Futo Journal Series (FUTOJNLS)
e-ISSN :2476-8456 p-ISSN : 2467-8325
Volume-2, Issue-1, pp- 107 - 117
www.futojnls.org

Research Paper July 2016

Design of a Biometric Attendance System with Online Monitoring for a University System

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Abstract

The continual absence of most staff and students to lectures and laboratory sessions is one of the major causes of decadence in the quality of graduates in developing countries. In this paper, an integrated Fingerprint Attendance System with remote monitoring for staff and students of tertiary institutions is presented. It also contains a web-based, real-time remote monitoring interface through which those in management level can view the staff and students as they check-in/out of the system. With this system, it takes about 2 seconds to verify and mark attendance per student as opposed to about 15 seconds for a manual process. For 71 students, attendance taking is sped up 7.3 times, and the institution managers (Heads of Ddepartments, Directors, Deans, etc.) could monitor daily attendance from anywhere in the world.

Keywords*: Attendance system, biometric, enrollment, online monitoring, UML*

1.0 Introduction

The need for unique and easy recognition of students and staff in various activities of which they are mandated to take part has become very important in tertiary institutions in developing countries. This is to checkmate truancy and lateness to work and classes by staff and students. Among the most important of these activities are Lecture and Laboratory attendance and Semester Examinations. It has become an academic rule that a student must attend 75 % of lectures in a course for a semester in order to be eligible to be tested in that course (as practiced in the Federal University of Technology Owerri). Thus the importance of uniquely identifying those that are eligible to offer a course and those who actually attended the classes cannot be over-emphasized. Impersonation must be completely eliminated in both lecture and examination.

For the lecture attendance, it has become very tiresome and nearly impracticable to collate the manual attendance sheets to know if students attended a class up to 75 % or not. Hence, a system that will capture the biometric fingerprint of students and use it to check attendance to both lectures and examinations is presented in this work. Also, passport is required for crosschecking and use as class album. The system will easily produce required reports for both lectures and examinations. For the staff, check-in by proxy needs to be eliminated and there should be a way of monitoring and automatically appraising the staff based on check-in/out time for each working day. Remote monitoring is allowed for managers because they may have travelled out of the four walls of the institution but still needs to know what is happening in real time. Remote check-in/out is NOT allowed. One has to be within the campus in order to check-in/out of the

system. However, remote monitoring is allowed for personnel in the management level. Biometrics ensures physical presence unlike password and card security systems which are transferable.

The work done by (Shoewu & Idowu, 2012) is comprehensive and it used fingerprint to take attendance in class. Also, the recommendation they made is highly commendable in terms of packaging for easy use and mobility. However, nothing was done about the examination aspect in terms of ensuring it is the particular person that attended the lectures that actually sat for the examination. Besides, no mention was made of the lecturer handling the course.

Rishabh & Prashant (2011) were more detailed in their design and analysis of student biometric attendance system. Their project was developed using MATLAB instead of C# as in (Shoewu & Idowu, 2012). They went further to explain how fingerprint identification works and how the data stored in the database will relate to each other.

In (Mohd, 2009) RFID was used to design class attendance system. In their proposed system, an active RFID reader was used to automatically trigger a tag on the student and the contained information then verified from a database of student information. Advantage of this system is its portability. However, the students will be required to carry tags around. This they may forget and thus marked absent from lecture attended. This is worse if the student forgets the tag during an examination. Another shortcoming of this approach is that it used Visual Basic 6.0, which Microsoft was no longer supporting even at the time and also they used Microsoft Access database, which is not an enterprise based database and may not support much simultaneous access and it does not manage concurrent access efficiently.

A web-based attendance and leave management system was designed by (Gapar & Johar, 2010). It did well in terms of time tracking and proof of attendance. However, it used smart card for attendance checking. This guarantees authorization but not authentication. Such cards are transferable and there is no way to ensure that no one person uses two cards. He recognized this by recommending Fingerprint and iris scan in future work.

Online students' attendance monitoring system using RFID was proposed by (Patel, Patel & Gajjar, 2012). They stressed the fact that there are certain things that students can learn only when they are together in a classroom. Examples of such are tolerance, team work, character building and making friends. However, they suggested the use of ID card affixed with RFID tag. Hence, when a student or staff forgets his ID card they will not be recognized as having attended class or work.

A number of researchers have worked on student attendance system using various biometric technologies such as Fingerprint, Iris and face recognition. Some used RFID system together with one of the biometric methods. However, all of those reviewed were limited to only lecture attendance by students. None included that of the Lecturer and signing-in and signing-out for both students and lecturers (invigilators) during examinations and on remote monitoring. This work is aimed at achieving this by designing a biometric attendance system with online monitoring capability for a university system.

1.1 The Unified Modelling Language (UML)

UML is a standard language for specifying, visualizing, constructing and documenting the components of a software system. UML 1.0 was released on the 13th of January, 1997 (Robert, 2014). UML is a link between the software system model and the actual code that implements the software model. Unlike the flowchart, data flow diagram and pseudocodes, UML models are pictorial tools that can be used to generate code in various Object-Oriented Programming (OOP) languages using the UML diagrams. UML aligns with the object-oriented paradigm in that it has a direct relationship with object-oriented design and analysis.

UML has come to replace flowcharts, which definitely do not relate to Object-oriented programming. Flowcharts do not show the relationship between objects and the relationship between data in objects. In OOP, an object contains the data and the methods (functions and procedures) that process the data. All the OOP concepts such as data hiding (encapsulation), abstraction, polymorphism, and inheritance can all be represented using UML.

Though there are various processes involved in UML modelling, the most important process is the final process which leads to the production of the various UML diagrams. These UML diagrams include: Class, Object, Use Case, Sequence, Collaboration, Activity State Chart, Deployment and Compoent diagrams. In this paper, we are going to use only the class and Use Case diagrams for modelling the biometric-based attendance system. The class diagram is used to describe the various objects that make up the system. A class diagram is made of class name, class attributes (data) and the class operations (methods). The structure of a class diagram is shown in Fig.1.

The use-case diagram is very important UML diagram that connects and summarizes all the other diagrams. It defines the different perspectives of a system by combining system design, implementation, process flow and system deployment. Use-case is used to define the high level functionalities of a system.

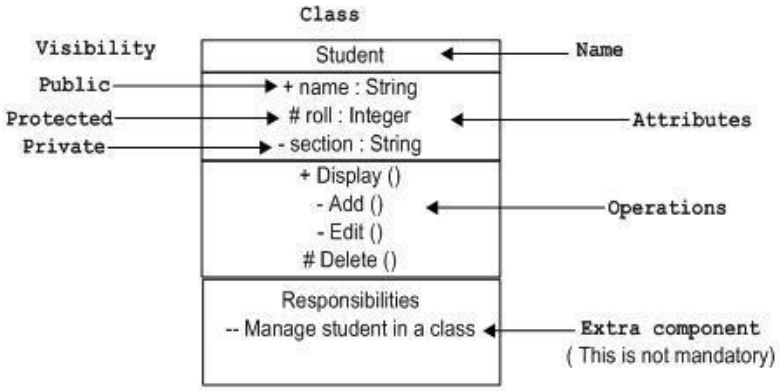

Figure 1. The structure of a class diagram

2.0 Materials and Method

The proposed system is made up of the ***data capture system*** (enrollment system), the ***check-in/check-out system*** (Identification and Verification system) and the ***web-based reporting and monitoring system***. It provides a user-friendly interface for Fingerprint enrollment and verification. The database design provides the data elements expected in the data capture phase. However, the most important ones are fingerprints, passport photo, Staff/Student Identification Number and type of user.

After initial registration which takes place by students and staff enrolling their ten (10) fingerprints, passports and other bio-data into the system, the data provided can be used as a digital class album, lecture attendance list, exam sign-in/sign-out, accreditation during elections and report generator for both student and staff use.

The system will generate a report concerning the percentage attendance of students to courses at the end of the semester. It will also help to compare the attendance to the lecture and the people who actually took the exam. Furthermore, it will help enable the invigilators for any exam to be tracked and also checkmate lecturers that gave their lectures during the semester. All these are present in the web interface,

which is also used to display information about the check-in and check-out as they occur inside the tertiary institution. The web-based monitoring system runs over a network, which is preferably a Virtual Private Network (VPN). This is because only authorized staff needs a secure access to the reporting and monitoring interface over the World Wide Web.

Unlike the type of network proposed by (Gapar & Johar, 2010) we need both LAN and WAN connection but the WAN should be a VPN. The web-based monitoring and desktop-based capture system uses the same database source. Hence, the database must be accessible over the network in use.

2.1 Software Design Methodology

As stated in Section II, the design method chosen is the use of the Class and Use case UML diagrams to model the software system.

2.2 Class Diagrams

Figure 2 is the program flowchart for the attendance and remote monitoring system. The software was designed and developed using VB.Net, ASP.Net and MS-SQL express programming languages. VB.Net is simple as it is just an Object-Oriented version of the simple BASIC language used since the origin of computers. MS-SQL Server is also an enterprise database that can handle bulky data like binary data for fingerprint and passports of staff and students.

Table 1: Selected Study Areas in Ifedore Local Government Area

Population density	Name of village	No. of questionnaire distributed	No. of questionnaire retrieved
	Igbara-oke	366	320
High density	Ilara-mokin	200	171
	Ijare	162	138
	Isarun	110	95
Medium density	Ibule-soro	72	55
	Ipogun	61	50
Low density	Irese	33	24
TOTAL		1004	853

Table 2: Enrol Fingers

Enrol Fingers
UserID: String
FullName:String
rightThumb: Byte
rightIndex: Byte
rightMiddle: Byte
rightRing:Byte
rightPink: Byte
leftThumb:Byte
leftIndex: Byte
leftRing: Byte
leftPink: Byte
isReaderConnected()
captureFingerPrint()
storeFingerprintTemplate()

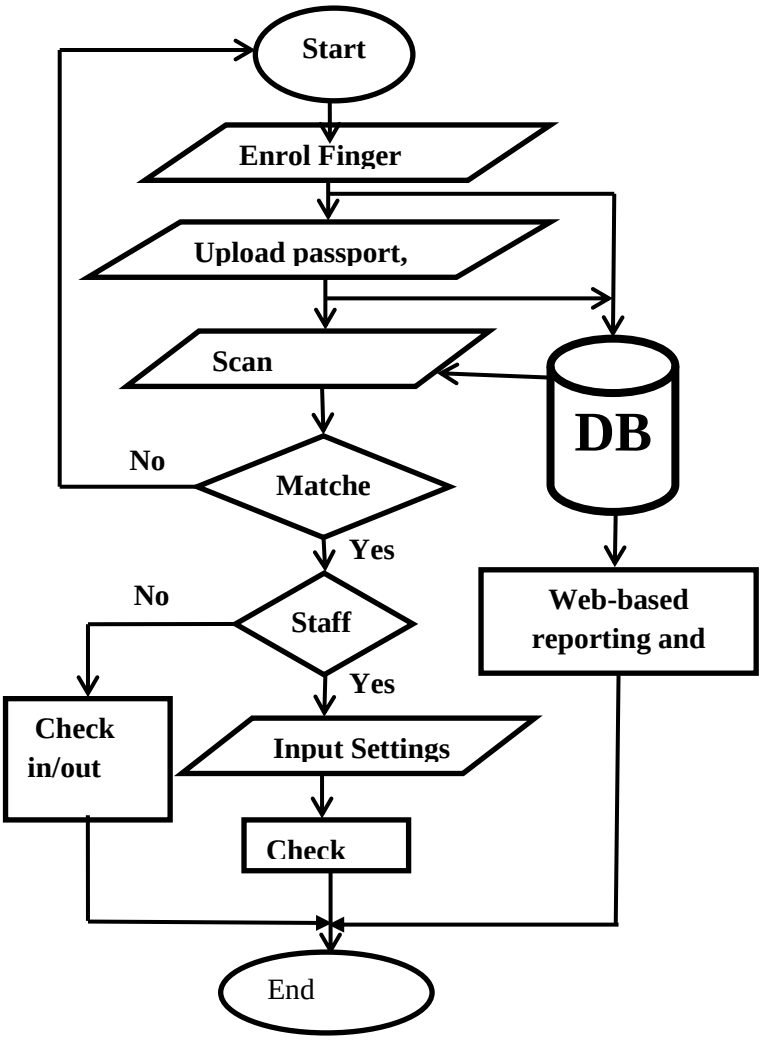

Figure 2. Flow chart for the integrated fingerprint attendance system

The major functionality of the attendance system is contained in the **Activities** menu. The enrollment by provision of fingerprint data and other bio-data is done here. Also the Check-in and Check-out into and from both Lectures and examinations are done here. The **File** menu enables one to view various reports based on number of enrollments, attendance to lecture for a given course in a given session and the number of students that actually sat for an exam in a course in a given session. Percentage attendance for each student in a course for a session is also obtained here. The **Settings** menu is used to configure default parameters for the entire software system and for the current course for which lecture or examination is being held. These settings are configured by a staff but only after biometric verification by the verification module. The **Help** menu teaches how to use the software and gives the version of the software and contact for support.

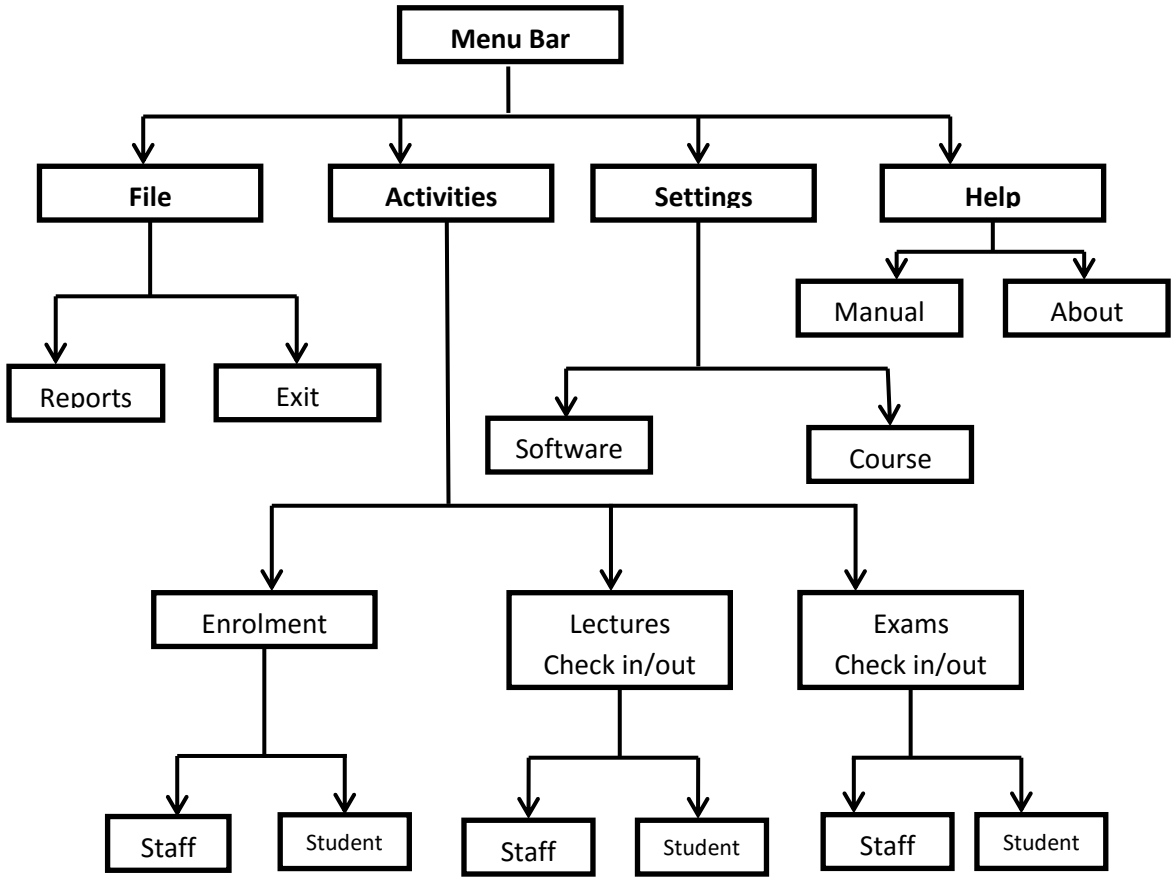

Figure 3: Attendance system menu hierarchy

The entire system requires data persistence in order to perform future activities and provides the required information when queried. Some of these information are those directly provided by users while others are intuitively generated by the software intelligence. The data input by the user are saved in various tables in the MS-SQL database using the table structures described in this section. Table 3 still contains useful data that defines the role that the given user will play in the scheme of the software functionality.

Table 4 keeps the most useful identifier for a particular user of the system. The final set of information required is the attendance to the classes/courses. Table 4 is the *Attendance list data* which collects information for both attendances to exams and lectures.

Table 3. User Role Data

Field Name	Data	TYPE	Constraint
userID	Varchar	11	Foreign Key
Photo	Varbinary	5000	Not Null
Department	Varchar	50	Not Null
Gender	Varchar	6	Not Null
Phone	Varchar	16	Null
Email	Varchar	50	Null
Residence	Varchar	100	Not Null
Usertype	Varchar	7	Not Null
Dateenrolled	DateTime		Not Null

Table 4. Attendance List Data

FieldName	Data	Type	Constraint
userID	Varchar	11	Foreign key
Course code	Varchar	7	Not null
Course title	Varchar	50	Null
Semester	Int		Not null
Session	Varchar	9	Not null
Checkin	datetime		Not null
Checkout	datetime		Not null
Day	Date		Not null
Attendance type	Varchar	10	Not null

2.3 Web Monitoring and Reporting System Design

The web monitoring and reporting application runs over a VPN network and has been referenced in the flow chart of Fig 2. However, in this subsection, we present a menu hierarchy of this output-based application. Figure 3 is the menu hierarchy for the proposed reporting system. An ordinary password login system was chosen because this job of monitoring and evaluating reports can be delegated. The real-time monitoring is for a specific staff or a particular department. The reporting is applicable to both students and staff. The actual information that is displayed when a menu is selected consists of tables and charts for comparison and evaluation reports. Thresholds (percentage) can be set to filter the students and staff presented in a given report.

2.4 Requirements For Implementation

Apart from the software requirements such as license for proprietary software, Microsoft SQL Server 2012 and Digital persona SDK authorization license that are needed for commercial roll-out, the following hardware are needed and are very necessary to complete the development and in-house deployment of the system:

1. A laptop system with a minimum of 1GB RAM and 160GB hard disk.
2. A digital persona U.are.U Fingerprint scanner (4000 or 4500 model).
3. Internet connection.
4. Database server.

These hardwares are needed only for development, testing and deployment of the system.

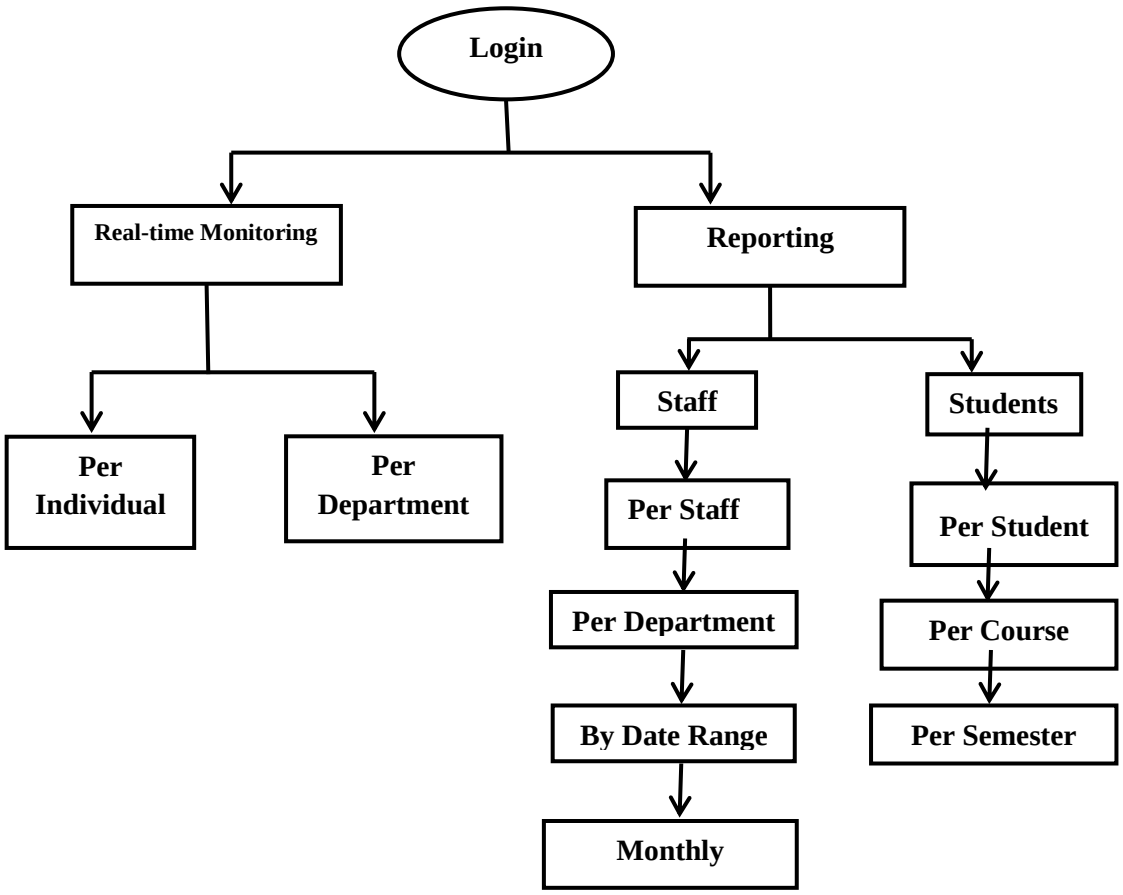

Figure 4. Menu hierarchy for the monitoring & reporting system

3.0 Results

Figure 5 is an enrollment screen. You click on a finger in order to enroll. On successful enrollment, the particular finger turns green as shown in Fig. 6 (instead of grey as shown above).

Figure 5. Fingerprint enrollment system showing menus (File, Activities, Settings and Help).

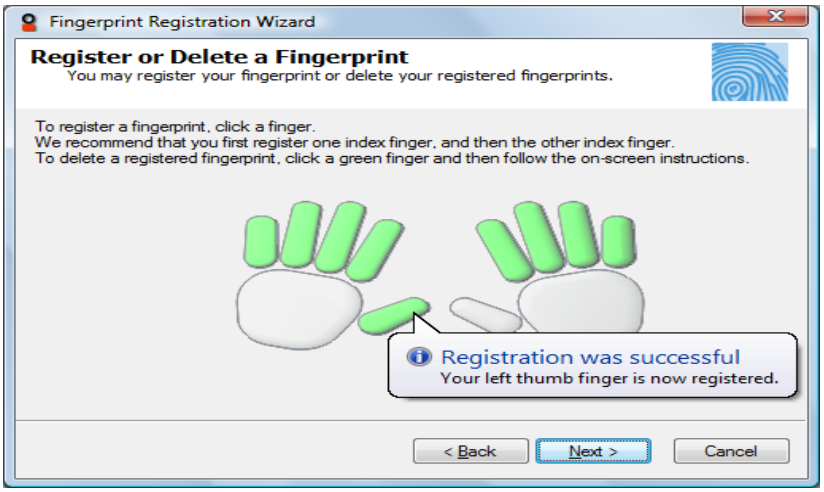

Figure 6. Successful fingerprint enrolment

Other biodata are then collected. In order to use the system as a class album as well, the file upload button was included to enable the software get the passport file and save it. On verification and authentication, the student's or lecturer's picture will appear to confirm the fingerprint. This is a double-check strategy.

Once you click on a finger to enroll, the software will check if a fingerprint scanner is connected. If none is connected, it will throw the exception shown in Fig. 7 and cancel the enrollment process. To correct this, check if there is proper connection of the scanner to the USB port or if the scanner driver was correctly installed.

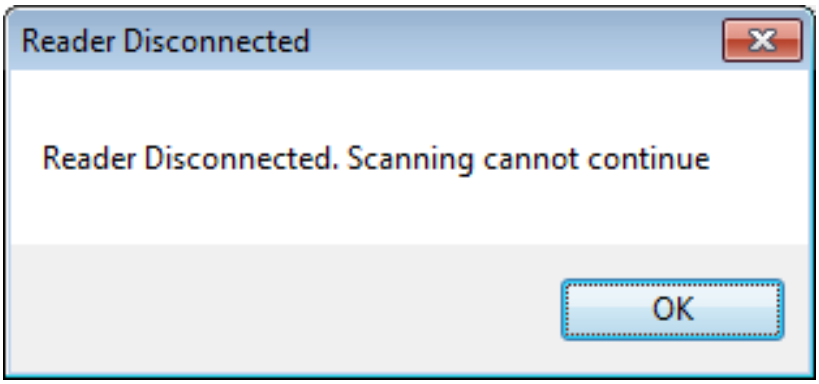

Figure 7. The No scanner error.

Fig. 8 is the verification screen for any action requiring identification and verification of identity. You need to click on a particular finger that you would like to use for identification and verification. The ten fingers are not required for verification.

Figure 8. Integrated check in and verification window for lectures and exams

Finally, Fig. 9 is the login screen for the web application used for monitoring and reporting. The screen is presented from the local host but should be hosted in an Internet Information System (IIS) server with internet access provided.

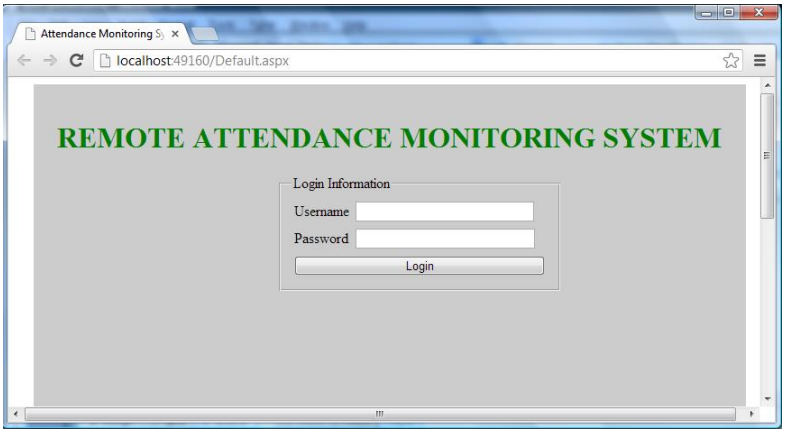

Figure 9. Login screen for remote monitoring and reporting

The bulk of the time taken by the system is during enrollment into the system. It took 2 seconds to enroll each finger. Hence, 20 seconds for 10 fingers. The other bio-data took an average of 75 seconds to be keyed into the computer. As, it is not network-based, the write-time into the database is almost instantaneous. Hence, the enrollment process for a student or lecturer is 95 seconds. For the 71 students and 2 lecturers in the Electronics/Computer Engineering Option in the Department of Electrical/Electronic Engineering at FUT, Owerri, used to test the system, it took 73 * 95 = 6935 sec = 115.58 mins = 1 hour 56 minutes.

One might be scared of such an enrollment time but the advantage comes while using the system for both lecture and examination check-in/out. With the same students and lecturers, and using Digital Persona U.are.U 4500 model, it took just 2 seconds to verify the identity of a user and display other bio-data on the computer screen. This totals to 73* 2 = 146 sec = 2 minutes 26 seconds. In the paper-based attendance and verification system, far more time is wasted. For average fast writers, it took 15 seconds to write serial number, full name, and matriculation number and sign their signature. When calculated for 71 students, this gives 71*15 = 1065 sec = 17.75 minutes. This is 7.3 times more than the automated process. Hence, with this, the time spent during enrollment is recovered over time. For examination purposes, the extra time spent by supervisors in arranging students in alphabetical order for easy comparison with class list and class album is also eliminated.

4.0 Discussion

4.1 Cost of a Prototype

The above costing assumes that a LAN already exists and the tertiary institution has web presence where they host their web applications. It is obvious that with bulk purchase and licensing, cost will reduce drastically.

Table 4: Costing of a Prototype

S/N	Item	Cost (₦)
1.	Fingerprint reader	15,000
2.	Computer system	21,000
3.	Database Server	40,000
4.	Software License	50,000
	TOTAL:	**126,000**
		≈($400.00)

5.0 Conclusion

The Biometric Attendance System with Online Monitoring, if faithfully implemented, will strongly improve the quality of graduates produced in our tertiary institutions and justify the salary paid to staff in our tertiary institutions. This work improves on the existing systems in (Shoewu & Idowu, 2009). It will also provide a good basis for appraising both the students and staff, and will reduce the worries of the top management on staff attendance to work. The system is strongly recommended for all tertiary institution in developing countries where e-learning and e-collaboration is not dominant. Finally, future work will focus on using smart cards to store user information and on improving the security and robustness of the designed system. The biometric data of staff and students would be captured on employment or admission and stored on a smart ID card to ensure that failure of biometric database will not hamper the usage of the system.

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