Development of Hybrid Radio Frequency Identification and Biometric Security Attendance System

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Abstract

Managing attendance in institutions and organizations has become a difficult challenge. The ability to compute attendance becomes a major task as manual computation produces errors, and also wastes a lot of time. Radio-frequency identification (RFID) and Biometrics have been individually used to solve the problem of attendance in recent years. RFID has a major security and integrity problem known as buddy punching. Although biometrics solved the security problem its complexity and longer execution time due to real time interaction with a central server which could be many distance away, has created a major setback to its implementation. Therefore, a hybrid attendance system using RFID and biometrics was developed. Students' environment was considered for the investigation. In this paper, a method to solve attendance problem through coordinated hardware and software design handshaking data communications among RFID tag, RFID reader and fingerprint scanner serially interfaced to the digital computer system was proposed. Biometric data and personal details are stored on the RFID tag to secure the tag and eliminate the dependency on the real time central server for authentication. Performance was evaluated in terms of read time with and without wallet, encoding, attendance, and enrollment feature using 50 trials. The results showed that average read time of 831,294ms with standard deviation of 35,75656254ms was obtained without barrier while with barrier (wallet), the average read time of 831,0600ms and standard deviation of 34,14399879ms were obtained. The results indicated high speed performance from coordination of the hardware and software and also the performances with and without wallet were almost the same, indicating no effect. The proposed method was able to achieve data integrity and security due to biometrics, low complexity due to RFID and average execution time of 0.831sec due to its structural programming pattern and data header structure.

Keywords: RFID, Biometrics, RFID tag, Fingerprint, Database

1. Introduction

Attendance is defined as the act of being present (at meetings or events), the frequency with which a person is present or the number of people that are present (Zainirah, 2007) and (Amiyana, 2011). This technology can be applied in real time applications such as for recording the attendance in big companies, industries, colleges, schools and so on where many candidates are involved. The system helps in recording the attendance of people easily within fraction of seconds.

Radio-frequency identification (RFID) is a technology that uses radio waves to transfer data from an electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose of identifying and tracking the object. Biometrics refers to the automatic identification of a person based on physiological or behavioral characteristics. Radio Frequency Identification (RFID) is a member of Automatic Identification and data capture (AIDC) technologies which is fast and reliable means of identifying just material object. Primarily, two main components are involved in a Radio Frequency Identification system, these are the Transponder (tags that are attached to the object) and the interrogator (RFID reader).

Communication between the RFID reader and the tags was wireless and generally doesn't require a line of sight between the devices (Bowman, 2008), (Anil, 2004), (Amiyana, 2011), (Shoewu and Idowu, 2012).

RFID tags are categorized as either active or passive. Active RFID tags are powered by an internal battery and are typically read/write i.e. tag data can be rewritten and/or modified. This tag varies according to application requirements; some system operates up to 1MB of memory. Passive RFID tags which operate without a separate external power source and obtain operating power generated from the reader were considered in this paper. Read-only tags typically passive were programmed with 32 to 128 bits set of data that cannot be modified. The reader has three main functions namely: energizing, demodulating and decoding (Shashauk et al, 2013).

Biometrics which refers to the automatic identification of a person based on physiological or behavioral characteristics includes fingerprint, iris, facial and retinal. This allows people to confirm or establish individual's identity based on "who is she?", rather than by "what to possess?" (e.g, an ID card) or "what she remembers" (e.g., a password). This technology is becoming the foundation of an extensive array of highly secure identification and personal verification solutions. Today, the technology is being spotlighted as the authentication method because of the need for reliable security (Zainirah, 2007), (Bowman, 2008), (Masruni, 2006), (ononimu and Nwaji, 2012) and (Arulogun et al, 2013).

Various methods are being used as attendance system to take records of events such as paper attendance method; this method lacks automation and required people to manually sign the attendance sheet every time the needs arise. The method is time wasting, irritating, having a lot of errors or mistake and as a result generate a lot of problems (Bowman, 2008) and (Arulogun et al, 2013).

RFID and Biometrics methods have been individually used to solve the problem of attendance in recent years. RFID has a major security and integrity problem known as buddy punching i.e. when a user presents a card on behalf of another user without the physical presence of that user. Although biometrics solves the security problem its complexity and longer execution time due to real time interaction with a central server which could be several kilometers away has created a major setback to its implementation. This paper developed hybrid RFID with biometric security attendance system which eliminate the need for a lot of paper work and help in tracking record of events such as employee's and students' absentee with dates which can still help organizations to have a global look. It combined the flexibility of RFID technology and the security of fingerprint biometrics.

The hybrid system developed consists of the following devices RFID reader, RFID tag, fingerprint scanner, system interfaces and databases. This system was developed to make sure that the devices capture accurate data, verify the integrity using biometrics and can interact with the information system accurately and efficiently. The necessary information was represented by meaningful data model suitable for application level interactions, including monitoring, tracking and application integration. The system was further investigated when the RFID card was inside and outside wallet. The read time was used to evaluate the performance of the proposed system. The result obtained showed no significant difference between the two scenarios.

2. System Model

The proposed system model consists of coordinated hardware and software designs handshaking data communications among RFID tag, RFID reader and fingerprint scanner serially interfaced to the digital computer system.

2.1 Hardware Architecture

Four major hardware's were used for the implementation of this system namely: RFID Card Reader, PC (Laptop), Fingerprint Scanner and RFID Tag. The reader used in this work was ACR122U NFC reader and the RFID card used was the Mifare 1k card. The ACR122U is a PC-linked Contactless Smart Card Reader/Writer developed on the 13.65MHz contactless card technology. It was used for accessing ISO14443-4 Type A and B, Mifare ISO 18092 or NFC, and Felica Tags. The fingerprint scanner used was SecuGen HDU03 fingerprint reader. The hardware setup was a very simple and straight forward process. The RFID card reader was connected to the PC via the USB interface. The RFID tag interacted with any active RFID reader within range and performed the sequence as instructed by the software. The fingerprint scanner was also connected to the PC via the USB interface. The PC was pre-equipped with the Windows operating system with a minimum hardware requirement of 1GB RAM, 160 GB Hard Disk Drive, 1.5GHz Processor.

2.2 Software Architecture

This is the application architecture which shows how to transform the logical design in to basic system coding to create the system. The result of this phase is application interface, database and system design specification. Microsoft Visual Basic .NET was used as the programming language and MySQL as the Database.

2.3 Database Structure

Any attendance system needs a place where its data will be saved or edited called Database of the system. The database is a very simple and efficient structure that supports easy modification and maintenance. It contains tables that represent a single subject which consists of relatively distinct fields, keeping the redundant data to an absolute minimum. Data integrity was imposed at the field, table, and relationship levels. These levels of integrity guarantee the validity of the data structures and their values accurately at all times.

2.4 Student_Table

This table represents where the student details were saved.

- Matric_No *[primary key; data type | string]*
- Surname *[data type | string]*
- Othername *[data type | string]*
- Sex *[data type | string]*
- Department *[data type | string]*
- Faculty *[data type | string]*
- Fingerprint *[data type | blob]*

3. Design Approach

3.1 Programming Language and Operating System

The programming language used was Microsoft Visual Basic.NET due to its rich IDE, intuitive Graphical User Interface tools and hardware friendly framework (.NET 3.5 frameworks). The windows operating system was used because of its large user base, functional services for hardware communications and so on.

3.2 Application Flow

This describes the operations of the main modules of the software application and their connections. It consists of three main phases namely: Enrollment, encoding, and attendance phase.

The Enrollment phase provides the user with a form to register a student on the software's database and prepare the data for encoding onto the RFID tag. This system was equipped with necessary error trapping method to avoid saving invalid data on the database and to maintain the integrity of the data on the database. Figure 1 shows the flowchart of the enrollment system.

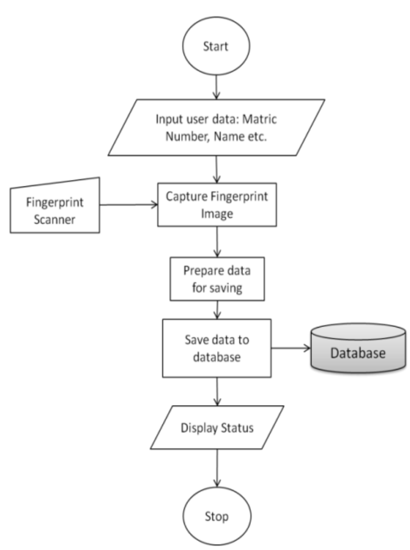

Figure1: Flowchart of Enrollment System

The Encoding phase transfer's key student details into the RFID tag for the attendance system. Some of the information that was saved on the RFID tag is Matriculation Number, Department, Surname, Other Names and Fingerprint data. The system kept records of the card serial number given to each student to avoid counterfeiting of the cards. This system was equipped with very interactive forms for ease of access and user friendliness. Figure 2 shows the flowchart of encoding system.

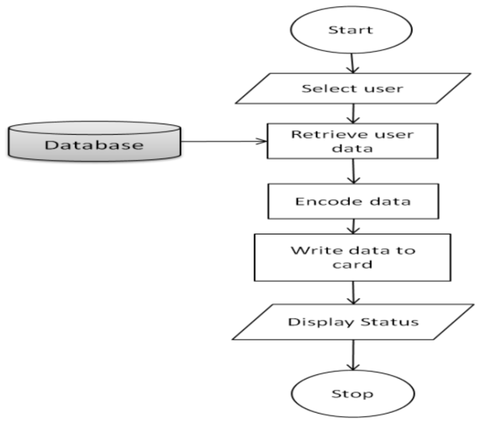

Figure 2: Flowchart of Encoding System

The attendance phase is the most functional part of the software where a new attendance instance is created and properly recorded on the database. This phase keeps tracking the activity of each student as regards to their attendance in a particular class and provides a detailed report for the user in charge at the end of the academic period. The fingerprint data stored on the RFID card along with other details was read into the computer memory. The stored data was used to authenticate the fingerprint of the user that was captured in real time by the fingerprint scanner. This system is fully automated from the data collection to the reporting with little or no effort from the user. The flowchart of attendance system is shown in Figure 3.

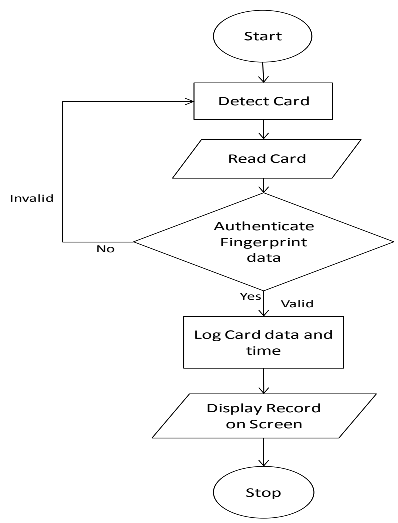

Figure 3: Flowchart of Attendance System

3.3 Security Architecture

The architecture explains in details the security features that were implemented in this paper to ensure the safety and integrity of user data and operation.

3.4 Data Header Structure

This structure defines the data that was stored in Sector 0-Block 1 of the Mifare 1k Card. The size of the data was 16 bytes. The first byte was used to determine a valid header structure, while the remaining 15 bytes represented the size of data stored in each sector from sector 1-15.

A value of FF in the first byte indicated a valid header structure while a 00 indicated an invalid header. The structure helped to perform a Cyclic Redundancy Check (CRC) on the cards' data. Mapping Layout of Data Header structure is shown in Figure 4.

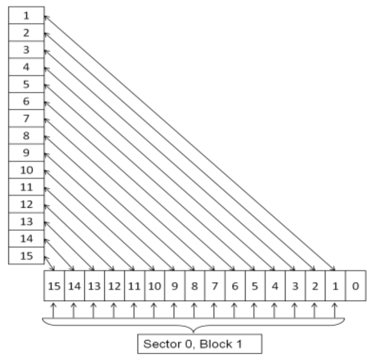

Figure 4: Mapping Layout of Data Header

4. Results and Discussion

The results of the development of the hybrid attendance system are presented in Figure 5 to Figure 11. These show the Home Screen interface used to access the main features of the attendance system software such as registration of student data, encoding of the data into the RFID card and creating the actual attendance. On the click of a button, the corresponding action was triggered without closing the home screen to allow the user to switch to another function without having to restart the program.

The student registration interface which captured the students' personal data, their fingerprint details and saved it in the database for further use such as encoding is presented in Figure 5. This interface captured the essential data only to improve the performance of the attendance system and reducing the amount of overhead data encoded into the RFID card. When the user clicked' on Capture Right Thumb, the interface scanned and displayed the image of the finger placed on the scanner. After all necessary data had been provided; the user could now click on the button Register to save the students' data in the database.

Figure 6 depicts the encoding interface which displayed a list of all students that registered into the database using the registration interface and prepared the data for encoding into RFID card. When the user selects a student and clicks the Encode data button, the interface encoded the students' data into the RFID card in range.

The attendance interface which generates the actual attendance with biometric authentication of each user trying to use their RFID card is shown in Figure 7. This interface continuously scanned for RFID card in range. When the card is detected, the interface read the data on the card and prompts the owner for a fingerprint authentication. If the authentication is successful, the user data adds to the attendance list else the user data is discarded. This interface is also equipped with the ability to export the attendance list to an excel sheet for further processing. This makes the attendance data generates very flexible and be adapted to any environment.

Figure 8 displays the time taken by the system to read an encoded RFID card without any physical barrier over 50 trials. The result was able to ascertain the fact that the read time varied at all trials but the standard deviation obtained (35.75656254ms) was within reasonable range. The result obtained gave an average read time of 831.2941ms indicating a high speed performance from the coordination of the hardware and software. The high speed performance was also traced to the data header structure algorithm that was implemented saving the hardware time spent in reading empty data blocks.

Figure 9 shows the time taken by the system to read an encoded RFID card with a physical barrier such as (Wallet) over 50 trials. This was investigated because most students' keep their identity cards in wallet which will make most of them using the RFID card from within their wallet. The result was able to ascertain the fact that reading the RFID card placed inside the wallet did not really affect the performance and the time taken to read the RFID card. The average read time was 831.0600ms and the standard deviation of 34.14399879ms was obtained.

Figure 10 compared the result of the Read time with and without physical wallet. It was observed that the maximum read time in the 50 trials performed was obtained when there was a barrier while the minimum read time was obtained when there was no physical barrier. This indicates hypothetically that the wallet did not have any effect.

Figure 11 displays the time taken to write encoded data into an RFID card over 30 trials. The result indicates a slightly increased write time as compared to the read time. This increase depicts a slower write speed compared to the read speed. The average write time was 932.1613ms and the standard deviation was 7.75068502ms indicating a much more consistent set of data unlike the read time result. However, the slightly increased write time did not indicate any drop in performance of the system because the difference between the write and read time average was less than 150ms.

Figure 5: Screenshot of Registration Interface

Figure 6: Screenshot of Encoding Interface

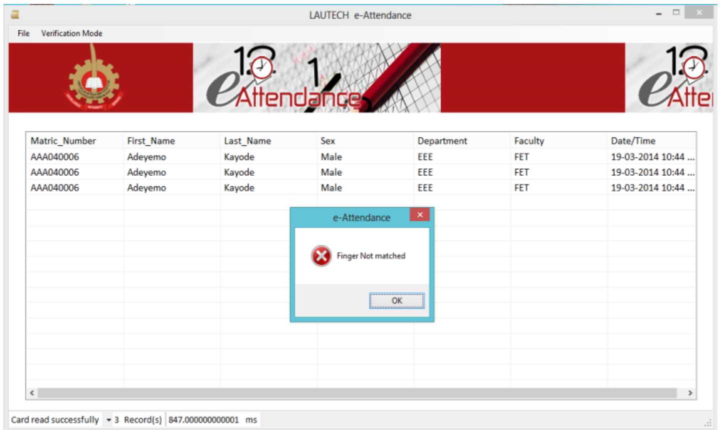

Figure 7: Screenshot of Attendance Interface

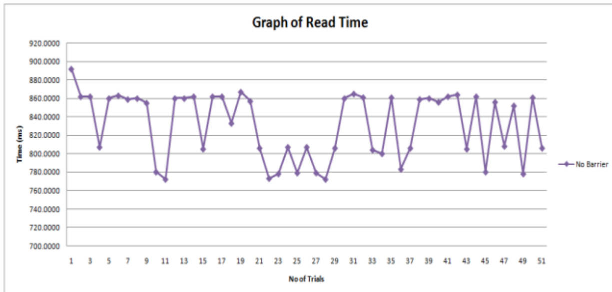

Figure 8: Read Time

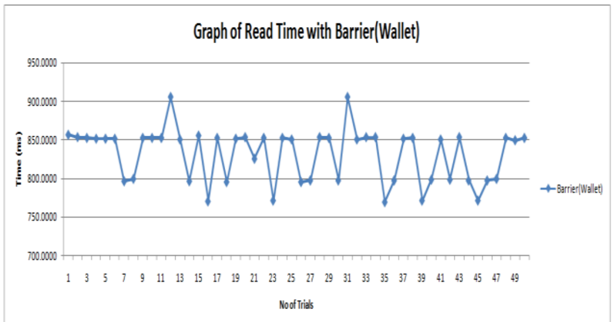

Figure 9: Read Time with Barrier (Wallet)

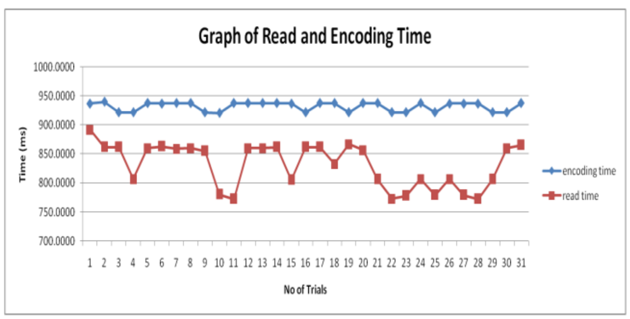

Figure 10: Comparism of Encoding and Read Time

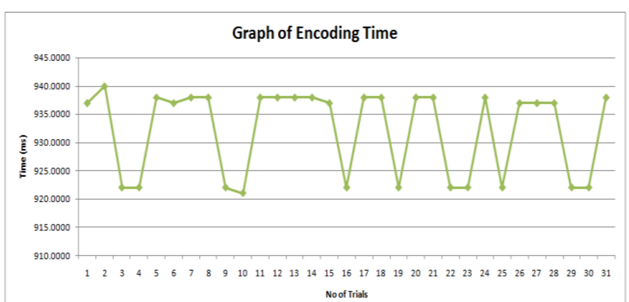

Figure 11: Encoding Time

5. Conclusion

Conclusively, a hybrid (Radio-frequency Identification and Biometric Security) attendance system using students for the investigation has been developed. The system model which consists of the coordinated hardware and software design was also developed. The performance was evaluated in terms of read time with and without wallet; the work has provided a convenient and secure method of attendance compared to the traditional method of attendance system. By using database, the data was more organized. Using fingerprint data header structure provides high security and high speed performance.

This system was also a user friendly system because data manipulation and retrieval can be done via the interface, making it a universal attendance system. Thus, it can be implemented in academic institutions or organizations.

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