Multi-Dimensional Context-Aware Adaptation of Service Front-Ends

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Deliverable D.1.3.3 SERENOA Outlook

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Executive Summary

The purpose of this deliverable is to indicate the priorities in research and development of the technological areas considered by the project in the near future.

In particular, after recalling the main results achieved in the project, we have considered the main relevant technological trends and then we have focused on particularly interesting evolutions in the area of service front ends: end user development for context-dependent applications, social and context-aware service support, and adaptive support for the elderly people.

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1 Introduction

1.1 Objectives

This deliverable presents an outlook of some interesting and promising research areas that can build new important contributions exploiting the results of the SERENOA project. The objective of this deliverable is to be used as a valuable information source for the service front-ends designers and developers community.

1.2 Audience

An important audience is represented by the project participants, the project reviewers and the officer, since this deliverable represents a good opportunity to discuss future work in the areas considered by the project. This document has a public dissemination level, so it is open to public consultation by the general public, thus it can provide useful information to any developer/scientist interested in the topics addressed by the SERENOA project.

1.3 Related documents

The most relevant documents which are related to this deliverable are:

- D3.3.2 AAL-DL: Semantics, Syntaxes and Stylistics (R2), which describes the updated language for specifying adaptation rules.
- D4.1.2 Runtime UI Generation Engine (R2), which describes the set of Runtime UI generators developed in the project
- D4.4.2 Context of Use Runtime Infrastructure (R2), which describes the context manager infrastructure that provides important information to obtain context-dependent applications.D5.1.2 SERENOA Framework (R2), which summarises the various results achieved in the project and how they are integrated.

1.4 Organization of this document

This deliverable is organised in the following way: Section 2 provides a brief overview about the main results of the SERENOA project. Section 3 describes the main technological trends. Sections 4-7 describe our analysis on some important areas such as end user development of context-dependent applications, social support, context-aware services, and adaptive support for the elderly. Lastly, Section 8 describes the conclusions of this deliverable.

2 SERENOA Results and Evolution

The SERENOA project has developed a first set of tools to support dynamic adaptation of service front-ends. The partners are committed to further improve them in order to achieve maximum impact. The software architecture of the SERENOA platform provides support for adaptation at various levels and in various domains.

The set of tools includes a multi-component Context Manager able to gather dynamic information regarding user, devices, environment and provides it to the other adaptation components. The Context Manager is able to interact with a device description repository for gathering information regarding the devices dynamically detected. The Context Manager has a client-server architecture. The Context Manager server receives the contextual information from the Context Delegates associated with each user/device, and which are able to supply the context data detected by the sensors connected to the devices. A Context Delegate can be implemented in different ways according to e.g. device capabilities. For instance, the Context Delegate for monitoring user position could be a lightweight stand-alone application that reads the GPS serial stream, extracts the terrestrial coordinates and forwards them to the Context Manager, while the Context Delegate for tracking user's Web activity can directly be included in the navigated Web page as JavaScript code. The Context Manager server uses an associated repository (Context Data) for e.g. storing and updating four types of context information: user (preferences, tasks, physical and emotional state, …), devices (interaction resources, connectivity, …), environment (light, noise, ..), and information concerning social relations (groups of users, privacy rules, …). All the data collected is gathered by the Context Manager server and stored in the Context Data repository. The Context Manager also provides an interface for performing typical operations on such repository.

In order to be able to express various types of adaptations, a specific language for adaptation has been developed [SPS12] within the SERENOA Project. It is structured in terms of events (related to something that happens in the application or the context of use), conditions (related to the current state or previous user interaction) and actions (indicating the effects that the adaptation should provide). The Adaptation module receives from the Context Manager information about updates of the status of contextual entities. Such updates will trigger the selection of suitable adaptation rules, which in turn will trigger the application of the needed (in the current context of use) adaptation actions. Such actions can be very simple (e.g. changing a background colour or font) or more complex (changing completely the user interface since a different interaction modality is more suitable for the current context of use). The Adaptation module will also consider the issue that information presentation may need to adapt to the same user even over time (as e.g. user abilities themselves can change/deteriorate over time). Finally, this module also addresses more specific user-related aspects by exploiting information contained in user models.

An adaptation engine is able to decide which rules to apply according to the events detected and the rule priorities. The changes triggered by the adaptation engine can imply modifications of the current user interface in terms of presentation, dynamic behaviour, and content. Such modifications can have various granularities: involve some attributes of the user interface (e.g. font attributes), change the type of interaction technique in order to achieve the same effect but in a more suitable manner, change the implementation of groups of elements or even change the entire user interface structure. The adaptation engine pushes one or more adaptation actions toward the interactive application components.

Such interactive components can support adaptation through the use of various techniques. In general, the adaptation depends on the current interaction style (form-based, direct manipulation, 3D, etc.). If a completed change of interaction style has to occur, for example because of battery low, then the corresponding adaptation is performed on the current state of the user interface, and an interface with a new interaction style is provided with the updated state.

3 General Research Trends

One important trend is that most interactive applications are written less and less by professional software developers, and more by people with expertise in other domains working towards goals supported by computation. Estimations from the U.S. Bureau of Labour and Statistics indicated that by 2012 in the United States there were fewer than 3 million professional programmers, but more than 55 million people using spread-sheets and databases at work, many writing formulas and queries to support their jobs [SSM05]. A July 2011 Gartner report indicates that citizen developers will build at least 25% of new business applications by 2014[1]. Computer programming, almost as much as computer use, is becoming a widespread, pervasive practice. In addition, according to Gartner Inc., context-aware technologies will affect $96 billion of annual consumer spending worldwide by 2015[2]. The technologies on Gartner's 2013 hype cycle for emerging technologies that make this possible include human augmentation, natural-language question answering, gamification, augmented reality, NFC[3], and gesture control. Many of these technologies have been ”emerging” for multiple years and are starting to become commonplace.

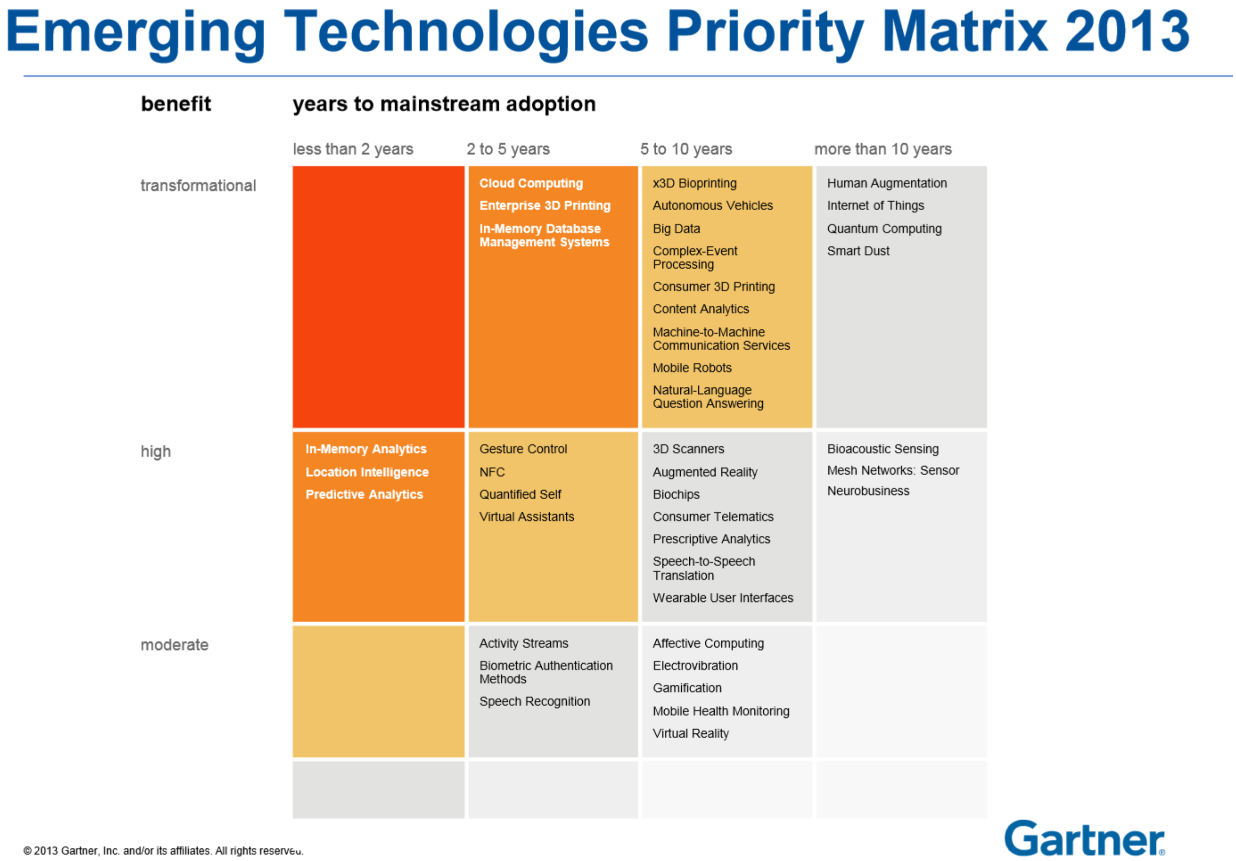

Figure 1: Gartner's Emerging Technologies Priority Matrix 2013[4]

The evolving relationship between humans and machines is the key theme of Gartner, Inc.'s "Hype Cycle for Emerging Technologies, 2013." Gartner has chosen to feature the relationship between humans and machines due to the increased hype around smart machines, cognitive computing and the Internet of Things. Analysts

[1] http://www.gartner.com/it/page.jsp?id=1744514
[2] http://www.gartner.com/it/page.jsp?id=1827614
[3] http://www.nfc-forum.org/home/
[4] http://public.brighttalk.com/resource/core/19507/august_21_hype_cycle_fenn_lehong_29685.pdf

believe that the relationship is being redefined through emerging technologies, narrowing the divide between humans and machines.

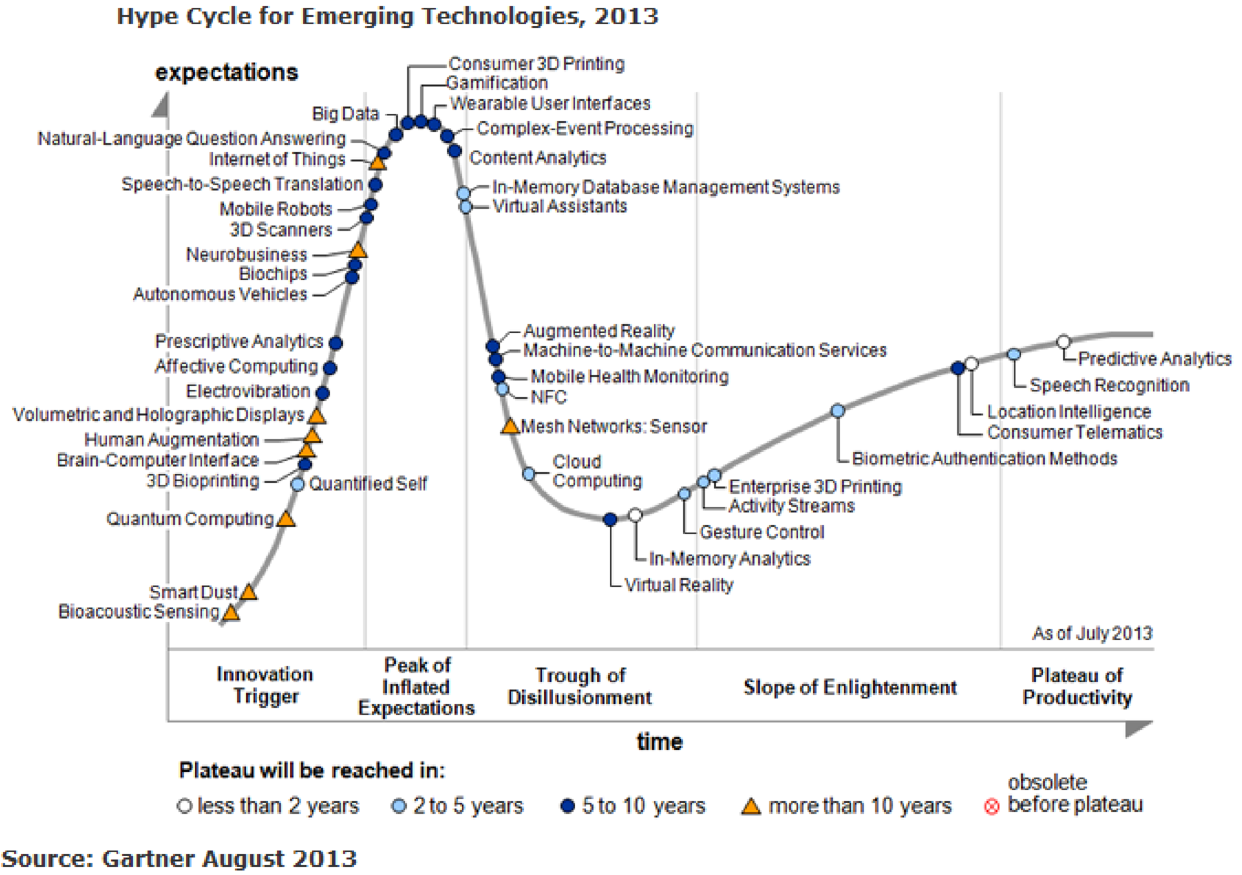

Figure 2: 2013 Gartner's Hype Cycle for Emerging Technologies

The 2013 Emerging Technologies Hype Cycle highlights technologies that support the following six areas.

3.1 Augmenting humans with technology

Technologies make it possible to augment human performance in physical, emotional and cognitive areas. The main benefit to enterprises in augmenting humans with technology is to create a more capable workforce. For example, consider if all employees had access to wearable technology that could answer any product or service question or pull up any enterprise data at will. The ability to improve productivity, sell better or serve customer better will increase significantly. Enterprises interested in these technologies should look to bioacoustic sensing, quantified self, 3D bioprinting, brain-computer interface, human augmentation, speech-to-speech translation, neurobusiness, wearable user interfaces, augmented reality and gesture control.

3.2 Machines replacing humans

There are clear opportunities for machines to replace humans: dangerous work, simpler yet expensive-to-perform tasks and repetitive tasks. The main benefit to having machines replace humans is improved productivity, less danger to humans and sometimes better quality work or responses. For example, a highly capable virtual customer service agent could field the many straightforward questions from customers and replace much of the customer service agents' "volume" work — with the most up-to-date information. Enterprises should look to some of these representative technologies for sources of innovation on how machines can take over human tasks: volumetric and holographic displays, autonomous vehicles, mobile robots and virtual assistants.

3.3 Humans and machines working alongside each other

Humans versus machines is not a binary decision, there are times when machines working alongside humans is a better choice. A new generation of robots is being built to work alongside humans. IBM's Watson does background research for doctors, just like a research assistant, to ensure they account for all the latest clinical, research and other information when making diagnoses or suggesting treatments. The main benefits of having machines working alongside humans are the ability to access the best of both worlds (that is, productivity and speed from machines, emotional intelligence and the ability to handle the unknown from humans). Technologies that represent and support this trend include autonomous vehicles, mobile robots, natural language question and answering, and virtual assistants.

The three trends that will change the workforce and the everyday lives of humans in the future are enabled by a set of technologies that help both machine and humans better understand each other. The following three areas are a necessary foundation for the synergistic relationships to evolve between humans and machines:

3.4 Machines better understanding humans and the environment

Machines and systems can only benefit from a better understanding of human context, humans and human emotion. This understanding leads to simple context-aware interactions, such as displaying an operational report for the location closest to the user; to better understanding customers, such as gauging consumer sentiment for a new product line by analyzing Facebook postings; to complex dialoguing with customers, such as virtual assistants using natural language question and answering to interact on customer inquiries. The technologies on this year's Hype Cycle that represent these capabilities include bioacoustic sensing, smart dust, quantified self, brain computer interface, affective computing, biochips, 3D scanners, natural-language question and answering (NLQA), content analytics, mobile health monitoring, gesture control, activity streams, biometric authentication methods, location intelligence and speech recognition.

3.5 Humans better understanding machines

As machines get smarter and start automating more human tasks, humans will need to trust the machines and feel safe. The technologies that make up the Internet of things will provide increased visibility into how machines are operating and the environmental situation they are operating in. For example, IBM's Watson provides "confidence" scores for the answers it provides to humans while Baxter shows a confused facial expression on its screen when it does not know what to do. MIT has also been working on Kismet, a robot that senses social cues from visual and auditory sensors, and responds with facial expressions that demonstrate understanding. These types of technology are very important in allowing humans and machines to work together.

3.6 Machines and humans becoming smarter

The surge in big data, analytics and cognitive computing approaches will provide decision support and automation to humans, and awareness and intelligence to machines. These technologies can be used to make both humans and things smarter. NLQA technology can improve a virtual customer service representative. NLQA can also be used by doctors to research huge amounts of medical journals and clinical tests to help diagnose an ailment or choose a suitable treatment plan. These supporting technologies are foundational for both humans and machines as we move forward to a digital future and enterprises should consider quantum computing, prescriptive analytics, neurobusiness, NLQA, big data, complex event processing, in-memory database management system (DBMS), cloud computing, in-memory analytics and predictive analytics.

4 End User Development for Context-Aware Applications

In recent years, we have witnessed how the success of mobile technologies has made it possible for people to use computers in an increasing number of possible contexts (e.g., location, user roles, user's preferences). In fact, mobile applications are beginning to take into account such context information in run-time (e.g., a smartphone that does not ring when the user is in a meeting). Moreover users, including non-professional software developers who are becoming more familiar with ICT technology, can use existing tools to create simple applications by themselves. Thus, one interesting trend is to further research end-user development of context-aware applications, delivering key conceptual and technical innovations to enable users who are not programmers but domain experts to flexibly design their context-dependent interactive applications.

4.1 End-User Development

Lieberman et al. [LPK06] defined *End-user development* (EUD) as "a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify or extend a software artefact." End-User Development (EUD) is a research field that focuses on enabling people who are not professional developers to design or customize their interactive applications. Since such people usually lack the training of professional software developers, it is simply not possible to use the traditional programming or authoring environments and methodologies for EUD. In addition, while topics related to EUD have already been investigated to some extent in recent years [KAB11], EUD of context-dependent applications has not yet been properly addressed. Further, there is a need to support EUD in multi-device environments.

There is also a need for authoring environments that incorporate social support to help those who lack professional development training. The rise of the World Wide Web has revolutionized how we access and make use of information by connecting to people and services across the globe. The untapped opportunity is to enable domain experts themselves to create applications that combine existing services, and expose new ones, and which build upon the Web of people for social support and crowdsourcing. A long standing example of domain expert development of interactive applications is the spread-sheet application. There is a need to develop and demonstrate techniques that mirror the simplicity of spread-sheets and avoid the need for end users to involve people with depth ICT developer skills. The benefit is faster development and better control over the application functionality and user experience.

4.2 Context-Aware Applications

Context can be defined as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." [ADB99]. In software development, context can be used to support execution and creation of novel applications. During runtime, context can enable the application to adapt to the current situation of the user. A context-aware application supports the user by providing her/him with the right service at the right moment. At creation time, context can enable the authoring tool to adjust itself to the technology, user, environment or social scenario, or suggest actions to support the user task. If the user context changes, the context-aware application should self-adapt or be adapted to the new context. The adaptation process should also be autonomous and try to support the user without too much interaction.

4.3 EUD Approaches

The number and variety of users of computational devices and tasks are increasing [SSM05]. User's background can be from management, engineering, construction, education, research, health, insurance, sales, administration or other areas. However, such users share a common requirement for software to support their common tasks which may rapidly vary. With a different range of backgrounds, their software needs are diverse, complex, and require frequent modifications.

On the other hand, slow software development cycles and lack of domain knowledge from software developers are limitations to address the requirements of each user. End-user development can help to mitigate this gap.

4.3.1 Desktop EUD

The main EUD approaches have considered only the desktop platform and applications not able to adapt to the changing context of use. For example, spread-sheets have been the most used EUD tools so far. Often EUD approaches support users in composing and customizing sets of available basic elements developed by programmers. Such basic elements are represented by and composed through intuitive metaphors, such as the jigsaw in which the basic elements correspond to the pieces to compose, or iconic data flow representations in which the icons correspond to the basic elements.

4.3.2 Mobile EUD

More recently, some EUD work has considered the user mobility but in limited manner. MIT App Inventor[5] is a EUD tool that allows users to create applications on the desktop to be executed on mobile devices, thus implying a rigid division between design time and run time. MIT App Inventor (see Figure 3) expresses the reasoning of building applications based on OpenBlocks[6], where programming is performed by combining jigsaw pieces. Domain specific tools have also been developed targeting context-sensitive applications ranging from support for a set of template applications for tourism [GPS09], domain-related content management to support guided tours [CM11], up to an EUD environment where the context is enriched through the addition of calendar events; and an EUD where the environment uses concepts such as: event-based rules or workflow rules [RRD11].More generally, desktop EUD environments lack the advantages of enabling end users to create applications opportunistically in mobile scenarios. Recent advances in smart phones have enabled the creation of mobile EUD environments. Contributions for mobile EUD address: easy parameter contextualization for mobile applications, as in Tasker[7]; frameworks to support mobile authoring and execution, as in Puzzle, a research prototype developed at CNR-ISTI [DP12]; creation of UIs through sketching or by adding interactive techniques in the touch screen [SPB11].

[5] http://appinventor.mit.edu
[6] http://education.mit.edu/openblocks
[7] http://tasker.dinglisch.net/

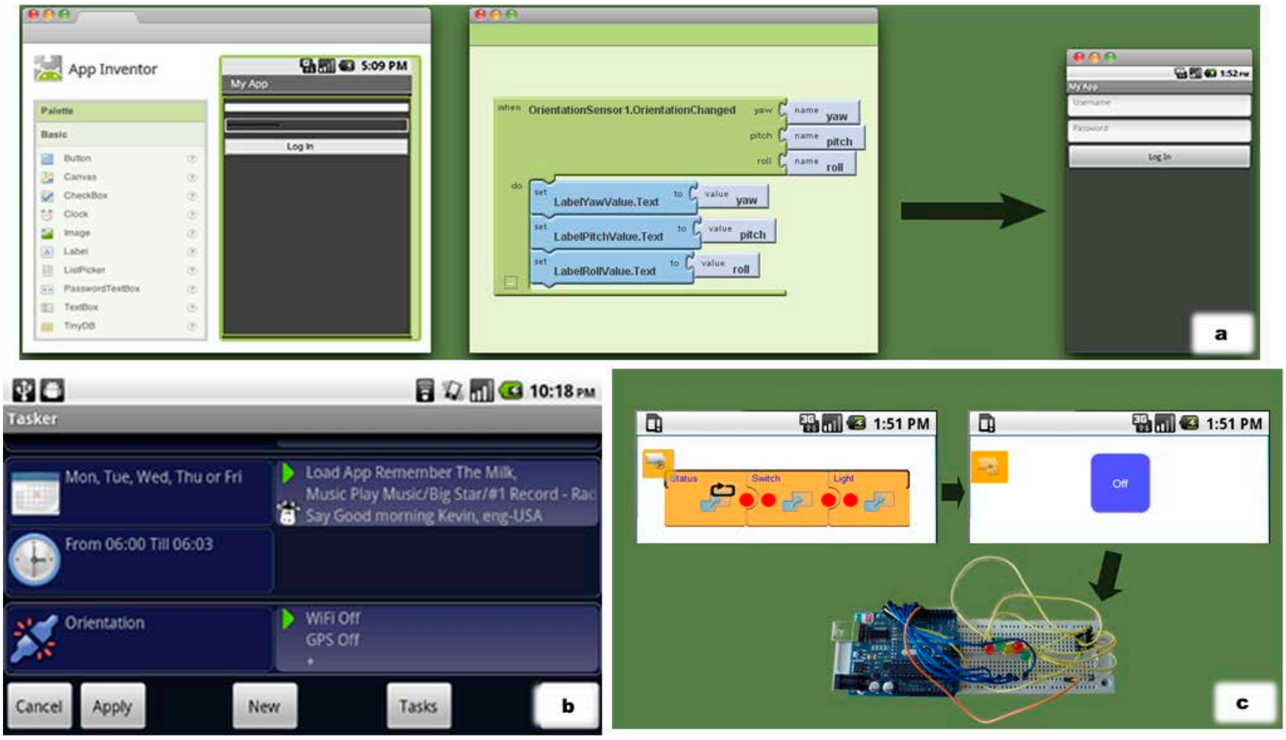

Figure 3: Examples of EUD Environments: AppInventor (top), Puzzle (bottom-right), Tasker (bottom-left).

4.3.3 Context-aware EUD

The evolution of EUD for mobile applications is particularly relevant for SERENOA, because users' mobility and the usage of smaller screens drive the need for context-awareness. However, the research in this field is currently at an early stage. Floch [F11] describes the initial design of a city guide that can be tailored by end users in order to include information from different service providers according to the visitor's position and visiting purpose. There is a need for platforms for general development of applications by end users, which will also offer the possibility to specify how the interactive application should behave according to the context of use.

Context-based EUD requires development processes and suitable underlying tools that are highly usable and easy to be learned. Thus, it is important to investigate novel metaphors, intelligent advisors, and multimodal user interfaces in order to achieve environments that allow users to easily express their concepts and intents. Then, such information should be easily mapped to available system services, with automated advisers to support domain experts in searching for components and for combining them. The purpose of the intelligent advisors tools is to make such development environments more effective, by exploiting some mechanisms able to monitor/capture end user behaviour and learn from it. The advisers would make use of machine interpretable information describing services and rule-based techniques for creating the glue to combine them in a given context. This would build upon earlier work on model based approaches that separate out different aspects of design.

In this area multimodality can play an important role through the combined use of natural language, gesture and/or graphical direct manipulation techniques in order to make expressing user intentions more intuitive. Indeed, the vocal interaction technology has recently improved substantially, as demonstrated by the SIRI iPhone assistant or Google Voice, and new standards[8] and libraries[9] are being developed that make its

[8] https://dvcs.w3.org/hg/speech-api/raw-file/tip/speechapi.html

exploitation easier and more reliable even in Web applications. We thus foresee allowing users to express what they want to achieve with their applications through a subset of natural language, combined with another mode of interaction in a way that is most suitable for given environmental conditions (e.g. noise, light).

4.3.4 Cooperative EUD

In addition, we see much potential in approaches that foster and support the cooperation among end user programmers since, by providing social mechanisms, we expect an improvement in cooperation and mutual help in their communities. There is a need to enhance EUD techniques with social support in multiplatform environments. Such social support will exploit social network federation tools to allow the end users to easily access multiple social networks (e.g. Facebook) during their development activities, and it will also provide means and techniques for sharing functionalities/data/examples so as to better support the cooperation of end-user programmers through social development environments. Since end users outnumber professional software developers by a high factor, EUD scales out software development activities by enabling a much larger pool of people to participate. This is possible because the number of domains to which context-based EUD support can be applied is very high.

[9] http://updates.html5rocks.com/2013/01/Voice-Driven-Web-Apps-Introduction-to-the-Web-Speech-API

5 Social and Context-aware Service Support

5.1 Social Support

By social support we refer to both social networking and crowdsourcing that we aim to integrate and enable as combined sources of human computation power. Based on platforms connecting millions of people online, such as Facebook, social networking support is now an important requirement of many applications ranging from the web, to mobile and digital TV applications revolutionizing and enriching the user experience in many ways. However, due to the proliferation of many different services and communities, there is an increased need for standardization with the goal of integrating available approaches. First industry initiatives, such as Facebook Platform or OpenSocial, aim to build on common features, such as Activity Streams, for information exchange and user awareness.

In research, motivational aspects and the design of incentives for groups of users to contribute towards a common goal have been the subjects of numerous research projects. Results suggest that the willingness to contribute can be increased, for example, by using principles of social psychology [B04] and exploiting social connectedness [B10]. Moreover, showing the value of contribution and letting participating users see their impact has been demonstrated to further motivate participation [R06].

Also crowdsourcing [H06] is currently an important topic in both research and industry where it has become a popular technique for activating user communities and allowing them to contribute with their experience and knowledge. Popular examples of crowdsourcing include Wikipedia, where millions of articles have been written through the collaboration of many volunteers distributed around the globe. While this kind of user-generated content is one result of employing a crowdsourcing model, other types can be found in Facebook and WordPress when looking at them as plain software artefacts. Many parts of both of these web-based platforms have been developed by volunteers and shared with users in the form of small applications, plugins or themes that can simply be installed into the running system in order to extend its features. The software engineering model presented in [KC09] refers to such examples as crowdsourced systems which provide a kernel application that other developers, or also end-users with sufficient programming experience, can complement and extend with new peripheral services and system functionality. Researchers have begun to look at the use of crowdsourcing, not only as a mean to support the adaptation of interfaces to different types of devices [NM11], but more generally as a tool to form an important part of the design and development process [NM12]. The primary challenges include appropriate task design for non-technical users to become involved in the engineering processes as well as methods and techniques to merge and combine results and improve the overall quality of crowd contributions.

In the HCI community, much of the work has been directed towards crowd-powered systems that aim to embed crowds directly into systems to enable rich functions and new human-computer interactions that neither computers nor humans could do alone. Much of the work in this new direction evolved from the early concept of the ESP game designed by [AD04]. While playing the game in pairs, the system implicitly gathers high-quality image labels based on their suggestions and agreement. Using this approach, should the game be deployed on popular gaming sites, it was estimated in 2004 that the majority of images on the web could be labelled in about a month’s time.

Moreover, much attention has been devoted to paid micro-task crowdsourcing markets such as Amazon Mechanical Turk. First studies have assessed it as a general platform for conducting online user studies [KCS08], some of which replicated previous lab studies and obtained similar results [HB10]. Other works have focused on financial incentives and varying compensation levels [MW09] as well as different task designs, e.g. comparing iterative vs. parallel processing steps [LCG10]. The findings so far suggest that higher pay rates may reduce response time, but not necessarily increase the quality of results. Experiments have also shown that iterative tasks can be very effective at improving the average quality of results, but parallel processes lead to a greater variety of responses.

Finally, there has also been an effort to design programming environments and languages on top of the Mechanical Turk platform. TurKit [LCGM10] is a prominent example that enabled several of the aforementioned crowd-powered systems.

5.2 Context-Aware Service Support

People naturally act according to the context they are in (an example is provided in [MPSS06]). Similarly, current devices can also detect and react on contextual data, because they have multiple sensors and processing performance to analyse the context. Such behaviour is called context-aware and a key to make user's tasks faster and more efficient in everyday life. Indeed, context can be used during creation or execution of an application to ease and make the process more efficient. Tang el al. [TGD08] proposes a context model and a context-aware workflow management algorithm for ubiquitous campus navigation modelled through Petri nets. IVO [RRD11] introduces an event-driven workflow framework to support composition of context-aware applications.

Context-aware tools such as Tasker[10] are being developed, where the user is able to define a set of contextual rules in the phone and trigger actions based on them. More recently, Microsoft launched a project on{X}[11] where users can explore native features of the phone through a JavaScript API to develop context-aware applications.

In service-based applications, there are three main levels at which service composition occurs [PSS11] (all levels are able to invoke services in specific orders through mechanisms that depend on the level considered):

- At the service level, the services are directly composed. For instance, this is the situation when the output of a service becomes the input of another service, as happens when using BPEL[12].
- At the application level, the composition is carried out by the application. This means that, for instance, the application can take the output of a service, process it and then provide input to another service.
- At the user interface level, the input or the output of the services is obtained directly through the user interface without additional processing, as happens in some mash-up applications.

There is a need to address all such levels even when context-dependent applications should be developed.

During service discovery, context can also improve the discovery results including context information along with service functional descriptions [BRO04]. There are various reasons for using context in service discovery [BRO04, KRI09] which include: *request completion* (exploiting additional information apart from the user input), *input completion* (retrieving missing input from user's context), *output adaptation* (adapting the output produced based on the user's device capabilities), and *added-value functionality* (e.g. producing discovery results for the next user task). Thus, context leads to a more accurate, effective, and personalized service discovery process.

Many approaches have been proposed for context-aware web service discovery, which can be classified as ontology-based [XZN10, YS07, ABB09, BRO04] or syntactic [M11, SIM05, CCP10, CML05, BSS08, DEY01, MTH03, DVV03, BW03, HP04, MMY05, SMZ07, LC06, RLS11] approaches. As the majority of these approaches regards context as a set of independent attributes, the context part of both queries and advertisements is represented as a set of key-value pairs. As such, complex conditions over the context attributes are not supported. Apart from their lack of utilizing a formal context model, none of those approaches fully exploits context information in service discovery according to the above four main points-advantages. Moreover, such approaches consider context information in isolation during service discovery

[10] http://tasker.dinglisch.net/
[11] www.onx.ms
[12] http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.pdf

and do not consider the impact of context matching for other service aspects (e.g. behavioural, structural matching).

6 Elderly Support Domain

Nowadays, population ageing is a common phenomenon in various countries, which has important implications on the labour market, as the ratio between the number of inactive individuals and the ones still active in the workforce will continue to rise [E09]. This leads to the consideration that for the economy and public health older workers should be encouraged to participate in or continue doing occupational activities, as there are several advantages. Indeed, raising the retirement age would increase the labour supply, so producing increased revenues from work and tax, and lead to lower pension costs. At the same time, there would be greater equity and intangible benefits for older workers e.g. improved sense of purpose/usefulness, respect, autonomy and higher self-esteem. Moreover, providing each person with a job could give them a sense of worth and responsibility, which adds more value to how they see themselves, while they feel less excluded from society.

In order to address this trend, it is important to provide the elderly with novel, technological Web-based context-aware platforms offering social features (e.g. sharing knowledge, crowdsourcing services, etc.) aimed to support, motivate and persuade seniors to continue to be active in the workforce so promoting their lifelong workability.

The use of persuasive strategies for encouraging elderly people to adopt healthy lifestyle habits has been considered in some previous work. In [RRMN12] the authors report some guidelines to motivate elders to do (physical) exercise by following a user-centred approach so as to design appropriate persuasive technology prone to be adopted by elders. In particular, in that paper, the authors report on the design and evaluation of an ambient information system for mobile phones, which supports a number of strategies for persuasion: abstraction, historical information and reflection, triggers for exercising, and positive and playful reinforcement. While doing physical exercise by the elderly has already been considered in the past, we focus on a quite novel and to some extent more difficult/demanding goal, which is encouraging the elderly to stay active in the labour workforce, which implies a more demanding commitment from them. This can be achieved by providing effective motivational strategies to stimulate seniors' behaviour change, by using just-in-time, context-dependent information, and present at the appropriate time/place, intuitive, timely and persuasive interactive services/suggestions stimulating them to change -or maintain- their attitude towards continuing being active. This can also be obtained by using natural and adaptive multimodal User Interfaces (UIs) that well fit specific elderly's needs, abilities, skills and characteristics.

In addition, it is important to monitor elderly's physiological parameters through suitable sensor-based technologies to check elderly's health status so that e.g. any possible signal of declining health (from sensorial, motor, and cognitive viewpoints) is detected and adequately managed. The technological solution will provide support for monitoring elderly's everyday routines, tasks and (social) experiences in order to assess their current level of occupational/social activity/wellbeing, to understand whether unusual activity/deviation appeared in seniors' everyday routines and act appropriately. Modelling routine tasks for improving users quality of life has also been used for various purposes in other works addressing ubiquitous environments. For instance, in [SVP13] the authors have exploited models in which users' routine tasks are specified with the goal of automating (tedious) routine tasks, so improving users' quality of life by making users' lives more comfortable, efficient, and productive, and helping them to stop wasting time in performing tasks that they do not enjoy. In order to do this, they propose a context-aware model driven approach and a software architecture in which the task model and the context model are used at runtime, by means of being interpreted by an automation engine which executes the tasks required to automate the routines specified in the models. To achieve the automation of user tasks in the opportune context, a context monitor is continuously updating the context model according to context changes. When a context change is detected, the context monitor updates the context model according to the detected change, and informs the automation engine about this change. The engine checks if some behaviour routine has to be executed in the current context: if so, it executes the tasks required to automate the routines as specified in the models. Differently from this work, another possible approach is that the routine tasks are just meant as the "expected" tasks and therefore they are analysed (namely: compared with the logged user's tasks) in order to check whether they are correctly carried out by users or deviations are occurring in their execution.

The architecture of such platforms (see Figure 4) can be Web-based to allow the elderly to access and use anytime and anywhere the platform from various devices (PCs, tablets, smartphones, TVs, ...).

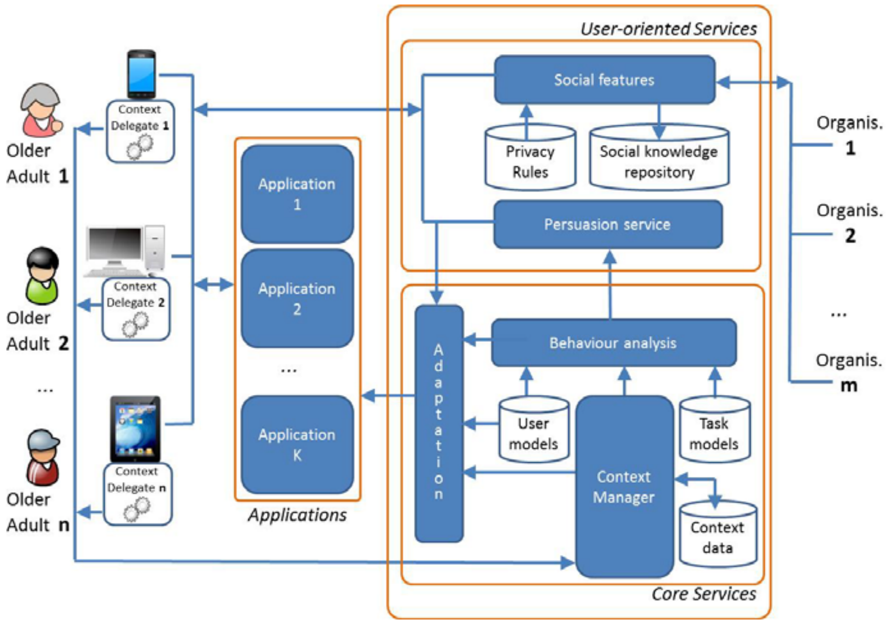

Figure 4: An Architectural Framework for Elderly Support.

The literature reports that electrophysiological body signals (e.g. galvanic skin response or skin conductivity, heart rate, facial electromyography, electroencephalography, blood pressure and respiration) are related to personal emotional state. Thus, they can be exploited to monitor the elderly's status so as to be able to develop algorithms for analysing/handling their emotional state.

Moreover, it is possible to perform an analysis of users' behaviour in order to detect whether abnormal deviations occur. The analysis can be carried out by comparing elderly routine/planned/expected user tasks, with the behaviour that they actually show. Routine tasks can be specified in task description repositories (e.g. CTT task models, which are specified in XML, a format which supports high flexibility/interoperability), while the actual behaviour of the elderly can be captured through various types of ubiquitous/body sensors. The analysis can be mainly carried out by comparing the expected actions (specified according to the hierarchical CTT task model) and the sequence of logged actions corresponding to the actual user behaviour, which are gathered in the current context and provided by the Context Manager. The outcome of such a comparison will be able to highlight a range of possibilities about where the main problem is, for instance performing actions in a wrong order, not performing at all an action, performing an action too many times, performing the action using incorrect resources, and so on. The various outcomes will then be classified in terms of importance/seriousness and adequate actions will be undertook accordingly by the platform (e.g. sending some messages to the user).

By comparing the usual elderly's routines with tasks they actually do, or more in general, by analysing their health status, it is possible to spot in advance early symptoms of a mild/progressive decline in their physical, mental/cognitive and social status. This, in the long term, could compromise their willingness/ability to remain active, then it is important to identify such deviations early so as to be able to act promptly.

A typical example of initial mental/cognitive decline can be represented by a non-adherence with medication, e.g. elderly start to mismanage their daily medicines (alter the doses, swap medicines), or they even forget to take them. If this occurs frequently it could be a sign of a mental decline. Another example considers the fact that older people often link the administration of such medication to specific lifestyle events, time and patterns of daily activities: involuntarily and frequently altering these patterns can be a symptom that the elderly is mildly/progressively experiencing a mental decline. Other deviations can occur when the elderly e.g. place objects in the wrong place, or when they are unable anymore to carry out common/essential daily activities autonomously, as they used to do before. Other changes could involve emotions: feelings of sadness over an extended period of time could indicate depression. However, it is worth pointing out that depression could also be connected with e.g. elderly not eating regularly anymore and/or staying in bed longer than usual.

In this area we can apply and extend results from SERENOA in order to obtain modules that support relevant context-aware techniques able to support runtime adaptation depending on the characteristics of e.g. users (characteristics, limitations, knowledge, skills, emotional state), available devices, surrounding environment.

It is also important to provide intuitive social/knowledge sharing mechanisms empowering seniors to e.g. share their experience/expertise with others, facilitate information transfer/communication, and get in contact with other people. This will have the benefit of e.g. helping the elderly in creating and maintaining social relationships and contacts, while limiting the risks of their social exclusion and isolation. In addition, the social/knowledge sharing features will support a process in which the elderly will be engaged in informal learning activities where people will be able to learn from life experiences of seniors, even in inter-generational interaction. Moreover, it is possible to exploit some Web-based crowdsourcing services supporting elderly in having an easier and more effective access to job/activity opportunities specifically targeted to them will be developed. Through this crowdsourcing services potential job providers (e.g. public/private organisations, industrial companies, etc.) can specify tasks and/or particular expertise/knowledge/skills they need. According to requested skills, users of the virtual elderly crowd will be able to respond, by offering their availability for filling that gap through their contribution/work. The crowdsourcing services can be built in such a way to support match-making between skills required and competences offered, as well as facilitate even non-technologically skilled senior people to access, be part and actively engage in the virtual elderly crowd. Another useful support can be given by persuasion services that support effective motivational strategies to stimulate seniors' behaviour change, by using just-in-time, context-dependent information, and present at the appropriate time/place simple and tailored triggering messages, to persuade elderly to have a target behaviour. Persuasive techniques will also be realised through positive reinforcement/rewarding strategies delivered to seniors when they perform the desired behaviour. They can be realised by using e.g. virtual points/scores or monetary incentives and/or by reminding users how good it is to them a certain behaviour and/or by providing them with suitable visualisation techniques for supporting self-awareness/monitoring of their current behaviour progress.

To summarise, there is a need of novel platforms able to support a variety of services for active elderly, e.g. sharing experiences and content across their communities, connecting job seekers that offer jobs for elderly, as well as persuading users to stay active through adequately adapted Web interfaces supporting anytime-anywhere access to the platform services.

7 Conclusions

In this deliverable we have discussed how the results of the SERENOA project can be exploited in the future and the relevant technological trends.

After reviewing the main technological trends, we have identified various possibilities to exploit and extend the SERENOA results in a set of representative areas, such as end user development of context-dependent applications, social and context-aware service support tools, and adaptive environments for the elderly.

These are areas that can benefit from the SERENOA results and build new important results. Thus, they deserve more attention at European level in order to provide support for integrated initiatives among the various actors (large companies, SMEs, research Institutes, and universities).

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