Towards a Friendly User Interface on the Cloud

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Abstract. The wide availability of high interconnection networks, powerful mobile devices and service-oriented architectures has paved the way for the delivery of cloud services. Moving information technology services to the cloud has imposed new ways of interaction with users. Users desire friendly looking, highly interactive, dynamically visualized and naturally controlled user interfaces (UI) that allow smooth navigation in the cloud space. Transferring the rich user interface of the desktop, where running the software dynamically online and instantly following up with social networking activities is relatively easy, to the web-browser on mobile devices is introducing many challenges. This has resulted in the emergence of innovative cloud services and implementation approaches specifically to handle the new user interface demands. However, a standardized consistent user interface metaphor for cloud services is still lacking. This paper presents a comprehensive study on the cloud user interface requirements, special services, implementation trends, technologies and efforts for standardization.

Keywords: cloud computing, user interface, standardization, service.

1 Introduction

Cloud computing is a revolutionary technology that is gaining popularity among various fields ranging from small businesses to complex scientific computations. The term "Cloud Computing" reflects the ability to use on demand computational services at affordable prices through the Internet. Accessibility, comfort and ubiquity are considered the main features of cloud-based applications. Having the data and software allocated in the clouds, the users will no longer need to invest in any type of storage media, costly software, or networking infrastructures [1].

Acquiring IT services online requires bringing the highly interactive user interface of the desktop to the web-browser, while accessing these services ubiquitously requires dynamic visualization and natural interaction with the user interface. Thus, developing a suitable user interface for cloud services is considered an important

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ingredient in the success of the cloud technology [2]. This paper reviews the requirements cloud computing is imposing on user interfaces in general, and on some special cloud services, such as social networking, media streaming and visualization, in particular.

To tackle challenges of implementing such highly demanding user interfaces, IT industry have introduced innovative approaches and technologies that have the potential of realizing futuristic cloud visions, such as Internet of Things (IoT), where computing is completely embedded in the surrounding and interactions and all responses happen naturally [30].

Despite the great efforts in developing innovative user interfaces for cloud-based applications, these approaches remain very specific to certain fields. That is why a number of recommendations focused on the need for standardization to help create a more unified experience with cloud applications and services [20].

The rest of this paper is organized as follows: section 2 gives an overview on the general features required for cloud user interface. In section 3, some special cloud-based user interface services are described. Approaches and technologies to implement cloud user interfaces are presented in section 4 and section 5 respectively. Section 6 highlights the needs for standardized user interface features in the Cloud. Finally, section 7 summarizes the paper giving some concluding remarks.

2 Requirements for Cloud Interfaces

The paradigm shift in IT led by cloud computing is demanding new requirements for user interfaces and services. In this section, we overview the user interface requirements that should be stressed when interacting with the cloud.

2.1 Seamless Interactivity

Developing an interactive user interface is an important need in Cloud applications especially in critical situations that require fast decisions. In [3] an Interactive multi agent based user interface has been proposed offering the balance between the interests of the end user and the mobile network cloud on the other side. An interactive simple architecture mobile agent manager showed the ability to understand, analyze and organize the services being offered by the cloud to meet the customer explicit on-demand needs.

In [4] an interactive interface for a healthcare cloud service has been developed to investigate utilizing the power of the Cloud to increase the quality of the nursing process through an intelligent nursing information system (INIS). The need to an interactive interface that uses different colors and icons has been emphasized.

2.2 Natural Interaction

Ubiquity of cloud computing is necessitating convenient interface that can be used in any location or situation, even on the move. Therefore, cloud applications should

support natural user interfaces such as voice, postures and gestures [5]. For example, the system proposed in [6] described a Speech-Controlled Interface on vehicle surveillance. The system allows the driver to give oral orders while the whole voice recognition task is made in the background Cloud. Advanced cloud applications may also utilize more sophisticated interfaces such as the real-time video/voice as proposed in [7] and wearable brain computer-brain interface (BCI) to convert brain activity signals into usable commands [8].

2.3 Dynamic Visualizations

Three dimensional (3D) visualizations can be considered as an important feature of future cloud-based applications. In fact, the conventional two dimensional (2D) user interfaces is no longer appropriate to interact with the vast amounts of resources offered anytime/anywhere through the cloud ecosystem. Microsoft Research Aisa has introduced a new hardware; "The Cloud Mouse", that enables an innovative way for the users to interact with the cloud [9]. In this context, the data is displayed as 3D visualizations and user can point the mouse up and down, and move deeper into multiple screens with great precision. With 360 degrees of movement, the Cloud Mouse can be used to navigate across multiple screens making the user feels like he/she is right inside in the cloud space.

3 User Interface for Special Cloud Services

Cloud-based applications provide a wide spectrum of services to a diverse number of fields. In particular social networking, media streaming and visualization are common services among cloud users. Each of these services actually imposes a set of requirements on their user interface. The following subsections give examples on some proposed user interface models that were specially designed to serve these specific areas.

3.1 Social Networking

A user interaction model for a "social desktop" was proposed in [10]. It presented a model that addresses both access control and organization of users' documents and resources. A key feature is a lightweight, user-created grouping construct, which provides a convenient mechanism to express context among a set of related resources while also implicitly specifying access control. Groups are similar to file folders, but with a few important distinctions.

3.2 Interfaces for Media Streaming

In [11] a prototype for a user interface that is specially designed to fit streaming for musical media has been described. DropTheBeat creates a real world representation that is customizable, designable, collectable, loanable, shareable and, above all, can

be experienced on a physical level, allowing for a more natural way of consuming cloud computing content.

3.3 Interfaces for Visualization Services

Searching in the internet for specific resources can be a nightmare with the exploded amounts of available online data. In [12] it has been anticipated that a visualization service is really needed to enable the user to obtain rich visualization result for his search content. This actually requires a user interface through which the user can specify the content, look, and quality of the visualization through a visual-based searching method. The system utilizes the computation power of the cloud to enable the user to effectively search through a vast repository of visualizations and retrieve or create their own visualizations.

3.4 Implementation Approaches

While cloud computing has become a mainstream by offering various innovative IT services, it has resulted in a diverse array of user interfaces with innovative implementation approaches. The following subsections survey the main approaches for implementing end user interfaces to interact with the Cloud.

3.5 User Interface as a Service

Due to the increasing demand for building customized and specialized user interfaces for various cloud services, a new cloud service has emerged to offer user interface as a service (UIaaS). Force.com is the pioneer that coined this service offering two techniques for creating and customizing the user interface of cloud applications: The first technique is a simple point-and-click/drag-and-drop interface that eases building and changing the layout of a page, renaming and re-ordering tabs, and even creating different views of the data for different users. The second technique offers a complete framework, Visualforce, for creating and running virtually any user interface, for any application on any device [13].

3.6 Dynamic Display Virtualization

Using the remote terminal\display services, clients can transmit user input to the server, and the server returns screen updates to them. Such services usually perform well in cloud environments even for thin clients making them highly responsive as if they are local machines [14][15]. However, complicated graphical interfaces and multimedia applications present technical challenges to thin client developers for achieving efficient transmissions with low bandwidth links. Therefore, some efforts to address these challenges have emerged.

A new architecture for cloud user interface has been proposed in [16] to dynamically generate interface elements. This architecture is composed of a cloud

server module and a terminal module. Most computations are performed on the cloud server which contains a database to store various parameters of terminals, such as screen size, internal display pixels, picture format and other dynamic user interface context parameters. Different user interfaces are dynamically generated for each type of terminals based on these parameters that are sent to the terminal module for final rendering and displaying. The terminal module collects the interface context parameters and sends them to the server for processing and generating the user interface accordingly. The idea is that each terminal should first retrieves an abstract description file of the user interface from the cloud server, analyzes it and draws the user interface based on it considering the current context.

With the escalating popularity of mobile devices, users now need graphic rich contents, from the cloud, rendered in their mobile devices. In [17] an adaptive display virtualization has been proposed for reducing interaction latency in mobile devices. The idea is to have all possible states that the user can go through during the next step on the client side. At the server side, the application decides which state will be requested to the rendering engine based on the application metadata.

3.7 Special Cloud User Interface Description Language

Since there is a wide range of terminal devices that have access to the Cloud, requirements of these devices differ greatly. Therefore, [16] proposed a new XML-based language, especially for cloud user interface which they called Cloud-UIDL. This language uses an XML interface description document to record information about the interface layout, components appearance and user generated actions. It also provides a special parser for the generated cloud interface description documents. The offered advantages by this language include, easy to parse, lightweight, high abstraction and rich user interface components making it suitable for defining various cloud user interfaces.

3.8 Embedded Accessibility Information

To reduce the security risks associated normally with public clouds [18] suggested enabling users to share their own applications with others on the cloud, rather than using untrusted software from service providers. The paper presented a prototype for a system that can automatically create a user interface to any application so this application can be transformed into a cloud based application. This is done using automation and accessibility information transparently embedded in programs binaries to generate a web-based “proxy” of the original program to be accessed through the Internet.

3.9 Ontology

Due to the wide range of users interacting with the cloud, it is essential for the user interface to make sure that user commands are understood correctly before sending them to the server. Therefore, [19] designed an ontology based cloud interface agent

that directly communicates user interaction activities with a backend information agent system in the cloud. The technique transforms user commands into an internal canonical format to conveniently and correctly process these commands avoiding incorrect information torrents that results in misunderstanding of the information intention of users.

4 Enabling Technologies

Cloud computing is not only changing the way IT technology is offered, it is also shifting how IT technology is interacted with; it has now become feasible to have high quality graphics and visuals "in your palm". Thanks to advanced user interface technologies that are helping cloud computing to rapidly expand and spread among various segments of users. These technologies are briefed in the following subsections.

4.1 Interactive Visualization Technologies

Interactive visualization technologies represent user interface aspects with visual image of color, size, shape and motion similar to real life objects. Adobe Flash, Microsoft Silverlight, Ajax, HTML5 and other Web 2.0 technologies are known examples of this category. Extensive description, of each of these technologies and how they are utilized in developing user interfaces for cloud computing, is provided in [30].

4.2 Location Positioning and Contextualization Technologies

These days, positioning technologies either cellular-based (e.g., GSM, 3G, 4G) or Wi-Fi and Global Positioning Systems (GPS) can determine the user location with an accuracy of up to a few meters and even in indoor environments. Additionally, 2D and 3D maps can accurately give the coordinates of the user's location and visualize it. This is very useful for dynamic context aware user interface for cloud computing in general, and mobile clouds in particular.

4.3 Natural User Interface (NUI) Technologies

These technologies represent the next evolution of the human-computer interface paradigm. They are gradually replacing the "Graphical User Interface" (GUI) by allowing the end-user to directly interact with computer using his body as a controller. NUI technologies are revolutionizing cloud computing by offering convenient access to the Cloud:

Motion detection and eye tracking technologies: Today, most smart devices and mobile phones are equipped with motion sensing capabilities such as accelerometers (detect rotation of the mobile phone screen), gyroscopes (measure orientation). They help users to interact naturally with the cloud by recoding movements and responding

accordingly. Eye tracking technologies measure the change in eye gaze and respond based on that [32]. Eye tracking technologies are becoming popular user interfaces especially for disabled people.

Voice and speech recognition technologies: voice recognition technologies are usually used to identify the identity of who is speaking. While speech recognitions can be used to answer user's queries and perform mundane operations [7]. For instance, the famous Apple service, Siri, can process users' speech in natural language, answers their questions verbally and perform routine tasks. Voice and speech recognition technologies are swiftly progressing and they are increasingly utilized to naturally interact with the Cloud, especially while people are moving.

Postures, gesture and facial expressions recognition technologies: Postures, gesture and facial expressions represent the non-verbal body-language. Develop syntactic representations to them will allow the system to seamlessly capture user behaviors and mental states and adapt its performance accordingly [33]. However, these technologies are still at infancy stage and hence, they are underutilized while interacting with the cloud.

5 The Need for Standardization

The expanded market of cloud applications resulted in diverse user interfaces. It may be discouraging for a user to switch between different cloud applications because of their disconnected look and feel. Therefore, this should be the right time to think about cloud user interface standards.

In fact, lacking consistency between different cloud applications may affect productivity and end user's satisfaction. Thus, creating a set of user interface standards will help minimize the time needed for the user to master a new cloud application. This should result in fewer errors and eventually will save the business a lot of money [20].

In [21], it has been highlighted that when standardization is of concern, people normally focus on issues such as security, interoperability and portability of data. However, user interfaces should attract the same amount of interest especially when considering the variety of cloud service models: SaaS, PaaS and IaaS. In fact, this variety of services are actually utilized by different types of users with different viewpoints and needs. Hence, user interface standards should be considered in the light of these differences.

Despite it is obvious how the cloud community will benefit from creating a set of user interface standards, this standardization efforts can't succeed without the collaboration of enterprise cloud vendors, such as Amazon and google, and industry titans, such as SAP and Oracle [20].

6 Conclusions

The spread of smart phones, powerful networks and service-oriented architecture has made access to cloud services easier and more prevalent than ever before. As a result,

the demand for an intuitive, interactive and dynamically visualized user interface is on the rise. While the desirable interface may be relatively easy to implement on a desktop computer, it is much more challenging to run it on thin clients and mobile devices without sacrificing some user demands. This has resulted in the emergence of a wide variety of implementation approaches and technologies for end users' interfaces to meet their requirements while navigating through the Cloud.

While the proliferation of cloud user interfaces can be considered as an advantage for spurring competition and innovation in the Cloud, it has resulted in difficulties due to the lack of standardization that may affect productivity and end user's satisfaction. Therefore, there is no doubt that creating a set of user interface standards is extremely desirable; however, it would not be possible without collaboration from both cloud vendors and industry titans.

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