A SMART CARD BASED CAMPUS DENTAL CLINIC SERVICES: EXPERIMENTAL TESTS

Elyas Palantei[1]
Department of Electrical Engineering, Faculty of Engineering
Universitas Hasanuddin, Gowa, South Sulawesi, Indonesia
elyas_palantei@unhas.ac.id

Dewiani[2]
Department of Electrical Engineering, Faculty of Engineering
Universitas Hasanuddin, Gowa, South Sulawesi, Indonesia
dewiani@unhas.ac.id

Asrul Ramadhan[3]
Department of Electrical Engineering, Faculty of Engineering
Universitas Hasanuddin, Gowa, South Sulawesi, Indonesia
asrulramadhan05@yahoo.com

Sigit Lukman[4]
Department of Electrical Engineering, Faculty of Engineering
Universitas Hasanuddin, Gowa, South Sulawesi, Indonesia
sigitlukman.eng@gmail.com

***Abstract* — Patients health records plays very important role in the medical field environment. The medical data recorded could be used as the doctor references for determining the appropriate medical procedures and provide the advanced prompt treatment information to improve the patients' health situation. A common best practice in Indonesia that the medical data recording have been regularly stored using an inefficient paper notes systems. The technique has many limitations. This scientific manuscript summaries the new approach of the dental clinic services based on a smart card transaction that operated and connected to the campus ICT network. A smart card based dental clinical services applied were significantly helping to maintain the administration procedures, the medical service billing/ payment and the medical data printing for an authorized purpose. In practice, the smart card was enormously used to run the web based dental clinical application installed in the local cloud server. The proposed clinical service allows more flexible, secure and efficient ways to store the medical data as a doctor completely performed the patient health diagnostic and treatment. A wide accessibility of the recorded medical data is possible to be real timely accessed. It would not only be used by an authorized doctor or nurse on duty in the clinic but it could also be permitted for the patient family and other healthcare centers to access through the internet connection from a remote location for an urgent and specific purpose. Some experimental testing were performed to both smartcard and reader parts in the actual environments. The testing results exhibited the excellent performance improvement of the proposed dental clinical service model of which outperformed the conventional one. The interested testing were uniquely obtained during the computing steps of the KSCI contact smart cards (KSCI – Indonesia Smart Card Consortium). The average programming speed to write the specific IDs of an authorized user into a smart card was in average 0.49 Second. Meanwhile, the average reading time to load the programmed smart card data into the local cloud server where the campus clinical service application installed was abruptly 16.3 Seconds.**

***Keywords — Medical data recording, KSCI smart card*, *Healthcare services, Mobile computing*, and Web based cloud computing.**

I. INTRODUCTION

The amendment of the 2008 health regulation by the Ministry of Health, Republic of Indonesia, was considered of how important the role of the medical data recording in the healthcare atmosphere. The medical record system regulation is necessary because it is the important documents of which recorded many things regarding the patient's condition and listed further possible medical actions preserved later on [1-8]. For a long time period, the medical records have actually existed in the form of the notes/ written papers or electronic devices that contained the information regarding the patient's identity, diagnosis, type of diseases, and others. Recently, the use of medical records in the form of the paper based notes are still very widely used as a database for storing patient health data and other related information. The technique has many disadvantages. These are much related to the standardization issue, time consuming and speed to retrace the required medical data to reuse as the reference for further healthcare treatment. A serious problem might be existed also while the medical notes was stored for a long time interval due to the paper damaged or the unclear written note.

Several number of the new electronic medical record based on smart card transaction was investigated elsewhere for more than ten decades. For instance, a typical medical record that uses a smart card based health computerization record system had been released in the papers [1-2]. Those types of medical record makes it possible to store all medical data or part of a medical data to record on a computer. This system makes it easier to recheck data and update it, also provide standardization of the medical record system to maintain consistency and quality of the system. The ease way of data analysis and the ability to process healthcare services efficiently will provide the great benefits both for patients and dentists.

The similar methods were previously studied in [3-5]. For instance, in reference [4], the research project regarding smart healthcare service was implemented at UI campus by deploying the smart card device based on Java card. Meanwhile, another interesting smart card based electronic health record system for a clinical practice presented in [5] was also demonstrated the interested outcome. The use of smart card will greatly assist the administrator while reading patient data because it only takes a very short time to carry out the admin process. Thus, it is expected to improve healthcare quality of services (QoS) considerably. The new proposed medical data record outlined in this manuscript is ensured to overcome the traditional manner of the medical data storage. The proposed real-time dental clinical service is also enable to utilize for another powerful verification tool to identify an unknown dead body performed by the authorized police and medical team in a particular crime investigation. The dead body could be easily and accurately recognized by identifying and comparing the teeth structure.

II. LITERATURE REVIEW

A. Medical Records: Background

According to Indonesia Medical Practice Law in the explanation of article 46 section (1) related to a medical

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records definition, it is mentioned that a recorded medical data is a file that contains records and documents about the patient's identity, health examination, treatment, actions and other services that have been given to the patient. The form of medical record in the form of a manual is written in full and clear or in electronic form according to the provisions. Medical records consist of patient data records carried out in health services. These records are very important for the sustainable health service to patients. A fully completed of the medical data recording can provide information on determining decisions for further treatment, medical action and others. Doctors or dentists are required to make medical records according to applicable rules [6].

B. Dentistry Medical Record

A dental medical record is a systematic documentation of a patient's dental health history by means of health services. This documentation can be found in the form of written notes or in electronic form, but must contain complete and accurate information about the patient's identity, diagnosis, course of the diseases, ICD 10 disease code, treatment process and medical action and documentation of examination results [7]. An odontogram is a map of the picture of the condition of the teeth in the mouth which is an integral part of the dentistry medical record (see Fig.1). The odontogram has several objectives, namely:

1. General purpose

To find out the condition of a person's teeth.

2. Specific goals

• Provide a general description of the condition of the patient's teeth and mouth.
• It is a legal document that can protect dentists and patients.
• As a resume, the condition of the patient's teeth and mouth both for the benefit of patients and referrals.
• As a basis for planning treatment/ needs of dental equipment/ materials through DMF/T calculations
• As research material.
• As the medium of identification [7].

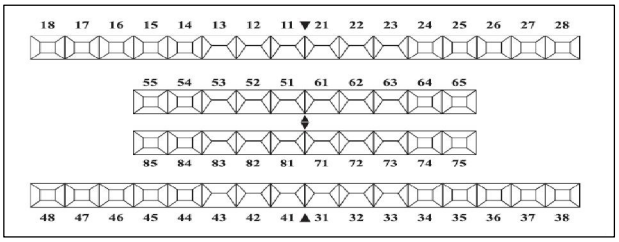

Figure 1 An Odontogram View

Based on the image, the first digit resembles the position of the teeth, 1-4 means the upper right, upper left, lower right, and lower left, respectively. Whereas 5-8 resembles the same thing but specifically for children's teeth. For the second digit, the smallest digit resembles the front teeth to the rear for the largest digit.

C. Telemedicine

In general, telemedicine-based health services are the use of information and communication technology combined with medical expertise to provide health services, ranging from consultations, diagnoses and medical actions carried out remotely. To be able to run well, this system requires communication technology that enables the transfer of data in the form of video, voice, and images interactively by integrating them into supporting technology. This include telemedicine support technology and image processing technology for analyzing various medical images. The use of telemedicine is highly dependent on the type of telemedicine applied in a particular environment situation such as tele-consultation, tele-assistance, tele-education and tele-monitoring.

With this system, a simple database will be arranged, which contains a history of the disease for each patient. Laboratory and x-ray results can be sent to support the diagnosis carried-out. Therefore, when conducting long-distance discussions directly, doctors on the other hand can also receive complete data [8].

III. System Design

There are three users involved (as shown in Fig.2) in the medical record and electronic telemedicine, namely.

1. Patient

Patients in this case get 3 access or facilities, namely Smart Card as a storage of medical record data, username and password as web login access to see the results of diagnosis when patients are not near the doctor and chat facilities as a function of the telemedicine system from patient to patient doctor.

2. Administrator

The only one who can access the database from the Smart Card is the administrator, who also has the duty to repair, manage, add, reduce the database, but the administrator does not have the right to add medical record diagnoses.

3. Doctor

Doctors get access or facilities namely ID as an identity and as a username from a doctor who can perform medical records on patients after diagnosing patients.

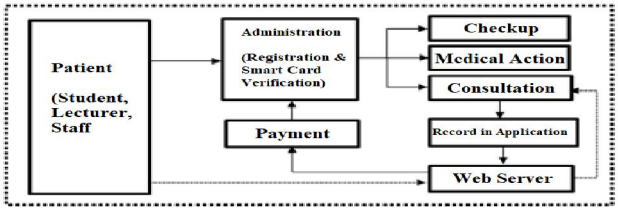

Figure 2 Block Diagram of Patient's Healthcare Check Up in Campus Dental Clinic Center

A. Hardware Configuration

The hardware design includes a series configuration of electronic parts such as the personal computer (PC), contact smart card reader unit, and smart card itself. The system was be designed as shown in the below picture. Whole reader, smart card and smart campus software application was originally constructed and produced by KSCI research team.

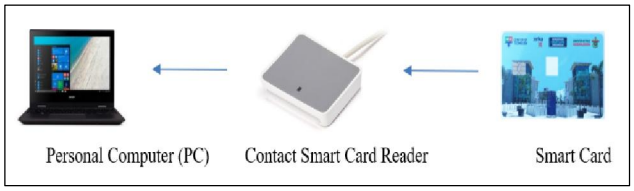

Figure 3 Hardware Configuration

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B. Software Designing

The smart campus application was designed in such manner using various software consisting of Apache Web Server, PHP, MySql and PhpMyAdmin. These all together installed in PC desktop. Another important software required to be configured is the Application Protocol Data Unit (APDU) PC / SC. The design of software installation can be executed using the XAMPP application. However, the configuration is performed by installing the required application one by one manually.

C. Database Designing

The database structure design was created in several tables with their corresponding fields and determine the data type and character size of each field. This is intended to provide a clear picture of what appears on the dental clinical website. Each of these tables consists of:

• Number;

• Field Name; contains any field names that exist in each web page. Examples of tables for Admin pages, there are admin id, name, address, date of birth, sex, phone, email, status, password, and photos.

• Data type; contains the data types of each field. The data types used in this study are as follows.
  - Varchar is a data type for storing data of character or alphabetic (a-z) type.
  - Integer or often short as Int is a data type used to hold data that is numeric or numeric (0-9).
  - Date is a data type used to hold data of the type of date, month, and year.
  - Text is a data type that can be filled with a combination of values between alphabetic and numeric
  - Range; contains the character length of each field. An example for a name field is 50 characters that can be filled.

D. Scenario of Testing

After designing the components that run on personal computers as servers and web services. The system that has been created must be able to handle certain cases that do not fit the scenario path. Following is the test design scenarios from the user side along with the expected output when running the implemented dental clinical system:

Table 1 System's Scenario Test Design

No	Scenario Tests	expected output
1	Useruses non-Xirca smart card to do the card reading	The message failed to read the card will be displayed by the system
2	User uses Xirca smart card to do the card reading	The message was successfully read by the system.
3	Useruses non-Xirca smart card to do the card writing	The message failed to read the card will be displayed by the system
4	Useruses Xirca smart card to do the card writing	The message was successfully read by the system.
5	User unplug smartcard while reading	The message failed to read the card will be displayed by the system
6	Smart card is empty / doesn't contain anything	The message failed to read the card will be displayed by the system
7	Smart card used by the user has data of photo more than 4kb	The message failed to read the card will be displayed by the system

IV. Result and Analysis

A. Page Views

The following is a display of the results from the main page of the medical record website. To access the medical record website, type localhost / record-medical in a web browser. Then the login form page will appear as shown in Fig.4. After successful accessing the local host/ medical record, an ID column, password and role will appear on the main page. This page has the main function as an identification of user access rights. The user accesses verification is shown in Figure 4.

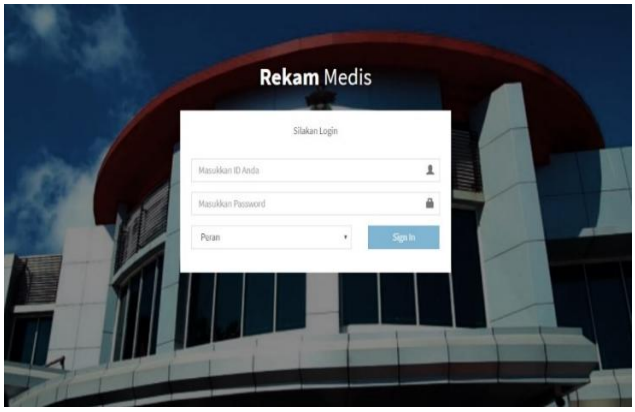

Figure 4. The main menu of the dental clinical Web cloud application

B. System Testing Operations

Smart card testing is carried-out by observing the writing speed of the card used by the reader. The following results of the test graph obtained based on the speed of writing into the smart card.

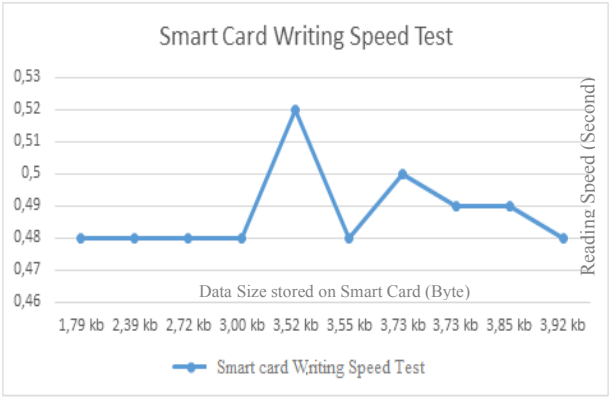

Figure 5 The average writing speed of the smart card

Figure 5 above describes the result of writing speed test of each smart card that has been performed before using a PC-connected smart reader. The average writing speed of the card is 0.49 seconds. In the first and second writing process it is obtained about 0.5 seconds while the next writing process is obtained around 0.48 seconds.

Subsequent testing was performed by observing the reading speed of the card using the PC-Linked Smart Reader. The reading test was carried out by focusing on the reading speed of the card installed on the first time the card is inserted. The following test results are obtained based on the reading speed of the smart card.

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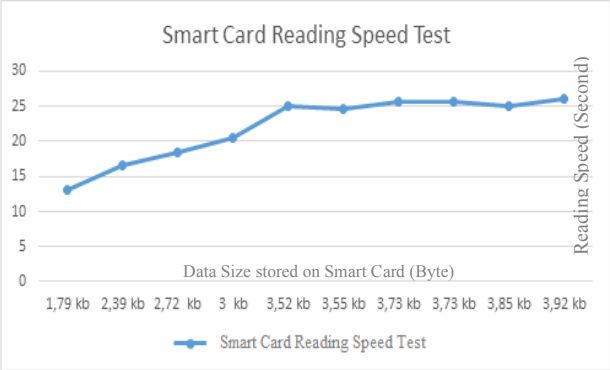

Figure 6 Average Card Reading Speed Graph

Figure 6 above illustrates the result of reading speed test of smart cards on each card. The average card reading speed was about 21.8 seconds, for the card that has the smallest data size that equal to 1.79 kb, the speed of 13.17 seconds was obtained while for the largest data size of 3.92 has a load time speed of 23.07 seconds. The reading process of the data stored inside smart card has a considerable time lag because of the size of the photo file stored in the smart card has a maximum of 4 Kb while the system can only manage 256 Bytes on a single APDU command sent.

The next test was by observing the speed of reading the smart card using two different readers, this was carried-out to test whether the difference use of the reader type will affect the reading process of the smart card. Testing was implemented by installing a smart card on two contact readers, namely ACR1281 1S Dual Reader ICC (reader 1) and PC-Linked Smart Reader (reader 2). The following figure illustrates the test results that were obtained based on the speed of reading the smart card.

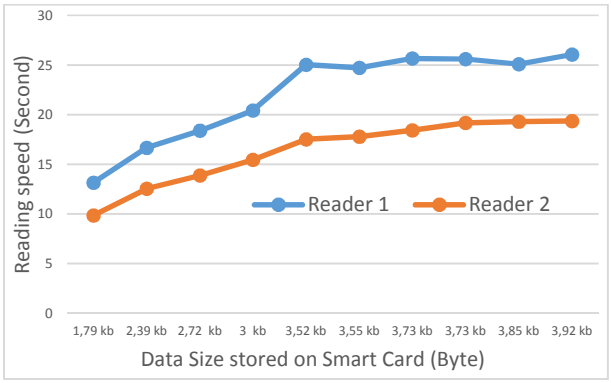

Figure 7 Comparison of the reading speed of two different readers

Figure 7 above demonstrates the result of the reading speed test of smart card on two different reader types. The test result obtained using a PC-linked smart reader (reader 1) that the reader performed an average speed of 17.52 seconds. While using the ACR1281 1S Dual ICC reader (reader 2) it performs an average speed of 26.07 seconds. In case of the largest file size 4 kB stored in a smart card the speed time of reader 1 is abruptly 21.8 seconds while using reader 2 the reading time is about 16.3 seconds.

After designing the components that run on the Personal Computer as a server and web service. The system that has been created must be able to handle certain cases that do not fit the defined path. The following is the test scenario designed from the user perception using two cards along with the output obtained when running the designed dental clinical service application.

Table 2 System Scenario Test

No	Scenario Test	Card 1 Output	Card 2 Output
1	User uses non-Xircа smart card to do the card reading	The message "failed to read the card" is displayed by the system. Notice: Uninitialized string offset	The message "failed to read the card" is displayed by the system. Notice: Uninitialized string offset
2	User uses Xircа smart card to do the card reading	Card Profile was successfully read by the system. The process of reading data is run by the system	Card Profile was successfully read by the system. The process of reading data is run by the system
3	User uses non-Xircа smart card to do the card Writing	The message "failed to read the card" is displayed by the system. Notice: Uninitialized string offset	The message "failed to read the card" is displayed by the system. Notice: Uninitialized string offset
4	User uses Xircа smart card to do the card Writing	Card Profile was successfully read by the system. The process of reading data is run by the system	Card Profile was successfully read by the system. The process of reading data is run by the system
5	User unplug smartcard while reading	The message "failed to read the card" is displayed by the system. Notice: Uninitialized string offset	The message "failed to read the card" is displayed by the system. Notice: Uninitialized string offset
6	Smart card is empty / doesn't contain anything	The message "failed to read the card" displayed by the system. Fatal Error : Maximum Execution Time	The message "failed to read the card" displayed by the system. Fatal Error : Maximum Execution Time
7	Smart card used by the user has data of photo more than 4kb	The message "failed to read the card" displayed by the system. : Data input doesn't success – File is more than 4kb	The message "failed to read the card" displayed by the system. : Data input doesn't success – File is more than 4kb

Based on Table 2 it was confirmed that following the 7 sequential testing scenarios on the dental clinical service application integrated with the developed web service, the whole web service has been successfully configured and operated. Whole smart campus services for dental clinical transaction has normally functioned.

V. Future Works

The current dental clinical system is remaining difficult to run online because there is an APDU protocol that must be installed in the server. The technical difficulty is hard to solve due to the actual problem when hosting in campus public domain network. This is caused the public hosting is not given permission to install the APDU protocol. Therefore, on the next development of smart campus application for dental clinical service to be eligible to run on-line it is required to use personal server to install the APDU protocol. Moreover it will become more interesting if the smart campus dental clinical apps could be modified to include a chatting

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communication features to allow the private consultation between the medical officer or admin on duty in the clinic and the patient in case an emergency situation. The private chat feature incorporated with the Clinic Web Service might provide the easier way for medical consultation if the patients have an emergency conditions that could not allow them to visit the clinic.

VI. Conclusion

The whole experimental testing of the proposed smart card based campus dental clinic services has demonstrated the excellence performance in terms of the quality of the smart campus configuration, the accuracy and the reading/ the writing rate of both reader and smart card parts, and the properties comparison of two different reader types deployed into the smart campus application, i.e. ACR1281 1S Dual Reader ICC and PC-Linked Smart Reader. The ACR1281 1S Reader Dual Reader ICC has a better speed than using a PC-Linked Smart Reader. In overall, the test results for reading smart cards have an average load time of 16.3 seconds. The developed smart campus services for dental clinical transaction system has the powerful impact on the way for recording the patient medical data. Even though, the medical record system constructed in the campus clinic at the moment could only run in the local host because the system requires the installation of APDU on the server while public servers do not allow the installation of APDU. It is currently required to use personal server immediately to successfully install APDU and run the system online. The relatively new medical recoding technique to store the patient's medical record on a smart card based medical service web server has extensively replaced the conventional paper based note. However, in the near future, the new proposed medical service is also possible providing the public access of the medical records stored on the web server. It could be accessed through on-line internet connection from everywhere and any time for a particular purpose. Those of course will be very much helping to improve the effectiveness and the efficient way to serve the patients and the authorized government organization.

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