeling across dimensions (Q-4)
- R3.3: Initial software release of the sensing framework (Q-6)
- R4.1: An approach for distributed large scale real-time processing of sensor data (Q-4)
- R5.1: Survey and selection of basic long-term pattern analytics methods, techniques, algorithms and open source components for adapting coaching application through personal mood estimation, contextual personalized recommendation and social network learning (Q4)
- R7.1: Requirements for Version 1 of Application (Q1)
- R7.2: Recommendation for device, technologies (client and server side) for the application and standardization of tools and technologies to be used by all partners for implementation (Q1)
- R7.3: Requirements for Version 2 of Application (Q1)
- R7.4: Interface specification and Integration plan defined and signed-off with all stakeholders (based on planned deliverables from all partners) (Q2)
- R7.5: End to end system architecture for Application (common effort for Version 1 and 2) (Q2)
- R7.6: UI prototype for smart phone application (version 1) (Q3)
- R7.7: Initial working prototype for version 1 with stubbed research components and platforms (mobile and cloud) (Q4)
- R7.8: Integrated application – version 1 (ready for controlled trial) (Q6* - depends on readiness of research components)
- R7.12: First Proof of Concept of the Intelligent Speech framework (Q4)
- R8.1: Constitution of ‘End User Advisory Board’ (Q2)
- R8.2: Dummy prototype with basic UI interface (Q4)

Year 2 (Q5-Q8):

- R1.2: Validated algorithms for assessing the quantity of exercise (Q8)
- R1.4: Validated algorithms for mental and emotion-related state assessment (Q8)
- R2.4: Report on User studies identifying effective motivational agent behaviours (Q8)
- R3.3: Context-based cloud offloading mechanism (Q-8)
- R3.4: Sensing strategy (Q-8)
- R4.2: Environment for deploying algorithms within the processing framework (Q-8)

- R5.2: Library and tests of basic personal mood estimators, contextual personalized recommender system and social network learner for application adaptation (Q6)
- R6.1: Survey of searchable encryption techniques, algorithms and proposing privacy preserved data access in theory considering the diversity of coaching sensor data in distributed environment (Q6)
- R6.2: Prototype of basic privacy preserving search tool (partial) that allows different participating entities to search on encrypted, while preserving the users' privacy (Q8)
- R7.13: Design of interaction engine and its implementation (Q8)
- R8.3: Working prototype as basis for long term user studies (Q8)

Year 3 (Q9-Q12):
- R1.3: Validated algorithms for assessing the quality of walking and running (Q12)
- R2.5: Guidelines for feedback on amount of exercise (Q10)
- R3.5: Distributed sensing framework to effectively support social (group) applications (Q-12)
- R4.3: Dynamic topologies for analysis processes (Q-10)
- R5.3: Advanced social media-based personal mood estimator, contextual personalized recommender system and social network learner for application adaptation in theory and practice (Q12)
- R6.3: Prototypes and evaluation of advanced privacy preserving tool (complete) that allows different participating entities to search on encrypted, while preserving the users' privacy (Q12)
- R7.9: Review and revision (if required) of additional requirements for version 2 (Q9)
- R7.10: Enhancements in UI for smartphone and cloud applications for version 2 (Q11)
- R7.14: First prototype of wellness platform intelligent speech interface (Q12)

Year 4 (Q13-Q16):
- R2.6: Guidelines for feedback to improve the quality of walking and running (Q14)
- R4.4: On the fly changing of processing topology during runtime (Q-16)
- R5.4: Prototypes and tests of advanced social media-based personal mood estimator, contextual personalized recommendation system and social network learner trained on large-scale data sets (Q14)
- R6.4: Privacy preserving fine grained access which will allow the participating entities to search on and have access to the encrypted data based on their roles for application adaptation in theory (Q15)
- R6.5: 4 conference/journal papers and presentations (Q16)
- R7.11: Integrated application – version 2 (ready for pilot) (Q14* - depends on readiness of research components)
- R8.1: User studies on compliance, consumer satisfaction, perceived app performance and post experiment evaluation (Q16)
- R8.4: Report on user studies identifying the extent to which specific system behaviours cause user behavioural change (Q16)
- R8.4: Fully operational golden demo (Q16)

14. Budget

Work Package no. →	Knowledge	[non]Profit	% matching (0 or 45 only)	1	2	3	4	5	6	7	8	Research material	TOTAL BUDGET	SUM Subsidy	SUM Matching
Partner name ↓				Costs	Costs	Costs	Costs	Costs	Costs	Costs	Costs	Costs	Costs	Costs	Costs
UT-HMI	1		45%		260.0						265.0	18.3	543.33	244.5	298.8
VU-HPDC	1		45%			469.8	67.1				0.0	6.3	543.202	244.4	298.8
VU-FHMS	1		45%	343.3	175.0						0.0	27.0	545	245.4	299.93
Sense Observation Systems		1	45%	52.8		52.8	369.6				44.0	23.3	542.53	244.1	298.4
HvA	1		45%	69.5	57.0			57.0			196.0	23.3	402.808	181.3	221.5
Almende B.V.		1	45%					330.0	15.0		15.0	7.3	367.33	165.3	202.03
Infosys		1	45%					363.0	363.0	363.0	22.0	0.0	1111	499.95	611.05
													0	0	0
													0	0	0
SUM				465.608	492	522.563	436.709	750	378	363	542	105.65	4055.53	1825	2230.5
SUM Knowledge				412.808	492	469.763	67.109	57	0	0	461	74.99	2034.67	915.6	1119.1
SUM [non]Profit				52.8	0	52.8	369.6	693	378	363	81	30.66	2020.86	909.39	1111.5
[non]Profit/total				11.3%	0.0%	10.1%	84.6%	92.4%	100.0%	100.0%	14.9%	29.0%	49.8%	49.8%	49.8%

Person months

Work Package no. →	Knowledge	[non]Profit	1	2	3	4	5	6	7	8	TOTAL Person Months
Partner name ↓			PM's	PM's	PM's	PM's	PM's	PM's	PM's	PM's	PM's
UT-HMI	1	0		24						26.5	50.5
VU-HPDC	1	0			42	6					48
VU-FHMS	1	0	62	15.5							77.5
Sense Observation Systems	0	1	6		6	42				5	59
HvA	1	0	6	6			6			18	36
Almende B.V.	0	1					33	1.5		1.5	36
Infosys	0	1					36	36	36	2	110
0	0	0									0
0	0	0									0
0	0	0									0
0	0	0									0
SUM			74	45.5	48	48	75	37.5	36	53	417
SUM Knowledge			68	45.5	42	6	6	0	0	44.5	212
SUM [non]Profit			6	0	6	42	69	37.5	36	8.5	205
[non]Profit/total			8.1%	0.0%	12.5%	87.5%	92.0%	100.0%	100.0%	16.0%	49.2%