Dental Application: The Steps toward the Implementation of the CephSmile Plus Services

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Abstract- Software plus Services might be the next step in the evolution of computing. Software plus Services is a concept that Software as a Service (SaaS) complements the traditional packaged software running on both client and server by services adding value. CephSmile V2 is dental application software for 2D cephalometric analysis, dental model analysis and focusing on orthodontics treatment planning and applied to simulate changes on the facial profile after receiving treatment. CephSmile V2 could be used to analyze craniofacial growth changes that lead to skeletal discrepancies and to study the cause of malocclusions. Since CephSmile V2 is intended to be sell as services or so called CephSmile plus Services, therefore, the implementation of the program to enable access to the web database is developed. There are two main steps for developing the CephSmile Plus Services. First step is the development of CephSmile V2 Program, which six main features have been developed as follows: Lateral Cephalometric Analysis, Superimposition, Orthodontic Treatment Simulation, PA Cephalometric Analysis, 3D Skull Simulation from 2D x-ray views and Dental Model Analysis. Second step is the implementation of CephSmile Plus Services, which divided in to two main steps: First step is the development of web database which is designed using PHP and MySQL. Second step is the further developing on the CephSmile V2 program to connect to the database via the network follow REST guideline using GET and POST methods. The result shows that CephSmile V2 can be used as a diagnostic tool for orthodontics treatment and simulation which requires username/password to login to database. The result also demonstrates the details of login user to use the CephSmile V2 program in term of amount of hours, amount of usage, functions that user has been accessing. Also the administrator is allowed to create the user account and setup the capabilities of user level in different packages: gold, silver, platinum and titanium packages. It is concluded that CephSmile plus Services can be provided to the orthodontist community as software plus services.

I. INTRODUCTION

For many years our lives, our businesses, and our social communities have been transformed by the World Wide Web (WWW) technology. Software plus Services [1-2], which is first introduced by Microsoft, might be the next step in the evolution of computing. Software plus Services is the combination between hosted network services and locally running software application. It describes composite applications created by combining traditional software with remote network services to provide a consistent and seamlessly integrated user experience across devices and form factors. Software plus Services is a concept that Software as a Service (SaaS) [3] complements the traditional packaged software running on both client or server by services adding value. One hope is that web services will enable cross-organizational applications that are at the heart of e-Business and e-Government. Web services are taking place in society with the goal of making it possible to easily link programs and data from various sources including WWW in a way that creates a new look at the data or even a new application. Web service is a topic that has garnered a lot of attention in the last few years. There are currently two ways of thought in developing web services: the traditional, standards-based approach SOAP (Simple Object Access Protocol) and conceptually simpler and the trendier new kid on the block REST (Representative State Transfer) [4].

CephSmile V2 [5] is dental application software for 2D cephalometric analysis, dental model analysis and focusing on orthodontics treatment planning and applied to simulate changes on the facial profile after receiving treatment. CephSmile could be used to analyze craniofacial growth changes that lead to skeletal discrepancies and to study the cause of malocclusions. The first version of CephSmile has become commercial software, available in the market since 2006 and a studying tool at Dept. of Orthodontics, Mahidol University. CephSmile v1.0 has been sold as a single license with hard lock for security protection. For the second version of CephSmile, the graphic user interface (GUI) is much more attractive, convenient and easy to use. Also more functions have been added and also the previous features have been enhanced for more analysis results as well.

The most important of CephSmile is cephalometric analysis function which is a standard procedure for orthodontic measurements. Furthermore, two-dimensional cephalometric measurements from lateral and/or frontal cephalograms were widely studied for diagnosing the abnormalities of skull bone and tissue and could be a tool that leads to an appropriated treatment planning by clinician as well. The dental software applications that similar to CephSmile and also focusing on cephalometric analysis are available such as OrisCeph® Rx3 by Elite computer Italia S.A. [6], OnyxCeph™ by Image Instruments GmbH [7], Dolphin Imaging [8], Quick Ceph Studio® by Quick Ceph System Inc. [9], Dr.Ceph® by For Your Imaging Technologies [10], WinCeph™ by Rise Corp.[11] and so on. But the only one that is available online as a service is cephX by cephX Inc [12]. However, cephX is available only cephalometric analysis function and need to connect to the
internet all the time when running because it is developed as a web application. Therefore, software plus service is probably better in terms of the users’ don’t need to connect to the internet all the time. Also software plus services is better to use in the rural area where the internet is not stable. Since CephSmile V2.0 is intended to be sell as services or so called CephSmile plus Services, therefore, the implementation of the program to enable access to the web database is developed.

II. METHODOLOGY

A. The Development of CephSmile V2

CephSmile V2 is a windows-based 2D & 3D computer graphic aided planning software for orthodontic diagnosis and treatment which allows users to perform the lateral, PA cephalometric analysis, dental model analysis and facial treatment simulation by the tools provided in this software. CephSmile V2 is written in C language and developed using Borland C++ Builder with the combination of image processing technology and openGL. CephSmile V2 has been designed for dental clinicians to perform cephalometric analysis with different types of analysis, both National Analyses (Mahidol, Chula, Songkha, Konkean) and International Analyses such as Down, Steiner, Tweed, Jaraback, Harvold, Rickette, McNamara ABO, and Sassouni Analysis which are the significant data that show the structural problems on skulls, face, and teeth. CephSmile V2 has the main features as followings:

1) Cephalometric Lateral Analyses [13]

CephSmile V2 program is able to perform curve fitting, and smoothing the trace lines by using a few landmarks before calculating the angles and distances according to trigonometric rules, and comparing the results with the standard cephalometric values for Thai people.

CephSmile can perform cephalometric analysis as shown in Fig. 1 with different types of analysis including Mahidol, Chula, Konkaen, Songkla, Chiangmai, Down, Steiner, Tweed, Jaraback, Harvold, Rickette, McNamara ABO, and Sassouni whose data from different types of cephalometric analyses indicate the structural problems on skulls, facial profiles, and malocclusion on the teeth.

2) Superimposition

CephSmile V2 is also able to record the results and display the recorded data for comparisons using Superimposition program to compare the results pre and post orthodontic operation. This function can show comparative changes on facial profile as well as dental structure during the orthodontic treatment periods, so that the patient can view changes as time has passed as shown in Fig 2.

3) Orthodontic Treatment Simulation [14]

CephSmile V2 can determine and simulate dental and facial changes on a patient’s face after orthodontic treatment. With this simulation, the patients are allowed to see the post-treatment facial structure before the actual orthodontic treatment has been executed as shown in Fig3, which the first image show the original photo and the last image show the simulation of treatment. Therefore, the patient who needs braces to correct the teeth’s positions would find the treatment more informative and useful.

4) PA Analysis [13]

CephSmile V2 can perform the frontal PA Cephalometric Analysis to make symmetry analyses and complete the cephalometric analysis process. The PA Analysis of CephSmile also has a function to perform curve fittings smoothing the trace lines by using only few landmarks before
calculating the distances according to trigonometric rules, and then compare the symmetrical analysis results relatively to different reference axes as can be displayed in Fig 4.

5) 3D Skull from Lateral-PA X-ray 2D Projections [15]

Since X-ray images can be obtained with ease from clinical procedure, so CephSmile V2 has presented the technique on 3D skull simulation based on 2D projections as a substitute for the expensive CT scan. CephSmile can perform the simulation of 3D skull by only applying an inexpensive X-Ray Images including lateral and PA views along with the corresponding cephalometric landmarks and line tracings. The result of the 3D simulation can be seen as in Fig 5.

6) Model Analysis [16]

CephSmile V2 can perform 2D Digital Model Analysis and Planning, including Bolton Analysis (the ratio between sum of the upper teeth widths and sum of the lower teeth widths), dental arch parameters along with dental segmentation before performing orthodontic simulation as shown in Fig 6.

CephSmile V2 also has been approved by Ethic Committee for clinical trial in the project “Study of the Accuracy and Reliability of CephSmile Program Version 2” by Faculty of Dentistry, Mahidol University, Thailand on 23 June 2009.
Fig. 8. Flowchart shows the system activity when the member login to the CephSmile V2 databases both via WWW and CephSmile V2 program.

2) Developing of CephSmile V2 program to connect to the database via the network.

2.1) Send message and receive a response via POST

For further development, the Internet Direct (Indy) components [17] have been applied for connecting to database via the network. Internet Direct (Indy) is an open source internet component suite comprised of popular internet protocols written in Delphi and based on blocking sockets. Fortunately, Indy is also included in Borland C++ Builder. The IdHttp component of Indy has been applied. The procedure of simple code below attempts to POST data to the website and receive a response. Then the message from the program needs to be checked for authentication every time it is running.

```
// C code for POST data to the website and receive a response.
data->Values["username"] = user;
data->Values["&password"] = pass;
data->Values["&timestamp"] = datetime;
IdHTTP1->Request->ContentType = "application/x-www-form-urlencoded";
IdHTTP1->Post(Trim(web), data, Receive);
Receive->Seek(0, 0);
Memo1->Lines->LoadFromStream(Receive);
```

2.2) Encode/Decode the message

Apart from the procedure to POST data to the website and receive a response, the Encode/Decode of the message that transferred via the network also should be done for the security issue as well.

There are some popular encode/decode algorithms available such as Encode/Decode of Base64, Base85, URL and only encoding but not decoding such as MD4 hash, MD5 hash, SHA1 hash [18]. Table 1 shows the example of encoder/decoder on example strings.

<table>
<thead>
<tr>
<th>Encoder Algorithms</th>
<th>Encoder String</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base64 Encode</td>
<td>Q2hhbmpcmEgU2ludGhhbmF5b3RoaW4=</td>
</tr>
<tr>
<td>Base85 Encode</td>
<td>&lt;-6YKuGC2%]4+B)uFD,*#@&lt;ld5BPD-&gt;</td>
</tr>
<tr>
<td>URL Encode</td>
<td>Chanjira+Sinhanayothin</td>
</tr>
<tr>
<td>MD4 hash</td>
<td>728153451b7875f5e8c6bd440da75d827</td>
</tr>
<tr>
<td>MD5 hash</td>
<td>40999261jd36ade4be677c6de1763</td>
</tr>
<tr>
<td>SHA1 hash</td>
<td>8Ec56a1138a3c27282b395e5295a45da6587fdb</td>
</tr>
</tbody>
</table>

2.3) Modify windows registry

For the security reason, the CephSmile V2 program has to send some values that always update every time the program is running to protect the copying of the message and the hacker might use it again and again for authentication. This can be done by modifying the windows registry. Windows stores its configuration information in a database called the registry. Registry is created from thousands of setting values. These setting values are categorized in a tree of folders. These folders are called keys. Setting values are inserted inside keys [19]. Normally registry can be edited and viewed with regedit.exe program that comes with windows by running it from command prompt. For our work, the registry needed to be accessed and edited using CephSmile V2 program. The example of C-code for update the value in registry can be shown as follows.

Fig. 9. The class diagram of CephSmile V2 database, which described the structure of the system.
// C - code for update the value in registry variable
#include <Registry.hpp>
TRegistry *Reg;
int reg_no;

int __fastcall CheckReg_no()
{
    Reg = new TRegistry;
    Reg->RootKey = HKEY_CURRENT_USER;
    if(Reg->OpenKey("SOFTWARE\xxx", true))
    {
        if((Reg->ValueExists("First Run")))
        {
            // Check if the Value
            reg_no = Reg->ReadInteger("First Run");
            reg_no++;
            Reg->WriteInteger("First Run", reg_no);
        }
        Reg->CloseKey();
    }
    Reg = NULL;
    return reg_no;
    delete Reg;
}

2.4) GET the message from server and check for authentication by the program.

Authentication is the act of establishing or confirming something or someone as authentic, that is, that claims made by or about the subject are true [20]. Normally, the authentication has been evaluated at a server side by checking the username/password for confirming the identity of a person. However, to protect the copying of the database to localhost for authentication of using the program, the message that always update should be sent from the server to the program for authentication as well. In CephSmile V2 program, the strings of characters or so called match password which have been set to cover ten years are prepared for 120 strings (one string/month). These match password strings are only known by administrator who can take responsibility to update the match password in the web database every month. Also the date/time when the program is running should be compared between the server date/time and client date/time as well to ensure that a client program is a trusted one.

III. RESULT

For the development of CephSmile V2 program, the program is evaluated from the study of accuracy and precision of CephSmile V2 in all functions that dealing with the measurement by Mahidol University. The results show that there are no significant different from using the CephSmile V2 in comparison to the tracing by manual with the P value greater than 0.05. Therefore, CephSmileV2 can be used as a diagnostic tool for orthodontics treatment and simulation. For the implement of CephSmile Plus Services, the web database and all messages, send and receive via POST from the program, are working well. CephSmile V2 Form for entering username/password and sending information to the database for authentication can be shown as Fig. 10. Also the examples of user account report in Fig. 11 and 12 show the date/time and details of functions respectively when user accessed the program and passed information to the database via the program.

Fig.10. CephSmile V2 Form for entering username/password and sending to the database for authentication.

<table>
<thead>
<tr>
<th>Month : June Of 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>03/06/2010</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>04/06/2010</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>27</td>
</tr>
<tr>
<td>22/06/2010</td>
</tr>
<tr>
<td>29</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>24/06/2010</td>
</tr>
<tr>
<td>31</td>
</tr>
</tbody>
</table>

Fig.11. Example of user account report shows the date/time when accessed to the database via the program.

<table>
<thead>
<tr>
<th>Time</th>
<th>ID</th>
<th>RegId</th>
<th>Function ID</th>
<th>Function Name</th>
<th>Function Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:21:43</td>
<td>19.229.38.15</td>
<td>761</td>
<td>1000</td>
<td>Start Program</td>
<td>0</td>
</tr>
<tr>
<td>10:22:09</td>
<td>19.229.38.15</td>
<td>762</td>
<td>1079</td>
<td>Click 79 Later</td>
<td>0:0:26</td>
</tr>
<tr>
<td>10:22:23</td>
<td>19.229.38.15</td>
<td>763</td>
<td>1791</td>
<td>Ceph Analyst 79</td>
<td>0:0:40</td>
</tr>
<tr>
<td>10:23:03</td>
<td>19.229.38.15</td>
<td>765</td>
<td>1101</td>
<td>Prediction</td>
<td>0:1:26</td>
</tr>
<tr>
<td>10:23:09</td>
<td>19.229.38.15</td>
<td>766</td>
<td>1090</td>
<td>Logout</td>
<td>0:1:26</td>
</tr>
</tbody>
</table>

Fig.12. Example of user account report shows the functions that the user has been accessed and duration times spend.
IV. DISCUSSION & CONCLUSION

The results of CephSmile V2 program, database system and CephSmile plus Services, have expressed that the system under discussion can perform the software plus services. With the CephSmile Plus Services, right now the pre-paid user access account can be set up in four different packages as shown in Fig. 13. Details are as following:

- **Silver package**: It is time-based user access controls with the limitation of the number of hours that the user is allow to use the program. All timing is measured in seconds, which provides great flexibility.
- **Gold package**: It is a number of usage based user access control with the limitation of the number of usage that the user is allowing to use the program. Also each time of running is limited within 2 hours maximum.
- **Platinum package**: It is duration based user access control with date time set up to start and end for using the program.
- **Titanium package**: It is group-based user access control with the limitation of IP address together with username/password for using the program. It is appropriated for the university or hospital that required frequent used of the program.

All Packages are also divided into three packs with the different in the number of functions that available for using. In addition, all packages can even be set to expire after a given number of days.

![Select package](image_url)

1. **Limit the number of hours**

   - **Package**
   - **Silver pack1**
   - **Silver pack2**
   - **Silver pack3**
   - **Buy**

2. **Limit the number of usages**

   - **Package**
   - **Gold pack2**
   - **Gold pack1**
   - **Gold pack3**
   - **Buy**

3. **Limit the number of days**

   - **Package**
   - **Platinum pack1**
   - **Platinum pack2**
   - **Platinum pack3**
   - **Buy**

4. **Limit of IP address (for group account)**

   - **Package**
   - **Titanium pack1**
   - **Buy**

Therefore, it is concluded that CephSmile plus Services can be provided to the orthodontist community as software plus services.

ACKNOWLEDGMENT

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REFERENCES

[1] Software Plus Services. Ref: [link]
[3] Software as a Service (SaaS). Ref: [link]
[7] OnyxCeph™ by Image Instruments GmbH, OnyxCeph, Ref: [link]
[8] Dolphin Imaging 10, by Dolphin Imaging System Inc. Ref: [link]
[9] QuickCeph 2000, by QuickCeph System Inc, Ref: [link]
[10] Dr.Ceph ® by For Your Imaging Technologies, Dr.Ceph (FYI) Ref: [link]
[12] CephX by cephX Inc, Ref: [link]
[17] The Indy Project. Ref: [link]
[18] Encoders / decoders. Ref: [link]
[19] Registry Prog. with C++ Builder and Delphi, Part I, Reading from registry. Online Programmer Ezine, Volume 2, No.4. Ref: [link]