Biometric-based Attendance System with Remote Real-time Monitoring for Tertiary Institutions in Developing Countries

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***Abstract* - The attitude of some staff and students of tertiary institutions in developing countries to classroom lectures and to office duties have been spotted as one of the 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 proposed. 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 took only 2seconds to verify and mark attendance per student as opposed to 15seconds for manual process. For 71 students', attendance taking was sped up 7.3 times, and the institution managers (HODs, Directors, Deans etc.) could monitor daily attendance from anywhere in the world.**

Keywords: Biometric, Check- in/out, Remote monitoring, Enrollment, Verification

I. INTRODUCTION

The need for unique and easy recognition of students and staff in various activities of which they are mandated to take part in 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, respectively. 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, we propose a system that will capture the biometric fingerprint of students and use it to check attendance to both lectures and examinations. 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.

II. REVIEW OF RELATED WORKS

A number of previous 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.

The work done by [1] 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 said about the examination aspect in terms of ensuring that it is the particular person that attended the lectures that actually sat for the exam. Besides, no mention was made of the lecturer taking the course.

The authors in [2] were more detailed in their design and analysis of student biometric attendance system. Their project was developed using MATLAB instead of C# as in [1]. They went further to explain how fingerprint identification works and how the data stored in the database will relate to each other.

In [3] 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 worst if the student forgot the tag during an examination. Another shortcoming of [3] is that they 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 [4]. 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 card are transferable and there no way to ensure that no one person uses two cards. He recognized this by recommending Fingerprint and iris scan in future work.

The authors in [5] proposed online students' attendance monitoring system using RFID. 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.

III. SYSTEM DESIGN

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 staffs 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 need a secure access to the reporting and monitoring interface over the World Wide Web.

Unlike the type of network proposed by [5] 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.

IV. SOFTWARE DESIGN METHODOLOGY

As a software system the design methodology chosen include software design, database design and web-portal design.

A. SOFTWARE DESIGN

Fig 1 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 staffs and students.

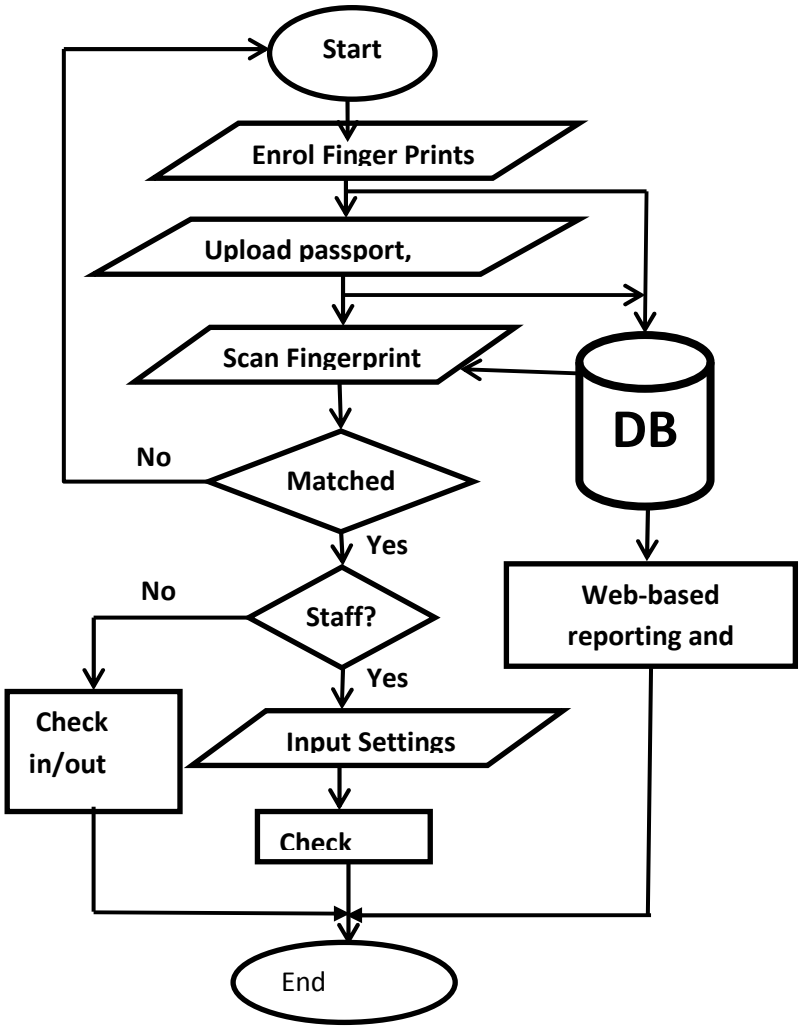

Figure 1 – ***Flow chart for the integrated Fingerprint Attendance System***

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 you how to use the software and gives you the version of the software and contact for support.

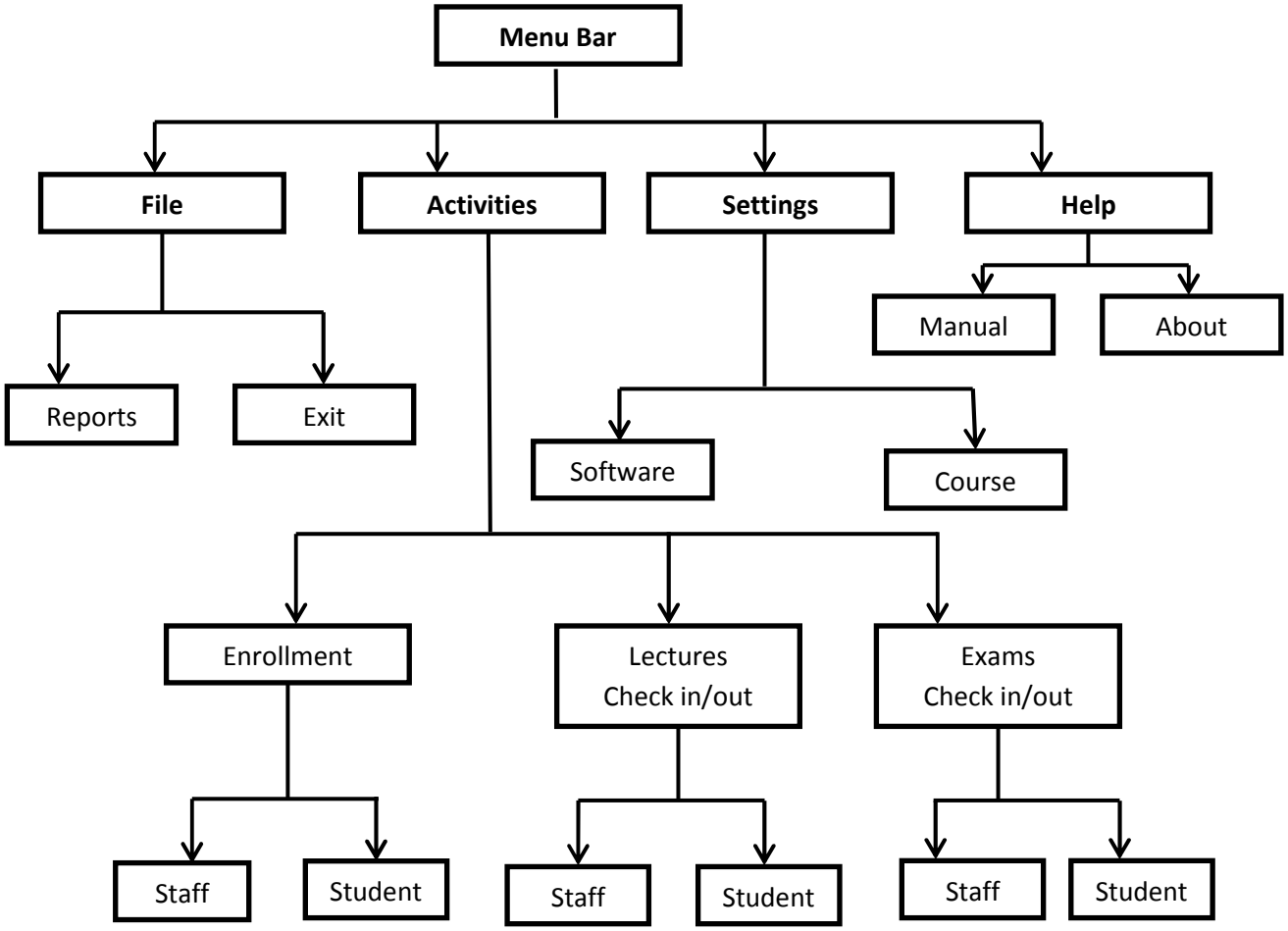

Figure 2 – *Attendance System menu hierarchy*

B. DATABASE DESIGN

The entire system requires data persistence in order to perform future activities and provides the required information when queried. Some of this 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.

The table below keeps the most useful identifier for a particular user of the system.

Table I: UserFingerPrintData.

Field Name	Data Type	Constraint
UserID	Varchar (11)	Primary Key
FullName	Varchar(50)	Not Null
rightThumb	Varbinary(5000)	Unique
rightIndex	Varbinary(5000)	Unique
rightMiddle	Varbinary(5000)	Unique
rightRing	Varbinary(5000)	Unique
rightPink	Varbinary(5000)	Unique
leftThumb	Varbinary(5000)	Unique
leftIndex	Varbinary(5000)	Unique
leftMiddle	Varbinary(5000)	Unique
leftRing	Varbinary(5000)	Unique
leftPink	Varbinary(5000)	Unique

Table II below still contains useful data that defines the role that the given user will play in the scheme of the software functionality

Table II: UserRoleData

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

The final set of information required is for the attendance to the classes/courses. Table III below is the *AttendanceListData* which collects information for both attendances to exams and lectures.

Table III: AttendanceListData

FieldName	Datatype	Constraint
userID	Varchar(11)	Foreign Key
Coursecode	Varchar(7)	Not null
Coursetitle	Varchar(50)	null
Semester	Int	Not null
Session	Varchar(9)	Not null
Checkin	datetime	Not null
Checkout	datetime	Not null
Day	Date	Not null
Attendancetype	Varchar(10)	Not null

C. 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 1. 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.

V. REQUIREMENTS FOR IMPLEMENTATION

Apart from the software requirements such as license for proprietary software such Microsoft SQL Server 2012 and Digital persona SDK authorization license that are needed for commercial roll-out, the following hardware are need 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.

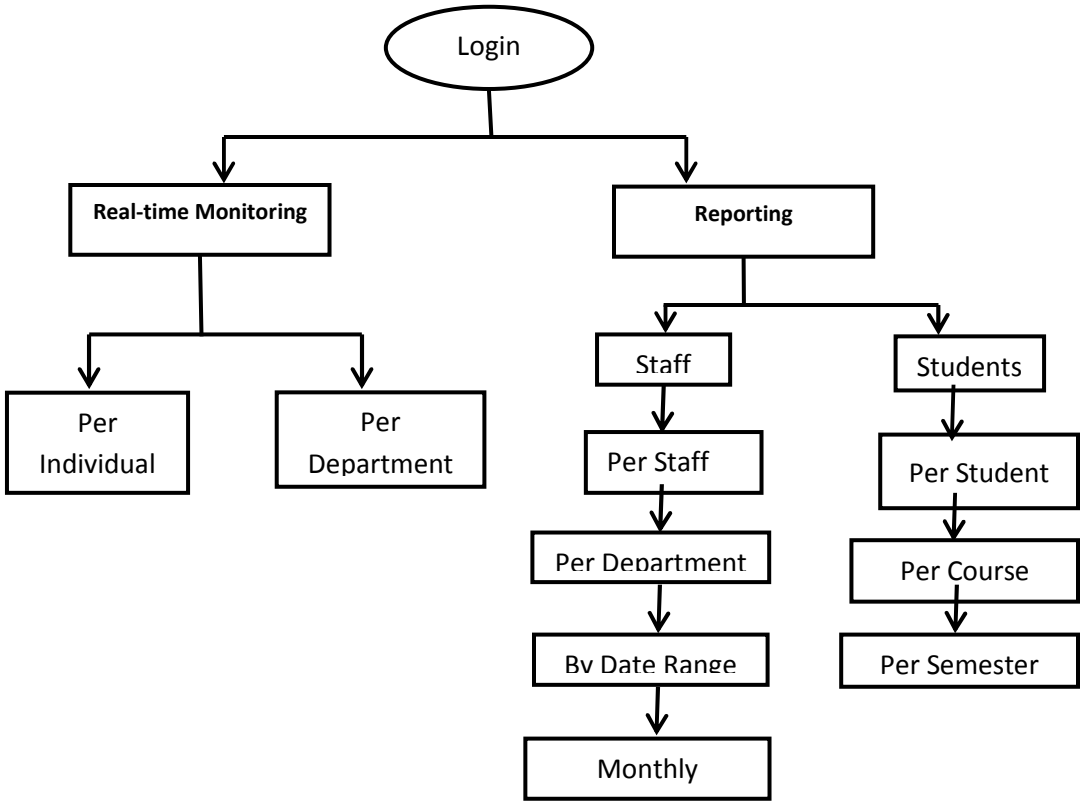

Figure 3 – *Menu hierarchy for the monitoring & Reporting System.*

VI. RESULTS, DISCUSSION AND SIGNIFICANCE

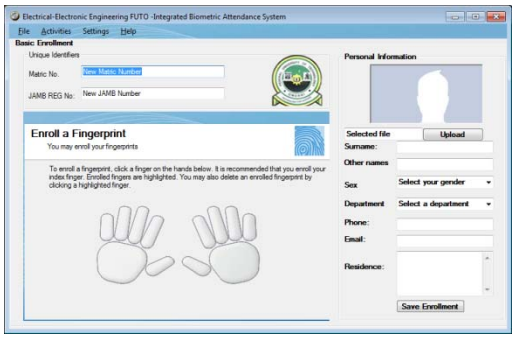

Figure 4 – *Fingerprint enrollment system showing menus (File, Activities, Settings and Help).*

Figure 4 above is an enrollment screen. You click on a finger in order to enroll it. On successful enrollment, the particular finger turns green as shown in fig 5 (instead ofgreyas shown above). Other biodata are then collected. In order to use the system as a class album as well, we included the file upload button to enable the software get the passport file and save it. On verification and authentication, the student's or lecturer's picture willappear to confirm the fingerprint. This is a double-check strategy.

Figure 5 – *Successful fingerprint enrollment.*

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 above exception shown in figure 6 and cancel the enrollment process. To correct this, check if their is proper connection of the scanner to the USB port or if the scanner driver was correctly installed.

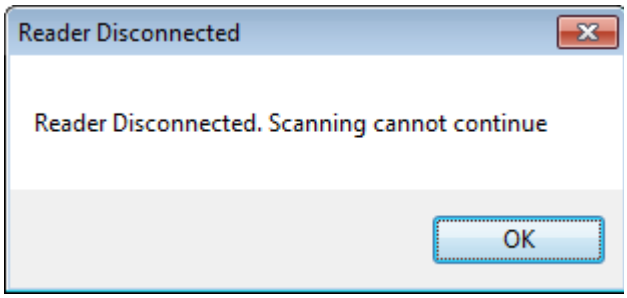

Figure 6 - *The No scanner error.*

Figure 7 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 7 – *Integrated Check in and Verification window for Lectures and Exams.*

Finally, Fig 8 is the login screen for the web application used for monitoring and reporting. The screen is presented from the localhost but should be hosted in an Internet Information system (IIS) server with internet access provided.

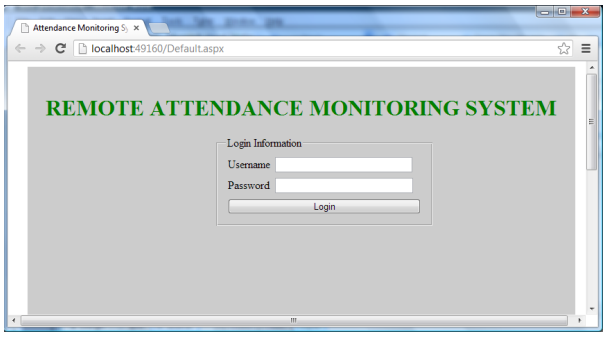

Figure 8 – *Login Screen for remote monitoring and reporting.*

The bulk of the time taken by the system is during enrollment into the system. It took 2seconds to enroll each finger. Hence, 20 seconds for 10 fingers. The other bio-data took 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 95seconds. 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 = 115.58mins= 1 hour 56 minutes.

One might be scared for such 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 15seconds 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.

IV. CONCLUSION

This system, if faithfully implemented, will strongly improve the quality of graduates produced in our tertiary institution and justify the salary paid to staff in our tertiary institutions. This work improves on the existing systems in [1]. [2] and [5], ensures proper implementation of academic regulations and minimizes both time and effort in checkmating attendance to lectures and other activities by both students and lecturers in developing countries. It will also provide a good basis for appraising both the students and staff. It will reduce the worry of the top management on worrying if a staff does come to work or not. We strongly recommend this for all tertiary institution in developing countries where e-learning and e-collaboration is not dominant. Finally, we recommend, for futuristic purpose, that a more portable system should be used instead of Laptop. For this portable system, a modular fingerprint should be used instead. Also, the biometric data of staff and students should be captured on employment or admission to ensure that uniform and correct data is used for all purpose for the duration of employment or study.

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APPENDIX A: COST OF A PROTOTYPE

Table IV: Costing

S/N	ITEM	COST(Naira)
1.	Fingerprint reader	15,000
2.	Computer system	21,000
3.	Database Server	40,000
4.	Software License	50,000
	TOTAL:	**126,000**
		=($773.01)

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