Computing, Information Systems, Development Informatics & Allied Research Journal
Vol. 9 No. 1, March, 2018 - www.cisdijournal.org

Performance Analysis on Radio Frequency Identification (RFID) Based Attendance Systems

[1]Ezekwe, G.C., [2]Ituma, I.C & [3]P. I. Okwu
[1&3],Electronics Development Institute, Awka
National agency for Science and Engineering Infrastructure (NASENI)
Federal ministry of Science and Technology, Nigeria
[2]Department of Computer Science, Ebonyi State University, Abakiliki
[1]norakingchi@yahoo.com [2]ichinagolum@gmail.com and okwupi@yahoo.com

ABSTRACT

Educational institutions' administrators in our country and the whole world are concerned about regularity of student attendance. Student overall academic performance is affected by it. The conventional method of taking attendance by calling names or signing on paper is very time consuming, and hence inefficient. This problem gave birth to research on Radio frequency identification (RFID) which is a technology that uses radio waves to transfer data from an electronic tag, called RFID tag, attached to a person, through a reader for the purpose of identifying and tracking the holder. Radio Frequency Identification (RFID) based class attendance system is a system that can automatically capture student's attendance by students passing through an RFID reader with the tag on them or swiping the tag on RFID reader with a web camera that captures their tags' electronic product code (EPC) and images respectively, compare and match them with what is already existing in the database (Microsoft access) for proper validation and authentication. Analysis were carried out on three attendance systems that have being implemented using Radio frequency Identification. The first one is on RFID Technology Based Attendance Management System, the second one is on Students' Attendance Management System Based on RFID And Fingerprint Reader and the third one was developed by us using RFID and image authentication. System analysis Performance evaluations were conducted on three attendance systems as shown in table 2. We observed that the time taken to take an attendance using RFID with image is only 0.2 second compared with the others that took 5 seconds and 10 seconds respectively and so on. A graph was generated as shown below to explain this more using Microsoft excel. We concluded that RFID with image authentication is presently the most efficient attendance system even at security level.

Keywords: Radio frequency identification (RFID), electronic product code (EPC), Radio frequency identification (RFID) tags, Radio frequency identification (RFID) reader

CISDI Journal Reference Format
Ezekwe, G.C., Ituma, I.C & P. I. Okwu (2018 Performance Analysis on Radio Frequency Identification (RFID) Based Attendance Systems. Computing, Information Systems, Development Informatics & Allied Research Journal. Vol 8 No 1. Pp 47-56
Available online at www.cisdijournal.org

1. INTRODUCTION

Educational institutions' administrators in our country and the whole world are concerned about regularity of student attendance. Student overall academic performance is affected by it. The conventional method of taking attendance by calling names or signing on paper is very time consuming, and hence inefficient. The most common means of tracking student attendance in the classroom is by enforcing the students to manually sign the attendance sheet, which is normally passed around the classroom while the lecturer is conducting the lecture. For instance, lecturers with a large class may find the hassle of having the attendance sheet being passed around the class and the manual signing of attendance by students are burdensome and most likely distract them from teaching and getting full attention from the students. Besides, as the attendance sheet is passed around the class, some students may accidentally or purposely sign another student's name. The first case leads to a student missing out their name, while the latter leads to a false attendance record. Another example of the conventional/ manual attendance system is taking of students' attendance by calling out their registration numbers and checking whether the right person answered before starting my lectures, in cases where the number of students is more than two hundred in number like the 100 level general class (this comprises of students from all the departments in the University with at times total number of three thousand (3000) students) it is impossible for me to use this method that might take the whole day. This method is more than time consuming and very clumsy. Another issue of having the attendance record in a hardcopy form is that a lecturer may lose the attendance sheet. In terms of attendance analysis, the lecturer also has to perform manual computation to obtain the students' attendance percentage, which normally consume a lot of time. This prompted us into looking for automatic identification (AUTO-ID) approaches that will help us handle the issues of conventional/manual attendance system.

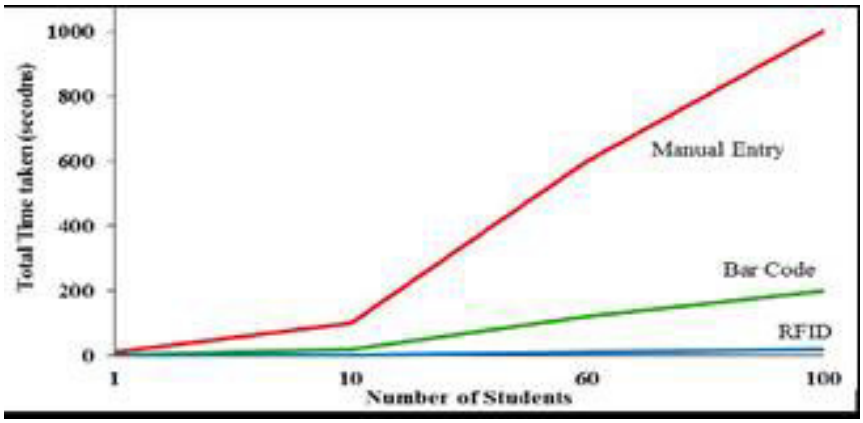

Figure 1: A line graph showing the comparison of total time taken to record the attendance of students (Sumita et al (2013)

2. Problems Statement

i. The conventional method of taking attendance by calling names or signing on paper is very time consuming, and hence inefficient.
ii. Another issue of having the attendance record in a hardcopy form is that a lecturer may lose or misplace the attendance sheet before the end of the semester when it will be used as part of the assessment.
iii. In terms of attendance analysis, the lecturer also has to perform manual computation to obtain the students' attendance percentage for assessment, this consumes a lot of time. based attendance system, therefore, it poses problem to academic progress.

2. LITERATURE REVIEW

2.1 Radio Frequency Identification (RFID)

RFID, which stands for Radio Frequency Identification, is an automatic identification technology used for retrieving from or storing data on to RFID Tags without any physical contact (Abdul and Jyothi, 2013). It is a technology that is used to collect information automatically by radio frequency data communication between mobile objects and an RFID reader, to identify, categorize and track the mobile objects. According to Lim et al, 2009, an RFID system primarily comprises of RFID Tags, RFID Reader, Middleware and a Backend database. RFID Tags are uniquely and universally identified by an identification sequence, governed by the rubrics of EPC (Electronic product code) global Tag Data Standard. A tag can either be passively activated by an RFID reader or it can actively transmit RF signals to the reader. The RFID reader, through its antenna, reads the information stored on these tags when it's in its vicinity.

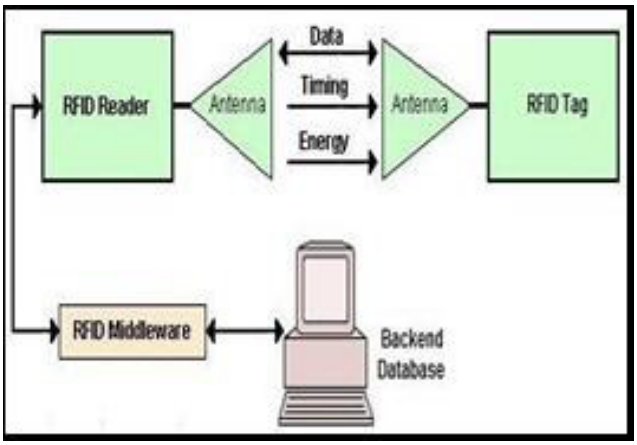

Figure 2: Radio Frequency Identification (RFID) system(Lim et al(2009)

The reader, whose effective range is based on its operational frequency, is designed to operate at a certain frequency. According to Amin et al, (2014), the operational frequency of the reader ranges from 125 KHz–2.4 GHz. The Middleware encompasses all those components that are responsible for the transmission of germane information from the reader to the backend management systems. The Middleware can include hardware components like cables and connectivity ports and embedded system software like Assembly language and embedded C that monitor and control the communication between the hardware and the computer system.

The Backend database stores individual tag identifiers to uniquely identify the roles of each tag. The database stores record entries pertaining to individual tags and its role in the system application. The RFID system is interdependent on its core components to achieve maximum efficiency and optimum performance of the application. Due to its high degree of flexibility, the system can be easily adopted for an array of applications ranging from small scale inventory cabinets to multifarious and highly agile supply chain management systems. Although, the cost of incorporating this technology has restricted its outreach, the technology promises to have untapped potential.

2.2 Components of an RFID System

According to Domdouzis et al.(2007), an RFID system consists of various components that are connected to one another by a dedicated communication path (see figure 3). The individual components are integrated into the system to implement the benefits of RFID solution. The components is as follows:

Tags

Tags are objects that are attached to any product and use a unique sequence of characters to define them. A tag consists of a microchip that stores a unique sequence identifier that is useful in identifying objects individually. The sequence is a numeric serial, which is stored in the RFID memory. The microchip includes minute circuitry and an embedded silicon chip. The tag memory can be permanent or re-writable, which can be re-programmed electronically by the reader multiple times. Tags are designed specific to its applications and environment.

For example, paper-thin tags are attached to books in a library management system. Tags are available in various shapes and sizes (see figure 5). Tags that are initiated by the reader are known as **Passive tags**, whilst those that do not require external initiation are called **Active tags**. A **Semi-Passive** tag exists, which has the features of both Active and Passive tags. Each tag type has its distinct characteristics, which are discussed in table 1. Tags are operable on Microwave (2.4 – 2.5 GHz), Ultra High Frequency (UHF) (860 – 1500 MHz), High Frequency (HF) (13.56 MHz) and Low Frequency (LF) (125 kHz).

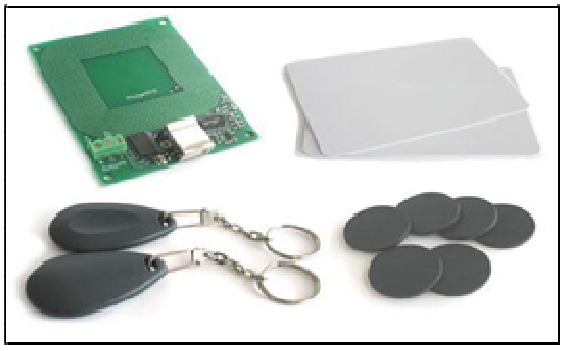

Figure 3: The Types of RFID tags (Domdouzis et al, 2007)

Table 1: Features of Types of Tags (Domdouzis et al, 2007)

Features	passive	active	Semi-passive
Read range	Short (up to 10m)	Long (up to 100m)	Long (up to 100m)
Battery	No	Yes	Yes
Lifespan	Up to 20 years	Between 5-10 years	Up to 10 years
Cost	Cheap	Very expensiv	Expensiv
Availability	Only in field of reader	Continuous	Only in field of reader
Storage	128 bytes read/ write	128 Kbytes read/ write	128 Kbytes read/ write
Application	EZ-Pass toll payment booths	Monitor the condition of fresh produce	Measurement of temperature periodically

Tags can be classified according to their power and memory resources. A tag's memory is classified as read-only, write−once, read−many and rewritable. In terms of power supply, tags are classified into three categories: passive, semi- passive and active. Tags are called passive if they have no power supplies, they receive their computational power from the electrical field generated by the reader. Semi-passive tags use a battery, but that battery is not for communication, instead, it is used to run the internal circuitry, and the energy of communication is provided by the reader. Active tags use a battery for both communication and running the internal circuitry. EPC Class 1 Generation 2 (EPC-C1-GEN2) has served as the most popular standard for passive tags. It supports on- chip 16-bit Pseudo-Random Number Generator (PRNG), and a 16-bit Cyclic redundancy Code (CRC) checksum is used to detect errors in the transmitted data.

Antenna

It is responsible for the transmission of information between the reader and tag using radio waves. The antenna is the medium through which the tag and reader communicate with each other. Antenna can activate a passive tag and transfer data by emitting wireless impulse that has electromagnetic properties. They come in following types:

i. Stick antennas,
ii. Di-pole or multi-pole antennas,
iii. Beam-forming or
iv. phased-array element antennas,
v. Circular polarized,
vi. Gate antennas,
vii. Patch antennas,
viii. Linear polarized,
ix. Adaptive antennas, and
x. Omni directional antennas

Figure 4: Types of antenna (Francisco et al, 2008)

Reader

A radio frequency identification reader (RFID reader) is a device used to gather information from an RFID tag, which is used to track individual objects (yeop et al, 2007). Radio waves are used to transfer data from the tag to a reader. Reader is a scanning device that uses the antenna to communicate to the tags that are in its vicinity. It transmits signals at a certain frequencies. RFID readers are usually ON, continuously transmitting radio energy and awaiting any tags that enter their field of operation.

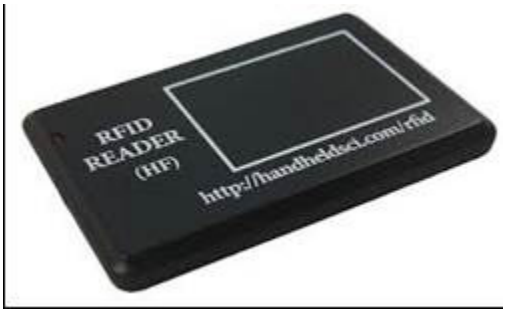

Figure 5: RFID reader(yeop et al, 2007).

Amin et al, (2014) classified RFID systems by the type of tag and reader;

i. A **Passive Reader Active Tag** (**PRAT**) system has a passive reader which only receives radio signals from active tags (battery operated, transmit only). The reception range of a PRAT system reader can be adjusted from 1–2,000 feet (0–600) allowing flexibility in applications such as asset protection and supervision.
ii. An **Active Reader Passive Tag** (**ARPT**) system has an active reader, which transmits interrogator signals and also receives authentication replies from passive tags.
iii. An **Active Reader Active Tag** (**ARAT**) system uses active tags awoken with an interrogator signal from the active reader. A variation of this system could also use a Battery-Assisted Passive (BAP) tag which acts like a passive tag but has a small battery to power the tag's return reporting signal.
iv. **Fixed readers** are set up to create a specific interrogation zone which can be tightly controlled. This allows a highly defined reading area for when tags go in and out of the interrogation zone.
v. **Mobile readers** may be hand-held or mounted on carts or vehicles.

The RFID tag it must be within the range of an RFID reader, which ranges from 3 to 300 feet, in order to be read. RFID technology allows several items to be quickly scanned and enables fast identification of a particular product, even when it is surrounded by several other items.

Backend database

A database is defined as an organized collection of data and tailored to system, the backend database primarily deals with the storage of relevant information recorded by the reader and communicated by the middleware. For this research work, we are going to use Microsoft access.

Middleware

Middleware is embedded system which is programmed to communicate via serial interface that control, interpret and process data being fed by the readers into the entire system. It takes into account all relevant ports of communication and a software application to represent this information. Middleware normally programmed in embedded C or assembly language manages the readers, the data coming from the tags, and passes it to the backend database system. Data from tags must go through middleware that can filter, convert, correct and relay it to the appropriate systems.

3. ANALYSIS ON DIFFERENT RADIO FREQUENCY IDENTIFICATION (RFID) ATTENDANCE SYSTEM

We wish to analyze three attendance systems that have being implemented using Radio frequency Identification. The first one is on RFID Technology Based Attendance Management System by Sumita Nainan, Romin Parekh and Tanvi Shah at India, the second one is on Students' Attendance Management System Based on RFID And Fingerprint Reader by Myint Thein, Chaw Myat New and Hla Myo Tun at Mandalay and the third one was developed by us using RFID and image authentication.

3.1 The First Attendance System

This research focuses on the development of an attendance management system using RFID technology to monitor the attendance for a group of students. It tends to overcome the human errors while recording student attendance and the creation of a data centric student attendance database system with an improved overall efficiency (Sumita et al, 2013). The application graphical user interface (GUI) is designed using Visual Basic 6.0 and Microsoft Access is used as the database provider. The Atmel AT89S52 is the heart of the system, which is a low-power high performance CMOS 8- bit microcontroller with 8K bytes of downloadable flash programmable and erasable read only memory. The system block diagram is as shown in figure 6.

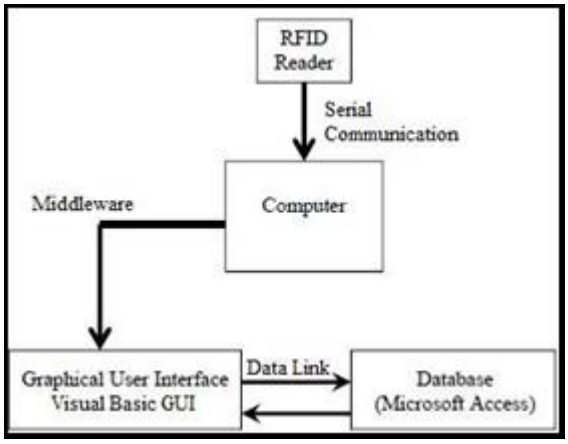

Figure 6: the system block diagram(Sumita et al, 2013).

The research was conducted on a sample of 60 students, enrolled in a particular course. On average, based on experiment, the total time taken to record the attendance of a class of 60 students by manual entry method took approximately 100 minutes. This implies that approximately 100 seconds per student was required to record their attendance. This time duration includes visual and written authentication, after which the teacher records the attendance. In comparison, the total time taken for recording the attendance of 60 students with this RFID technology is 12 seconds.

3.1.1 The Merits Of The First Attendance System

From the analysis above we can see that the existing system has some advantages which include:

i. Automation of students' attendance system.
ii. Time was saved in the present attendance system compare to the manual method.
iii. Human energy and efforts were saved in this system.
iv. A permanent students attendance data base was created
v. In cases where the students' attendance is used as part of the continuous assessment, it will be easy for the lecturer to assign a scores to the attendance

3.1.2 The Demerit Of The First Attendance System

After a careful review and analysis of this existing, we found out that there are some limitations in it which include:

i. The raw data fed into the middleware are Unique tag sequence (UTS) number or the electronic product code (EPC) of each tag, this means that the system takes the attendance only when it sees the EPC or the UTS no matter who is carry the tag.
ii. The security was not properly considered especially in the data authentication part.
iii. The reader/tag frequency is very low which means the students must bring their tags close to the reader before authentication.
iv. Incomplete student data at the point of registration this means this system cannot be used as course registration but only for attendance.

3.2 The Second Attendance System

The system was designed with the help of Microsoft Visual studio2012, Microsoft SQL Server 2012, RFID and fingerprint technology. C # language is used to implement this system (Yeop, 2007). This system could be used by two categories of people mainly admin/teacher and student. In admin category, admin can register/save/delete/update teachers and students profiles, and details to the database and find the teachers/students details (if any).In this system, admin may register every student with specific RFID card ID and finger ID to attend lectures. Whenever a new student is registered to attend the lecture, an RFID tag is attached into the student ID card and his/her fingerprint is registered and saved in database, and the information of students such as student name, his/her card ID and finger ID, and personalities of student are also captured in the computer database. Each teacher is registered and supplied with a username and password by the administrator as identification data for them. In this system, if teachers want to calculate students' attendance, they don't need to use manual roll call calculation. System will automatically calculate students' attendance by reading students' unique ID card with RFID tag number and finger ID number and comparing this RFID card ID number and finger ID number with information stored on the DBMS according to their ID's that have being assigned to them.

In student portion, the attendance management software is interfaced to a RFID and fingerprint device. The student bio data (Matriculation number, Name, Gender and Date of Birth),card ID number and finger ID number is enrolled first into the database. The aim is to create a system with one sever to which PC's are connected, so all data will be saved in one data base, marking the monitoring of the information effortless. In this all classes must have a PC with a connected RFID reader that can read student RFID-cards, as well as a fingerprint reader that take their fingerprints. The fingerprint reader is meant to prevent a student from giving his/her RFID-card to classmate who attends the lecture, scanning the another student's RFID-card to make it appear as if he/she had also attended. When a student enters class, this RFID reader reads his/her student ID from the tag, and his/her fingerprint will be fed into the fingerprint reader. The RFID tag ID and fingerprint data will be sent to a PC with a connected RFID-reader and fingerprint reader. The PC, in turn, sends all the data it has collected to the server database form Graphical User Interface (GUI). For attendance, student RFID card ID firstly read from RFID reader. According to their RFID card ID that have being stored in database, system will show student details. For verification, student must press his/her finger on fingerprint reader. If these RFID card ID and finger ID are valid, student will get roll call percentage for today subject .

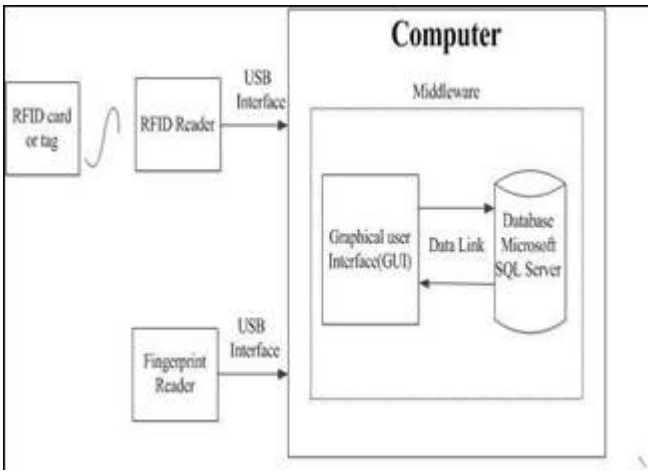

Figure 7: the system block diagram (Yeop, 2007).

3.2.1 The Merits Of The Second Attendance System

From the analysis above we can see that the existing system has some advantages which include:

i. Automation of students' attendance system.
ii. Time was saved in the present attendance system compare to the manual method.
iii. Human energy and efforts were saved in this system.
iv. A permanent students attendance data base was created
v. In cases where the students' attendance is used as part of the continuous assessment, it will be easy for the lecturer to assign a scores to the attendance.
vi. Proper tag EPC verification and authentication was done using the finger print scanner.
vii. Pattern matching was achieved between the tag EPC and the fingerprint ID, so a student can never attend classes with another student tag.

3.2.2 The Demerit Of The Second Attendance System

After a careful review and analysis of this existing, we found out that there are some limitations in it which include:

i. The reader/tag frequency is very low which means the students must bring their tags close to the reader before authentication.
ii. Incomplete student data at the point of registration this means this system cannot be used as course registration but only for attendance.
iii. The system will attract queue at the point of fingerprint data verification and authentication therefore making the system clumsy.
iv. With the present technology, fingerprints can be copied and stick to another person finger for verification and authentication.

3.3 The Third Attendance System Mode Of Operation

This system provided solution to former attendance problems through coordinated hardware and software design handshaking data communications between RFID tag and RFID reader as shown in figure 8. This system was based on passive RFID tag. The RFID reader was mounted at the entrance door of any class room which was also connect with the class room computer or the lecturers' laptop or system. Software running on the system had tag id/electronic product code, student name, student registration number, date of birth, course name, course code, date, time, and class room location etc. This information passed through hardware which provides the filtering operation. The ATMEL 128kb microcontroller takes inputs from the RFID reader and the webcam, process and send them to PC through MAX232 for storing the attendance and verification of the images with the EPC. Each student has a unique RFID tag and whenever student enters the RF receiver zone the attendance registers automatically with proper images matching attached to particular EPC. The data is then compared with the pre-assigned data in the database and based on that the attendance is taken to the particular student. The transmitter will hold a unique address which will be transmitted by the means of radio frequency to a particular region. The 2.3GHZ transponder will continuously respond to the incoming data and will gather the data from the transmitter.

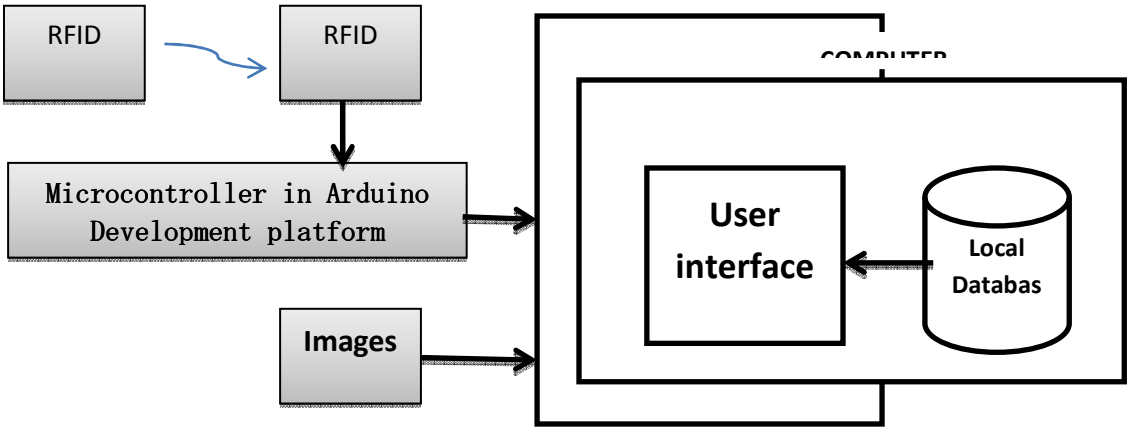

Figure 8: The third attendance System block diagram

The research was conducted on a sample of forty (40) students with forty (40) RFID tags uniquely assigned to each student enrolled in a particular PhD course. On point of registration, the students images were also captured, the unique ID/EPC of the tags are assigned only for a tag for a particular student. As described above no two students can use one tag or student's attendance must be accepted only when he/she uses the tag assigned to him/her.

3.3.1 The third attendance system algorithm:

1 Step1. RFID card was initially sensed by the reader.
2 Step2. RFID reader starts to match the string which was available on the card with the database entries as RFi .RFi . T= I, RFi .RFj . T= 0 RiRF+tagEPC of individual.
3 Step 3. Web camera capture image send to permanent database for matching the patterns which were in the database entries as RFi .RFi . T= I, RFi .RFj . T= 0 RiRF+image of individual.
4 Step 4. Using hardware perform the filtering operation to remove unwanted field and extract and attach tag EPCs and images to the student bio identity.
5 Step 5. Search student tags EPC in permanent database with incoming RFID student's tags.

6 Step 5.1 search for the images in the permanent database with the new captured image, image matching will be analyzed with face recognizer if it recognized FPi .FPi . T= 1, FPi . FPj T=0. The image pattern is pre-processed and is converted into a binary pattern as: B(i)=1 if I(i) ≥ T = 0 I(i) if found go to step 5.2 else go to step 4.
7 Step5.2. Search class room id, if found go to step 5.3. else go to step 4.
8 Step5.3. Search course id, if found go to step 5.4. else go to step 4.
9 Step5.4. Search student id, if found go to step 6. else go to step 4.
10 Step6. Compare detected student's image and tag EPC with class time table and if match found than go to step 7 else go to step 3.
11 Step7. Check person type and mark the presence.
12 Step.8 Repeat step 3 to step 7 for all present RFID tags and images.

3.3.2 The Advantages Of Third Attendance System

What follows are the advantages of the third system

a. Automation of students' attendance system.
b. Time was saved in the present attendance system compare to the manual method
c. Human energy and efforts were saved in this system.
d. A permanent students attendance data base was created
e. In cases where the students' attendance is used as part of the continuous assessment, it will be easy for the lecturer to assign scores to the attendance.
f. Proper tag EPC verification and authentication was done via image processing.
g. Pattern matching was achieved between the tag EPC and the image (face) eigen factor, so a student can only be verified with his/her preregistered tag.
h. The reader/tag frequency is high which means the students can be verified on entrance into the classroom.
i. The system will not attract queue at the point of data verification and authentication therefore making the system faster than others.

4. JUSTIFICATION OF THE THIRD ATTENDANCE SYSTEM

The effects of attendance on class performance has been widely researched and studied which is behind the key factor that motivated us into this research. From the analysis we did. It is obvious that this research work is necessary and at least to save our education system especially at the university level. It is also justified that students' academic performance is directly proportional to their attendances to classes from strong empirical observation we carried out for at least for sixteen years. From the analysis done on the three systems, this system has a lot of advantages especially in the area of data security, verification and authentication. This will be ensured at the point of registration; the students images are captured, the unique ID/EPC of the tags are assigned only for a particular tag and for a particular student which must be used at verification and authentication point before attendance will be ticked for students.

5. SYSTEMS ANALYSIS PERFORMANCE EVALUATION

System analysis Performance evaluations were conducted on three attendance systems as shown in table 2. We observed that the time taken to take an attendance using RFID with image is only 0.2 second compared with the others that took 5 seconds and 10 seconds respectively and so on. A graph was generated as shown below to explain this more Using Microsoft excel. We concluded that RFID with image authentication is presently the most efficient attendance system even at security level. Table 2: evaluation of attendance systems

Method	**Total Number of Students**			
	1	**10**	**60**	**100**
Manual Entry	10 seconds	100 seconds	600 seconds	1000 seconds
RFID with finger print	5 seconds	50 seconds	300 seconds	500 seconds
RFID with image	0.2 seconds	2 seconds	12 seconds	20 seconds

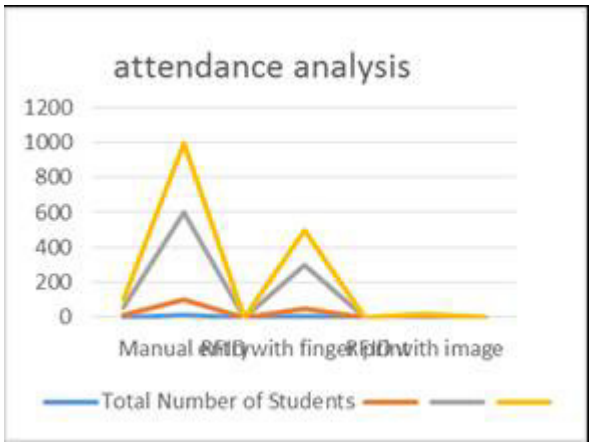

Figure 9: attendance evaluation graph using Microsoft excel

REFERENCES

1. Abdul A. M. and Jyothi K. (2013). "Web-Serverbased Student Attendance System using RFID Technology", International Journal of Engineering Trends and Technology
2. Amin M., Zahra A., and Mohammad R. (2014)."Analysis and Improvement of the securing RFID systems conforming to EPC Class 1 Generation 2" standard in *4th Internationa Conference on Information Security Practice and Experience – ISPEC 2008*, ser. Lecture Notes in Computer Science.
3. Arulogun O. T., Olatunbosun, A., Fakolujo O. A., and Olaniyi, O. M.,(2013) "RFID- Based Students Attendance Management System International Journal of Scientific & Engineering Research Volume 4, Issue 2. (IJETT)–Volume 4 Issue 5.
4. Domdouzis K., Kumar B., and Anumba C.(2007). "Radio- Frequency Identification (RFID) applications: A brief introduction.", Advanced Engineering Informatics, Vol.21.
5. Lim T.S., Sim S.C. and Mansor M.M.(2009). "RFID Based Attendance System," in Proceedings of the IEEE Symposium on Industrial Electronics and Applications.
6. Sumita N., Romin P. and Tanvi S. (2013). "RFID Technology Based Attendance Management System" International Journal of Information and Computation Technology. ISSN 0974-2239 Volume 3, pp. 131-138© International Research Publications House http://www. irphouse.com/ijict.htm\
7. Yeop Sabri M. K., Abdul Aziz M. Z. A., Mohd Shah M. S. R., and Abd Kadir M. F (2007). "Smart Attendance System by Using RFID," Asia Pacific Conference on Applied Electromagnetic Pro.