Mobile Monitoring and Inquiry System Using Fingerprint Biometrics and SMS Technology

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ABSTRACT

This paper described a mobile monitoring and inquiry system using the fingerprint biometrics and Short Message Service (SMS) technology. It was specifically developed for the monitoring of preschoolers' attendance during their schooling, which is beneficial to the working parents. The system adopted the Rational Unified Process (RUP), Visual C#.Net 2008 and MySQL Server 5.1 database and software development kit (SDK). The system was designed to automatically sends an alert SMS to the parents/guardians whenever the pupils logged-in/logged-out in the system. Likewise, it could receive an SMS inquiry and sent an SMS reply to the parents/guardians when no alert message was received after the expected time of logged-in/logged-out of the pupil. All the text messages used a predefined content of 160 characters or less, without graphics and are local texting only. Results of the system evaluation showed that the fingerprint scanning records an average of 93.48 % and 93.81 % accuracy for the login and logout respectively. The average time of sending an alert message to the parents/guardians is 27.20 s while 23.08 s for the reply of an SMS inquiry. The mobile monitoring and inquiry system using the fingerprint biometrics and SMS technology is convenient, economical and reliable method of monitoring, identifying and/or verifying users since it no longer requires identity cards or passwords memorization. Thus, the system could be used by the other levels of pupils depending on their monitoring needs. However, there is a need for some innovation like designing a multiple detection and recognition using a high resolution of camera for easy use of login and logout in the system.

Keywords: Mobile Monitoring, SMS Inquiry System, Fingerprint biometrics, SMS Technology

I.   INTRODUCTION

School environment must be conducive to learning and free from any untoward incidents (e.g. illegal entry and kidnapping). As such several strategies were implemented by the school administrators to address such dilemma. Provision of proper student identification card, as they enter or leave the school campus was one of those strategies adopted by the school administrators.

However, based from observations, traditional personal authentication systems used personal token like Identification card (ID) that could be forgotten, lost or stolen. Thus, it does not suffice the issue on proper identification of students.

Hence, school administrators shifted to modern techniques of authentication analogous with the technology advancement i.e. use of personal computers, internet, swipe cards, PINs, use of password and the use of biometric finger scanning. All these, except for the biometrics, do not meet the stringent security requisites of authentication as these could easily be passed over, lost or guessed by other users.

Further observations showed that biometric fingerprint scanning was one of the best alternative and accepted method of authentication nowadays. It provided accurate identification of users, track and audit records of users. It can't be lost or stolen, no password memorization, thus, more reliable and user-friendly. It has a wide range of application such as attendance and payroll management, visitor management, access control, and door locks.

It was in this premise that the researchers thought of reinventing the current authentication system of school operators and administrators. This system would provide accurate user identification, monitoring, SMS alert and inquiry which could be used by the school administrators and the parents of the pupils. Thus, the researchers integrated the biometric finger scanning and short message service (SMS) or popularly known as texting. The SMS served as an information transmission between system and parents of the pupils. The system made use of wireless networks, mobile phone, Global System for Mobile communication (GSM) modem and biometric device.

A.   STATEMENT OF THE PROBLEM

One of the major thrusts in any institution is to promote sound environment for its clientele and its staff. Hence, a safe and secure school premises is a requirement rather than a necessity only. Presence of any form of violence within school premises would adversely affect the educational process and operations of the institution; students' academic performance; and the loss of trust and confidence of the clientele. Nonetheless, school authorities got difficulty in responding these issues.

For this reason, the researchers designed and developed a system that would help the school operators and administrator to provide a safe and secure environment. A system that would enable the parents/guardians monitors their students and makes an inquiry about their pupil's attendance in the school through the integration of biometric fingerprint scanners and SMS or text messages.

B.   OBJECTIVES OF THE STUDY

The general objective of this study was to design and implement a mobile monitoring and inquiry system using the fingerprint biometrics and SMS technology for preschoolers aged 4-6 years. Specifically, it aimed to:

1. Develop an authentication system for the pupil's entry and/or exit in the school campus.
2. Design an application software that would combine monitoring and alert system of pupils coming in and out of the school campus through biometric fingerprint scanning and text messaging (SMS) sent to students' parents or guardians.
3. Develop an SMS inquiry system between the school authorities and their clientele.
4. Conduct the testing of the system to both kinder and nursery pupils in terms of:
   a. Biometric fingerprint scanning,
   b. Text Messaging, and
   c. SMS inquiry.

C. SIGNIFICANCE OF THE STUDY

The researcher is confident that the results of the study were deemed beneficial to the following stakeholders:

Pupils. Results of the study would ensure the authentication of the pupil's true identity, promote a sound environment for learning – thus, outstanding academic performance is highly expected. Also, students were exposed to a state- of- the-art information and communications technology (ICT) coping up with the modern world.

Parents. Results of the study provided the parents/guardians a most affordable mobile monitoring and inquiry system which enabled them checked and monitored their children's attendance to school through cellular phones, provided peace and security; checked as they would be automatically informed about the school attendance of their children. Consequently, it would promote a strong and effective partnership between the parent and the school administrators.

School Administrators. This technology would empower the school operators and administrators in conveying excellent services to their clientele as well as safe and peaceful learning environment to their clientele. Moreover, it would permit a creative and dynamic tripartite interaction among the school-parents and students.

Researcher. This study would enhance the researcher's technical knowledge and understanding on his field of specialization. Thereby, the difficulties encountered broaden the researcher's horizon in applying the new gained principles.

Future Researchers. This would serve as avenue for the improvement of future related studies on monitoring and security issues in any institution of concerned. Further, this would serve as vital inputs to future researchers who may embark in the development of a new technology associated with monitoring and security matters.

D. SCOPE AND DELIMITATION

The study focused on the development of a software intended for mobile monitoring, alert and inquiry system through the integration of biometric fingerprint scanning and short messaging service (SMS) popularly known as text messaging.

Generally, it is consisted of a computer, biometric device, GSM modem, and cellular phone connected in the wireless network. The system could generate automatic alert message sends to the parent/guardians as the pupils performed the login and logout in the system. Likewise, an inquiry and reply messages could be done on the system particularly when the parents/guardian received no texts after the expected logged-in or logged-out of the pupils. All the texts messages must not exceed 160 characters, no graphics and were local texting only.

The system is designed specifically for nursery and kindergarten pupils from age 4 to 6 years old. However, it can be used by the other pupils depending on their monitoring and security requirements.

This was a six (6) months study that commenced on April 2013 and ended on September 2013.

II. METHODOLOGY

This study employed a descriptive developmental method of research in the context of system development. Descriptive was used in discussing the results of the testing phase while developmental was used during the system development. The data were analyzed using the percentage technique and arithmetic mean after conducted the testing of the biometric fingerprint scanning, Text Messaging and SMS Inquiry.

The researcher made used of the fingerprint biometrics for authentication or verification of pupils in the school campus. The DigitaPersona was used as fingerprint reader to capture the fingerprint image of the pupils when performing the login and logout in the system. The Microsoft Visual C#.Net 2008 was used to develop the system and the Software Development Kit (SDK) called *DigitalPersona One Touch for Windows SDK 1.4.0.1* was used for registration and recognition of the fingerprint images. A total of 76 fingerprint images of the pupils was stored in the database for the system's matching and verification process purposes. When the pupils placed or put his/her finger on the fingerprint reader, the device captured the fingerprint image and matched it sequentially on the different fingerprint images stored in the database. Once a match was found, the searching and matching of images automatically stopped. Otherwise, a message prompted on screen informing that no matched found.

The Software Development Life Cycle (SDLC) was used in designing the software application of the system. The Rational Unified Process (RUP) methodology was adopted for the SDLC where RUP addresses the complete software development lifecycle wherein it was broken into cycles and each cycle working on a new generation of the software. These four major cycles of RUP are inception, elaboration, construction, and transition.

Inception. This is the planning cycle of the system development wherein the researcher developed an SMS-based application using the fingerprint biometrics which authenticates the pupils true identity based on his/her physical attributes. The activities included were the identification of the hardware and software requirements in the development of the system, scope of the project (attendance monitoring), schedule of activities (Gantt chart), and the total budget cost.

Elaboration. In this cycle, the researcher designed the requirements needed in system development. Included were the system components, system architecture, contextual diagram,

data flow diagram, data dictionary, entity relationship diagram, user interface design, and system flowchart. These processes were discussed in this chapter.

Construction. The researcher made used of Microsoft Visual C#.Net 2008 and MySQL Server 5.1 to initially start the coding process. Additional tools for the software development kit (SDK) were used such as fingerprint reader, webcam, and GSM modem. Debugging and testing of the program for fixing bugs or errors of the design was also done in this cycle. Finally, the system was released and tested as beta version thru conducting a pilot test for five days.

Transition. After the beta testing, minor refinement was done to integrate corrections of bugs and the users' feedbacks which were focused mainly on fine-tuning of system, configuring, installing, and usability issues. In this cycle, the researcher was assured of the usability of the system to its target clienteles (the pupils). The user's manual is prepared to facilitate using of the system. Screenshots of the human-machine interfaces, simplified diagram and software installation instructions were clearly presented in the manual.

In the development of SMS Inquiry system, the researcher was used of the GSM modem (USB SmartBro) and the mobile phone which are connected to the system. The GSM was used for sending the alert messages and receiving the text messages from the parents/or guardians. The mobile phone was used for receiving the text messages and alert messages from the system. The content of the alert message, text message, and SMS inquiry are in a predefined format and shown in the appendices. The system was used of the *Core.Net SMS Library 1.2* for the Software Development Kit (SDK) used in Microsoft Visual C#.Net 2008 when developing the SMS Inquiry system.

The system was tested and conducted at San Juanico Pre-School, Goa, Camarines Sur for the biometric fingerprint scanning of pupils thru logging-in and logging-out in the system at the school campus. The pupils were performed in the system for the duration of five (5) days in using the fingerprint scanner on the regular classes of 8:00-10:00 AM and 1:00-4:00 PM for the nursery and kindergarten pupils. The total number of pupils was registered in the system is 76 for both nursery and kindergarten pupils.

The researcher was conducted the testing of the text messaging and SMS inquiry using a mobile phone and the system. The system and the mobile phone are connected through a wireless network using the GSM modem (USB SmartBro) configured to the system. The testing of the mobile phone was used for the alert messages and text messages together with the system sent to the parents/or guardians. The alert messages are the messages received by the parents from the system after the pupils performed the login and logout at school campus. The text messages are the messages received by the parents from the system after the SMS inquiry thru mobile phone. The testing was conducted for a total of five (5) trails in both text messaging and SMS inquiry.

III. RESULTS AND DISCUSSION

A. System Components

As shown Figure 1, the four major interconnected components of the system were the biometric device, GSM device, mobile phone and database. The biometric device was

used to capture the fingerprint image and verify the pupils by logging-in or logging-out in the system for the purpose of authenticating the pupil's identity. The GSM device served as the gateway to connect with the mobile phone users and the system. It is also used to send and receive the text messages via SMS. The text message sent and received by the system was stored in the database. The database recorded the logins and logouts, and saved the records of the incoming and outgoing text messages. The mobile phone is the last component of the system. This is used to make an SMS inquiry and text messaging service between the system and the parents/guardians.
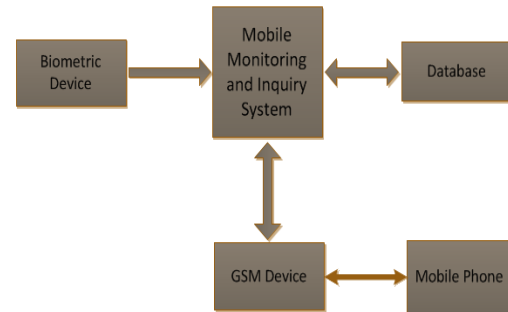

Figure 1: System Components

B. System Architecture

The Mobile Monitoring and Inquiry System (MMIS) is capable for monitoring the pupils in the school campus through sending an alert message and text message to the parents/guardians via SMS (Fig. 2). The system and the parents/guardians are connected through a wireless network. The two types of clients served by the system were the pupils and their parents/guardians. The pupil pressed his/her finger on the fingerprint reader and was recognized by the system through his own fingerprint. This act led to sending the pupils' parents/guardians an alert message which was received through mobile phone. The GSM device is responsible for sending an alert message or text message from the system to the parents. The mobile phone receives the information that was made by the system.
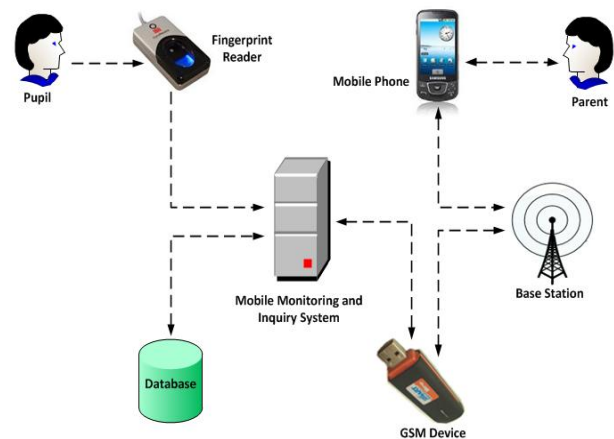

Figure 2: System Architecture

C. Context Diagram

The system requires two external inputs as illustrated in figure 3. One is the attendance details (finger print) coming from

the pupils which served as the first input needed to be feed into the system which resulted to sending automatically an SMS alert to the parents/guardians. The second external input is the SMS Request sent by the parents/guardians that the system will received upon inquiry of the parents for not receiving an alert message that his son/daughter had already performed logged-in or logged-out from the school. The system replied via a predefined content SMS with the following pupils' information, name of the pupil, logged in / logged out time and the date of transaction.
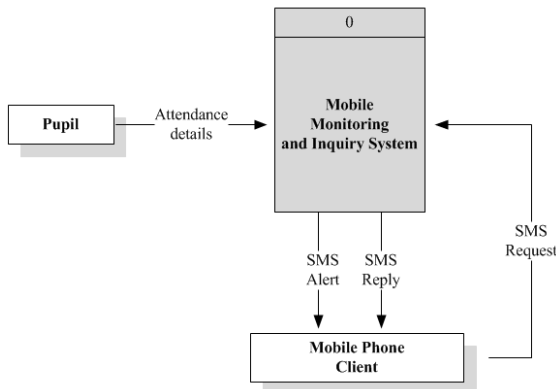

Figure 3: Contextual Diagram

D. Data Flow Diagram Level-0

Figure 4 shows the five major functions of the MMIS. These five major functions are Register Account, Login/Logout, Send SMS, Receive SMS, and Reply SMS. The Register Account function is used for the registration of the pupils and the fingerprint image capturing. The Login/Logout function authenticates the pupils when he/she logins or logouts in the system and process an SMS alert message. The Send SMS function is used to send the Outgoing SMS needed to receive by the parent/guardian. The Receive SMS function is used for accepting the request or inquiry sent by the parents/guardians. The Reply SMS function sends the text reply to the guardian made by the system.
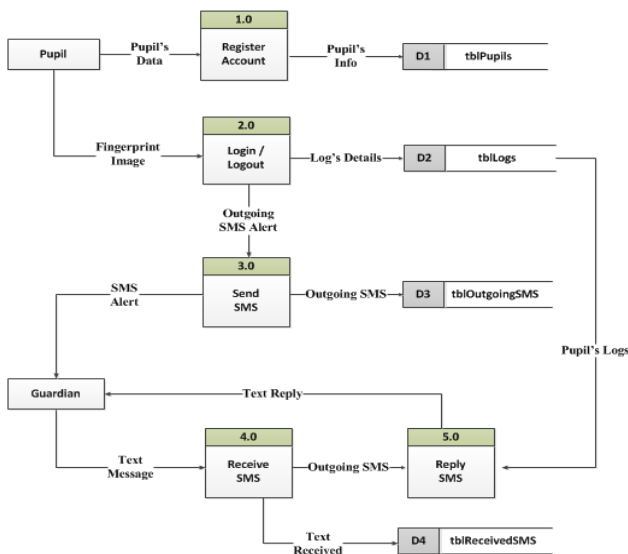

Figure 4: DFD Level 0

E. Entity Relationship Diagram (ERD)

Figure 5 shows the design and structure of the database that keeps the records of the pupils, fingerprint images, logs, sends and receives text messages. The data entry in the registration, login and logout, received and sent messages are stored in the database.
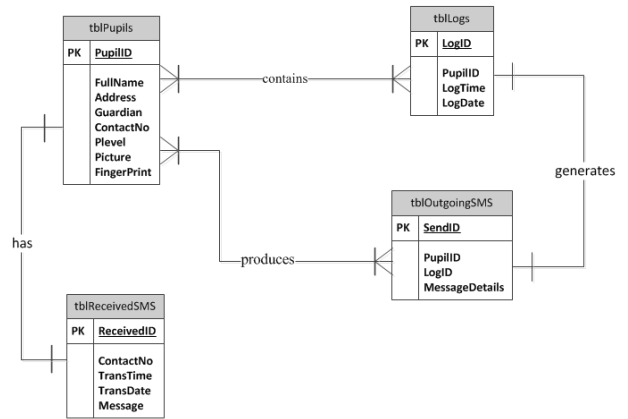

Figure 5: Entity Relationship Diagram

F. Testing Result for Biometric Fingerprint Scanning

The testing of the fingerprint biometrics focused on the execution of login and logout of the pupils. The use of the fingerprint biometrics is for the identification and verification of the pupils before sending an alert message to the parents/guardians. Table 1 shows the results after conducting the biometric fingerprint scanning. During logged in, 71 pupils on the average had performed the logged in in the school campus. Of this number, 93.48 % of the pupils were succesfully recorded for the first attempt of pressing their fingers on the fingerprint scanner. The remaining 6.52%, 4.53 % of which was only recognized after the second attempt and this was due to improper position of finger . One and seventy hundreths (1.70) % were not recognized due to unregistered fingerprints.

Documentation of the logged out was also done. When the pupils performed the logged out in the system, 93.81% acceptance were recorded for the first attempt, while 5.24% done it twice. The remaining 0.5 % are for the unregistered fingerprint.

In the actual experimentation, 29.77% of the tested pupils missed out the logouts since they already approached their parents who were there to fetched them.

Table 1: Biometric Fingerprint Scanning

Day	Transaction	1st Attempt		2nd Attempt		3rd Attempt		4th Attempt		5th Attempt		Number of Pupils
		Number	%	Number	%	Number	%	Number	%	Number	%	
Day 1	IN	56	87.50%	4	6.25%	1	1.56%	0	0%	3	4.69%	64
	OUT	40	88.89%	3	6.67%	1	2.22%	1	2.22%	0	0%	45
Day 2	IN	65	91.55%	4	5.63%	0	0%	0	0%	2	2.82%	71
	OUT	45	95.74%	2	4.26%	0	0%	0	0%	0	0%	47
Day 3	IN	81	95.29%	3	3.53%	0	0%	0	0%	1	1.18%	85
	OUT	63	96.92%	2	3.08%	0	0%	0	0%	0	0%	65
Day 4	IN	75	96.15%	3	3.85%	0	0%	0	0%	0	0%	78
	OUT	49	92.45%	4	7.55%	0	0%	0	0%	0	0%	53
Day 5	IN	53	96.36%	2	3.64%	0	0%	0	0%	0	0%	55
Average	IN	66	93.48%	3.2	4.53%	0.2	0.28%	0	0%	1.2	1.70%	71
	OUT	49	93.81%	2.75	5.24%	0.25	0.48%	0.25	0.48%	0	0%	53

G. Testing Result for SMS Inquiry and Text Messaging

The mobile phone is used to connect with the system and the parents/guardians through SMS technology. The parent/guardian had regularly received an alert message from the system when the pupils performed the login or logout in the school campus. Table 2 shows the results of an SMS inquiry and text messaging. The alert message sent by the system to the parents/guardians has recorded an average received time of 27.20 seconds after the pupils performed the login or logout in the school campus. The shortest and longest time of sending an alert message is recorded to be 26.43 seconds and 28.41 seconds respectively. The SMS inquiry was also documented in terms of speed of recipient. The response time of sending the text message after the parents/guardians had sent their SMS inquiry to the system was recorded on the average of 23.08 seconds while the shortest and longest time were 16.49 seconds and 37.56 seconds respectively.

Table 2: SMS Inquiry and Text Messaging

Transaction	TRIAL					Average
	1st	2nd	3rd	4th	5th	
The time elapsed when an alert message received by the parent/guardian after the pupils performed the login or logout in the system.	28.41 s	26.43 s	27.55 s	26.83 s	26.78 s	27.20 s
The time elapsed when a response text message received by the student guardian/or parent after sending an inquiry SMS request to the system.	16.49 s	20.50 s	19.77 s	21.09 s	37.56 s	23.08 s

IV. CONCLUSION

The Mobile Monitoring and Inquiry System (MMIS) was specifically developed for monitoring the pupil's attendance in the school campus thru SMS Inquiry, and logging-in and logging-out in the system using the fingerprint biometrics and SMS technology. The system was used of the fingerprint scanner for the login and logout of pupils using their fingerprint at the school campus and the mobile was used for the SMS Inquiry or in the text messaging service. The used of the fingerprint scanner and the system provides most economical and accurate identifying of pupils since it no longer requires identity cards (ID) or passwords memorization. Thus, the system could be used by the other levels of pupils depending on their monitoring needs. Through the use of fingerprint scanner, the system sends a reliable text message or alert message to the parents/or guardians. The system combines the functionality of the fingerprint scanner and the GSM modem (USB SmartBro) in monitoring the attendance of pupils and sends the messages to parents/or guardians. The system provides a convenient way of monitoring the pupils through the use of mobile phone which is a common personal communication medium in most of the parents/or guardians today. The parents received automatically the alert messages from the system within the country only when they are working at the office or in other places after performing the pupils for the login and logout in the system. The system provides an SMS Inquiry for the clientele (parents, guardians) in monitoring of attendance of pupils at the school campus. The system thru SMS Inquiry delivered the text messages using the GSM modem and the mobile phone which are connected in the wireless network.

V. RECOMMENDATIONS

After conducting the testing, the researcher recommends for the future researchers in order to further improve the system. Some of the following recommendations were made:

1. Develop a multiple face detection and recognition device as a replacement of the fingerprint reader for easy login and logout transaction in the system. The system will use a high resolution of camera in detecting and recognizing faces of the pupils when entering and leaving the school campus. The system is capable of multiple face detections and recognitions using the camera that are uses for login and logout of the pupils and it sends automatically a text message to the parents based on the detected and recognized faces of the system.

2. Develop a fuzzy logic application for multiple face detection and recognition in recording the login and logout of pupils.

3. Design an embedded system for combining the use of the fingerprint reader and the GSM modem (USB SmartBro) in monitoring the pupil's attendance at the school campus thru logging-in and logging-out and sends a text message to the parents/guardians using their fingerprints.

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