# TaaS - Telemedicine as a Service

D. González Méndez & O. Ferrer-Roca

***Abstract*— Technology should provide widespread healthcare access in an affordable, decentralized and low cost manner. Smartphones and cloud services are essential in this evolution. Massive data storage and accessibility, virtual remote control and operating system virtualization among others, will lower health care costs requiring less labour forces.**

**This article designs a TaaS (telemedicine as a service) application to take advantage of a cloud teleconsultation. It is based on smartphones and Internet. Written and image data is sent and stored in the cloud. Written data is obtained by voice recognition using the recording system Dragon™® and image data is obtained using the smartphone camera. From the cloud, people are able to access for diagnosis/training purposes and to answer based on the same principle of voice recognition.**

**The application was tested for training purposes using pathology cases for medical students. Students found the application easy to handle and professors easy to create the database. Possible application of the design TaaS application is discussed.**

***Index Terms* — Cloud Computing, iOS, Android, Xcode, SaaS, TaaS.**

***Abstract*— La tecnología debe asegurar un sistema de provisión de servicios en sanidad, viable económicamente, descentralizado y ubicuo todo ello a bajo coste.**

**Los teléfonos inteligentes y los servicios en la Nube van a ser determinantes en esta evolución. El almacenamiento masivo de datos y su accesibilidad y control remoto con virtualización disminuirán costes y el personal.**

**En este artículo se diseña una aplicación de TaaS (Telemedicina como Servicio) con la finalidad de sacarle rendimiento a la teleconsulta en la Nube. Basada en Internet y terminales telefónicos inteligentes, los datos son almacenados con sistemas de grabación y reconocimiento de voz (Dragon™®) y con las cámaras del teléfono inteligente siendo enviados a la Nube para su almacenamiento. Desde allí el personal autorizado puede acceder para su diagnostico/entrenamiento enviando una respuesta basada igualmente en los principios de reconocimiento de voz.**

**El programa se ha comprobado en un entorno de Docencia de la Anatomía Patológica para los estudiantes de medicina. Tanto estudiantes como profesores encuentran la aplicación sencilla y fácil de usar. Se discuten otras posibles aplicaciones del TaaS.**

***Palabras clave* — Cloud Computing, iOS, Android, Xcode, SaaS, TaaS.**

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## I. Introduction

Cloud computing allows hardware and software products become hardware and software services. Designed not to worry about how to configure a server or how to maintain it, they just contract the services they need for theirs applications. Cloud computing provides a level of abstraction in computing programing.

Seeking for the future of technological advances there is no discussion for the cloud to be there. In recent technology conferences, cloud products are now the norm and it looks like next years are going to maintain this tendency. Storage and synchronize data using the Internet, virtualization of operating systems or rich Internet applications are only few possibilities of cloud computing.

On the other hand, smartphone market share has rapidly increased and changed in the last few years. The capabilities of smartphones now allow more opportunities for more advanced applications.

For the time being, the technical gap between smartphones and personal computers has been lowering. There is a common necessity for each application to be in different platforms such as personal computers and smartphones/tablets both. Consequently, developing an app is related to deal with its flexibility.

This article introduces a TaaS (Telemedicine as a Service) system based on smartphone applications and the Cloud to storage and access data for diagnosis or e-learning purposes. The app could be used in other different fields where teleconsultation is required.

## II. Design and architecture

In this section we will manage the design and architecture of the application. The proposed software allows sharing clinical cases for consulting or teaching purposes. The application works with in administrator and user mode. The former is used by the professor or doctor to add or remove cases. The latter is used by consultant people or students, to either make diagnosis or learn pathology diagnosis.

### *A. Available Platforms for the app*

Cloud applications can run in PCs (Personal Computers) and portables devices (Smartphones/Tablets). According to the nature of the platform, a distinction must be made between both. On the one hand are the PCs (desktops and laptops) that run an OS (Operating System) and on the other hand are the mobiles (tablets and smartphones) that run a mobile OS. Those two platforms are totally different

according to the interface, the connectivity, the developing platform and other features such as touchscreen.

### *B. PC-based infrastructure*

A Rich Internet Application (RIA) is a Web application that has many of the characteristics of desktop application software, typically delivered by way of a site-specific browser, via browser plug-in, independent sandboxes, extensive use of JavaScript, or virtual machines.

For the tele-consultation application, RIAs are a good choice. They can deliver a worthy interface as well as flexibility and adaptation to communicate with the database.

Adobe Flash, JavaFX, and Microsoft Silverlight are currently the three most common platforms, which desktop browser penetration rates around 96%, 76%, and 66% respectively (as of August 2011). [6]

At the end of 2011 there were a great number of announcements that demonstrated a decline in demand for RIA architectures. Adobe announced that Flash would no longer be produced for mobile [7] (refocusing its efforts on HTML5). YouTube, little by little, are focusing con HTML5 rather than continue with Flash. It is questioned its continued or steady relevance even on the desktop and described it as "the beginning of the end" [8]. Rumours state that Microsoft is to abandon Silverlight after version 5 is released. The combination of these announcements had some proclaiming it "the end of the line for browser plugins" [23].

In this context we will assume the future for RIAs is going to be focus on HTML5. One of the main advantages using HTML5 is the useless of browser plugins. Those are not needed anymore. In addition, the design of apps does not depend on the platform chosen (or OS such as Windows, MAC OS or Linux). Some build releases will work in the same browser for different OSs. The adaptability of the code is higher even for dissimilar browsers. [9]

On the other hand, HTML5 is still in developed and the designing tools are insufficient and BETA versions.

The chosen architecture has to be flexible such as HTML5 and straightforward to program such as Flash or Silverlight. This moment can be analogous to an inflection point in the transition from RIAs to Web Applications using HTML5.

### *C. PC-base app.*

Releasing the tele-consultation app for PC based on RIAs or HTML5 does mean to release a service. In other words, the app is not to be installed. Instead, every time you ask for a service in this case a **TaaS** (Telemedicine as a Service) being all data workflow streaming and execute AT this moment. The app is built on the Internet and clients access it. But, to store the application in the Could require a server. This service will be detail in the section Cloud Computing.

### *D. Smartphone & Tablet infrastructure*

According with Gartner [10], the mobile OS market share in the third quarter of 2011 is: 52,5 % for Android, 16,9% for Symbian, 15% for iOS, 11% for RIM and 4,6% for others include Windows. Market share has rapidly changed in the last two years. Android is now the most sold whereas Symbian has a tendency to disappear in the next years. In the other hand RIM market share is decreasing and the iOS´s is increasing. Consequently, we will assume the most important platforms to develop an app are Android and iOS.

Is web app or RIAs the best solution for mobile? Yes, if we are seeking for flexible web apps. The same app developed for PC can work with little code changes. However, using RIAs or Web apps bring two difficulties:

- The screen and interface of mobiles are different. A smaller screen must show only the essential information, whereas a quite big screen (PC) can show almost every feature of the application. Moreover the interface of mobiles based on iOS or Android are different in the way of using **multitouch interface** for a better app performance.
- Data delivering is in a mobile network (3G, GSM or LTE). And apps need to be optimized for data download.

To solve these two problems, we have to approach a different solution. In the world of mobile OS, apps are the most used tool to deliver mobile content and services. Using TaaS app solves the previous difficulties.

The data download requirements is lowered because the app is installed in the mobile. The app connects to the server only to access data cases, whereas in a Web application needs to access data and the app itself.

In the other hand the platform tools for developing apps allow better interface-handling, fitting the essential information in the screen and using the multitouch event for controlling the app behaviour.

As we said before, iOS and Android are the future platforms for mobile. These two platforms use different tools and programming languages to design apps, but the bases are the same. Forward we will deal with the app design in iOS.

### *E. Smartphones & Tablets app*

Delivering an app for both iOS and Android is simply. The AppStore in iOS and Android Market in Android are the tools and the only way to deliver apps in these mobile platforms. The procedure to publicize, sell, and distribute the apps are similar in both platforms and only there is little work for the designers.

Designers needs a developer account and to pay a fee. After the developer uploads the app and waits for approval. Once the approval is guarantee, the app is distributed.

## III. CLOUD COMPUTING

In this section we will provide a specific approach to cloud computing for a better understanding of how services can improve the TaaS application.

### *A. Official definition*

There's some confusion about what exactly constitutes cloud computing, but one thing experts tend to agree on is the evolutionary effect this will have on IT (Information Technologies) [1].

Nevertheless, cloud computing is defined by NIST (National Institute of Standards and Technology of USA) as:

> *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."[2]*

The NIST defines cloud computing as **a "model" to access** computing resources with a minimal management effort. There are different no-official definitions that differ from the NIST.

One controversial question is about *private clouds*, because according with the definition, a private company running its own private cloud does not release a service with a "minimal management effort", the company is responsible for the whole management. Consequently, private clouds might not be considered as a cloud, but as a private network.

### *B. Product as a Service*

The model or *the idea of the cloud is to transform a product into a service*. Using services, compared with products, permits an abstraction on many things such as the management of hardware systems or the actualizations of the platforms and applications. In addition, this model allows new whole group of opportunities for innovative ideas where companies can specialize to deliver high quality services.

### *C. Layers*

The cloud can be separated in different layers according with its service function. The three main layers are:

1. Application
2. Platform
3. Infrastructure

Cloud application services or "Software as a Service (**SaaS**)" deliver software as a service over the Internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support. **¡Error! No se encuentra el origen de la referencia.**

Cloud platform services, also known as "Platform as a Service (**PaaS**)", deliver a computing platform and/or solution stack as a service, often consuming cloud infrastructure and sustaining cloud applications. [4]

Cloud infrastructure services, also known as "Infrastructure as a Service" (**IaaS**), deliver computer infrastructure – typically a platform virtualization environment – as a service, along with raw (block) storage and networking.

Whether the **TaaS** is a mixture, or can stand in one of these three services will be discussed latter on.

### *D. Using services to design the consulting application*

Designing a consulting smartphone application for medicine using cloud services call for a previous cloud services market study. It is important to have a big picture about cloud services and how can be implementing in the app.

We have to make a distinction here. As we said in the previous section, we need to storage the app and the data cases. The first one is only necessary for PC, whereas the second are needed from PC and mobile both.

### *E. Services to host the app*

Delivering apps in PC via Web Applications needs a **server** where the app is hosted. Besides, a Web Page to facilitate the app access must be hosted additionally.

There is a wide offer of cloud servers with many options: Windows or Linux based server OS, backups, firewalls and DNS options. In addition, there are hardware options where you have to choose the number of cores and the size of RAM and storage.

One important feature of cloud server services is their **scalability**. If you demand more power you can simply acquire it. Other advantage is that all the management is provided, so developers do not need to worry about.

### *F. Services to load and upload the data cases*

This application needs cloud **storage** for data. This data includes images, audio and text information. It has to be a service that delivers data storage and access any time is needed. This service can be considered as IaaS.

There are two possibilities for the way data is loading and uploading from the services.

1. The most simply one is to use the **natural formats** to store the data. These formats can be PNG or JPG for images, TXT for plain text and MP3 for audio recorders. The data is accessible not only for the app, but for any file explorer. In addition, the organization of the data has to be managed by the application. This is a service of no-relational data.
2. The second and more appropriate method is to use a cloud based database service. This is in concordance with the cloud model, because in similar way, it means a level of abstraction. Data relations and structure are managed by the database. **Relational database services** can be found in the cloud. Seven of the most important ones are Xeround, Microsoft SQL Azure Database, Amazon Web Services, Google AppEngine Data Store, Database.com, ClearDB and CouchOne. [5]

It is important to mention that using those services imply not to worry about the maintenance of the database. The designer only has to connect to the database and use queries to ask for data.

## IV. MATERIAL AND METHODS

In this section we explain how to put into practice a design and architecture of a generic TaaS app into specific iOS app, together with the structure and computing program workflow.

The proposed software allows sharing clinical cases for consulting/teaching medicine using iOS (Apple´s mobile Operating System) devices and the Internet connection to access the Cloud. The application works on administrator and user modes. The prior input new cases. The latter, provide the answers. In both cases images are taken with the smartphone and data is input by voice recognition (Dragon ™ [11]).

### *A. iOS Integrated Development Environment*

The IDE (Integrated Development Environment) taken is Xcode, which contains all the tools to design for iOS. The app is compatible with iPhone, iPod and iPad. Xcode supports Objective C, C and C++ languages among others. To use the powerful tools inside Cocoa Touch provided by Apple is necessary to use the object oriented language Objective C.

For iOS devices, the interface is controlled by the API (Application Programming Interface) Cocoa Touch. Specifically this API is an extension Cocoa API for MAC OS (Macintosh Operation System) that allows gesture recognition and animation.

The Core Data is a system utility and part of Cocoa API that allows data organized by the relational entity-attribute model to be serialized into XML (Extensible Markup Language), binary, or SQLite (Lite version of Structured Query Language) stores, which storage format is defined by the designer. The data can be manipulated using higher level objects representing entities and their relationships. Core Data interfaces directly with SQLite, insulating the developer from the underlying SQL.

### *B. iOS Application Architecture*

The app architecture is based on Model-Controller-View (M-C-V) architectural pattern, permitting independent development for each mode (User and Administrator).

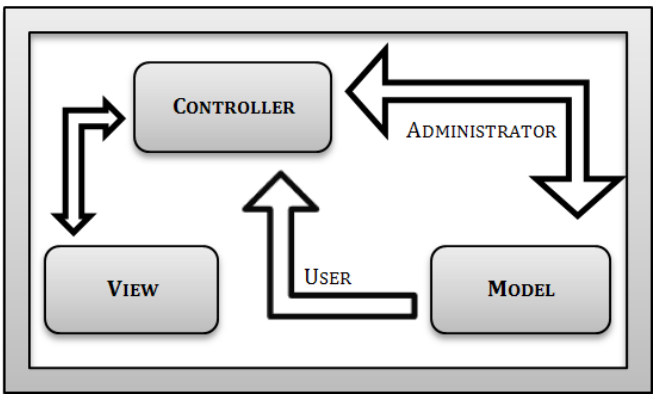


**Figure 1: Architectural Pattern**

The Figure 1 summarizes the behavior of the M-C-V for the application. The **Model module** manages the data, controlling the information using the Cocoa´s Core Data system utility. The **Controller** handles different View modules using classes and methods defined in the Cocoa´s Application Kit (UIKit). The specifics UIKit classes are: UIViewController for the controllers and UIView for the views. The communication between the Controller and the Model depends on the application mode. For the administrator mode, the Controller has full access to the Model module to retrieve and storage data for the clinical cases. In the user mode, the Controller only has the capacity of retrieve data of the Model.

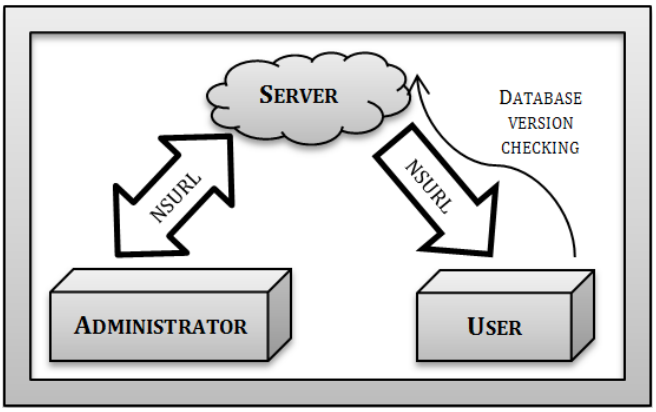


**Figure 2: Connection Workflow**

The Figure 2 shows the connection workflow. The data is uploading (Administrator mode) to an Internet server using the device 3G or WIFI Internet connection. The application manages the connection using NSURL classes (NeXt Step class based on Universal Resource Locator) included in the Foundation Kit. The connection could be established with HTTP and FTP protocols. The application usually checks database version to update new cases. Once the application detects a new version, the user is notified by a Cocoa local notification.

### *C. Novel features and applications*

Using the Administrator mode, the app supports a novel feature to link images and text.

#### *1) Images*

Images are taken with the iPhone/iPod/iPad camera or any other portable camera. The iPhone 4S has an 8 megapixel sensor, iPhone 4 has 5 megapixels whereas the iPhone 3GS and the iPhone 3G have 3 and 2 megapixel sensors respectively. The 5 megapixel sensor allows sample images of 2592 x 1936 pixels with an aspect ratio of 4.02:3. We consider this is enough quality for clinical cases. New products are going to increase the quality of the camera. Using **Skylight®** [14] we can even take direct images from the microscope as can be seen in Figure 3.

**Figure 3: Skylight® mobile adaptor for the microscope**

The camera sensor is controlled by the *UIKit class* called *UIImagePickerController*.

*2) Text data*

To avoid the inconveniences to write long sentences in portable devices, a dictation tool with voice recognition is integrated in the application. This dictation tool is developed with Dragon Dictation Mobile SDK [11] (Software Development Kit designed by Nuance Communications Inc.).

This dictation tool can be considered as a Cloud service itself. Every time a dictation is made, all data audio data is sent to a Nuance server to make the conversion into text. The iOS app receives the converted text from the server. This service is classified into the SaaS.

### *D. TaaS Data structure*

Teleconsultation case is integrated by a defined **data structure**. The structure is a multimedia data structure that contains a mix of *text* (ID case/ ID owner / clinical-diagnostic information/ multiple chose answer/ ID answer / answer data) together with samples integrated by one or several *images*.

Text contains a field that points the correct diagnosis and an automatic prompt for training purposes. The Figure 4 shows the data encapsulated for each clinical case.

Each case as a whole and every property have a visible and non-visible flag.

To implement the multimedia structure inside a "box" the standards are considered to increase the app interoperability.

The norm ISO/IEC 24800 defines how the metadata for JPEG and JPEG2000 images is inserted inside. This standard allows integrating the metadata field for the JPSearch (search engine) queries. In addition, there is another important tool inside this ISO standard; the possibility to create annotations or tags in regions inside the image only with coordinates. Therefore, the data is encapsulated in the header of the file using XML. The use of this standard is considered an advantage due to the fact that the data cases are standardized.

On the other hand, JPEG2000 guaranties some advantages from JPEG such as superior compression performance, multiple resolution representation and progressive transmission among others. Nevertheless, JPEG2000 is not as much extended as JPEG and special software or hardware is sometimes required.

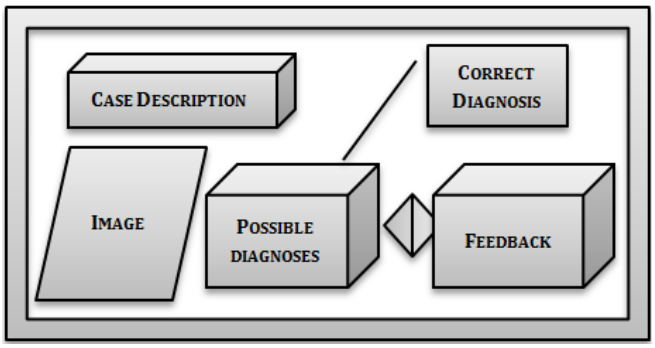


**Figure 4: Encapsulated data structure**

### *E. TaaS model implemented*

For the present paper we implemented the training TaaS model in which the Administrator is the professor of pathology that upload images from autopsy cases, biopsy, microscopic cases etc… with a clinical data and provide a multiple chose test to the student.

Data recorded include the everyday routine work in a pathology lab, and is about 5-6 cases per day visible for the students a maximum two days, in such a way that they can participate in the routine work of a pathology lab.

The student is able to access the everyday cases and provide their diagnostic opinion, which will or will not be ratify by the professor.

## V. RESULTS

A daily experience is exported from the pathology laboratory to the iOS devices. This is a real-time updated system that allows access to learning resources for medical students. The clinical information enclosed each clinical case together with the questionnaire tests student´s diagnostic skills and measures the improvement in the learning curve. In the other hand, multi-touch interface lets them visualize images with a simple and intuitive tool, facilitating the diagnosis.

### *A. iOS Application Interface*

The application´s interface is easy-to-use and intuitive, using touchable objects like buttons, labels and a navigation bar. The app supports portrait and landscape orientation both.

### *B. Capture of the data*

The administrator mode allows catching the data in simple way and the data (image and text) to present the clinical case is shown in the screen as you can see in the Figure 5. As we said before, the text can be obtained from a dictation tool or keyboard. To use the dictation you only have to set the cursor in a specific text field and press de record button.

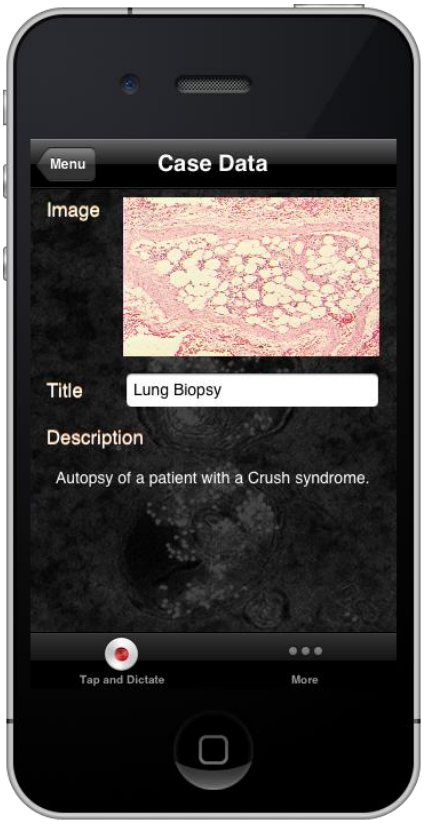


**Figure 5: iOS app administrator mode**

### *C. Tele-consulting and Questionnaire*

The information of clinical cases is presented using a concise and a clear structure. Mobile´s screens are limited in size and then the text that can be shown is limited as well. For this reason, the application uses a scroll view for the text, so moving through the text involves using the finger to drag the view. To point out if a diagnosis is correct, the interface change its colour. A screen shot can be in Figure 6 (left).

### *D. Image Visualization Interface*

The app has a specific image interface which allows zooming in/out, drag and move the image inside the screen. The interface supports both orientations as well as the main application. A screen shot can be seen in Figure 6 (right).

### *E. User satisfaction*

Pathologist were very happy to use the application that find it very user-friendly and versatile

Students find interesting to have access to everyday cases and found the application easy to handle.


**Figure 6: iOS app user mode**

## VI. DISCUSSION

The present TaaS solution using the Cloud, have been proved easy to handle on everyday overloading activity to record and store interesting clinical cases to be seen for the students.

Our TaaS paradigm approach has been proved extremely good and simple, providing a low cost solution for multiple data recording or teleconsultation problems medical or non-medical (car-crash, journalist reports, steady moments…)

Novelty of the solution is to integrate in a mobile device image and voice recording transformed into text by means of a dictation tool integrated in the app, together with the selection of the most possible diagnosis.

Up to date the most advanced iPad tool for mobile Learning links the mobile devices to a web-based learning environment [12] i.e. Moodle [13]. The present application builds a cloud database for sharing daily clinical experiences, but is not limited to e-learning, since it can be useful to introduce multimedia data to any EHR (Electronically Health Record) or to make a distant consultation.

This software delivers a service in telemedicine (TaaS) and can be considered as SaaS, because it is an application that delivers a service specified in the consultation field.

We have defined above the use of metadata field in the JPEG and JPEG2000 for the integration on data cases. The use of the standards generates an advantage but there some difficulties; the iOS platform is not compatible with JPEG2000. In addition using the metadata for JPEG images is not implemented in the iOS platform. Therefore in the application there is a specific XML interpreter to read the JPEG header.

## REFERENCES

[1] Schurr, A. "Keep an eye on cloud computing" *Network World*, July 08, 2008, http://www.networkworld.com/newsletters/itlead/2008/070708itlead1.html citing the Gartner report, "Cloud Computing Confusion Leads to Opportunity".

[2] Mell, P. & Grance, T." The NIST Definition of Cloud Computing". *NIST* Special Publication 800-145. NIST

[3] Hamdaqa M., Livogiannis T. and Tahvildari L. "A reference model for developing cloud applications." *Proceedings of the 1st International Conference on Cloud Computing and Services* Science, pages 98-103. (2011)

[4] Schofield, J. "Google angles for business users with 'platform as a service'". *The Guardian*. 2008-04-17 < http://www.guardian.co.uk/technology/2008/apr/17/google.software >

[5] Finley, F. "7 Cloud-Based Database Services" *ReadWriteCloud.com* January 12, 2011. < http://www.readwriteweb.com/cloud/2011/01/7-cloud-based-database-service.php >

[6] "Rich Internet Application Market Share. RIA Market Penetration and Global Usage." *StatOwl.com* < *http://www.statowl.com/custom_ria_market_penetration.php* >

[7] Bonderud, D. "Adobe Flash Player Turfed for Mobile Devices" *infoBoom. November 10, 2011* < *http://www.theinfoboom.com/articles/adobe-flash-player-turfed-for-mobile-devices/* >

[8] Perlow, J. "Without mobile, Adobe Flash is irrelevant" *ZDNet* November 9, 2011 < http://www.zdnet.com/blog/perlow/without-mobile-adobe-flash-is-irrelevant/19247 >

[9] "HTML5 differences from HTML4" *W3C* < *http://www.w3.org/TR/html5-diff/* >

[10] "Gartner Says Sales of Mobile Devices Grew 5.6 Percent in Third Quarter of 2011; Smartphone Sales Increased 42 Percent" *Gartner* < *http://www.gartner.com/it/page.jsp?id=1848514* >

[11] "Nuance Mobile Developer Centre" *Nuance* < http://dragonmobile.nuancemobiledeveloper.com>

[12] Ferrer-Roca O., Figueredo A., Franco K., Cardenas A. *Telemedicine Intelligent Learning. Ontology for Agent Technology"*. Trans. on Adv. Res. Jul 2005, Vol 1, N. 2, 46-54

[13] Enrique Agudo J., Rico M., Sanchez H., Valor M. Registro de aprendizaje movil en Moodle mediante servicios Web. IEEE-RITA vol 6 (3): 95-102, 2011.

[14] "Skylight" <http://www.skylightscope.com/>

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