Mobilizing Digital Museum Explorer

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ABSTRACT

Museum artifacts information is usually enormous. They can become ubiquitous media through the dissemination of wireless communication networks. With the advent of interactive mobile devices such as smart phones and tablets, we are redesigning a ubiquitous media exhibition platform named "Mobilizing Digital Museum Explorer" for museum artifacts. This paper focuses on using the state of art ICT (Information and Communication Technology) technology not only providing museum innovative services but also bringing users utterly new experiences on museum artifacts. We employ PaaS (Platform as a Service) of cloud computing allowing users to access museum's information anytime and anywhere. Besides, the cloud server is able to collect and analyze users behaviors and preferences, and then prompt personalized information to individual users. We also exploited Augmented Reality (AR), 3D imaging and path planning technics giving users brand new browsing and navigation experience. Mobilizing Digital Museum Explorer is customized for Taiwan's National Palace Museum (NPM), which is one of the top five world-renown museums, as an illustration. All the developed technics are applicable to other digital museums.

Keyword: Digital Museum, Cloud Computing, National Palace Museum

1. Exhibition Platform Architecture

Almost all countries are undergoing national projects to digitize and archive their historical documents. Digitizing museum archives has become an important national project worldwide. Taiwan's National Palace Museum (NPM), which archives the most important Chinese treasure, has digitized their archives for many years and become one of the most popular digital museums in the world. Taking the wave of the advanced ICT technology, tablets and smart phones are offering excellent platforms because of their strong capabilities of human-machine interaction, networking, as well as mobility. Facilitating by these powerful devices, it is time for digital museums to disseminate their ubiquitous media to demonstrate their culture radiation power.

In this paper, we propose a Mobilizing Digital Museum Explorer (MDME) for Taiwan's National Palace Museum. The explorer consists of two parts: cloud service system and mobile exhibition platform. Figure 1 shows the underlying technics employed to build the NPM Mobilizing Digital Museum Explorer. Qualcomm Vuforia is used to make Augmented Reality (AR) more interactive than ever before. OpenGL ES is used to generate 3D artifacts model. On the other hand, cloud service is built upon Heroku PaaS (Platform as a Service). Ruby on Rails framework makes the code clean and concise. Urban Airship expedites the development and provides cross-platform (iOS, Android, Windows Phone) support. Though MDME is running with iOS, the same exploited technics can be ported to Android platform.

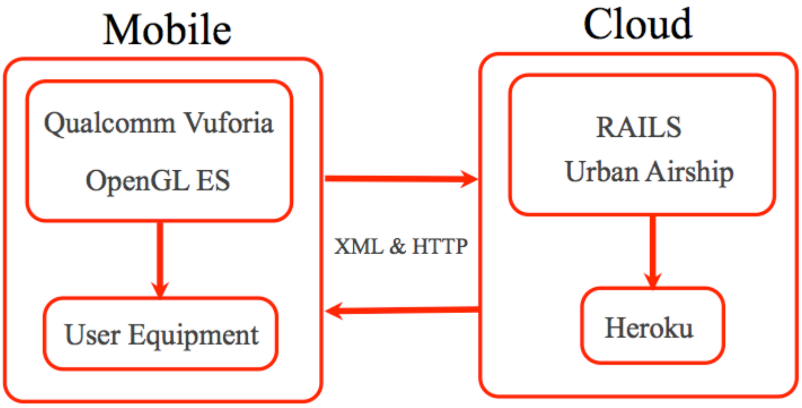

Figure 1. Technics employed by Mobilizing Digital Museum Explorer.

2. Cloud Service System

Cloud technique has high performance of computing capability and cloud server is able to provide vast amount of data storage. Cloud is thus suitable for supporting exhibition and navigation of museum artifacts. On the other hand, the hardware requirements of mobile devices can be largely reduced due to the major computing loading and data storage can be offloaded to cloud. We used Heroku's PaaS platform together with Ruby on Rails to rapidly develop server management interface. Ruby on Rails is based on MVC (Model, View, Controller) framework, so the front-end and back-end can be easily separated. The advantage of the management interface is that the administrator can easily synchronize the updated data with all the other platforms. Mobile users may preload or update those interested information from cloud server in advance on their ways to the museum. When they come to the museum, they will be able to read those preloaded information offline even if the network is congested. In addition, users can subscribe to specific services from cloud server. Once the server has any subscribed information updated, it can be pushed to the subscribers via push notification service. Such design makes the cloud server shoulders the major responsibility of cost-intensive computation. As a thin client, the mobile device can thus experience smooth browsing and navigation.

2.1 Data Management

With Ruby on Rails, we can use *scaffold* command to easily create and edit a variety of tables and management interfaces. The syntax of *scaffold* command is as follows.

```
rails g scaffold name attribute name : attribute type (attribute name : attribute type ……)
```

The data administrator can use *scaffold* to quickly create and manage a database with a variety of tables. Museum staff can thus use these tables to create and update those kinds of information including artifacts, exhibitions, etc. For example, the following statement quickly creates an "antiques" database with three data attributes (name, era, description), and establishes data display interface (Figure 2), data creation interface, and data editing interface (Figure 3) at the same time.

```
rails g scaffold antiques name : string era : string description: text
```

This really saves a lot of time and effort comparing with traditional ways. Note that the data displayed in Figure 2 is retrieved from the server of National Palace Museum automatically.

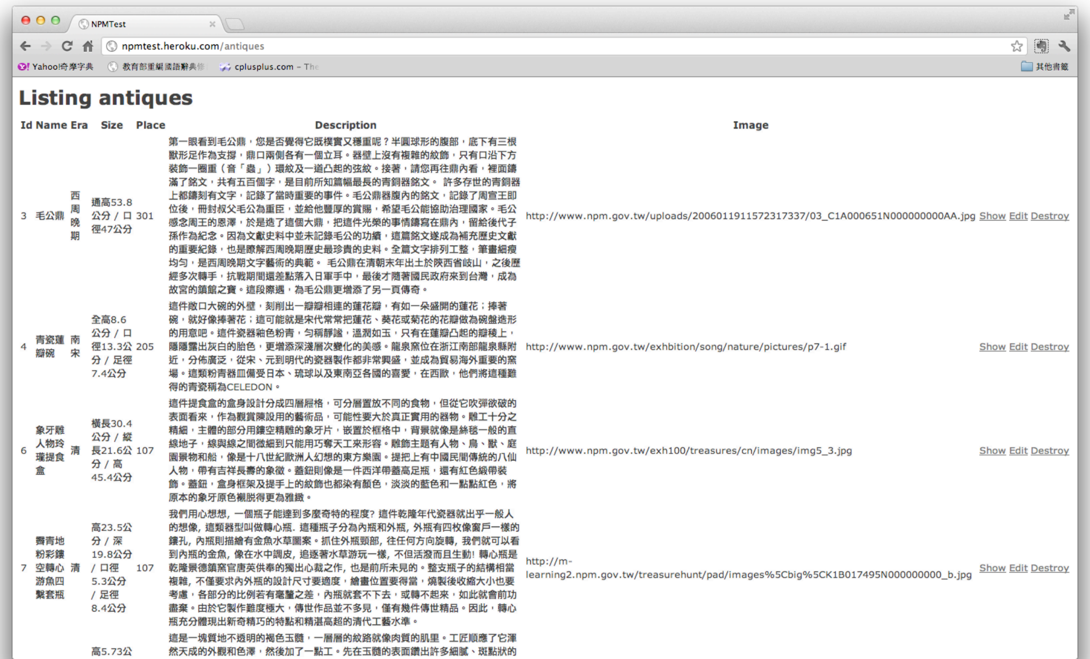

Figure 2. Data display interface.

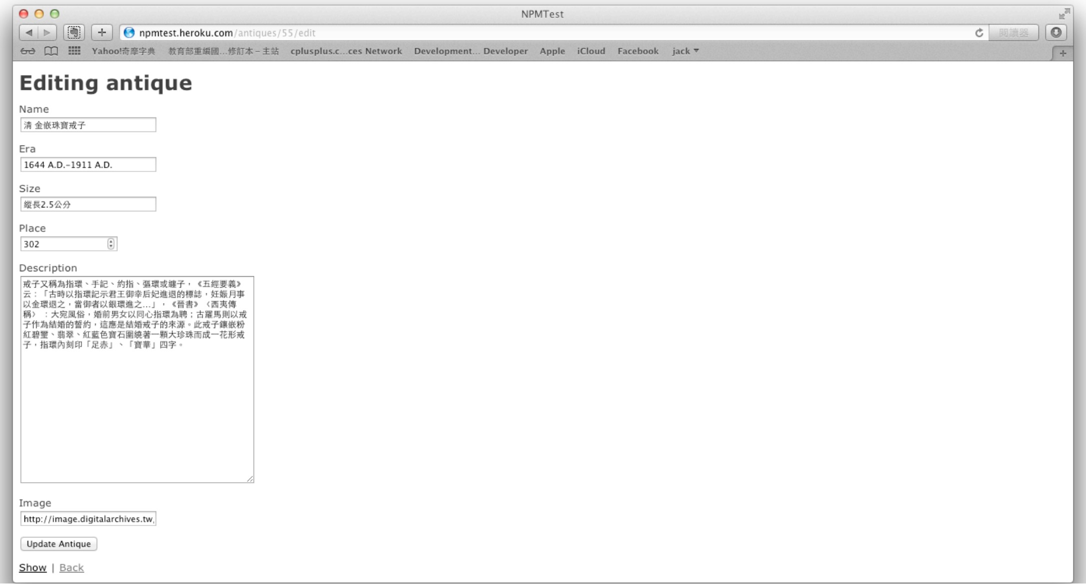

Figure 3. Data editing interface.

2.2 XML Based Data Exchange

XML based data exchange between mobile and web page can be easily done using Ruby on Rails Framework. For example, the following code generates a corresponding XML format.

```
xml.antique do
   xml.id 1
   xml.name “test”
end
```

```
<antique>
   <id>1</id>
   <name>test</name>
</antique>
```

Hence, given the following XML data, the mobile will be able to exchange data with cloud server using HTTP Get / Post.

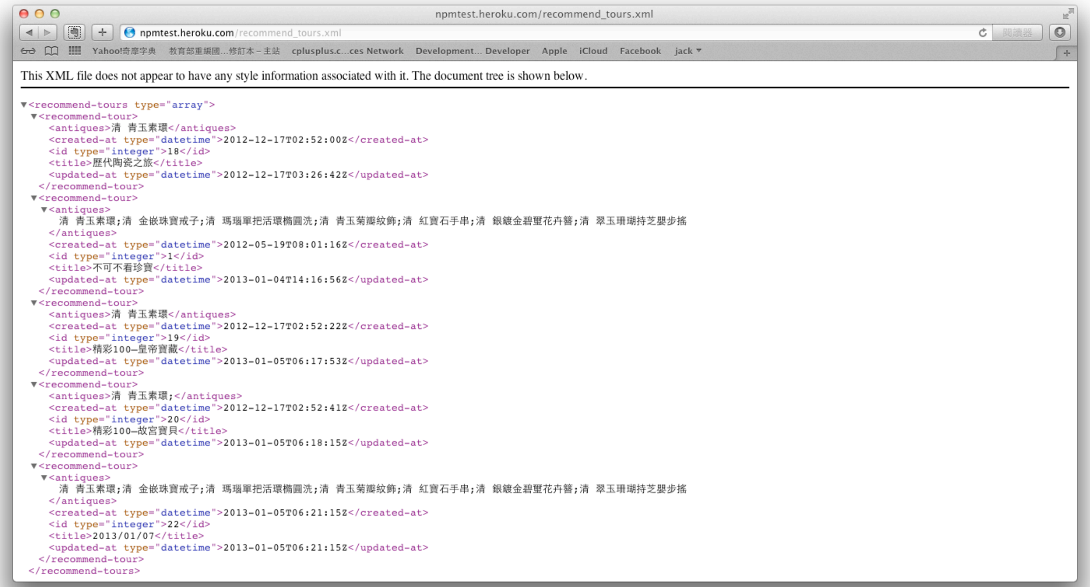

Figure 4. XML based data exchange between mobile and cloud server.

2.3 Push Notification Service

Mobile users may subscribe to a set of services, e.g., artifact exhibitions, special events, etc. Since each mobile device has a unique device token, which can be used to determine the services subscribed by a specific mobile user. Cloud server can then timely push personalized information to individual users using push notification service once the subscribed information is updated. Figure 5 shows the service subscription interface on mobile device.

Figure 5. Service subscription interface on mobile device.

We implement the push notification service using Urban Airship push service library. Note that the developed service supports cross-platform. When the museum staff updates the data in the cloud server, the system is able to determine which users have subscribed to this updated information. If any, the push notification is triggered and the information will be pushed out. The implementation code of push notification is as follows:

```
notification = {# hash structure of push notification content
:schedule_for => [1.second.from_now],
      #time to push the notification
      :device_tokens => ['DEVICE-TOKEN-ONE', 'DEVICE-
        TOKEN-TWO'],
      #which mobiles will receive notification
      :aps => {:alert => 'New exhibition ! ', :badge => +1}
      #message content and the notification number will add one}
Urbanairship.push(notification)
     #Send notification to Urban Airship server for pushing
```

3. Mobile Exhibition Platform

In the beginning, we intended to use PhoneGap as our mobile development framework. PhoneGap enables software programmers to build applications for mobile devices using JavaScript, HTML5 and CSS3. Using PhoneGap, developers can write once and deploy on various mobile platforms. However, the resulting cross-platform applications are neither truly native nor purely web-based and have the following problems:

- Since all layout rendering is done via web views instead of the platform's native UI framework, it fails to have all the features and interfaces coming out of iOS native programs.
- It claims that developing PhoneGap APP is as easy as developing web page. However, the resulting APP has a poor performance since it is hard to resolve the performance bottleneck of the mobile’s lower layer functionalities through PhoneGap API.

We therefore choose to develop the proposed exhibition platform using iOS native programs to preserve all the native features and interfaces provided by iOS as well as to achieve higher system performance.

3.1 Exhibition Floor Plan

We used Scroll View to enable users intuitively switching between floors and zooming in/out the floor plan. Users can check the detail exhibition information of each exhibition room by tapping the room icon as shown in Figure 6.

Figure 6. Exhibition floor plan and zoom in/out interfaces.

3.2 Artifact Browsing

As to artifact browsing, the platform supports the following innovative browsing features: asynchronous picture downloading, intelligent artifact searching, interactive 3D artifact model browsing, and AR artifact.

- Asynchronous picture download: Artifact information is updated through network. However, these kinds of information usually come together with pictures. Synchronous download may slow down the information display due to large information size or limited bandwidth. Therefore, we used asynchronous picture download to accelerate information display. This feature is performed by downloading text before picture. In the subsequent browsing, the system always pre-caches a number of forthcoming pictures based on navigation sequence. Experiment results show that asynchronous picture download is able to make artifact browsing smooth and no noticeable lag as shown in Figure 7.

Figure 7. Asynchronous picture download.

- Intelligent artifact search: We make good use of iOS Search Bar to expedite type-in artifact search. Once the user keys in the initial word string, the system uses the embedded “LIKE” function to match the keyword against database, and pops out the matching list into an array. The user can then easily make selection at a glance.

Figure 8. Artifacts search through Search Bar.

- Interactive 3D artifact model browsing: This feature allows users to have an intuitive close-up view of artifacts, which may be physically impossible due to distance and static exhibition. Users are able to play with the 3D models by zooming in-and-out, rotating up-and-down without any coffin corner. In addition, we place tags on the artifact pictures, which allows users to tap for extended information. Figure 9 shows the interactive 3D artifact model browsing. As we tap the Buddha's head, the APP pops up “這是佛像的頭”.

Figure 9. Interactive 3D artifact model browsing (zoom in and pop up).

As to the implementation, we used OpenGL ES library together with native gesture recognition function. Note that there is no glBegin() and glEnd() in OpenGL ES as that with OpenGL. Instead, OpenGL ES pumps data into a buffer for artifact plotting in order to expedite the processing. The following code is used to plot the vertexArray points:

```
glVertexPointer(3, GL_FLOAT, 0, vertexArray);
//set the vertex buffer
glDrawArrays(GL_TRIANGLES, 0, vertexArrayNum);
//choose the export format
```

To implement pop-up information feature, OpenGL uses color coding for object picking, which requires two frame buffers for background and foreground, respectively, and distinct coding colors for different objects. We simplify color coding method without using two frame buffers. In the beginning, each candidate object is assigned a distinct color with 100% opacity. When a user taps the screen, the iOS snapshot function together with gesture recognition point to determine the selected object according to the color code of the individual object. The code of the proposed method is as follows:

```
// iOS gesture recognition setting function
UITapGestureRecognizer *tap = [[UITapGestureRecognizer alloc]
initWithTarget:self action:@selector(tapped:)];
[tapProfileImageRecognizer setNumberOfTapsRequired:1];
[glkView addGestureRecognizer:tapProfileImageRecognizer];
//Color code assignment (draw function)
if (flag == 1) { //user tap screen flag
    //set special color
    glColor4ub(255, 255, 255, 0);
    glDrawArrays(GL_TRIANGLE_STRIP, 0, 24);
    flag=0;
}
//User tapped the screen (tapped function)
UIImage *snapshot = [(GLKView*)self.view snapshot];
NSUInteger x=touchPoint.x;
NSUInteger y=touchPoint.y;
//Get the color code according to the snapshot info and tapped point …
```

- AR artifact: Wikipedia defines Augmented Reality (AR) as a live, direct or indirect, view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. Here we used Qualcomm Vuforia AR library to generate AR artifact model and tags. With these models, users may have utterly new experiences on the artifacts expression. Figure 10 shows an AR teapot artifact, which pops out of a plane surface.

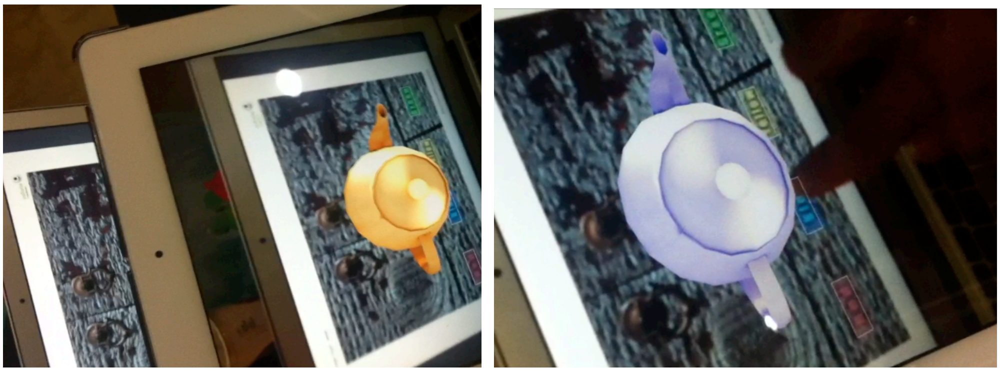

Figure 10. Viewing artifact using Augmented Reality technic.

3.3 Push Notification of Recent Special Exhibition

Push notification of recent special exhibition is an example of personalized push notification service. Figure 11 shows a pop-up push notification "NPMApp 有您訂閱的展覽出現了" on the top of the mobile. The APP brings you to the exhibition page once the user taps the message.

Figure 11. Push notification of special exhibition.

3.4 General Navigation of Artifacts

- Artifact information navigation: We used Table View enabling users to itemize artifact information as shown in Figure 12. The information is optionally displayed in either "text & audio" or "video" as shown in Figure 13.

Figure 12. Itemized information navigation.

Figure 13. Artifacts information displays in two alternatives.

- On-the-spot AR artifact direction guide: Even though a museum usually gives its vistor a floor map, visirors often get lost in the museum and cannot find the right way toward his/her interested artifacts quickly. Using OpenGL ES together with camera, we developped an on-site AR artifact direction guide. By simply tapping the icons of both the current and target artifacts, the system is able to calculate the moving path and show it on the screen with an arrow sign as shown in Figure 14.

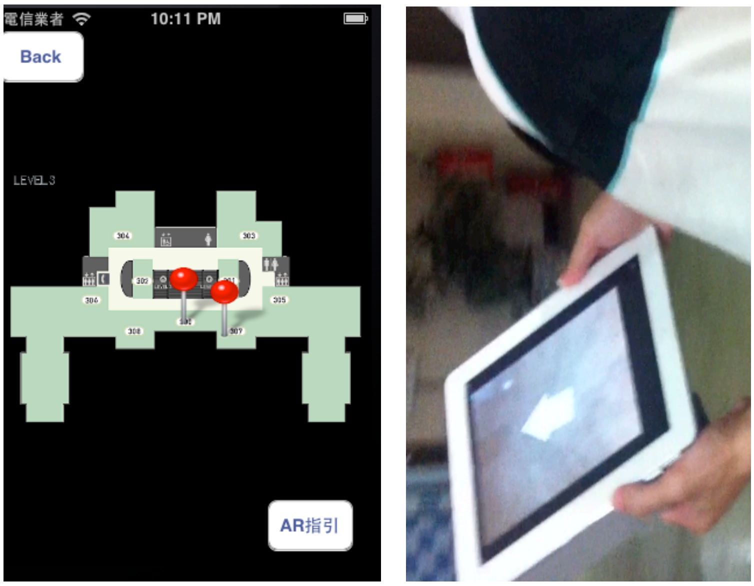

Figure 14. Floor plan map vs. AR direction guide.

The arrow is generated by OpenGL ES and should be perpendicular to the gravity, which is generated by gravity sensor (G-sensor). That is, the direction of gravity should be the normal vector to the plane where the arrow lies in. To simplify the problem, we assume that the mobile device is placed on the horizontal plane. The system calculates the degree difference between the direction of gravity and the horizontal plane. The resulting degree is then used to adjust the degree of rotation of the arrow sign to make it perpendicular to the direction of gravity.

4. Conclusion

In this paper, we proposed a Mobilizing Digital Museum Explorer customized for Taiwan's National Palace Museum. The platform consists of cloud service system and mobile exhibition platform. The cloud service system supports data management, XML based data exchange, and push notification. The mobile exhibition platform supports exhibition floor plan, artifact browsing (asynchronous picture download, intelligent artifact search, interactive 3D artifact model browsing, AR artifact), push notification of recent special exhibition, and general navigation of artifacts (artifact information navigation, on-the-spot AR artifact direction guide). The techniques exploited are cloud computing, augmented reality, OpenGL ES, 3D model generation, etc. All the developed technics are applicable to other digital museums.

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