Multimed Tools Appl (2018) 77:9885–9896
https://doi.org/10.1007/s11042-017-5521-0

Skin care management support system based on cloud computing

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Received: 21 June 2017 / Revised: 1 November 2017 / Accepted: 7 December 2017 /
Published online: 12 December 2017

Abstract In this paper, we propose a skin care management support system that can provide easy intercommunication between patients and medical staff for optimal management of skin treatment and an aid to diagnosis. This system provides self-management and treatment advice for patients from medical staff. Our research is specially focused on the management of conditions such as psoriasis and melanoma. Although there exist systems have been developed for various medical applications, including some that provide self-monitoring via smartphones, the patient participation rate in using these applications has been low after initial use. This is because obtaining useful information regarding the diagnosis and treatment of disease without the support of medical staff is difficult. We propose a skin care management support system with an enhanced interaction method. It leverages a data synchronization mechanism to enable patients and medical staff to view simultaneously. The system environment is based on cloud computing environment, which provides secure communication by using an Advanced Encryption Standard (AES) between patients and medical staff. Finally, we demonstrate the complete skin care management procedure for skin diseases using a smartphone-based portal service.

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Keywords Skin disease · Skin care management support system · Cloud computing · Interaction method · Data synchronization · Psoriasis and melanoma

1 Introduction

In recent years, the prevalence of skin disease has increased owing to factors such as air pollution, environmental changes, and misuse of drugs. The number of skin disease cases has increased over the past few decades [5, 7, 13]. Furthermore, skin cancer is emerging as critical medical issue as the cancer incidence rate has rapidly increased [1]. Most skin diseases are caused by an excessive exposure to ultraviolet (UV) rays. Most UV exposure is related to increased solar radiation due to ozone depletion, but some may be related to artificial light sources, such as indoor UV-devices, like an Ozone apparatus [6, 11]. A hospital provides various levels of skin care services to patients. Theses services can help to provide useful information on skin diseases, early diagnosis, and preventive care [14]. Obviously, early detection is the best way to treat a disease and obtain a high success rate. That is, most skin diseases can be prevented with adherence to a self-care routine. In this regard, numerous studies related to skin care are being conducted to promote prevention and diagnostic monitoring.

The purpose of the development of our suggested system is not only to support patient management of skin diseases and medical staff treatment, but also to help patients monitor self-management efforts on their own. If patients do not adhere to the self-care processes and healthcare recommendations given, it can result in a worsening of their health status and lead to more serious condition such as skin cancer. Thus, the skin care system includes a clinical information system for integrating hospital administration and patient care. In addition, the spread of smartphones and tablets has enabled the hospital medical information system to support smart devices [2, 4]. Most existing skin care applications (called apps) in smart devices focused on self-management with a camera [3, 8, 9].

However, the rate of patient participation in the application has been shown to be low after initial use because it is difficult to obtain useful information about relevant disease using a smartphone application rather than going to the hospital. In other word, a system without interaction with medical staff is not useful to patients. In addition, it is not easy for patients to follow and confirm procedures and instructions of the medical staff, such as nurses, practitioners, medical doctors, or consultants. Hence, we have implemented a skin care management support system based on an enhanced interaction method which provides effective interactions between patients and medical staff. Our system environment consists of smart devices for patients and a skin care portal server for medical staff. Given the variety of devices, we have implemented an active interaction method for the skin care management support system that is based on the cloud computing environment. This feature enables the system to support an attractive interaction with skin images being shared by the detection mechanism.

The paper is organized as follows. Section 2 describes the system's physical and software structure and their functions, and how to interact with the skin care management procedures. Section 3 describes the executed results on their entirely using interaction methods and demonstrates the skin care application services functionality based on the results. Finally, section 4 summarizes our research results, and explains the future development and implementation of the system.

2 Skin care management support system's environment

In this section, we describe the proposed skin care management support system's environment and interaction methods for supporting skin care management between patients and medical staff.

2.1 Physical structure and software architecture

The physical structure of the skin care management support system is shown in Fig. 1. This system is based on Cloud computing and consists of smartphones and a skin Care Portal Server. Additionally, this system provides push services via skin image-data synchronization-supporting smart devices using a Wi-Fi communication interface module. The Skin Care Portal Server is a web-based system designed for medical staff to engage and monitor the skin care information of patients. The primary users of the skin care portal service would be the medical staff who can support the patients. Most medical staff uses a desktop, laptop, or tablet computer to access the necessary information via a skin care portal service. Based on our proposed system, the medical staff can provide each patient with individual instructions for continuing the previously defined skin self-care processes or routines. The skin care portal service consists of observing new skin images issued, explaining skin trouble and reporting cure comments with skin problems' solutions using message exchanging procedures among patients, medical staff and the supporting system.

Figure 2 shows the software architecture divided into the following three layers. The physical layer includes the hardware system and mobile devices, like smartphones and the Skin Care Portal Server. The service supporting component layer includes some components such as skin care information management, file management and security

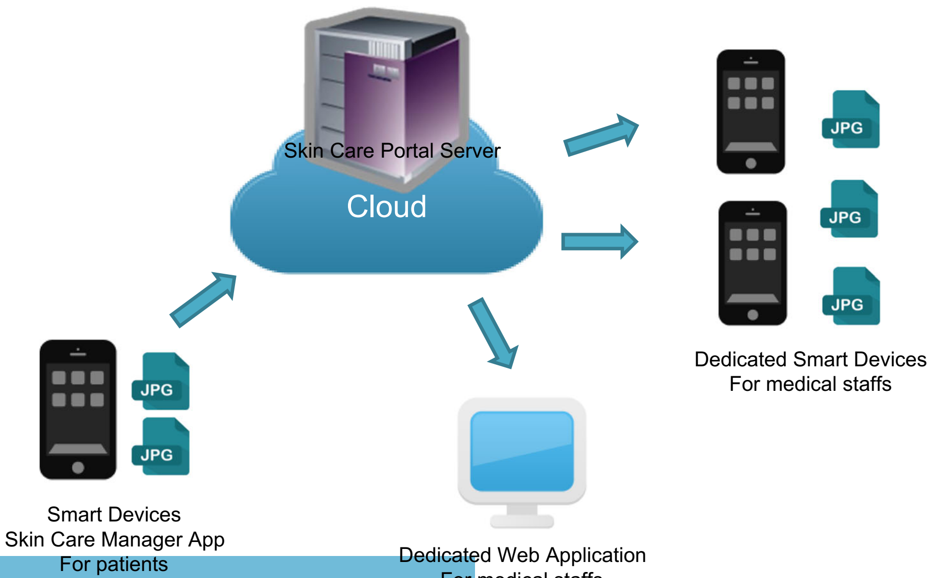

Fig. 1 The physical structure of a skin care management support system

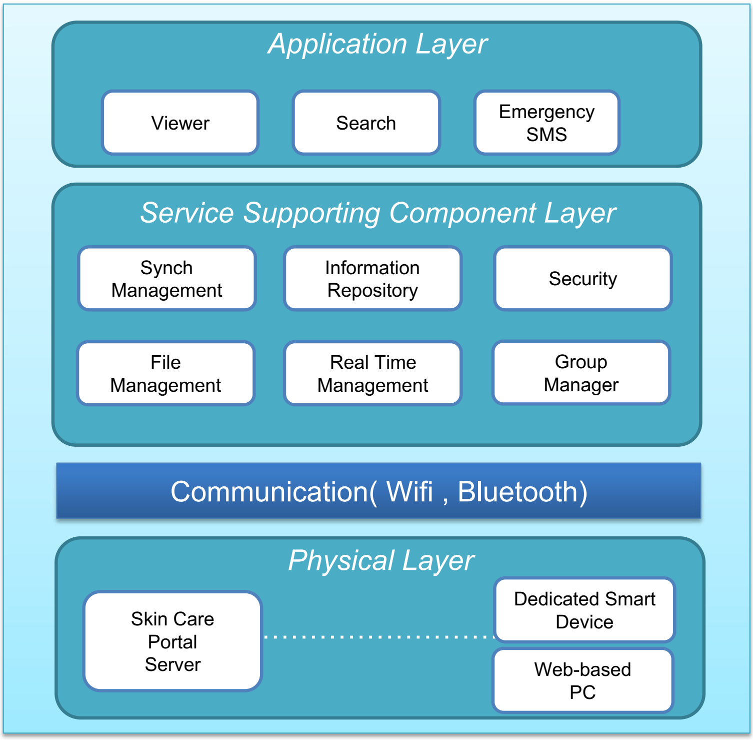

Fig. 2 The software architecture of a skin care management support system

and is responsible for the data synchronization with the Skin Care Portal Server and mobile devices. The upper application layer includes the distribution of the application supporting skin image service to all patients and medical staff. In addition, this layer consists of service functions such as viewing and searching for skin care information, and emergency SMS.

The proposed system allows patients and medical staff to share the patient's skin images at the same time through the synchronization mechanism of the system. Conversely, it is possible to access these skin images from the proposed system using the smart devices at the request of the patients and medical staff.

2.2 Interaction approach

The existing system used a synchronization algorithm based on the comparison of the message values of the selected rows of both the server-side database and the mobile database which is required for synchronization [10, 12, 15].

Thus, we consider the system environment for supporting the skin care service. In our system, an interaction approach is used to detect the creation of skin images for data synchronization. This approach relies on a general mechanism for establishing which skin images have been created since the last synchronization. For this reason, maintaining a change log on the server side is nearly impossible. Figure 3 demonstrates the creation detection process in the Skin Care Portal Server.

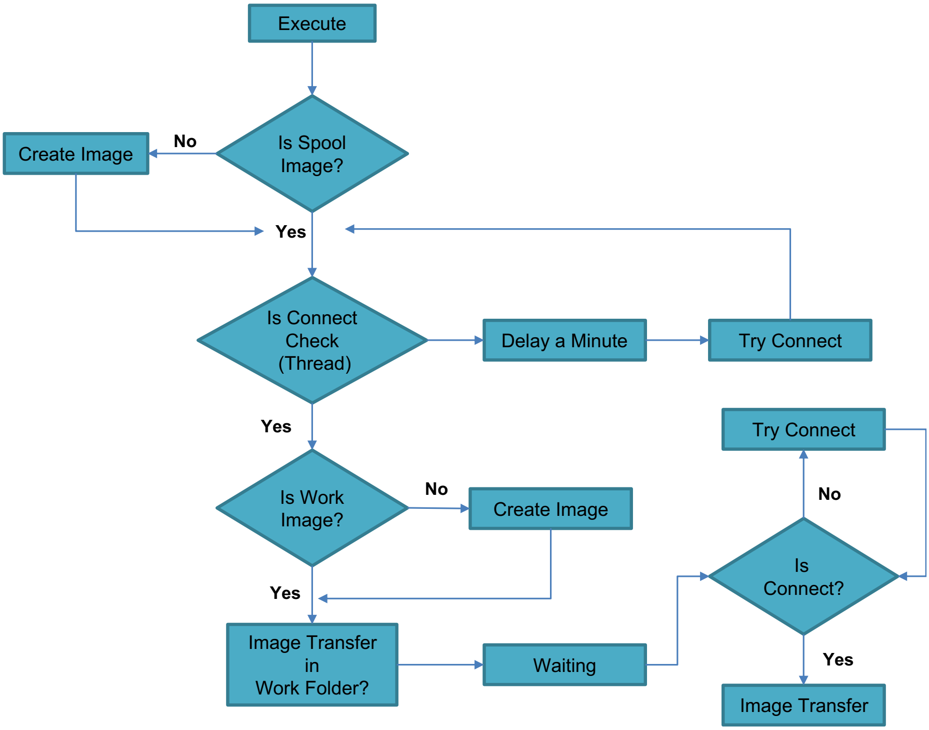

Fig. 3 Creation/detection processes in a skin care portal server

So as displayed in Fig. 3, the interaction between the Skin Care Portal Server and the smart devices consists of four-step procedure:

1) Running at the same time to check the spool folder in the Skin Care Portal Server.
2) Checking whether the devices are connected to the network or not.
3) Initiating skin images transfer to the Skin Care Portal Server and smart devices for patients and dedicating smart devices to medical staff.
4) Finally, a skin image lists displays on each device.

The detection process can be initiated by using the events raised in the Spool folder on the Skin Care Portal Server and by using the FileSystemWatcher class on the. NET Framework. Figure 4 shows the data synchronization procedure between components of the proposed system through an Event Tracing Diagram. In order to synchronize data, as seen in Fig. 4, there are two important procedures such as Sync agreement and Sync process. The Sync agreement establishes the agreement between the Skin Care Manager application, the Skin Care Portal Server and the dedicated smart devices for the medical staff by sending the Sync request() function. As a result, all of the components will send back a response by using the Agree device() function. After that, the Sync process will initiate the transfer of the skin images to the Skin Care Portal Server as well as to the dedicated smart device for medical staff. The detection can also be archived using a timestamp record denotation of the generated skin images in the system. Synchronization agreement is obtained by transferring all created skin images in the manner depicted by Fig. 4. Each system depends on wireless communication;

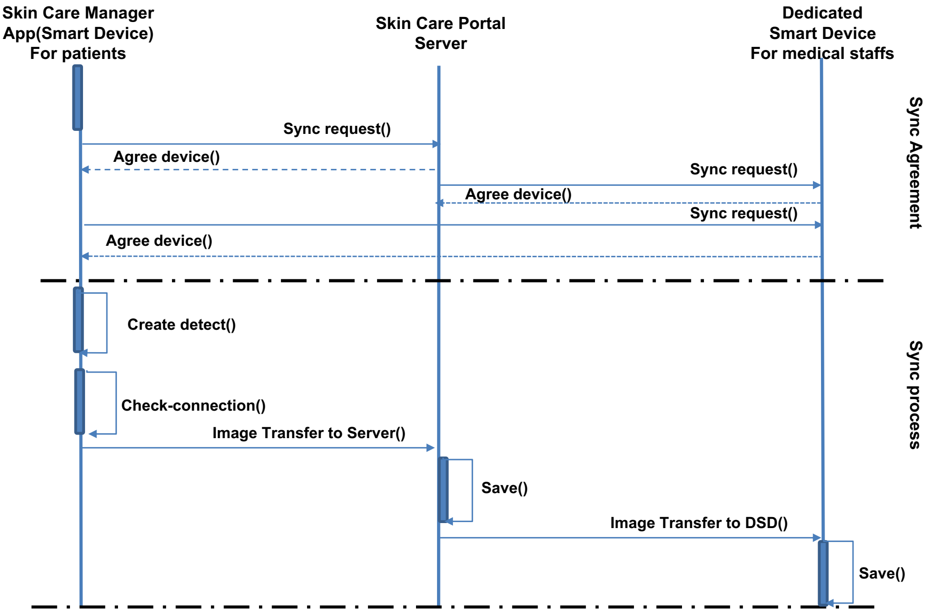

Fig. 4 Data synchronization procedures

only the smart devices, with access to both Wi-Fi and 3G/4G networks, are able to use all wireless communication functionality. The connection is restricted to the perimeters of the hospital. Leveraging 802.11 standards and Wi-Fi hotspots is a convenient way to implement wireless LAN communication.

3 Experimental results

In this section, we describe the results of the skin care management procedures between the smartphone and the Skin Care Portal Server and demonstrate the results of executing the skin care application on our system. As shown in Fig. 5, according to the data synchronization mechanism in the file manager of the system, the skin images created are stored in the spool folder by our skin care management support system, and these skin images are transmitted to the medical staff's smartphone simultaneously. Finally, these skin images are stored on the Skin Care Portal Server.

3.1 The skin care manager app for patients

The Skin Care Manager app consisted of four main features: reminders, skin imaging and reporting, skin history tracking, and secure messaging. The reminder feature is designed to allow patients to schedule a daily visual inspection or skin care task. A patient can set up his or her own schedule, choose a time, set a ringtone or vibrate audio trigger, and add notes such as the body area that needs to be checked. The schedule can be repeated every day—or any day of the week—and can be modified or removed. The reminder pops up at the reserved time and the corresponding ring tone rings. The reminder keeps ringing until the patient confirms that

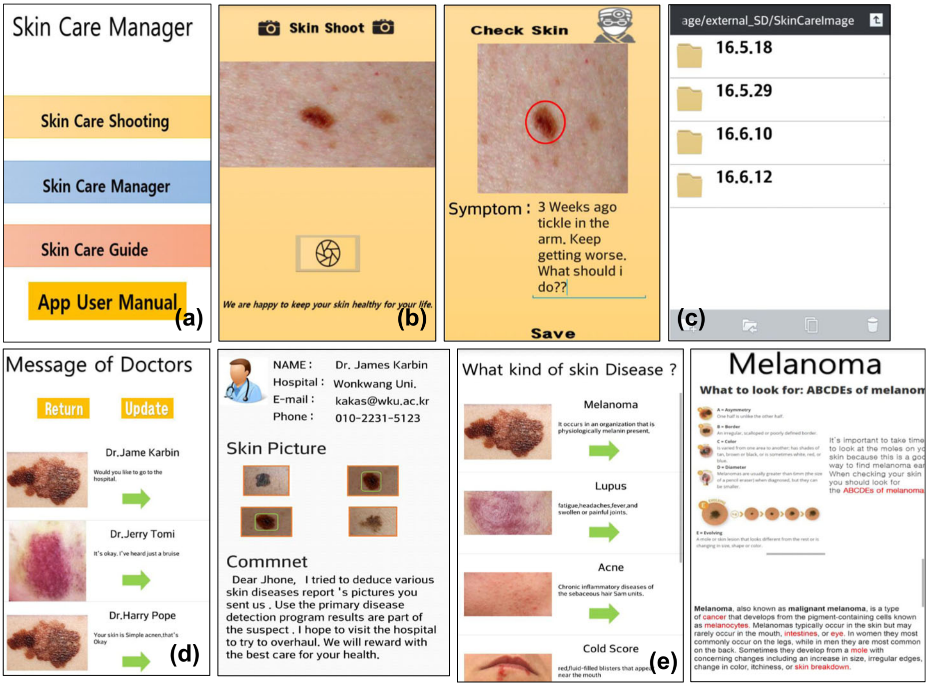

Fig. 5 Executing results of skincare manager app

the reminder has been received and the patient clicks "Skin check" during the visual inspection or treatment for the area.

In the skin imaging and reporting feature, if during the skin image checking, the patient discovers a new skin issue, the app will allow the patient to report information regarding the issue to medical staff, and send this information to the Skin Care Portal Server. The reporting contents consist of skin images and a brief description. Figure 5a displays the Skin Care Manager app interfaces that patients access to process the activity related to their skin problem. When the patient discovers a new skin problem, in Fig. 5b, the patient can use the Skin Care shooting function which uses the smartphone camera to shoot one or more photos of the skin problem or the affected area. Then, the patient can input a description related to the symptom of the skin condition according to a guided example. The patient may provide a description of the skin problem, including location (left, right, top or bottom), size, color, condition, depth and general notes about the skin affected. These descriptions are intended to help medical staff obtain a better understanding of the condition. This detailed information is also used to identify photos that warrant immediate attention from medical staff. The patient inputs a skin report using a text editor according to a guided example. In addition, to help create new reports for patients, the human body's color-coded diagrams and color-coded area lists help patients easily identify the location of the affected areas. After the patient has taken their own photo, the application opens the skincare camera viewfinder to view the skin image photos. The patient can view his or her own skin images along with the date taken, as shown in 5(c). After the skin images are sent, Fig. 5d shows the comments providing by medical staff to patients related to their skin problem and whether they need to visit a hospital or manage using self-skin care routines. Figure 5e displays the list view related to a skin disease, a patient can click on it and find more detailed information related to the disease, such as disease condition and the cause of disease.

The Skin Care Manager app we designed provides the skin history tracking feature that allow patients to track the progress of their skin problems. Figure 5c shows the collection of skin images which allow patients to view the changing development of their skin problem. By comparison, patients could organize their skin images periodically to keep track of the progress of their skin disease. Skin Care Administrators can keep records and photos from separate skin problems and combine them together in a single case to track as many skin problems as needed. The organization of pictures into cases allows the patients and medical staff to easily track progress by comparing the pictures over time. In the main screen of the Skin Care Manager app, users can view all the cases and a picture of each case's most recent history. A patient can click on the case and will start with the most recent case and display all the records for that skin care case. Furthermore, Fig. 6 displays the daily patient checking of the medical staff's smartphone. The medical staff can view the list of patient messages, update messages related to patients' skin problems. Also, the medical staff can view the patient information and as well as send comments back to patients about their skin conditions. As a secure messaging feature, the patients and the medical staff in our system can communicate with each other securely to discuss skin problems by using an Advanced Encryption Standard (AES). When the patient checks their skin care, the image generated from the photo sensors are protected carefully by using an implementation of an AES security method that converts the raw data into transformed information called cipher text which usually has a random appearance. Also, all data is encrypted and transmitted to the server, where data is again decrypted in order to be saved in the database. The purpose of encryption is to maintain the integrity and the authenticity of patient information in a cloud computing environment. We explain the data protocol method, the data sending package, which provided high security to the skin care data in detail as shown in Fig. 7. It displays how the skin care related data sending package was divided into four parts, which included Start, Data, Session Key and End block. When sending the package, the start-block and end-block must be in sequence to complete one package. Then, each subsequent data block must attach a unique session key used for identifying the data. The session key was crucial to separating the sensor data and translating the encrypted data to plain text to be saved into the database in a readable format.

Figure 8 demonstrates how the skin care information and session key were formed through the AES algorithm. First, we obtained image data from a smartphone and through the AES algorithm; Session key was composed of three processes (Sub Bytes, Shift Rows, and Mix Columns). Next, both the data and session key were carried out by the Register Module and the data was transformed to cipher text.

3.2 The skin care portal server for medical staff

The Web-based portal services for medical staff are designed to allow medical staff to monitor a patient's conditions and send a treatment-plan to a patient's smartphone. Figure 9 displays the web-based interface for medical staffs to view the skin images of patients, their patient information and skin symptoms. Medical staff can also provide comments related to patients' skin conditions through the skin care portal service. The skin care portal service stores all data including skin images and reports, patient alert notifications, and patient messages sent from the Skin Care Manager app. The portal service is designed as a dashboard, divided into four main areas. On the left side is the

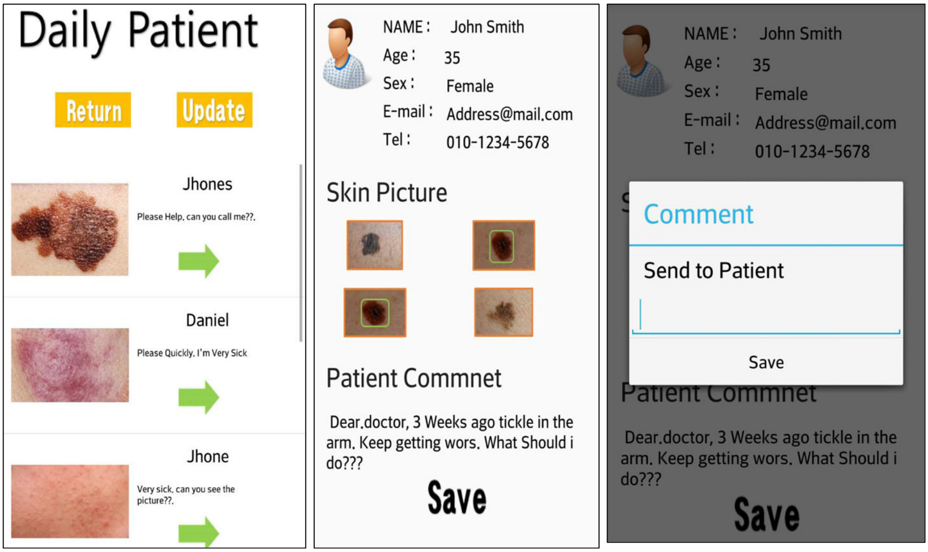

Fig. 6 The daily patient checking of medical staff 's mobile smart phone

patient list and the following status of the patient's smartphone app: Active or Connected is indicated by green check; otherwise, it is indicated with a cross. The staff can review and check the patient's schedule, modify it, or create a new schedule. The primary function of the portal service is to support the skin care comments located in the middle of the portal service screen. The organization of the skin images in the portal service is similar to the skin images tracking on the smartphone app. Medical staff can open a case that consists of a series of skin images by expanding a case folder. Cases can be marked as closed, and this will be indicated to patients, though it is not possible to delete records from the portal service. The series of skin images provides the opportunity for medical staff to compare skin conditions over time, which enhances the capability for medical staff to diagnose a skin condition and to detect skin problems more quickly. This portal service allows medical staff to repeatedly access the series of skin images from the Skin Care Portal Server without visiting the clinic. Therefore, we can potentially reduce health care costs while maintaining good skin care. The ability to detect skin problems without time and space limitations is one of the potential benefits of mobile health systems. This service also allows medical staff to actively participate in helping manage their patient's skin care. For each skin image taken by the patients, medical staff can add a note with instructions on how to treat skin problems. These notes are sent to the patient and attached to the appropriate record of the device. The third function of the portal service is to allow medical staff to engage patients using a secure message, which adapts the AES secure method. The purpose of the messaging is to allow patients and medical staffs to engage in the consultation, and discuss skin problems and how to conduct skin care routines.

Fig. 7 Skin care information protocol

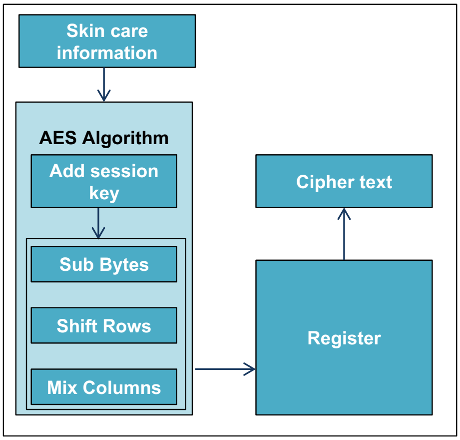

Fig. 8 Encryption flow of skin care information

4 Conclusion

In the near future, smart mobile based health systems must be able to be support patient skin care management for various skin conditions as part of a more comprehensive system that supports hybrid (simple and/or complex) conditions. For this purpose, we proposed a skin care management support system that provides skin care management services between patients and medical staffs for skin treatment and uses real-time interactions with a data synchronization mechanism based on cloud-computing environments.

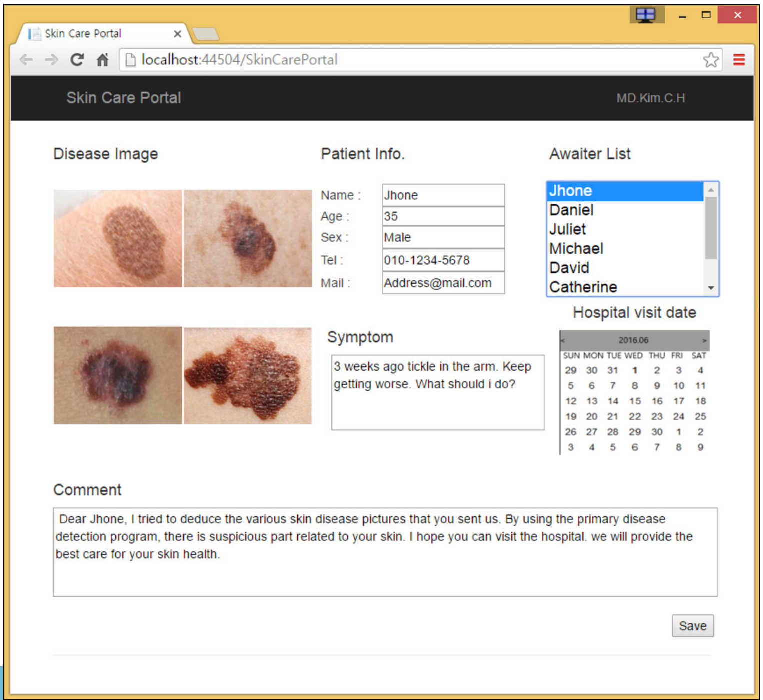

Fig. 9 The skin care portal service's result screen

Most skin diseases can be prevented with adherence to a self-care routine. In this regard, various studies related to skin care are being conducted for early prevention and diagnostic monitoring using smart health environments. However, self-care routines have limitations in diagnosis and treatment. To solve this problem, we proposed a simple means to share skin images between patients and medical staff using a cloud computing environment.

In particular, this study focused on system environment research supporting data synchronization for effective communication, such as message exchanges between patients and medical staff. We demonstrated the experimental results of the synchronization procedure and the skin care management service. We expect that the proposed system in this study will be useful for skin management and treatment.

Our future research includes the application of an advanced intelligent algorithm for skin disease auto detection using a deep learning approach. We will also extend the functionality of our developed system and its evaluation in a clinical field-test.

Acknowledgements This work was supported by Wonkwang University in 2017.

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