Cloud4all: Scope, Evolution and Challenges

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Abstract. There are currently important barriers that hinder the access to ICT, especially for the elderly and people with disability. This paper presents the approach adopted by the Cloud4all Consortium to create the technical core of the Global Public Inclusive Infrastructure (GPII). The GPII aims at producing a real impact on achieving global access to ICT. Already in the second half of the project, the current status of developments and main outcomes are presented together with the key components of the architecture. Cloud4all is compared to other approaches to the same problem, defining the scope of the project and unveiling the upcoming new challenges as a result of the research.

Keywords: Cloud4all, Auto-Personalisation from preferences, cloud, accessibility, personalisation, GPII, context-awareness, matchmaking.

1 Introduction

Statistics show the positive correlation between the age and disability prevalence [1]. In 2010, 13% of the population in the United States were over 65, 17% in Europe and about 24% in Japan [2] [3] [4]. The population projection foresees an ageing process of the world population in the next few decades that will cause an increase of disability. Considering that access to ICT is no longer optional and barriers are more important among these population groups, access to ICT becomes a major challenge for a vast percentage of population.

The current situation hinders the access to basic social and economic rights and increases the risk of exclusion from education, health, employment and civic participation [5]. In Europe, the current eAccessibility deployment risks to digitally exclude as many as 110 million Europeans between persons with disabilities and older persons [6]. Additionally, the economic downturn is not reducing the two main barriers for assistive technology (AT) acquisition: cost and lack of information [7]. The problem of cost grows up when the target audience of a given AT is small and mainstream technologies are not available in the market.

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Although the ageing process is an opportunity for AT markets, some studies discussed in 1996 the overwhelming task of discovering which is the most suitable AT product for a user when over 1000 new AT products arrive [8]. Interestingly, that happened before the boom of apps for smartphones, the uprising of browser extensions and wearable computing. Now, the number of devices, markets and platforms is larger and the task of finding the most suitable AT more challenging. Even when users are able to find the appropriate assistive technology, they still need to install it, set it up and learn how to use it [9].

This situation suggests that a new approach could benefit both users and AT developers. Cloud4all is implementing the development of a global infrastructure that could be used from any device, anywhere, to launch and configure the ATs needed reducing the complexity and keeping privacy. This infrastructure will also help users learn about new solutions fitting their needs, hence reducing the gap between supply and demand in the AT market. Next section places Cloud4all inside GPII and other complementary projects. Section 3 explains the approach followed in the project and settles the scope whereas section 4 shows the components of the architecture. Then, in section 5, main outcomes so far are presented, and evaluation procedures and goals are depicted in section 6. Finally, section 7 discusses open issues and future work.

2 Cloud4all and GPII

Cloud4all[1] is a 4-year project from the 7th European Framework partially funded by the EC and led by Technosite, a Spanish company devoted to the accessibility growth. Cloud4all is the technical core of GPII[2], a broader initiative coordinated by Raising the Floor to create a Global Public Inclusive Infrastructure [10] to cope with some of the main problems to access ICT.

GPII stands on three pillar functions [11]:

- Discovery: Providing a way for people to discover useful solutions for them, select those that better fit their needs and store their preferences.
- Personalization: Making it really easy to set-up any device, anywhere.
- Market: Boosting the supply side for the sake of an active and efficient AT market by providing tools, training and help.

There are two FP7 projects contributing to the overall GPII effort and moving this vision towards reality: Cloud4all and Prosperity4all. Whereas Cloud4all is focused on providing simple, instant accessibility for all anywhere and at any device, Prosperity4all centres its efforts on better connecting supply and demand, and providing an affordable method for offering diversity needed.

[1] http://cloud4all.info
[2] http://wiki.gpii.net

3 Approach and Scope

Cloud4all steps towards a new way to face accessibility by tailoring any device, any platform, mainstream or minority market solutions, to the user needs and preferences. The goal is to produce an effective impact on access to ICT by moving:

- From individual, hand-operated adaptation of products and services to automatic, instant, simplified activation of any AT product or service.
- From user-group setup of devices, platforms and applications (DPA) to individual customisation, following a one-size-fits-one approach to accessibility and usability.
- From solution-specific activation of accessibility settings to a common easy triggering method, making accessibility easier.
- From isolated non-adaptive DPA configurations to context-aware, adaptive customisations.

Cloud4all researches on effective personalisation to enhance accessibility and leveraging from current solutions rather than creating a new AT. Cloud4all does not create user profiles or user models or defines users as members of categories [12]. The approach is to let users set their needs and preferences defined without aprioristic categorisations. Users will never be requested to name their disabilities but to state how they want to interact with ICT in general terms. Instead of asking users to identify with a cluster of other users labelled as 'low vision', users will only have to state that they prefer bigger font size and higher contrast.

Cloud4all will adapt the accessibility features of different devices, platforms and applications depending on the needs and preferences expressed by the userHowever, this approach is quite different from other research projects on UI personalisation from needs and preferences [13] [14] [15], that usually rely on a component in charge of generating and adapting interfaces. SUPPLE project defines cost functions to estimate the optimum UIs. First, a feature vector that parameterizes UIs is defined and then optimized considering device features or personal preferences. The INREDIS project created a model of the target device and then represented it according to user needs in a user device (typically PC or smartphone). Although it was inspired by previous works on the Universal Remote Console [16], INREDIS finally implemented an architecture based on an Enterprise Service Bus that iteratively applied XSLT transformations to generate XHTML user interfaces. APSIS4all [17] provides the most similar approach to Cloud4all. A wizard for configuring needs and preferences[3] is alreadyrunning and public digital terminals like ATMs and ticket vending machines (TVMs) use its own interface generators to match user needs. APSIS4all has managed to deploy about 1000 ATMs with this technology in Spain and 24 TVMs in Paderborn. However, the approach followed in this project is focused just on self-service machines using

[3] https://cajerofacil.apsis4all.eu/

ad-hoc interface generators. Thus, it can be considered a market deployment of Cloud4all ideas with a technology with the added value both projects are working together to make their technologies compatible. Cloud4all plans to take this concept of personalization from one specific device to any interactive device the user might encounter. Besides, Cloud4all relies on a loosely coupled architecture where components can be running either locally or in the cloud. The architecture launches and manages the settings of available ATs (built-in, installed or cloud-hosted) to configure any DPA according to the user preferences. Instead of being a user interface generator, Cloud4all benefits from the existing solutions and configures them to provide comparable user experiences in any DPA. In brief, Cloud4all is activating adaptions through already existing dedicated software and not creating a new UI generator.

One of the most relevant contributions of Cloud4all are the first steps in developing context-aware systems. Previous work by [18] [19] proposed a commonly used definition and an early use case while [20] [21] categorize content for more complex use cases but still not considering some basic user characteristics like language. The treatment of context in Cloud4all started with environmental variables that may affect the user-device interaction. Some frontiers [22] are defined at thresholds where the interaction mode needs to be switched. For instance, when an excess of light prevents the user from reading a screen, in some cases, the context-aware system may decide to add a screen reader to the interaction. Besides providing the auto-personalization from preferences, Cloud4all will support the personalization of the accessibility features of specific devices or applications depending on the environment where the application is taking place. Similarly, SERENOA project [23] mixes context-awareness with UI generation putting the focus on web applications and UI generation whereas Cloud4all focuses on configuration of available ATs. Both efforts are complementary and improve universal personalisation and accessibility.

4 Components

Cloud4all is developing the technical infrastructure to enable Auto-Personalisation from Preferences (APfP) of any device or platform. In order to gather these preferences, an online tool has been developed. When a user interacts with a device, the preferences are used later to calculate the most suitable ATs and their settings for a user, in a given device, under specific environmental conditions. Finding out the correct settings implies a mechanism for estimating the best possible configuration given other similar configurations for other users or for the user itself in other devices under specific conditions. The matching mechanism is run by the Matchmaker (see Figure 1).

The architecture has evolved from the original designs [24]to include context-awareness. The main components of the Cloud4all architecture are represented in Figure 1 and explained below (see [25] for further details):

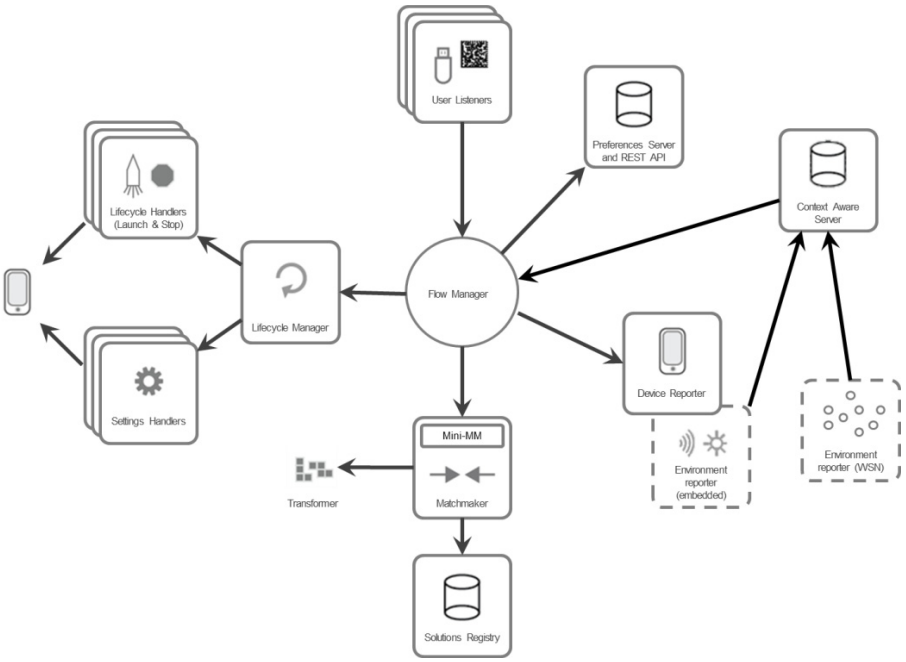

Fig. 1. Cloud4all architecture (Source: Cloud4all [26])

- The Flow Manager is an event-driven asynchronous orchestrator of the whole architecture in charge of managing the workflow of the personalisation process.
- The Matchmakers are in charge of calculating the optimum setting values under certain constraints. There are two implementations: the Rule-Based Matchmaker that relies on an ontology and expert reasoning mechanism, and the Statistical Matchmaker that makes statistical inferences for setting values.
- The Preference server stores and delivers user preferences.
- The Context-aware server centralizes information from sensors about environmental conditions to be used by the Matchmakers.
- User Listener: this component is responsible for reading the user token and starting the process personalization.
- The Lifecycle manager and Settings handlers launch and stop applications with the appropriate configuration and apply changes on-the-fly.
- The Solution registry stores a list of applications, access features and assistive technologies, and replies to queries about the solutions available for a user in a platform.

Other relevant components are:

- Preference editors: 1) a full editor called Preference Management Tool that let users define the value of all possible interaction preferences, and 2) the Personal Control Panel that is a light preference adjuster with an almost always visible GUI

for the user to do minor changes in frequently used settings. Both editors share a common code base that makes them more flexible, sustainable and easier to maintain.
- Semantic infrastructure: A group of ontologies and applications to provide a semantic semi-automatic characterization and reasoning mechanisms over applications and services.

5 Outcomes

After two years of Cloud4all project, a user could now be able to switch from one device to another (PC, smartphone, slate, feature phone) varying the operating systems (Linux, Windows, Android) and having an accessible and comparable experience. Some of the key results achieved so far are:

- Advanced and mature preference editors[4]
- A distributed, local and cloud-based, loosely coupled architecture that supports the components in Figure 1.
- A context infrastructure to provide real time context awareness to Cloud4all. The variables considered at this stage are two environmental variables: sound and light.
- The Common terms registry[5] keeps growing. This registry is a compilation of semantically equivalent terms in different solutions that helps Cloud4all estimate equivalent values for semantically aligned settings across solutions.
- Extensions for Chrome and Firefox. These cross platform web browsers have a combined market share above 50%[6] and represent an efficient way to reach platforms still not compatible with Cloud4all.
- Up to 12 solutions are now compatible with Cloud4all including the aforementioned OS and web browser extensions but also comprising ATs for PCs and smart phones, and feature phones.
- The semantic infrastructure in place let developers register and describe their solutions, and even set relations among the variable settings in their solutions and the existing common terms.

6 Evaluation

The Cloud4all evaluation plan aims to study all factors affecting the user experience and acceptance of the Cloud4all solutions, as well as to provide iterative feedback for developers. The developments carried out can be divided into those with a user interface and those without.

Three iterations are planned. The first iteration has finished successfully, achieving the goal of getting early feedback about the first developments and Lo-Fi prototypes.

[4] http://wiki.gpii.net/index.php/User_Preferences_UX
[5] http://wiki.gpii.net/index.php/Common_Terms_Registry
[6] https://blog.shareaholic.com/browser-share-report-10-2013/

The second will take place at Q2-2014. During this iteration, Me-Fi prototypes of the preference editors and the fully integrated APfP architecture deployed with basic functionality will be tested with prospective end users. The last iteration will test the final versions (under the scope of Cloud4all) of the architecture and tools developed.

The first iteration of Cloud4all tests involved 90 users, 30 developers, 15 stakeholders in 3 countries (Spain, Germany and Greece). Three main aspects were evaluated:

- Cloud4all concept: An explanation, a video and some demos helped user understand the Cloud4all concept in practice and imagine its future use and how useful (or not) it could be for them and other people.
- Auto-Personalization scenario: Two PCs, one with Windows and one Linux, with similar accessibility solutions, were used to evaluate the user experience of the APfP process. Users were requested to define and adjust their settings in order to perform a common task in one of the platforms, and then move to the other platform and do a similar task. The new platform had the configuration calculated by the architecture. These tests were also used to study comparatively the results and accuracy of the two matchmakers.
- The Preference Management Tool and the Semantic Alignment Tool were the two tools available designed within the Project with a GUI. Standard usability studies were performed with each tool's target users: final users for the PMT (usually people with disability) and developers for the SAT.

On average, users found Cloud4all very useful for their future daily lives, strengthening its ability to make some tasks easier and especially valuable for public devices. Developers and other stakeholders were even more enthusiastic about the Project as they rely on the possibility to open a new AT market. The Auto-Personalization scenario turned out to be pretty accurate although 1) the number of devices tested was very limited, and 2) operations on new devices are still a challenge. For instance, shortcuts are completely different for same type of solutions. The tools for managing preferences and align semantically applications are still a work in progress. Usability needs to be improved and new advanced features added.

7 Future Work

Year three of the Project envisions important challenges. First, Cloud4all will have to develop rock solid implementations (reliable and scalable) of some components already developed: the Preference server, user-installable platform modules for Windows, Linux and Android, the Common Terms Registry and Unified Listing, and the Matchmakers. The Preference Management Tools and the Semantic Alignment Tool are still in a previous stage, as well as the extension and jetpack for Chrome and Firefox, respectively. These plugins for cross-platform web browsers are especially relevant as Cloud4all can service this way on still non-compatible platforms. Next year, about 20 applications are expected to be compatible, registered and working with Cloud4all in an ever growing effort to involve a broader community, especially AT

developers and mainstream technology providers. A package for developers[7] will be ready to help early adopters make their applications Cloud4all compatible. This will be the first step towards the creation of a more active and efficient AT market although major efforts in this direction are part of Prosperity4all project.

Further research need to be done in the semi-automatic generation of metadata as well as in Context-responsive components. Now, only light and sound variables are considered but the architecture is ready to be responsive to other environmental variables like individual conditions, activity or time. Another important challenge in context management is to decide if some decisions and which ones might avoid user control. Under some circumstances where context conditions prevent users to interact, the context-aware system could add or switch to other interaction mode.

New advanced features relating matchmaking and preference management are planned. Maybe the most important is the ability to suggest new ATs or configurations to a user based on the knowledge gathered about the user interaction.

Next year will also provide some answers to open questions about simultaneously shared devices like TVs. When people with different needs share a device, the optimum settings for each user may not be the optimum for the group. There are also a number of open issues on security. Users are provided with a token to get access to the Cloud4all service, but if the token is lost by the user there is no way to recover it easily without using some contact information. Email is of common use, but other personal details can be traced back from the email address. Additionally, when Cloud4all is used in devices like ATMs, not controlled by the user, settings are downloaded and applied by the device, and can be recorded together with the identification information. The overall problem is to manage privacy levels for different devices, platforms, applications or companies. Users should be able to manage these privacy aspects according to their own interest and preferences should be shared with these solutions up to some point.

Finally, one of the most interesting issues to be covered is the first interaction with a device. How users can know that Cloud4all is running in this device and what key-in methods are available are two problems not solved yet. The project is working in some images and sounds that can be associated to Cloud4all but it also has to do with the creation of a brand.

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