Embedded Computer-Based Lecture Attendance Management System

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ABSTRACT
Electronic cards like magnetic cards and smart cards have been used worldwide for different functions such as electronic payment system (credit card and debit/ATM cards), electronic voting system, personnel identification system and security system. In this paper, we present an electronic card-based solution to the lecture attendance problem in higher institutions in the developing countries. Ours is based on single-chip computer based subsystems interfaced serially to the serial port of the digital computer. The developed system could speed up the process of taking students lecture attendance and allows for error free and faster verification process of authenticating student lecture attendance policy required for writing examination in a campus environment.

Keywords: Microcontroller, PIC16f84, Lecture, Attendance, AT89C52, Serial Port

1. INTRODUCTION

In most institutions of higher learning in the developing countries, no student is qualified to write examination unless a record of minimum of seventy percent of the lecture attendance is attained. This policy has not been totally observed because a proper protocol of observance has not been established.

The usual practice is that students are given sheets of paper to write down their names, matriculation number and signature. This manual method of taking attendance is obviously not effective as it is attributed to the following challenges: The sheets of paper become cumbersome and untidy as the population of student increases; time consuming and a waste of human and material resources; high level of impersonation as absentee can be on the list through their friends that attended the class due to the lower lecturer/student ratio and large class size. Consequently, it is very difficult to manage the attendance and determine whether each student actually made seventy percent (70%) of lecture attendance.

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As a result of these flaws in the classical method of taking student attendance, there is need for faster, easier, more accurate and effective method, using modern technology of the present age. A number of tools have been used to solve this problem, this include Barcode Readers [10],Radio Frequency Identification System[15] and Bluetooth[16].These tools were not only expensive when first introduced, they had limited usage[13].

This work seeks to shift paradigm from these referred methods by formulating and implementing a simplified and cost effective model of embedded computer based solution to the classical and/or manual method of managing student lecture attendance problem in higher institutions in developing countries like Nigeria. The paper is divided into seven sections: section 2 discusses related works in the problem domain, Section 3 highlights the general overview of the proposed system, Section 4 details design considerations of the system, both at the hardware and software level, Section 5 discusses the operation and how the system was tested in conformity to system design and functional objectives. Section 6 concludes the paper while section 7 identified gaps and make recommendations for future improvement.

2. RELATED WORKS

A number of related works exist in literature on application of different electronic engineering principles to student attendance monitoring problem. In [2], an automatic attendance system using fingerprint verification technique was proposed. The fingerprint technique verification was achieved using extraction of abnormal point on the ridge of user's fingerprint or minutiae technique.

The verification confirms the authenticity of an authorized user by performing one to one comparison of a captured fingerprint templates against the stored templates in the database. The proposed automatic attendance system signals either true or false based on logical result of previous one to one verification of person's authenticity. Authors in [6] also reviewed and proposed biometric system using fingerprint identification for attendance automation of employees in an organization.

Consequently, authors in [14] proposed student wolf pack club tracking system to simplify and speed up the process of student wolf pack club ticket distribution for athletic event. Similar solution was proffered for tracking and counting students in [13] during Eastern Mediterranean University seminars using barcodes and readers. Also, authors in [11] proposed the use of electronic finger print scanner to solve students lecture attendance monitoring problem of Bells University of Technology, Ota, Nigeria.

The fingerprint technique verification was achieved using extraction of the biometric fingerprint feature of each undergraduate student. The application software of the proposed system lacks report generation and audit trail system and thus made students attendance to be entered manually. In [9] authors proposed student tracking using Radio frequency identification system (RFID). It involves the use of the student card to get student attendance. The author tried to solve the problem of manual computation of attendance but his work does not eliminate the risk of impersonation. Similar solution to attendance monitoring problem can be found in barcode readers as does in [13].

In [2], Artificial Neural Networks and Facial Recognition in Artificial Intelligence were used to develop a security door system where authorization of facial appearance of privilege users in the database is the only guarantee for entrance. In the system, the personal computer processes the user's face recognized by the system digital camera and compares data with privileged users in the database. The control program either sends a control signal to open the electromechanical door upon facial existence or deny entry.

Ours is a simplified and cost effective model of embedded computer based automated students lecture attendance system that allows lecturers to electronically monitor student attendance and verify if each student made the required percentage to sit for an examination using an improvised electronic card. The proposed system does not only speeds up the process of taking attendance but allows for less error and faster verification process of authenticating student lecture attendance policy required for writing examination in a campus environment.

3. SYSTEM OVERVIEW

The proposed system provides solution to lecture attendance problem through coordinated hardware and software design synergy that exists between an improvised electronic card and the card reader serially interfaced to the digital computer system [9]. The electronic card is a model of a smart card containing the student identity (ID-Name, Matriculation Number and five pin encrypted code).

The student ID is authenticated by the card reader which compares the entrance code with the encrypted code on the card swiped through the card reader. The student is granted and/or denies specific lecture attendance based on the result of the comparison by the backend software system running on the PC to which the card reader is serially interfaced as shown in Figure 1.0

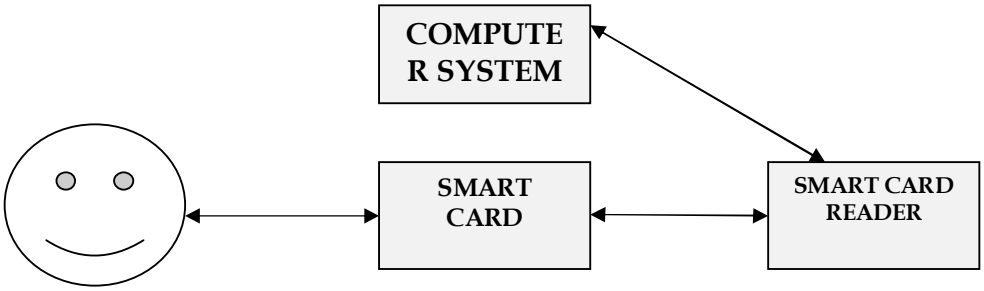

Figure 1.0: Block diagram of an Embedded Computer Based Lecture attendance system

4.0 SYSTEM DESIGN

In an attempt to solve above the following lecture attendance problem, the proposed system from figure 1.0 interacts with students on lecture by lecture basis for proper student identification, organization and authentication. The system major design considerations were functionality, simplicity, availability of component, ease of use and cost. From the block diagram, the electronic smart card contains an embedded computer based system or microcontroller with a non-volatile storage memory system to hold student identification details.

The card reader also contains a microcontroller which receives the data and sends data to the computer system for attendance authentication and/or denial. The computer system contains an interactive Object Oriented paradigm (OOP) based software system that modifies student attendance information and updates it on the system database. It also provides an interface where attendance is taken, and results could be given when required. The section 4.1 and 4.2 give the detail hardware and software design considerations for the proposed system design idealization.

4.1 HARDWARE DESIGN CONSIDERATIONS

The hardware subsystem consists of two main parts the card and the card-reader. These parts are discussed as follows:

4.1.1 The Electronic Smart Card

The card initial design considerations include data storage and data security. For data storage, different chips were considered, they include: serial EEPROM, RAM, Battery Backed-Up RAM, and SD memory cards. For cost consideration, an intelligent microcontroller device that will not only provide data security but also has the ability for permanent storage was chosen. Although there are different options of microcontrollers such as; PIC16f648a which has large memory capacity and operates at high speed and have a lot of additional features, but they were not readily available and expensive. The microcontroller used for the card is the PIC16F84A, which is readily available and easy to use.

The PIC16F84A belongs to the mid-range family of the PICmicro® microcontroller devices. Figure 2.0 shows the block diagram of the device. The program memory contains 1K words, which translates to 1024 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes and Data EEPROM is 64 bytes. There are also 13 input/output (I/O) pins that are user-configured on a pin-to-pin basis [1]. Some of the pins are multiplexed with other device functions.

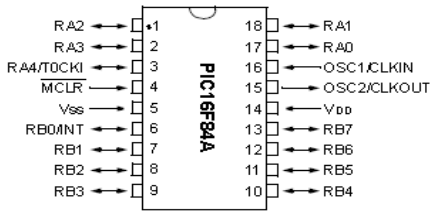

Figure 2.0: PIC16F84 pin details

For the card microcontroller oscillation design consideration, the data sheet in [7] of the PIC16F84 stipulated that the crystal oscillator can operate in four modes: 1) LP Low Power Crystal 2) XT Crystal/Resonator 3) HS High Speed Crystal/Resonator and 4) RC Resistor/Capacitor. Our card design emphasize the XT mode (crystal/resonator) shown in figure 3.0.

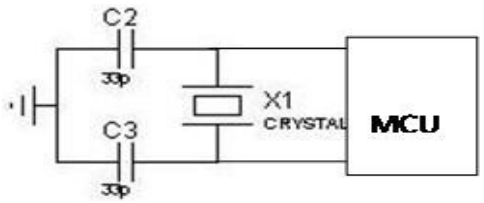

Figure 3.0: Crystal Resonator XT Configuration

A crystal or ceramic resonator is connected to the OSC1/CLKIN and OSC2/CLKOUT pins to establish oscillation. This is illustrated in Table 1.0.

TABLE 1.0: Capacitor Selection for Ceramic Resonators

Mode	Freq	OSC1/C1	OSC2/C2
XT	455 kHz 2.0 MHz 4.0 MHz	47 - 100 pF 15 - 33 pF 15 - 33 pF	47 - 100 pF 15 - 33 pF 15 - 33 pF

From the table above, a 4.5MHZ crystal oscillator with two 33pf capacitors attached, constantly supply power irrespective of the break in contact with the reader. Higher capacitance increases the stability of the crystal oscillator while lower capacitance reduces start-up time. Any size of crystal oscillator could have been used, because the higher the crystal oscillator, the more power it consumes and the lower it is, the more time it would take for the card to transfer data to the card reader so, 4.5MHZ was a good compromise between power consumption and speed.

The processing speed of the PIC18F64 from the data sheet [7] is:

PIC18F64 processing speed = Frequency of Crystal Oscillator/4 = 4.5/4=1.15MHz.. (1)

So, the processing speed of the PIC18F64 Microcontroller on the card is 1.15MH. The overall circuit diagram for the system electronic card subsystem is thus shown in figure 4.0:

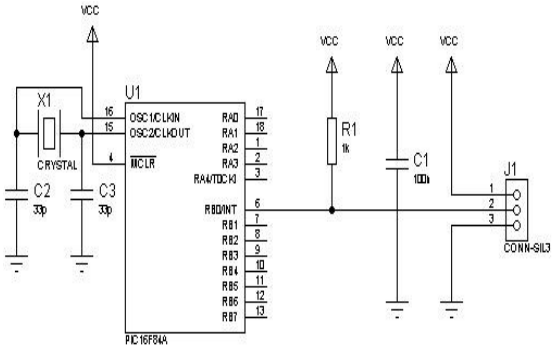

Figure 4.0: Electronic card circuit diagram

For cost and space design reasons, different options were considered for the integration of the various electronic components attached to the individual subsystems. Two methods under consideration were to use a veroboard or try to design a printed circuit board (PCB) to attach the microcontroller of the card and card reader. To ensure high precision when sliding the electronic card through the reader and minimize error in system operation, our improvised lecture entrance electronic card features the design of 2.2 inches X 3 Inches PCB in single sided copper clad of one (1) oz of figure 4.0 as figure 4.1.

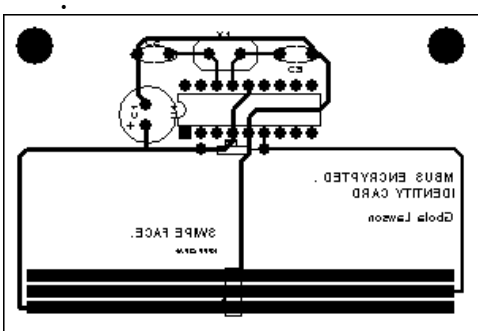

Figure 4.1 PCB Layout for card

4.1.2 The Card Reader

The size and simplicity of the device were the two major design considerations taken the in card reader design. Its primary functions are as follows: 1) Ability to read from and write to the improvised lecture entrance card in a secure manner, 2) Ability to communicate with the computer system and effectively interacts with each student upon arrival to lecture venue.

For the communication with card, the microcontroller used for the card reader was the Atmel's AT89C52 which is a variation of Intel's 8051 (with similar instruction sets). AT89C52 is readily available in the open market and has a low-power, high-performance CMOS 8-bit microprocessor with 256 bytes of data RAM, 8K bytes of Flash programmable and erasable read only memory (EEPROM). Other features of the AT89C52 MCU considered for this application are: 32 Programmable I/O Lines; Eight Interrupt Sources; Endurance: 1,000 Write/Erase Cycles; Fully Static Operation: 0 Hz to 24 MHz, Three-level Program Memory Lock and Low-power Idle and Power-down Modes. The embedded data RAM acts as a temporary storage or buffer for transferring data between the computer system and the card. AT89C52 MCU is volatile and would only retain data while power is connected to the device.

Consequently for oscillation design consideration, the crystal oscillator used was faster than that on the card. The MCU operates at 1/12 of the crystal oscillator speed (compared to the ¼ of the PIC18F64). A higher frequency that would be in the same range with the processing speed of the card is needed. The processing speed of the AT89C52 which from the data sheet from equation 1, thus is:

AT89C52 processing speed = Frequency of Crystal Oscillator/12=8/12=0.66MHz (2)

The recommended capacitance for the capacitor according to the data sheet for the crystal oscillator was C1, C2 = 30 pF, 10 pF for crystals respectively. Since 33pf capacitor was used for the entrance electronic card we decided to use the same for the card reader's crystal oscillator. There is also a power on reset circuit (Figure **5.0**) connected to the pin 9 (RST) of the AT89C52 MCU. When power is connected to the device, current flows through the capacitor (c) to the RST pin for a time (t) till the capacitor becomes fully charged, since the RST pin is active high, the voltage present at the pin causes the MCU to reset, after which the capacitor becomes cut off and the pin is connected to the ground through resistor (R).The time it takes to reset the MCU is: $0.5 = e^{-t/RC}$. Thus, t was calculated as: t = log 0.5 X (-RC) =t = log 0.5 X (-5600 x 10E-6) t = 1.6858 x 10^{-10}sec (3)

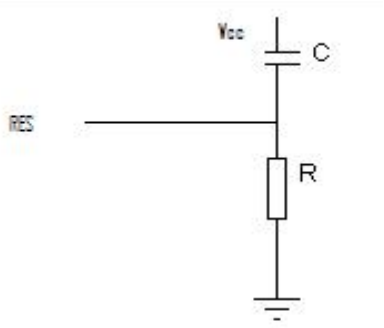

Figure 5.0: The Reset Circuit

A red light emitting diode (LED) was connected to pin 21 of the MCU. Its serves as an indicator to show when the card is connected to the reader (The led comes on) and it blinks when data has been stored into the card. The 1k resistor (R2) connected to the LED acts as a limiting resistor to reduce the voltage across the diode. Pin 32(port 0 pin 7) was used for simplex communication with the card. For communication with computer system, we considered serial interfacing with the computer system, this was also a criterion we used in selecting the MCU used for the reader since AT89C52 MCU has programmable serial channel capabilities which enables it to serially transmit and receive from the computer.
In the chip, Pin P3.0/ RXD was used to receive data while Pin P3.1/ TXD was used for data transmission.
UART chip takes the parallel output from processor bus and transform it to serial form for transmission and vice versa [5]. Typical chip along this purpose is MAX232 Transceiver. Because, the 5v (0 – 5v used) in the devices was incompatible with the 25v (-12v to + 12v) signal level used by the serial port. A MAX232 transceiver was introduced to interface the reader and the computer system. The MAX232E line drivers/receivers are designed for RS-232 and V.28 communications in harsh environments. Each transmitter output and receiver input is protected against ±15kV, electrostatic discharge (ESD) shocks, without latch up.

Other power electronic components used for the design include: KA7805 Voltage Regulator and Adjustable base voltage and current capacitors. For durability, flexibility and power protection of the overall electronic circuitry; it was necessary for the reader to operate over a wide range of voltage. This was achieved by introducing a voltage regulator KA7805 IC. The IC is part of the KA78XXA series of three-terminal positive regulator with several fixed output voltages. KA7805 has a fixed output voltage of (5Vdc), with a wide range of input voltage between 3.5Vdc to 6Vdc, it employs an internal current limiting, thermal shut down and safe operating protection, making it essentially indestructible[8].

If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents. The two 10uf capacitors C1 and C2 in figure 6.0 connected to the voltage regulator are used to regulate the flow of current. In our design, the KA7805 acts as a constant voltage (5v) power source for both the reader and the card when connected [6]. The overall circuit diagram for the card reader is shown in figure 7.0:

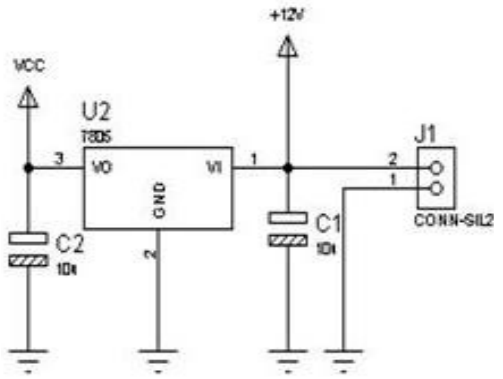

Figure 6.0: Three Terminal 7805 circuit for power protection

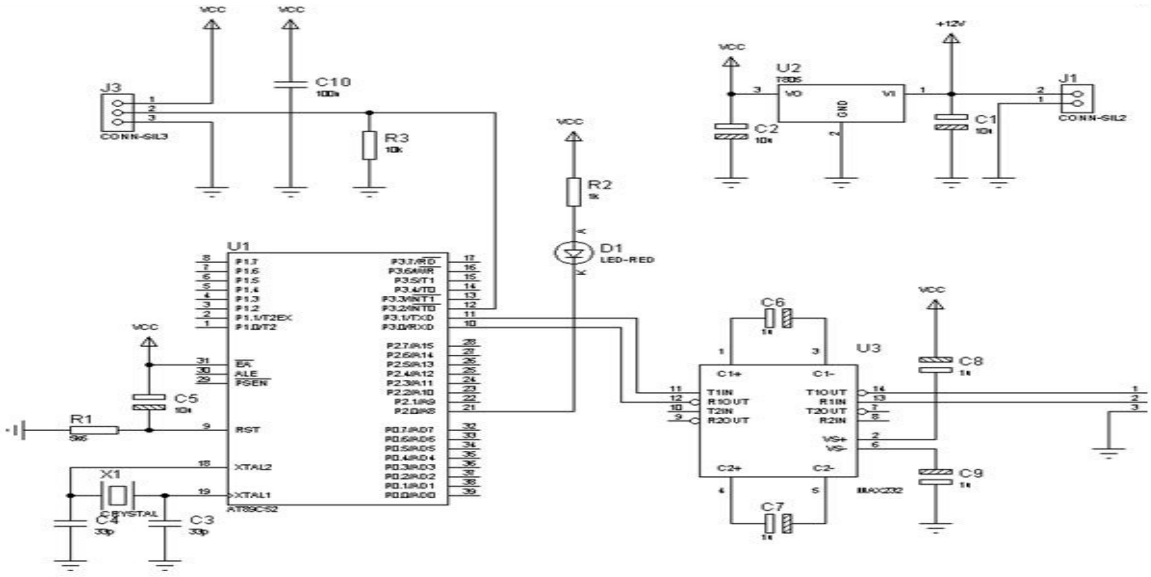

Figure 7.0: Card reader overall circuit diagram

Consequently for the reader, the card reader features the design of 3.6 inches X 5.4 Inches PCB in single sided copper clad of one (1) oz of figure 7.0 as figure 7.1. Also noted was the swiping space of the reader because of the electronic card 1.2mm thickness.

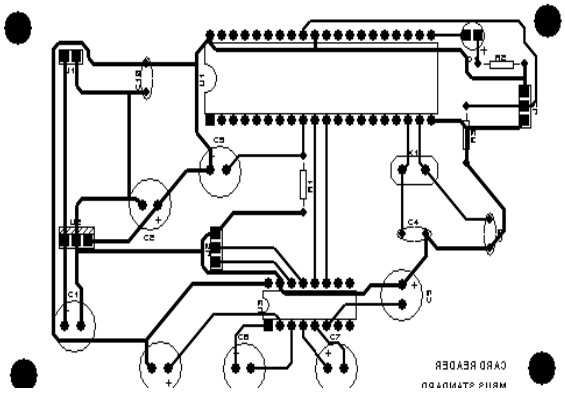

Figure 4.1 PCB Layout of the Card reader

4.2 SOFTWARE DESIGN CONSIDERATIONS

The software design was considered in two schools of thought: embedded microcontroller development and OOP Software based system development.

Embedded Microcontroller Development

The microcontroller programs can be written in C, Max-Forth or Assembly. The small procedural paradigm C programming language was chosen for flexibility and code economy reasons. Program codes could be reused in C Programming, and allowed excellent flexibility in future modification.

For the lecture entrance card, we used HITECH MPLAB software, which provided us with a series of tools such as the PIC LITE compiler, an emulator interface and linker in programming the PIC16F84 microcontroller. The PIC PROG programmer was used to burn the code into the PIC16F84.For the reader, the programming language platform used to program the AT89C52 microcontroller was the KEIL C compiler, while ISP in circuit programmer was used to burn the code into the microcontroller.

OOP Based Software System Development

The software system is architecturally, a two tier client server software system. The system front end or the user interface was design and implemented with Visual BASIC 6.0 (VB6), a rapid development (RAD) tool that allows application development in less time. The main reason why VB6 was considered for the system graphical user interface (GUI), is that, it contains software methods that allow easy access to the serial communication port of the computer. The backend was implemented with MySQL 2000 DBMS for robustness and scalability reasons for database development.

5.0 SYSTEM OPERATION, TESTING AND DISCUSSION

The entire system operates by swiping the improvised electronic card along the edge of the card reader. The swipe mechanism was used in contrast to an insert mechanism due to easier implementation and communication of the card with the reader. On the card are 0.18 inches, three parallel conducting lines, two for power (+5vdc and ground) and one in the middle for half duplex communication with reader. The reader has three parallel conducting springs corresponding to each conducting line of the card, in four different points to ensure that adequate contact is made between the card and reader. By swiping the card on the reader ,the automated lecture attendance management software system graphical user interfaces show as follows for student to register attendance:

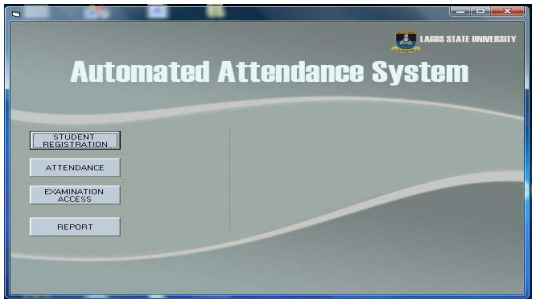

Figure 8.0: Home Page

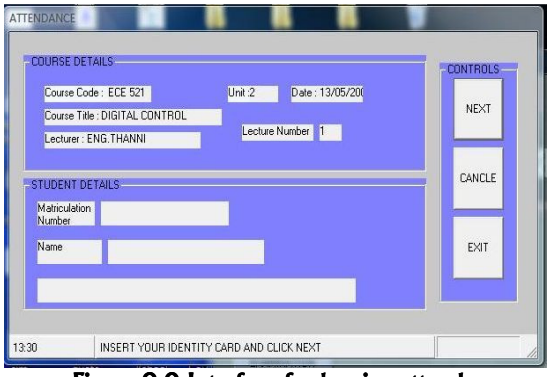

Figure 9.0 Interface for logging attendance

The application was developed to automatically detect when the card is slot into the reader (through the serial port) and proper pre-configuration of the card. The system requests for the student PIN and automatically increments the student's attendance per course at the backend (The database) as shown in Figure 8.0 and Figure 9.0.

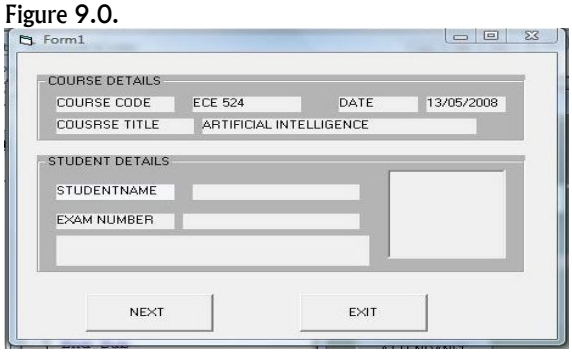

Figure 10.0: Examination authentication

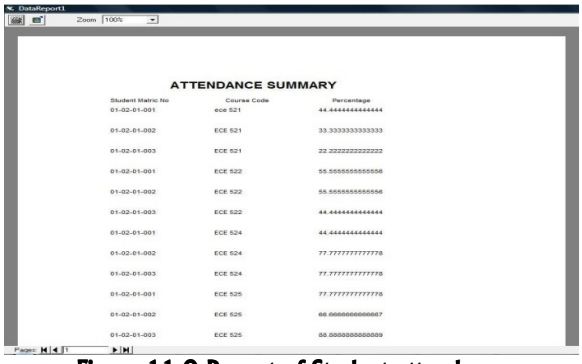

Figure 11.0 Report of Student attendance

Figure 10.0 used shows the GUI for examination authentication. Similar to the attendance form, it detects the card and displays what percentage per lecture each student has attended compared to the number of lectures taken by the lecturer. If 70% and above lecture attendance record is made by the student, it displayed that the student is qualified to write the examination. Consequently, Figure 11.0 is a printable sheet that displays the percentage of lectures attended by student for various courses for official verification.

During system testing, it was discovered that the card reader could not detect electronic entrance card, when inserted, so we used R1 (figure 4.1) as a pull up resistor to represent a signal alert to the reader when entrance card is swiped against it as shown in figure 4.0. The card reader and lecture attendance electronic card was package with synthetic materials to protect the component from mechanical damage, extreme heat, humidity and temperature variation as shown in figure 12.0, 13.0 and figure 14.0 respectively.

Table 4.1 speed of manual attendance compared to electronic method of attendance (sample for 25 student

Student number	Manual Attendance in (sec)	Automated Lecture Attendance in (sec)	Automated Exam Attendance in (sec)
1	14.97	6.02	4.01
2	15.16	6.07	4.01
3	15.18	7.05	4.01
4	16.54	7.07	4.03
5	16.59	7.12	4.05
6	16.92	7.14	4.05
7	16.95	7.26	4.05
8	17.61	7.54	4.06
9	17.72	7.55	4.57
10	17.78	8.02	4.57
11	18.01	8.05	4.62
12	18.25	8.13	4.7
13	18.62	8.24	4.7
14	19.19	8.45	4.85
15	19.34	8.52	4.93
16	19.67	8.55	5.06
17	19.72	8.62	5.12
18	19.85	8.72	5.13
19	19.89	9.45	5.27
20	20.52	9.55	5.31
21	20.91	10.05	5.47
22	22.03	10.12	5.65
23	23.16	10.14	5.77
24	23.19	11.52	5.77
25	24.21	11.64	5.99

Figure 12.0: Electronic Card

Figure 13.0: Connections for The System

Figure 14.0: Left and Top view of the Card reader

The effectiveness of our system software and hardware design consideration was further tested by comparison of time difference in the conventional/manual method of lecture attendance with the proposed electronic method by testing the system with twenty five students of the Department of Electronic and Computer Engineering, Lagos State University, Epe, Nigeria. The study from table 2.0 shows that the electronic approach was more accurate, faster and efficient.

6.0 CONCLUSION

This paper has successfully presented a simplified, low cost embedded computer based system solution to the management of lecture attendance problem in developing countries. The operation of the system is based on guidelines surrounding the conduct of lecture on one (the Lecturer) to many (students) lecture environment and policy of taking and writing examination in campus environment. The system could authenticate, verify, grant and/ or deny a student attendance to lecture when an electronic card is swipe on the card reader. PIC serves as a Microcontroller unit(MCU) for vehicle of data storage while different programming language platforms considered are fundamental to software design based on the initial requirements gathering, specifications, and planned operation of the system. The major strength of the system lies in its portability and high scalability but with less flexibility in programming as compared to the previous design and implementation in [3, 4, 6, and 12]. By careful examination, it can be inferred that the proposed system could not only speed up the process of taking attendance but allows for less error and faster verification process of authenticating student lecture attendance policy required for writing examination in a campus environment.

7.0 RECOMMENDATION FOR FUTURE WORK

The functionalities of the system can be further enhanced through the following recommendations:

- The linkage of the proposed automated system at each lecture venue to a dedicated server centrally managed by the University ICT Department. This would allow the system to extract user information from the ICT database directly and eliminate the need to store this information within the card and increase the overall system response time.
- Investigate student attendance monitoring through hybridized Biometric features like face, iris fingerprint and Wireless radio transmission through RFID for better performance.

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