E-health Web Application Frameworks Based on Cloud Technology

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Abstract

The Responsive Web Design (RWD) aims at crafting sites to provide an optimal viewing experience in easy reading and navigation with a minimum of resizing, panning, and scrolling across a wide range of devices such as from desktop computer monitors to mobile phones. And the modern-day healthcare needs and delivery is complex, and the use of Information and Communications Technologies (ICT) has made some positive impact in attending to such needs that e-health applications require. This paper deals with E-health web application framework, cloud platform and responsive web design, which aim to adjust the presentation on mobile devices. This work presents the whole development process of the self-care management web-app framework, which provides instructive supports for future other E-health field application. A prototype is developed by using. Net, CSS3, Java script and HTML5 technologies. The system test and evaluation is made to show the system's usability.

Keywords: RWD, E-health, Cloud platform, Web design

1 Introduction

With the rapid development of smart phones and mobile devices, it becomes very popular that people more prefer to access the information through this flexible way. So the requirement of proper interface according to different devices become a hot topic and the goal will motivate the use of RWD [1-4] (Responsive Web Design). It aims at crafting sites to provide an optimal viewing experience in easy reading and navigation with a minimum of resizing, panning, and scrolling across a wide range of devices such as from desktop computer monitors to mobile phones. What's more, now days E-health has gradually aroused great attention all over world. And the modern-day healthcare needs and delivery is complex, and the use of ICT [5-7] has made some positive impact in attending to such needs that e-health applications require. The thesis is about E-health [8-12] web application framework and responsive web design which base on the cloud platform. This idea comes from instructor Dr. Eric Chen's project proposal. Though there are some existing researches in above fields, there is less or almost none related work, which combines these fields to provide a basic frame specifically focusing on the e-health. Right information at right time saves lives, so an E-health web application framework and platform based on the cloud is a part of information and communication technology supported self-care system for the diabetes. The thesis mainly focuses on the responsive web design and E-health, which nowadays become hot research topic over the word. In this thesis, it well combines these two fields to set up a basic E-health web application framework, which has a reference meaning in some extent in the future. In addition, the thesis summarized a systematic method on how to realize the responsive web design to get a better user experience. This work offers a detail guideline for future related work. Moreover, the whole thesis project will base on the cloud platform database which are newly spring out can be met the requirement for large data volume.

The rest of this paper is organized as follows: Section 2 introduces the E-health. Then in the Section 3, presents four principle methods to realize the responsive design and the RWD Guideline. In Section 4, the security problem will be discussed. A flexible user management and access permission control will be introduced in detail to provide desired privacy and security. And in Section 5, a systematic comparison between existing cloud platform and database will be done to select a most suitable vendor. Then the core part of the project will be introduced in Section6. This part introduces the whole project development process

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DOI: 10.3966/160792642018031902002

in detail and some encountered problems and solutions. Section 7 gives the application's system test, evaluation. Section 8 has the conclusion remarks and future works outlook.

2 E-health

There are many definitions for E-Health until now but still there is not consensus on one common definition. This is because of its ubiquitous and dynamic nature. The E-health information is widely used with different meanings and purposes. In our work, we develop the E-health application mostly used for diabetes patient.

Joaquin (2010), who is one of the World health organization members, defined E-health as the use of Information and Communications Technologies (ICT) in favor of health and health-related fields, containing health-care services, health supervision, health literature, and health self-management education, knowledge and research and stated that E-health has the potential to greatly improve health service efficiency, it should expand or extend treatment delivery to more than thousands of patients in developing countries, and also improve patient results [13].

2.1 Advantages of E-health

There are many advantages in using E-Health concepts. One key example is Electronic Health Records. Before E-health came into use, we used the papers based system to record patient health data. These paper-based systems may have errors, while entering the patient records into papers. Coming to E-health, data store electronically and it is more simple and efficient way of data storing [14]. Grogan stated that there is an evidence to suggest that E-health provide more complete and error free methods for storing patient data [15].

By using E-health, there are many benefits to different people such as doctors, patients, etc. For example, doctor's orders can be placed electronically, which avoid wrong elucidation of hand wrote orders. And with the help of E-health, most doctors reduce the time of locating and reading patient health information. To the patient, they can begin to be gradually aware of the importance of self-care management. Moreover, it is also convenient for maintaining only with some experts in medical and application developers.

2.2 Barriers to E-Health

The followings list is the main barriers to E-health.

2.2.1 Operational Barriers

This area of concern relates to the interoperability of systems which e-Health aims to provide [16-17]. First, a system has to be developed with an interface allowing existing computer system to communicate with new system, which e-Health will introduce. Second, there must be a common standard electronic language to cross communicate between different healthcare organization about the medical data, such as patient records and hospital internal record. There must be formal agreement on what the best method to communicate such data between organizations [18-19].

2.2.2 Cost/Benefit Barriers

As the name suggest it is the barrier related to the cost in implementing e-Health solutions, whether it is feasible in-terms of cost wise i.e. do the benefit of e-Health outweigh the cost required to implement E-health. From the technical side, the implementation of E-health solutions is clearly advantageous in comparison with past methods such as the paper-based record keeping systems but from the healthcare organization side these benefits may not outweigh the cost of implementing e-Health solutions. The cost of implementing e-Health solutions can be tens of thousands of dollars and this does not even include the requirement of hiring teams of IT professionals to support and maintain the software throughout its life cycle [20-21].

2.3 E-Health in EU

Most European governments have set up combined systems of healthcare insurance, in which public compulsory health insurance coexists with private companies (which are optional most of the time). Globally, the European population is aging, which translates into an increasing demand for healthcare, and an increased cost of treatment. On a global basis, many governments in Europe are transferring expenses from public insurance to private ones. The ongoing economic crisis leads both governments and private bodies to be in demand for better cost optimization, leading to a globally better governance of the healthcare system.

The combination of social and policy factors described in the previous section has already created the basis for a strong European demand for E-Health services and applications. Based on an analysis undertaken by Capgemini Consulting in the context of this project, the European E-Health market was about at EUR14.269 million in 2008 year and it is also projected to reach EUR15.619 million by 2012, it grows with a rate of 2.9%. A per-country analysis of the results confirms that France, Germany, Italy, Spain and the United Kingdom are the principal European E-Health markets. However, the analysis also confirms that over the next three years all national E-Health markets will experience some form of growth in this area [22-23].

2.4 E-h*ea*lth Requirement

Aiming to the specific field, we should take the following main parts into account that is the designing, computing and data format.

Interaction design. The E-health frame should meet different roles' requirement and access authority management, which will be used as a basic model in some specific application in the future. For example, different roles such as diabetes patients, doctors and administrator can be created, and the discussion between patients and doctors should be available.

UI design. The E-health website page should be shown concise so that it should be comfortable for the users' administrators and developers, and the responsive web design was used to fulfill the requirement which can be well suited to different type devices with flexible screen, such as the PC, mobile phone, etc.

Mobility and powerful computing capabilities. The E-health website should be visited at anyplace with anytime. So, the real-time interaction should be an important issue and taken into account. Additionally, a powerful computing capability should be owned to solve the problem that if too many users access the website.

Data format. The data in the system should follow the medical standard format and rules, such as the unit of glucose, it is mmol/L. The medical words should be used seriously.

Data storage. Considering the security issue of the data storage, such as the storage format and privacy information data protection. A proper database with higher security level should be chose.

Data presentation. In order to provide a concise and beautiful view of the data. The data presentation can combine with different presentation formats, such as histogram and table, etc, according the medical data requirement.

3 RWD

In 2010, Ethan Marcotte wrote an introductory article about the Responsive Web Design. Responsive web design refers to the ability of a web page to respond and adapt to whatever device on which the page is being viewed. It aimed at providing an optimal viewing experience: easy reading with the proper resizing, panning, and scrolling.

3.1 Four Principle Methods

There are four principle methods to realize the responsive design when building a website: the media query, view-port, fluid grids and flexible images. These four are the key point to realize the responsive web design.

3.1.1 Media Query

To design a responsive web, we should use the @media queries technique to change the layout of the page based on the width of browser and CSS. Media query are a bit of CSS in a web page that can inspect the physical characteristic (i.e., the width and height of the screen in pixels) of the device, which request service.

We added a few media queries to provide an improved experience on smaller screens, like those on a tablet or smart phone. Instead of targeting specific device resolutions, we went with a relatively broad set of breakpoints based on each handheld resolution as it shown in the Figure 1.

Based on the Table 1, we choose the most popular browser for apple product IOS Safari 6.0 and chrome 26.0 for our testing.

There is a way worth mentioned regarding the responsive web design is that different CSS style sheet can be chosen based on the function characteristic of the request device.

<link href = "styles.css" type = "text/css" media = "screen" rel = "stylesheet"/>

<link href = "print.css" type = "text/css" media = "print" rel = "stylesheet"/>

This is an old way which based on the media attribute with such references as media = "screen" or media = "print". But it can't realize static responsive web design.

The media queries allowing us to target styles based on a number of device attributes, including screen width, orientation, resolution, and so on. Media queries allow us to target not only certain devices and classes of devices, but also allow us to actually inspect the physical characteristics of the device.

Table 1. Physical pixels on the screen for apple product

Displays of current models						
Model	Generations	Diagonal cm(in)	Resolution	ppcm(PPI)	Aspect ratio	Css pixel ratio
ipod Classic	5th Gen,6th Gen	6.4(2.5)	320×240	64(163)	4:3	
ipod Nano	7th Gen	6.4(2.5)	240×432	80(202)	5:9	
iphone4/ipod Touch	4s/4th Gen	8.9(3.5)	960×640	128(326)	3:2	2
iphone4s/ipod touch	4s/4th Gen	8.9(3.5)	960×640	128(326)	3:2	2
iphone5/ipod touch	5/5th Gen	10(4)	1136×640	128(326)	71:40	2
ipad mini	1st Gen	20(7,9)	1024×768	64(163)	4:3	1
ipad	1st Gen,2	25(9,7)	1024×768	52(132)	4:3	1
ipad	3rd Gen,4th Gen	25(9,7)	2048×1536	104(264)	4:3	2

3.1.2 View-port

The media query can already do a good job when we adjust the size of the browser, but it does not meet the mobile browser's requirement, this is because the mobile client browser (iPhone, iPad/Safari, Android/Chrome) will default the page is designed for wide-screen, so it will shrink the entire page to fit the small screen. This indicated that just media query technology is inadequate to realize responsive web design, the solution is to combine the media query with Apple's viewpoint mega tag in the head of the document.

```
<meta name="viewport" content="...">
```

There are two ways to type in the content, "width=device-width" is available, but it will just meet the requirement when the device is portrait, but when the device is rotated to landscape, the screen will not responsive. We use the second method which set the content attribute value to "initial-scale=1.0, maximum-scale=1.0", the setting of initial-scale=1.0 means that initializing the page without zooming, the effect of maximum-scale=1.0 is to prevent the page zoom in rotation. But it also brought a more serious problem: preventing the user to manually zoom in or out on the page.

3.1.3 Fluid Grids

A fluid is a substance that continually deforms (flows) under an applied shear stress, generally, web pages are made up of columns and rows. Traditionally, this is always done with the use of fixed widths, like width: 20px; Responsive web design make the size of these pages relative to the screen size, rather than a fixed width. Without setting specific number of pixels wide, the container is instructed to occupy 25% percent of the width of the screen. If different device request service from the website, the block will change relatively. Fluid grid layout is constructed by percentage, instead of pixel. Following is an example of fluid grid:

```
  div
{
  width: 90%;
}
```

To determine the percentage of the fluid grid, you have to calculate the proportions for each page element, you must divide the target element by its context, we can calculate the extents for each page element with the formula given below:

target / context = result.

It is easy to understand this formula with the example "body {font: normal 100%;}" Let us assume that the font default width size to be 10px, we can apply such font-size on the formula. We have to divide the target value (20px) by the font-size of its container (10px): 20÷10=2.

So header h1 is two time of its default body font. We can denote it by em, then we can put into our CSS style sheet with ".h1 {font-size: 2em;}" (1em is equal to the current font size).

While fixed-width layout is constructed by specific pixel measurement. This type of layout is commonly used for web design. Following is an example of fixed grid.

```
  div
{
  width: 900px;
}
```

Fixed grid seems more intuitive to set the div width-size with practical value;

When selecting which method to be used in our E-health model, we take these two into consideration. Now more and more people would like to use high end and fast system/devices (it is clear that the user of iPad and iPhone occupied the most proportion.), so our E-health Website will mainly suitable for the mainstream handhelds such as iPhone and iPad users. With this precondition, four CSS style sheet are enough for our E-health website application. There is no doubt that fluid grid works better than fixed grid, but when applying fluid grid in the model, some shortcomings come out, for example, when design a new web page, we should first assign the whole layout of each module for every handheld device and compute the relative percentage size of the component, it would take much time and energy on the overall design. It is indeed that fluid grid display perfectly on most of the device, but in some specific condition such as when we have already arranged an font size proportion and it will change relatively between the scope from 0-300px, it also display suitable for the device whose resolution is 200px but not perfect because of the deforming image or font-size, which will not meet the user's aesthetic feeling, while fixed grids becomes more simple, just setting the practical value will be more convenient, and it looks more intuitive. Considering all of these practical situations, we combine the fixed grids with fluid grids method together.

3.1.4 Flexible Images

When a grid scales in size, then generally the images and text inside it also need to scale. Originally, if the actual width of the image is wider than the width of the device, this will distract the container, to solve this problem, just the same as fluid grids, images (or any

content in a grid) are instructed to take up a certain percentage of pixel space relative to the container they are in. When the container changes, the images inside change, too. Following is an example of flexible images, the principle is same as fluid grids and use the same formula to calculate the percentage too.

```
   image
{
   width: 30%;
}
```

3.2 RWD Guideline

To design a responsive web page, we should use the technologies we have already mentioned above. Following will be the detail guideline of how to use the responsive web design in a E-health application. And we will also give a basic framework structure of the responsive UI designing according to the different devices, such as the PC, iPad, and iPhone.

Firstly, in the structure, no matter which type of the devices you use, firstly we should initialize the page without zooming when the devices is portrait or landscape as the following:

```
<meta name="viewport" content="initial-scale=1.0, maximum-scale=1.0"
```

Secondly, for the different devices, the media query has been used for its display. In the structure, four basic ranges for the device width has been defined. For a screen resolution max width within 1024 pixels, we present the page as the PC and iPad landscape originally designed. For max width within 768px, the page can get the styles for narrower desktop and iPad portrait. For max width within 480px, the page can get the styles for mobile phone landscape. And for max width within 320px, the page can get the styles for mobile phone portrait.

In the structure, for different size devices with the same page, four basic modules with the initial width and height have been defined. And at the same time, endue all the style of each module with “float: left “style. For the PC and iPad (no matter portrait or landscape), each module width will be pre-defined as 50% relative to the width of the screen (Figure 1).

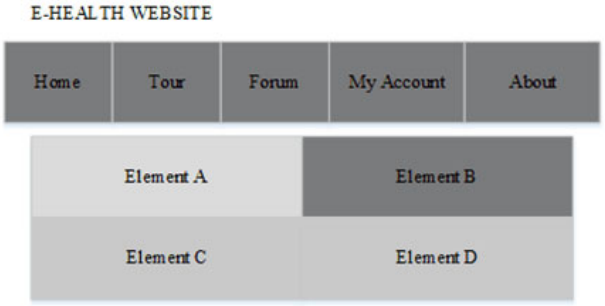

Figure 1. E-Health website 1

And for mobile phone (no matter portrait or landscape), considering the module’s presenting possible smaller if four modules arranged as the PC or iPad, so each module width will be pre-defined as 100% relative to the width of the screen (Figure 2). It will be more suitable for the mobile phone device with smaller screen.

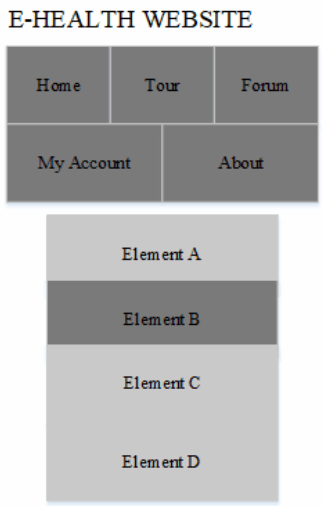

Figure 2. E-Health website 2

Once having the basic framework, some development workload and time will be saved if a new application can directly use this framework. In addition, the developer can do some proper modifications according the real requirements of a specific application. For example, three modules can be arranged in one row and set the corresponding width as the fluid grids method has been introduced. Lastly, continuous testing and change the style of the element in CSS with proper size and location.

4 Security and Privacy

There is a set of national existing standards named HIPAA security rules (Health Insurance Portability and Accountability Act), which is proposed by the U.S. Department of Health and Human Services in 2005 to offer administrative, technical and physical standards to ensure the security of protected health information (PHI) in the E-health IT system. Combining these rules, some proper rules’ modification will be done to be suitable for the E-health security framework in our project

4.1 Security and Privacy Guideline

The systematic guideline about the security and privacy will be designed and created in the framework as the bellowing:

4.1.1 Account Management

(1) Determine which individuals are authorized to

work with electronic physical health information in accordance with a role-based access approach, in general, there are three basic roles in the framework, which are users, doctors and administrators.

(2) To make sure that each account specified for unique users with correctly bounded.

(3) To offer a proper way for the authorized users' access to any electronic physical health information. For the systems which need a strong electronic authentication like sufficiently complex password [24-26].

(4) Establish account maintenance procedures that make sure some terminated account will have no access control to the information.

(5) The system administrator's number should be carefully managed and kept the minimum number and provided only to personnel authorized to perform identified functions.

(6) The Log activities will be monitored by system administrator logs on a regular basis.

4.1.2 Information Management

(1) Conduct the risk assessments to identify the electronic information resources, and to understand the document risks from security failures that may cause loss of confidentiality, integrity, or availability. The risk assessments should include analysis of situations which may led to modification of e-PHI by unauthorized sources.

(2) Select the appropriate mechanism to protect sensitive or critical relative data which is determined by risk assessment.

- The e-PHI system need to be hardened against known operating system vulnerabilities.
- Protect sensitive data with using appropriate strategies, such as the use of web browser security standards, virtual private networks, and encryption
- Protect all devices against the malicious software, like computer viruses, Trojan horses, etc

(3) Implementation appropriate logical security measures such as encryption to protect data from unauthorized access if the system or workstation including e-PHI cannot be housed in a professionally managed in a secure location.

(4) Implementing procedures to ensure periodic review of logs, including inconsistencies in the report.

(5) Conduct back up of data and software on an fixed timetable. Backup copies should be stored in a physically separate location from the data source.

4.1.3 Information for Users

(1) You should use a complex password to access the information system that containing the e-PHI, the password is very secret so that others can't get it.

(2) Portable devices, such as laptops, if containing e-PHI, the password should be protected or encrypted, since they cannot be physically secured.

(3) Encrypt electronic transmissions containing EPHI whenever deemed possible (like email containing e-PHI). If the encryption is not possible, just considering e-mail a public document.

4.1.4 Other Related

(1) Establish procedures to ensure that electric protected health information can be accessed if an emergency happens.

(2) All confidential emails must be sent via secure channels.

(3) Remind the patients the risks of unsecured emails.

(4) All remote facility access into UC networks must be by secure methods, for example the authorized VPNs.

4.2 General Login and Access Control Structure

4.2.1 Login Structure

(1) Allow the user to login with either his username or his e-mail address.

(2) Allow the user to determine his own password.

(3) Allow the user to login at once.

(4) Offer a login form on access denied pages for the user who are not login.

(5) Using two e-mail fields to ensure accuracy when registered.

(6) The page will redirect to a specific page when the user login.

(7) The page will redirect a specific page after the validation of user's e-mail address.

(8) A user message will be displayed when the user successfully login.

(9) Provide a Public Key encryption for password and related information such as e-mail, etc.

4.2.2 AccesS COntrol Structure

There are many existing access control models can be used to meet the legal requirement such as: Role-Based Access Control (RBAC), Digital Right Management (DRM), Usage Control (UCON), Mandatory Access Control (MAC). According to the specific E-health field, a systematic comparison will be done to choose a proper model and make appropriate adjustment to be suited to our frame.

RBAC. A prospect succedaneum of traditional access control (Autonomic Access Control, Mandatory Access Control). In our model, the authorities are directly related to roles. When a user registered, the user can set a role for himself when they become a member of it, users are assigned to corresponding role based on their responsibility and qualification, and the

diabetes patients and physicians can access their related page with specify role [27-32].

DRM. Pair of keys was generated, including public key and private key. The key pair is distributed by a third part called digital authorization center, which is trusted by users. Public key is used to encrypt while private key is used to decrypt. The message can be read only by the private key holder. The key pair is generated by the record creator.

MAC. In the MAC model, the administrator manages the access control and design the basic strategy. And the other role such as user can't change the rules. Once the strategy is defined, the object access authorization has been assigned to a fixed subject. Though owning a higher security level, this kind of access control model is possible to cause some problems such as the flexible roles' authority. The other roles can only follow the strategy the administrator made instead of flexible role authorization.

UCON. The UCON [33-36] is made up by eight elements: subject, object and right, object attribute, right, authentications, obligations, conditions, it is different with traditional model which has not just subject, object and right, three elements. The authority is based on the attributions of subject and object, and authority requirement. Access right can be assigned before or being the access actions. Mutable attribute is the most different quality, compared with other access control models. Mutable attribute can change along with the change of access result. UCON model includes RBAC, MAC and DRM. It's a new generation of accessing to control model.

Compared with all the access control models, UCON is a more potential model for future design. It's a new generation of access control model. But A UCON based system is more complex than others. It not only costs more money, but also spends more time to design and implement such a system. The MAC's disadvantage is not flexible: access rights are defined for different users; this mechanism implies many administrative operations. At the same time, RBAC model is much easier to design than UCON model. It has the attributes of efficient security and flexibility in E-health system. Based on all the advantages and disadvantages of all the models and considering the specific characteristic of multiple-roles and user-oriented as the following figure shows.

The RBAC is relative suitable for the E-health frame model. In our frame, the RBAC model divides all the users into three basic parts: Administrator, user and doctor. According the different requirement of each role, we set up the different corresponding permissions and actions in the basic frame.

5 Design and Implementation

From the above introduction, the RBAC model (Figure 3) in security and access control part, MWA cloud platform selected as the deployment platform, azure cloud database as the data storage and responsive web design technique used to realize automatically transferring from PC or tablet to handheld devices with concise and comfortable view.

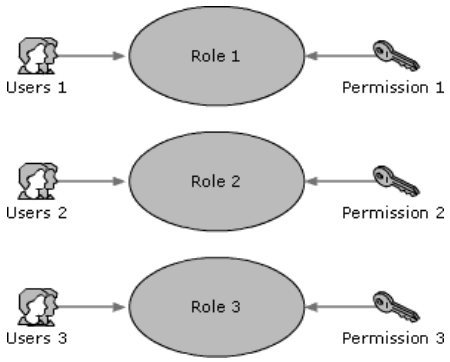

Figure 3. The RBAC model

5.1 Cloud Platform

Cloud computing [37-39] is a framework that make convenient, on-demand network access to a shared pool of configurable computing resources enable. (for example, networks, servers, storage, applications, services and so on) which can be released with minimal management effort or service provider interaction and rapidly supplied and published.

Cloud is a combination of hardware and software, which are being delivered through services. There is three service models provided by cloud computing which offer different levels of control and security. These levels are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), which are in decreasing order of control and increasing order of security [40-43]. According to the requirement and characteristic of the E-health field, we choose the PaaS layer as the basic service model, which has a relative complementary between the control and security. In this level, the user has the ability to develop and deploy the custom applications to the cloud platform.

And now days there are three main cloud platform providers, which are Microsoft Windows Azure (MWA), Google App Engine (GAE) and GroundOS (GOS) in the PaaS level. Among these platform, MWA and GAE are the proprietary clouds, whereas the GOS is an open source cloud. Through a systematic comparison with the providers' general offerings and security protection, some important aspects will be listed in detail as Table 2.

Table 2. Comparison of three popular could platform

	GAE	MWA	Ground OS
Availability	No SLA and no mention of guaranteed uptime	Provided by SLA	Problem of user
Intergrity	Encryption Authentication	Encryption Authentication	Problem of user
Confidentiality	Privacy policy Encryption Authentication	Privacy policy Encryption Authentication	Problem of User Encryption
Authentication	Single-sign on Username & password	Username Password	Problem of user Encryption
SLA	No	Yes	Username&Password
Automated Fail over System	Yes	Yes	No
Price	Normal	Normal	No
Operability	normal	easy	normal

5.2 System Description & Requirement analysis

In the diabetes self-care management web application, some basic modules which common E-health field needed will be designed and implemented. The most important point and initial idea of the whole application aims to offer a platform where the user can realize self-care management and health self-education. In addition, the application will include three different basic roles according to the RBAC model introduced in Section 4. For different roles, the system developers set corresponding authorities according the reality requirement. Then some basic function modules will be developed, such as the Home Page Introduction, Forum page offering a platform to communicating and getting the admin's global notifications and different roles' function modules, etc. The next step is to apply the responsive web design technique to realize the proper view and layout transferring from the PC or tablet to handheld devices automatically. Then another important part about the diabetes patients' data collecting and presentation will be involved in this system to offer a longtime recording and checking for specific properties such as glucoses, weight, exercises and diets, etc. Once referencing to the data storage, the database selection and designing will be considered. Moreover, the personal privacy and data security will be solved in the system. Lastly, the whole will be deployed on the MWA web server to serve for the user and make its sense. The system function and modules designing will be introduced in detail as the following:

Self-care education. The application should offer an education tour platform where the user can obtain some basic information what they want for the diabetes such as the diabetes influence factors, diabetes treatment, diabetes types and nursing method, etc.

Communication platform. The application should offer a communication platform where different roles can share the resources what you have and get the information what they want. In this part, the user can create a subject and read the existed content and the admin can publish the global notification to all the users.

Authorities assigning. The application should offer different roles management, which is the user, doctor and admin. For different roles, they will have corresponding authorities.

- The user can login in its specific page to record and present its own data. Moreover, the user can assign some specific permission to the other users or doctors who they want to share the personal information with.
- The doctor also has its authorities that they can access the specific user's information according to the awarded authorities.
- The admin has the authority to view all the user and doctor's information such as the username, e-mail except login password.

Data collecting and presentation. Aiming at the user's personal data, the application should offer an easier method to record their personal data and offer a concise presentation.

The presentation should include the query to different data according to the record date time with different presentation format such as, histogram, line chart and pie chart, etc.

Concise view. Due to this application mainly serve for the diabetes, and the major crowds of the diabetes patients are the older people. So, the application should have a concise view both on the PC and handheld by responsive web design method. Bigger text and more figure presentation will be preferred by the users.

Security. It's a quite important point for any user due to the privacy data existing. Nobody wants its personal information exposed to the public. So, it requires the protection measures such as access control and database selection and management.

Reliability. The application will offer a longtime service for self-care, education and personal diabetes data storage and checking. So, the system should have a relative reliable performance. So, it references to the database and cloud platform selection, etc.

5.3 Selection of Operating Systems, Tools and Database

5.3.1 Win7, IOS & Android System

Now days Win 7 is the mainstream operating system all over the world and in smart phone market, IOS system and android system has occupied a large part of the market share. So, we choose the Win7, IOS & Android system as the application developed and applied system

5.3.2 HTML5 & CSS3.0

HTML5: HTML5 is the latest version of HTML or Hypertext Markup Language. More accessible on mobile phone applications when written in HTML5 because you needn't write applications for a specific smart phone, but create commonly used applications for all phones and it loads much quicker than the older version because it equipped with the Web Sockets.

CSS3 (Cascading Style Sheets): The presentation of website view can be realized with its flexibility and it makes content prettier. Comparing with trying to obtain the same effect by using some plug-in such as Java Script or offering several different versions of the same image, CSS3 seems much easier to accomplish. Combing the HTML5 with CSS3 together will help you to gain more measures for the responsive web design technique.

5.3.3 PHP & ASP.NET

PHP can be installed on any operating system and Web server other than ASP. NET is only recommended for Windows IIS. In our frame designing, MWA cloud platform and windows cloud database have been chosen as prior Section introducing, so considering the uniformity, asp.net is more preferred in this specific application. Though investigation, it found that PHP is recommended for small-to-medium projects and asp.net for medium-to-big applications.

5.3.4 Cloud Database & Local Database

Cloud Computing can be defined as a service or a platform, or an operating system over the Internet to perform tasks. Database has become a part and parcel of life and is being used in almost every computer application. As it is considered the most basic thing, Cloud Computing also offers this database service. There are two different databases now available in our project, which is Azure cloud database [35] and Microsoft SQL server database server.

In our thesis project, when we have already put the website on the cloud, there are two ways available to store the data, one is storing on the cloud and another is storing the data in local SQL server, we take these two ways into comparison and get the result that the Azure cloud database is better because of four advantage parts: the most important point is that the access speed for the website request with the cloud database will be more faster than the local database when the website has been published on the cloud platform. The second is that it will be flexible and reliable on the cloud platform, the third is that the customer will cost less but own a rapid computation capability and ultimate storage. The last reason is that we don't need keep the local SQL server online all the day but the cloud plbh\atform will satisfy the demand, at any place andanytime, the user can access the website as they like. In the E-health website, the data storage will be huge and the situation will also happen that too many users' login in the record, it may lead to the bottleneck. Although it is also feasible with local SQL server, Azure Cloud SQL server appears much more outstanding.

5.4 System Architecture Design

The whole E-health application frame applies the B/S (Browser/Server) architecture which the mainstream web architecture model (Figure 4). The web browser is the most important application of the client. This model simplifies the client's task and put the core part of the system functions to the server to largely simplify the system development, maintenance and use. Just install a Browser on the client such as Internet Explorer, server install the database such as SQL server, the browser data interaction can be realized with the database through the web server. This greatly simplifies the client computer loads and reduces system maintenance and upgrade cost and effort reducing the overall cost of ownership.

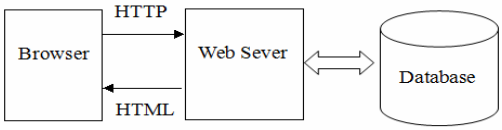

Figure 4. B/S architecture

5.5 System Functions and Module Implementation

Based on the design frame defined in previous Section, a demo web-application aiming to the diabetes self-management will be developed to display how the model can be used into a specific application. The system's functions can be mainly divided into the below several categories: Self-care education, forum platform, data collecting and presentation and security authority setting.

5.5.1 Self-care Management

For the home page and tour page in the web-app on PC. The home page mainly offers a simple introduction and an initial idea of the diabetes and its harm. And the

tour page mainly introduces the causing factors such as the exercise, diet, glucose, etc and how to protect the diabetes.

5.5.2 Communication Platform

In the forum page, it offers a public communication platform for all the users sharing the information and publishes the topic they concern about. In order to fulfill the page, two basic modules, Grid-view and Detail view has been selected to use.

Grid-view. Grid-view table are used for combining the corresponding data from the database and organize with some format to present the information what the users care about.

Text-box. It is the basic components in web-application. The user can put what they want to publish in the text-box and the content can be store into the corresponding table in the database through the back-end operation.

Buttons. Once fulfilling the text, the users can decide whether to send or cancel sending data to server by clckingclicking the Submit button and Cancel button. And some actions of the buttons will be done in the back-end programming.

Detail-view. Detail-view table is used for view the user's detail information rather than the grid-view. Once the user want to view a detail information of a record from the grid-view, it can be easily realized by clicking the Select link. Certainly, corresponding data combining will be done.

5.5.3 Data Collecting and Presentation

For example, it will collect users' exercise condition, food and weight and record the data into the database for the user. What's more, through the Calendar module, each record of the user can be stored according to the date and now-time. For the user data presentation, the user can view either the historical records or some specific records during some periods through selecting the date form the start calender and end calender. The other data presentation page is roughly the same.

5.6 Security and Privacy

5.6.1 Password Security

When a new user surf the website, he needs register a new unique account for himself which can be used to identify who is him when he surfs the site again later. And the user should offer his e-mail address, age, and protecting answer, etc some basic information which is possible to be used in password setting and getting back pages. Through password verification, the user's information can be well protected.

Besides the password setting, we can through answer the security question and fulfill the right now password registered before, the user can realize the password changing to improve the password security. What's more, when user forget the password, the user only needs to answer the security question and username, the password will be sent to his personal e-mail box automatically.

5.6.2 Authority Management

This is the model what has been discussed in previous Section. And in this section, a detail process will illustrate how to apply the RBAC model. This part includes user page, doctor page and admin page.

Through setting three different roles according the RBAC rules, the whole website can realize the access control and privacy security. The user can access his own personal data collecting and presentation, moreover, he can set some specific permissions for the specific user and doctor. Only those authorities granted information such as glucose, diet, etc, can be viewed by the specified doctor. It well protects the user's privacy data and offer a better mechanism to give the permissions to the doctor and the other user. The doctor can view some specific information of the patient only when the user grants the permission. Then the doctor can offer some professional advice and the other user having a relationship with the user can observe and take care of the patient., in the administrator page. In this page, the admin has the permission to view the user and doctor's detail register information except the password. It is a good measure to protect the user information security without arbitrary changing. In addition, the admin also has the permission to delete a specific user or doctor, once he confirms the user is a malicious or false user. Publishing global notification permission is also granted to the admin to give some important notes in the forum platform.

To sum up, the above illustration presents the basic applying process with the basic model, and more security measures can be added in the future work.

5.7 Responsive Web Design Methods Application

The page displays differently to different devices, following are the three different views when laptop, iPad and iPhone visit the website.

We will give an example of our home page to introduce how to use the framework defined before to realize the responsive web design.

(1) Firstly we should change the header to <meta name = "viewport" content = "initial-scale = 1.0, maximum-scale = 1.0">

(2) Secondly we put all the words and image in div container with HTML programming language. And enduing all the style of the div with "float: left "style.

In the application, four basic modules have been used. But some modifications have been done because the page will have more contents and information, so

more modules have been added into the structure according to the requirement. Moreover, we can set all the element in the div container with flexible size or fixed size (Figure 5).

(3) Thirdly with the help of the media query technology, affording another CSS style, which has already set breakpoint of the scope for different device. And enduring another CSS style with the flexible and fixed technology (Figure 6).

```
<div class="homeupright" id="2" style="display:none">
    <asp:Image ID="Image4" class="Image1" runat="server" ImageUrl="~/picture/logo.jpg"
        Height="229px" Width="358px" style="display:none"/>
    <asp:Image ID="Image5" class="Image1" runat="server" ImageUrl="~/picture/dia.jpg"
        Height="229px" Width="358px" />
     <asp:Image ID="Image9" class="Image1" runat="server" ImageUrl="~/picture/oldpeople.png"
        Height="229px" Width="358px" style="display:none"/>
```

Figure 5. The core code for this part

```
@media (max-width: 320px)                    /*mobile phone, orientation:portrait */
{
    .page{width:320px;}

    /*---------------Home Page-----------------*/
    .homecontent{width:300px;}
    .homeupleft{max-width:30%;float:left;text-align:left;font-weight:bold;}
    .homeupright{max-width:280px;float:left;margin-top:15px;}
    .homedownleft{max-width:280px;float:left;margin-top:15px;}
    .homedownright{max-width:280px;float:left;text-align:left;margin-top:15px;margin-bottom:20px;font-weight:bold;}
    .Image1{max-width:260px;}
    .Image2{max-width:260px;}

    .firsttitle{max-width:300px;}
    .video{max-width:80%;max-height:203px;}
    .AdRotator1{max-width:270px;}
    .AdRotator2{max-width:270px;}
    .homebottom1left{max-width:270px;}
    .homebottom1right{max-width:270px;}
    .homebottom2left{max-width:80%;}
    .homebottom2middle{max-width:80%;}
    .homebottom3right{margin-left:0px;max-width:270px;}
    .homebottom3right iframe{margin-left:0px;max-width:270px;}
    .line hr{ max-width:270px;}
    .line p{ float:left;}
    div.menu ul li a, div.menu ul li a:visited{margin-left:0px;}
    /*---------------Home Page-----------------*/
```

Figure 6. The core code for this part (Step 3)

(4) Lastly, continuous testing and change the style of the element in CSS with proper size and location.

6 System Test and Evaluation

6.1 Performance Testing

Page loading time is an important part of providing a responsive user experience, and extensive web research suggests that it correlates to how long users will stay on a website and how satisfied they are with the interaction. It also directly determines the search engine ranking of this website.

Most users will wait only 6 to 10 seconds for a site to load. As page load speed is very important, we have to consider about how to improve the speed, the download speed of the network would be considered first. We separately test our two websites with responsive and no responsive technology, with the chrome browser. When testing the speed of these two websites, we use the page speed tool comes from Google and www.webpagetest.org, these two tools are very useful which would generate the report of testing. With the help of these reports, we can directly recognize the advantage of responsive web design. From the detailed report of using the same device to detect the website which is with and without responsive web design. We can see that the result from Google page speed tool: The page default got an overall PageSpeed Score of 88 (out of 100). (responsive page) The page default got an overall PageSpeed Score of 83 (out of 100). (no responsive page). We can draw the conclusion that the user can get more faster and simper experience with the responsive website since it is more faster which is 4.172s while the non-responsive website get the page load speed of 7.072s. Speed is a core feature in website creation, responsive web design not only meet the customer's requirement and also help the web provider restore the loss.

6.2 Black Box Testing

Black box testing is applied during the development of project work. Black box testing is primarily used for testing the functionality of the system website function black box testing (Table 3).

Table 3. Table for website function black box testing

Test number	Description	Expected outcome	Pass / Fail
1	Register a user with all the information fulfilled: (1) Input all the information in the text box and scroll all Seekbars to a certain value (2) press the submit button	A successful messageshows on thescreen, indicates register successfully.	Pass
2	Register a user without all the information fulfilled: (1) Input the information in one text box (2) press the submit button	An error message should pop up on the screen that indicates registering data unsuccessfully.	Pass
3	Register a user with the password less than 7 byte	An error message should pop up on the screen that indicates minimum password should be 7	Pass
4	Change the password with the security answered the same when the user registered	A successful message shows on the screen, indicates change the password successfully.	Pass
5	Change the password with the security answered not the same when the user registered	An error message should pop up on the screen that indicates the security answer is not correct	Pass
6	Change the password with the old password not the same when the user registered	An error message should pop up on the screen that indicates the old password is not correct	Pass
7	Cancel the data fields (1) Click cancel button	Seekbar's and EditText's values need reset to default values.	Pass
8	Cancel the data fields (1) Input the data in one of the data field or scroll one Seekbar (2) Click cancel button	Seekbar's and EditText'svalues need reset to default values.	Pass
9	Forget the password with choosing the correct security question and typing the security answer correctly	An email with old password will be sent from the official E-health email	Pass
10	Forget the password with choosing the wrong security question	An error message should pop up on the screen that indicates the security question is not correct	Pass
11	Forget the password with typing the security answer wrongly	An error message should pop up on the screen that indicates the security answer is not correct	Pass
12	Plot data (1) type in all the information and submitted	The glucose chart, exercise chart, weight chart and diet grid-view will display correctly	Pass
13	Zooming in and out (1) Visiting the website with iPhone and iPad (2) Turn the device in different orientation	The website will display well whether the iPhone or iPad visits, and whether it is portrait or landscape	Pass
14	Search the doctor and give the specified doctor authority to access the patients specified items	The authenticated doctor will view the specific items of the patient	Pass

All successful testing results indicate the diabetes system's functions according to user's requirement have been generally realized.

Combining the performance testing result in Section 6.1, the two testing, which emphasis on different fields indicate that the core context expressed in this thesis such as the E-health field, RBAC access model, responsive web design guideline and cloud platform, can be well involved in realistic project design and development. In addition, the performance testing result shows that it also can achieve satisfactory results for user experience with a relative shorter time costing. To sum up, the point and guideline presented in this thesis have a certain practical significance and reference value for the future related work (Figure 7 to Figure 10).

7 Conclusions and Future Work

The main purpose of the thesis is to establish a general E-health web application framework including the cloud platform selecting, security mechanisms defining and the usage of the responsive web design technique. Through the systematic comparison, the MWA cloud platform and ASP.Net, HTML5, CSS3 has been chosen as the main tools due to the good compatibility and operability. In addition, a general security guideline, common login structure and RBAC access control structure has been given to protect the personal information.

Moreover, four main methods used to realize the responsive web design have been introduced in the report. And a responsive web framework has been designed to offer a basic referenced model for the future specific application. Finally, a prototype web

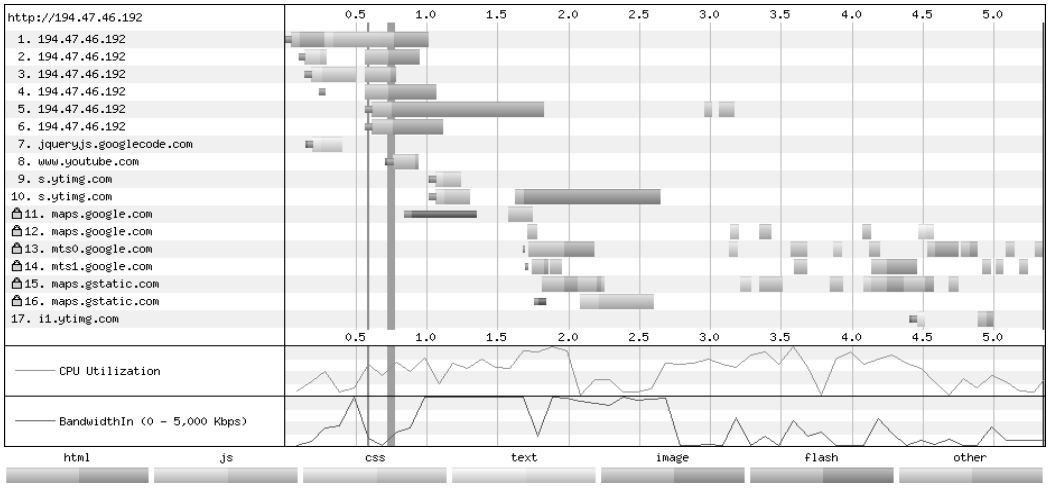

Figure 7. The connection view without using the responsive web design

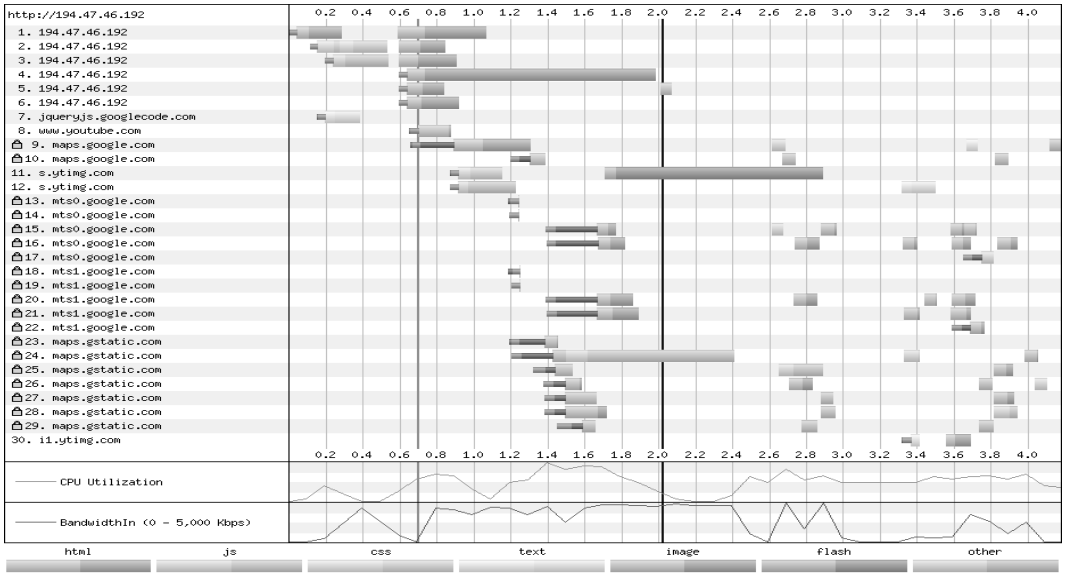

Figure 8. The connection view with using the responsive web design

							Document Complete			Fully Loaded		
Load Time	First Byte	Start Render	Visually Complete	Speed Index	DOM Elements	Result (error code)	Time	Requests	Bytes In	Time	Requests	Bytes In
2.018s	0.100s	0.692s	6.200s	2348	1169	0	2.018s	34	1,228 KB	4.172s	70	1,449 KB

Figure 9. The figure show the detail speed of visiting the responsive web

						Document Complete			Fully Loaded		
Load Time	First Byte	Start Render	Visually Complete	Speed Index	Result (error code)	Time	Requests	Bytes In	Time	Requests	Bytes In
5.349s	0.101s	0.580s	6.600s	2722	99999	5.349s	68	1,490 KB	7.072s	68	1,568 KB

Figure 10. The figure shows the detail speed of visiting the no responsive web

application based on the general framework has been designed and implemented. Through testing, it proved that the responsive web page loads faster than the non-responsive web page.

Since the framework and a prototype have been done in the thesis with in limited time, there are some ways that our method can be further improved and implemented in the future work. First of all, personal data storage will be a main risk for privacy security, especially the password encryption in the cloud database. Some kinds of encryption measures, such as RSA and DES, etc, can be applied to improve the data

security level. Secondly, this prototype just a simple application to show how the framework is applied, so the responsive web design mainly aims to the mainstream handheld device (iPhone and iPad) in the market. Lastly, since the MS cloud database has been selected as the development part of the model, so the data transfer will be further researched and implemented in case the. owner of the website want to change the database vender. Huge amount of data transfer will be a big problem in the future if this situation will happen.

Acknowledgment

This research was supported by Shanghai Science and Technology Innovation Action Plan Project (16111107502) and Shanghai key lab of modern optical system, and also supported by is supported by National Science Foundation of China (No. 61370210).

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