MOBILE CLOUD COMPUTING ARCHITECTURE FOR UBIQUITOUS EMPOWERING OF PEOPLE WITH DISABILITIES

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Abstract: Information and Communication Technologies are more and more present in the modern society. The penetration of personal devices in worldwide citizens is daily increasing. In addition, the accessibility of those devices is being more and more improved in order to profit the technology advances to help people with disabilities in daily life. Nevertheless, the processing capabilities of those personal devices are not enough to cover the need of intelligence for holistic assistive technologies. This addressesinnovative approaches in which remote resources can be remotely accessed and consumed by mobile devices . In this paper, a cloud-based architecture is presented. The CORE infrastructure provides an intelligent and pervasive environment composed of remote services to assistive applications.

1 INTRODUCTION

For approximately 80 million of Europeans with a disability, there are major obstacles that put activities such as travelling out of reach. To break down the barriers that prevent persons with disabilities from participating in society on an equal basis it is needed the creation of smart and personalized inclusion, involving Information and Communication Technologies (ICT) tools.

Due to their penetration, mobile phones are more and more used as a tool for create innovative solutions within the area of assistive technologies. These devices have increased exponentially their capacity and process capability in few years. In this way, several large scale human-centric ubiquitous computing and smart space projects have been completed during the last years, like PERSONA (045459,), ASKIT (Consortium, 2008a) and OASIS (Consortium, 2008b). Furthermore, modern smart devices are not currently limited to mobile phone considering the strong and continuous convergence between mobility and computation: the last generation of relatively low-cost mobile devices (e.g. phones, tablets, PDAs) is provided with increased capabilities in terms of computation and data-storage as well as with a set of advanced sensors.

To profit the potential of those devices, the accessibility in mobile phones is an interesting problem to solve. This allows the creation of more and more intelligent applications that assists the citizen with disabilities in mobile scenarios. Design for All or Universal Design (Story et al., 1998) constitutes an approach for building modern applications that need to accommodate for heterogeneity in user characteristics, devices and contexts of use. However, one of the main difficulties encountered by developers is the general lack of indication on how to instantiate its principles. Universal Design does not necessarily solve all accessibility problems, it does incorporate a human factors (*user-centred approach*) to producing products, so that they can be used by as many individuals as possible regardless of age, abilities, skills, requirements, situations, and preferences. Therefore, a critical property of interactive artifacts becomes their capability for intelligent adaptation and personalization, their ability to communicate in a common open area.

Although the increasing of capabilities of personal devices, there is not enough in them for the current processing needs of last generation assistive technologies. This is because the high level of personalization and the high complexity of intelligent services that are claimed by people with disabilities. To solve this problem, it is needed to create processing environments that provide more intelligence to mobile personal use cases.

By a technological point of view, these environments have to be designed according to a high-flexible model that allows a fundamental dynamism respect to

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concrete applications/services as well as to different business models (Foster et al., 2008).

Virtual environments based on scalable service models appear at the moment as a high competitive solution that, under the assumption of always connected devices and relatively high bandwidth, could be the most realistic and effective approach in order to enable complex services on mobile devices.

In this paper, an architecture aimed to provide a mobile solution to the distribution of services needed by assistive technologies based on the Cloud Computing paradigm is presented.

The paper is structured in three main parts: first an overview at the most relevant aspects of assistive technologies, than a brief analysis of main advantages of cloud technologies and finally a "big picture" of the proposed infrastructure are proposed.

2 ASSISTIVE TECHNOLOGIES

ICTs are commonly used to empower impaired people in their daily life. In this way, the concept of assistive technologies is defined (S et al., 2009). Assistive technologies are solutions to provide disabled people with assistive, adaptive and rehabilitative devices. These framework promotes the independence by enabling people to perform common tasks that are not able to perform by themselves of had a great difficulty to accomplish them.

To achieve this, Assistive Technologies, must, first of all, be able to gather all the information available about the user that will be the projection of the user on the system. This is the concept of context (Preuveneers, 2010). In this framework, context can be defined as any information that can be used to explain the situation that is relevant to the interaction between the users and the application. In this approach, the key is to automatically determine whether observed behavioral cues share a common cause - for example, whether the mouth movements and audio signals complement to indicate an active known or unknown speaker (how, who, where) and whether his or her focus of attention is another person or a computer (what, why).

The Context data can be gathered not only from the user directly but also from the ambient. Existing localization techniques will be combined (fused) with information coming from the vision sensors in order to track a person inside an apartment or any other equipped enviroment. A person in the line of sight of a vision sensor is located with great precision: one knows in which room he/she is, even in which part of the room, given the angle of the camera. A Wireless Sensor Network localization algorithm can use this information as a starting point for tracking someone in places out of the sight of any vision sensor. When the subject enters the field of sight of a visual device again, the information is dispatched and used to correct an eventual error of the radio-based localization algorithm. This scheme will follow a mobile device-centred approach.

An assistive application must not only gather the information of the context but also be aware of them and react to specific situations. This is the mission of Context-Awareness systems (Preuveneers, 2010). Context-awareness is a very important aspect of the emerging pervasive and autonomic computing paradigm. The efficient management of contextual information requires detailed and thorough modeling along with specific processing and inference capabilities. Mobile nodes that know more about the user context are able to function efficiently and transparently adapt to the current user situation. Data fusion combines the information originating from different sources. It is one of the primary elements of modern tracking techniques. Its objective is to maximize the useful information and make it more reliable, obtain more efficient data and information representation, and detect higher-order relationships between different data types.

Interactive and affective behavior may involve and modulate all human communicative signals: facial expression, speech, vocal intonation, body posture and gestures, hand gesticulation, non-linguistic vocal outbursts, such as laughter and sighs, and physiological reactions, like heartbeat and clamminess. Sensing and analysis of all these modalities have improved significantly in the recent years. Vision-based technologies for facial features, head, hand and body tracking have advanced significantly with sequential state estimation approaches, as for example Kalman (Chui and Chen, 1987) and particle filtering, which reduced the sensitivity of the detection and tracking schemes to occlusion, clutter, and changes in illumination.

Recent advent of non-intrusive sensors and wearable computers, which promise less invasive physiological sensing, opened up possibilities for including tactile modality into automatic analyzers of human behavior. However, virtually all technologies for sensing and analysis of different human communicative modalities and for detection and tracking of human behavioral cues have been trained and tested using audio and/or video recordings of posed, controlled displays. Hence, these technologies, like the ones developed in FP6 AMI and CHIL projects (explained below), are, in principle, inapplicable for sensing, tracking, and analysis of human behavioural cues occurring in spontaneous displays (as opposed to posed displays) of human interactive and affective behavior. More specifically, it will be developed a mutually informed face detector, facial feature tracker, body parts tracker, head pose estimator, and body pose estimator, which can be used for processing subtle human behavior typical for real-world scenarios.

Mobile phones are a suitable entry point for assistive applications in mobile scenarios (EMB, 2010). Mobile devices can be connected to Personal Area Network (PAN) of the user as well as to the Local Area Network (LAN) of the ambient in order to gather the required data to fill the context. Nevertheless, the execution of complex data fusion and reasoning techniques are unaffordable by the limited processing capability of current mobile devices and must be performed in external servers.

3 CLOUD COMPUTING TECHNOLOGY

Cloud Computing (Miller, 2008) is a technological solution aimed to provide remote computational solutions (normally on demand) through computer networks.

Cloud technologies are more and more present in real systems to provide them a more efficient way to build scalable systems. Cloud resources can be dynamically changed. These resources are extremely dynamic by the hardware point of view. Available or assigned resources could be increased in order to make the system able to deal with great amounts of requests in certain moments and decreased on the opposite case.

This allows the systems to be more efficient and scalable as well as assuring potential benefits by power consumption point of view (green approach) (Baliga et al., 2011).

The economic impact of cloud approach to distributed systems is one of the key aspects for the effective realization of commercial infrastructures: resources can be consumed on demand (the user only pays for what he is really consuming) as well as according to a great number of business models (Chang et al., 2010).

Other advantage of cloud computing is its flexibility respect to the information storage model and, more in general, respect to the independence of applications from access devices. Cloud servers proposes an interesting and competitive cost model based on a scalable approach: they are maintained by IT experts and there are no need of IT personnel in enterprises to be constantly worried about constant server updates and other computing issues, reducing the cost of maintaining the system being, in this case, more sustainable and more protected to hacker attacks.

In addition, the cloud is always available on internet and people can access information wherever they are.

In our problem, assistive technologies can need a different bandwidth depending on the kind of services. At the same time, an assistive platform requires the efficient coordination and cooperation of contextual services: as the service provider is the basic stakeholder, the infrastructure is the technologic core in order to assure an adequate quality of experience.

4 MOBILE CLOUD ASSISTIVE ENVIRONMENTS

According with the need of Assistive Technologies in mobile environments, the data collected by the personal system must be processed to create intelligence in the context-aware system to allow the applications to react to the demands of users.

Figure 1 summarize the needs of mobile assistive environments. The mobile device is in charge of collect the data to populate the context as well as provide the UI to offer the adequate contents to the user. This is made through the Human Computer Interface(HCI). The HCI is also divided in two different modules; the *Input HCI* and the *Output HCI*:

The *Input HCI* is in charge of collect the basic data of the user context. This data represent the data directly captured from the user via the basic sensors installed on the mobile phone. The selection of those sensors depends specifically on the characteristics of the user. For example, speech recognition systems to implements voice commands are suitable for blind people but are not appropriate for people with speech disorders. Examples of these kind of sensors that can be found in existing mobile devices are: GPS, speech recognition systems, microphone, Camera, compass, etc.

The *Output HCI* is in charge to provide to user the assistive information needed depending on the current activity in which the user is involved. For example, when a blind user is asking for some information about timetables in an airport, the mobile phone can use a text-to-speech system or a braille AT to provide the required information in an individualized way. In this case, deaf people must use different systems to access that information.

To provide the proper information to the individual, a higher level intelligent processing is needed.

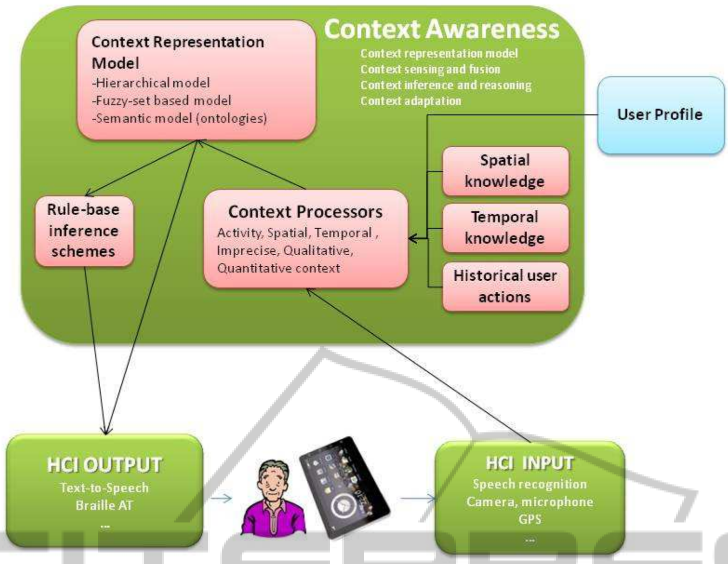

Figure 1: Context Awareness.

The basic data collected by the user is received by context processors that infers high level data. This high level data is dependent on the user profile and the specific status and situation in which the user is involved. In this way, the system should be able to sense, interpret and react to changes in the environment a user is situated in. For that reason, a context aware system has to deal with:

- Context Representation by adopting certain knowledge representation model rich in semantics,
- Context Sensing and Fusion by considering the heterogeneous sources and their reliability on capturing contextual data,
- Context Inference and Reasoning by adopting inference engines capable for extracting further knowledge (new context) from the sensed context, and,
- Context Adaptation by adopting certain mechanism able to adjust specific system parameter (e.g., presentation issues, learning rates) upon user feedback.

In this case, the context processors collect information from heterogeneous context sources, such as, the context-centred and user-centred sensors, user profile and historical user actions. The combination of such sensor data (e.g., noise, level, lightness) with spatial knowledge (e.g., location, proximity) and temporal knowledge (e.g., history of events, current time), leads to a detailed depiction of the environment, i.e., inferred context or current user situation. The situation of a user indicates additional knowledge derived from the environment of the user that are conveniently and semantically tagged according to the context representation model

In order to allow the systems to be proactive, some rule-based inference schemes can be processed as Event Condition Action rules. This allow to the system to react to specific events and conditions via starting adequate actions to support the user. For example, fall detection event can suppose the execution of an alarm action.

As it was mentioned previously, the mobile device is not able to process information. Then, it is necessary to distribute the execution. In Figure 2 it is shown the processing distribution. HCI adaptation is performed in the mobile phone. This is because the basic data and the interaction with the user must be near the user. Nevertheless, the context awareness system should be allocated in the cloud. This is because the context processors might need large amounts of process capabilities (i.e., image processing). The use of cloud computing paradigm give potentially unlimited processing power and storage to the system. In addition, private clouds could be used in smart spaces to provide specific smart applications depending on the specific space (i. e. hospitals, airports, etc.)

The global evaluation of the architecture should be approached according to a two side-perspective (service/technical perspective and business perspective). This analysis will be object of the following subsections.

4.1 A Technologic Perspective: Service Model

An deeper analysis of the CORE infrastructure allows

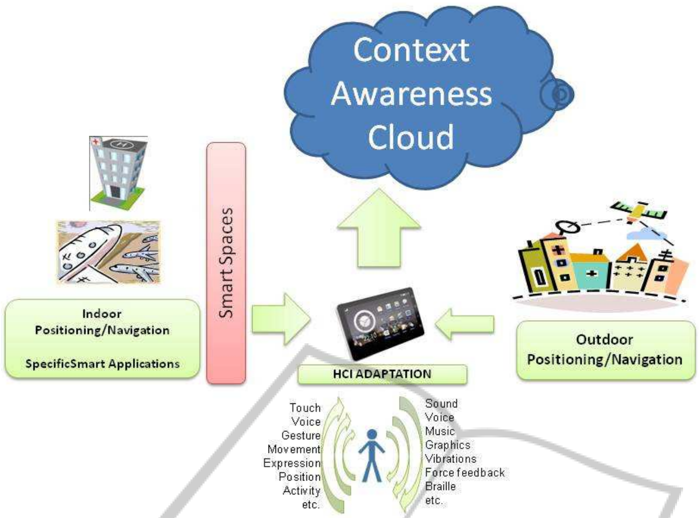

Figure 2: Context Awareness in Cloud.

to distinguish three different kind of services:

- Basic Service (third-part service): they are provided by service providers according to a pervasive approach. These services are not directly accessible by end-users but they are the "bricks" to build end-user services. Examples are the services provided by smart spaces or any kind of intelligent ambient.
- CORE Service: services provided by the platform in order to coordinate basic services and/or to provide any kind of contextual matching and/or optimization. In other words, they provide any kind of required elaboration (e.g. contextualization) on Basic Services that are so available as personalized services for the end-user.
- End-user Service: as in the common mean.

As implicitly mentioned, the Basic Services provide a strong support for the mobility: the remote execution of services enables complex services in smart devices (Kovachev et al., 2010). The current technologies, able to support the various cloud solutions (e.g. IaaS, Paas, SaaS), provide a strong and advanced technologic environment that reflect a full service-oriented view at distributed systems in which services are available as virtual resources in the platform. A further technologic point of interest is the "appliance" approach (Wikipedia, 2011) that can assure always updated applications as well as no explicit service configuration, no need of intrusive software, etc. The key issue for the success "in the real world" of this class of infrastructure is the enterprise approach to the service that allows realistic business models as explained in the following subsection.

4.2 A Business Perspective: Stakeholders and Business Models

One of the key aspects of the proposed architecture is its flexibility respect to the business model. First of all, the platform was designed under realistic assumptions for the great part of users: Always Connected/Always Best Connected devices, (relatively) high-capable network connection and last generation mobile devices. The platform evidently takes advantage by general benefits provided by the Cloud approach in terms of scalability, consumption, competivity, etc. Furthermore, the benefits introduced by cloud approach for mobile environments and the availability of optimized smart and intelligent environments assure a global, flexible and advanced technologic solution. The key business stakeholder is evidently the service provider: multiple realistic business scenarios and marketplaces for both governmental and private institutions are easy to be detected. Governments and, more in general, public institutions could find a competitive solution to assist disable people in the everyday life. Private institutions and enterprises could find new publicity channels for disable people as well as for their entourage (e.g. parents and friends). This last aspect has to be evaluated considering common ethic rules (as well as other aspects such us privacy need a clear policy). Most generally, the services classification in function of the level of confidence should be welcome.

5 CONCLUSIONS

The use of cloud-based solution can provide effective solutions to the problem of mobile assistive technologies in which public spaces (e.g. airports, metro stations, museums, hotels etc.) and the services they provide are fully accessible by impaired people. At the moment, there is a notable request of services able to support (above all) visually impaired persons or people with kinetic problems in order to enhance inclusion, mobility and autonomy. However it is easy to foresee a quick increasing of the availability of services supporting any class of disability as soon as effective platforms will be available in a commercial context.

These platforms, taking advance by a completely distributed and scalable approach, will allow the development of always more advanced smart applications that can provide disabled people with the same opportunities that the rest of citizens to perform their daily tasks in a context of economic sustainability.

REFERENCES

(2010). *Information and Assistance bubbles to help elderly people in public environments*.

045459, V. F. P. I. P. Persona project. perceptive spaces promoting independent aging.

Baliga, J., Ayre, R., Hinton, K., and Tucker, R. (2011). Green cloud computing: Balancing energy in processing, storage, and transport. *Proceedingd of IEEE*, 99:149–167.

Chang, V., Wills, G., and De Roure, D. (2010). A review of cloud business models and sustainability. In *Proceedings of the 2010 IEEE 3rd International Conference on Cloud Computing*, CLOUD '10, pages 43–50, Washington, DC, USA. IEEE Computer Society.

Chui, C. K. and Chen, G. (1987). *Kalman filtering with real-time applications*. Springer-Verlag New York, Inc., New York, NY, USA.

Consortium, A. (2003-2008a). Ask-it project: Ambient intelligence system of agents for knowledge-based and integrated services. http://www.ask-it.org/.

Consortium, O. (2003-2008b). Oasis project: Open architecture for accessible services integration and standardisation.

Foster, I., Zhao, Y., Raicu, I., and Lu, S. (2008). Cloud computing and grid computing 360-degree compared. *2008 Grid Computing Environments Workshop*, abs/0901.0(5):1–10.

Kovachev, D., Renzel, D., Klamma, R., and Cao, Y. (2010). Mobile community cloud computing: Emerges and evolves. In *Mobile Data Management'10*, pages 393–395.

Miller, M. (2008). *Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online*. Que Publishing Company, 1 edition.

Preuveneers, D. (2010). *Context-aware adaptation for Ambient Intelligence: Concepts, methods and applications*. LAP Lambert Academic Publishing, Germany.

S, K., M, M., H, W. K., M, P., and R, H. (2009). On health enabling and ambient-assistive technologies. what has been achieved and where do we have to go? *Methods Inf Med*, 48(1):29–37.

Story, M. F., Mueller, J. L., and Mace, R. L. (1998). *THE UNIVERSAL DESIGN FILE Designing for People of All Ages and Abilities*. The Center for Universal Design.

Wikipedia (2011). Wikipedia. software appliance http://en.wikipedia.org/wiki/software_appliance.