Design of an Automatic Class Attendance System as an Undergraduate Senior Design Project

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Ali Eydgahi started his career in higher education as a faculty member at the Rensselaer Polytechnic Institute in 1985. Since then, he has been with the State University of New York, University of Maryland Eastern Shore, and Eastern Michigan University. During 2006-2010, he was Chair of the Department of Engineering and Aviation Sciences, Founder and Director of the Center for 3-D Visualization and Virtual Reality Applications, and Technical Director of the NASA funded MIST Space Vehicle Mission Planning Laboratory at the University of Maryland Eastern Shore. In 2010, he joined Eastern Michigan University as an Associate Dean in the College of Technology and currently is a Professor in the School of Engineering Technology. He has an extensive experience in curriculum and laboratory design and development. Dr. Eydgahi has served as a member of the Board of Directors for Tau Alpha Pi, as a member of Advisory and Editorial boards for many International Journals in Engineering and Technology, as a member of review panel for NASA and Department of Education, as a regional and chapter chairman of IEEE, SME, and ASEE, and as a session chair and as a member of scientific and international committees for many international conferences.

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Abstract

One of the goals of senior design courses in undergraduate engineering programs is to involve students in a meaningful project so that they gain real-life experience in practicing their knowledge and independent thinking to enhance their learning.

Most of the instructors keep track of student attendance by printing student lists from the registrar's database and passing it around during class periods. Instructors have to manually check student names and match it with each student's daily class attendance. The process of managing student attendance using this paper-based method consumes precious time. An automated attendance system that automatically record student attendance is very beneficial to both instructors and students.

The main objective of this project was to involve an undergraduate engineering student in design of an automatic identification system that is capable of scanning and processing data stored on student ID cards to record attendance of students. The designed system had to consist of an automatic ID card reader, a database that stores the data retrieved from the IDs, a wired communication system between the reader and the database server, and a wireless communication system between the automatic reader and the database server. The design approach was divided into four categories of hardware communication, application interfaces for various designs, server connection design, and database design.

The design process and details of the project along with educational outcomes of the student activities are described in this paper. The project was designed and implemented by an undergraduate engineering student as a senior design project. The student used principles of radio frequency identification technique to read identification of each person from their ID cards. The information retrieved by the reader is transferred with the aid of Transmission Control Protocol/Internet Protocol (TCP/IP) to a Structured Query Language (SQL) database on the server and then is processed for generating an attendance list.

Introduction

In senior design or capstone courses, students are required to demonstrate their abilities as engineers by engaging and utilizing engineering design process for design and development of meaningful projects or products. By defining a real-life project relevant to students' program of study, a valuable practical experience is provided to the students that enhances their knowledge and independent thinking outcomes. The outcomes of this independent learning experience result in increased technical communication skills and real-life technical competences and provide an understanding of the importance of lifelong learning [1]-[6].

Identification is defined as the capability to find, retrieve, report, change, or delete specific data without ambiguity. The automatic identification concept has been given a major attention in the past decades and as a result, different types of identification systems have been invented. Some of the existing identification systems that are widely used nowadays include fingerprint identification, barcode systems, smart cards, and radio frequency identification (RFID) that are utilized in different products, stores, shopping malls, airports, etc. [7]-[10].

Historically, the most common method to measure student attendance has been through roll calls, distributing attendance sheets, and other paper-based methods. While arguably useful in the past, these techniques are often time-consuming and tedious. These methods take away from valuable in-class time that otherwise can be dedicated to teaching. Moreover, because attendance sheets are manually recorded, they are also prone to error.

A RFID system is comprised of a transponder (tag), an interrogator (reader), and an antenna. The basic mode of operation for a RFID system begins with the reader sending out electro-magnetic waves. The transponder is tuned to receive the incoming waves generated by the reader. With the aid of an antenna, the passive transponder draws power from the field created by the reader and uses it to power the microchip circuits embedded in the transponder to modulate the waves that the transponder sends back to the reader. Then, the reader converts these new waves into digital data and sent it to the database, where it is matched with the registered information [11]-[17].

One early form of a RFID system was called "The Thing", which was also known as the "Great Seal Bug" [18]-[19]. "The Thing" consisted of a tiny capacitive membrane connected to a small quarter-wavelength antenna. It used no electric power supply, nor did it required any active electronic components for operation. It was considered to be the predecessor of RFID technology because it used passive techniques to transfer signals. “The Thing” was energized and activated via electromagnetic waves from an outside source. In 1973, “Transponder Apparatus and System” was patented, which resembled the modern RFID technology of a passive radio transponder with memory. This was followed by the first patent associated with the abbreviation “RFID” [20].

With the advent of relatively inexpensive RFID technology, tracking students’ attendance in the classroom can be vastly simplified and accurately recorded. The RFID-based attendance system provides a convenient method in taking attendance by providing a RFID reader to uniquely identify the student carrying their ID.

In this paper, an undergraduate senior design project is presented that utilizes the principles of RFID operation to develop and implement an automated class attendance system. In the designed system, the student ID is used as a passive transponder. The design requirements of the project were:

- Be capable of automatically taking class attendance.
- Be capable of reading attendance data of all classes that are offered in the same classroom.
- Be capable of transmitting student attendance wirelessly to a database.
- Be capable of using student school IDs as tags.

Design Approach

The design approach was divided into four categories of hardware communication, application Interfaces for various designs, server connection design, and database design. The purpose of each design category was as follow:

1. ***<u>Hardware Communication:</u>***

The system had to be implemented by using the available resources in the department, which at the time was a Melexis electromagnetic wave generator as shown in figure 1. This board was modified by connecting a variable resistor to the Tx driver of the board to serve as an RFID reader. The electromagnetic wave generated by the evaluation board was utilized for scanning information from students' ID card. An EM microcontroller was used to connect all the hardware parts. The microcontroller was programmed using Java.

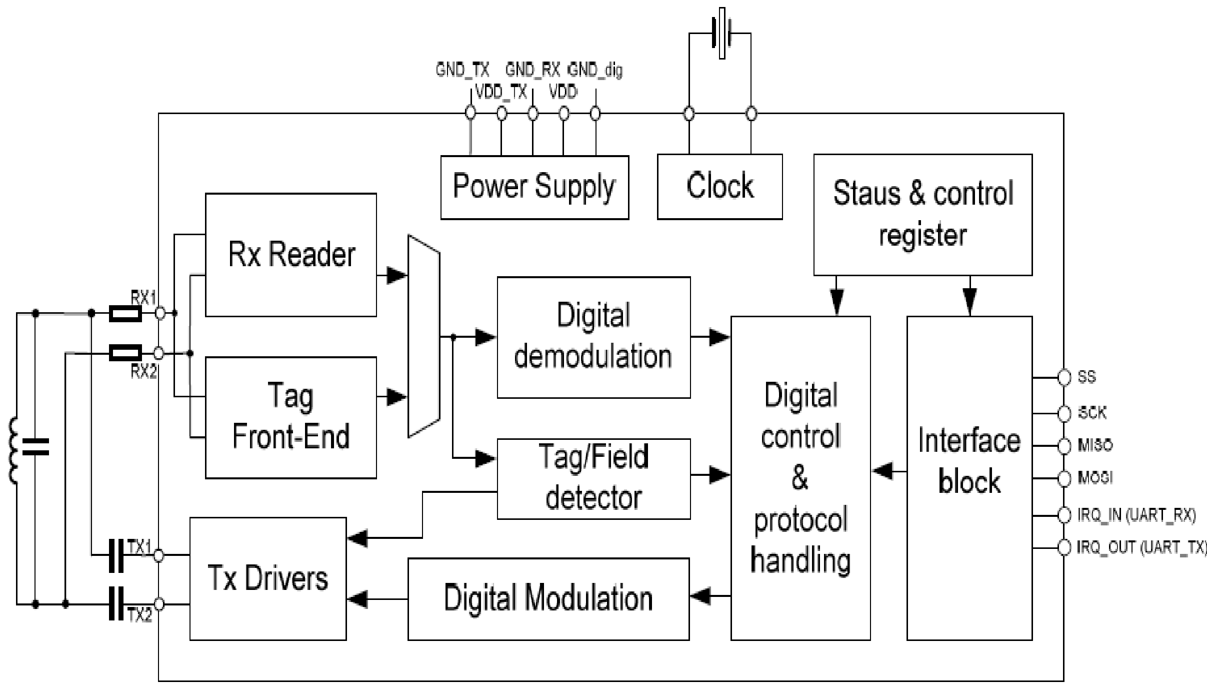

Figure 1: The Melexis RF evaluation board schematic diagram

2. ***<u>Application Interfaces (APIs):</u>***

APIs were designed to allow the user to perform various tasks with the system. Some of the APIs designed are as follows:

- Login interface
- Network connection interface
- Query for various features in the database

A General API was designed based on various factors such as shape, color, size, and each path of the interface. This General API was used as a template upon which other APIs were designed. The General API algorithm is shown in figure 2.

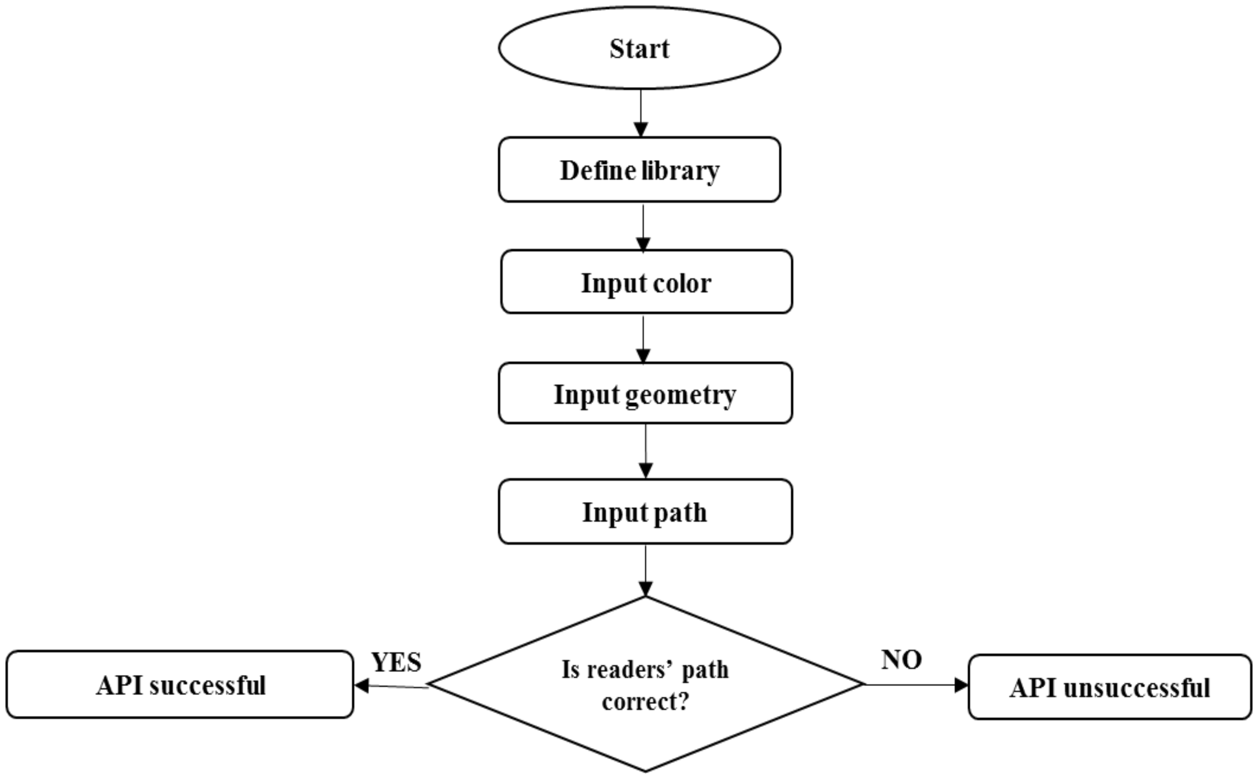

Figure 2: The General API algorithm template.

The algorithm in figure 2 was designed as an interface to serve as a user's principal tool within the system, allowing either the administrator or the teacher to have access to the source codes of various programs used for different tasks. This algorithm defines the library and the layout of the system interface.

The program for the API was written in Java Advanced Imaging (JAI) and was merged with the Tibbo open-source database as demonstrated in figure 3. As shown in figure 3, the steps identified as key design elements were define the library path, write the color, shape and size, and input the component path's code. After writing these variables, then check if the reader's code path is correct. If the path is correct, the API will link to the reader and also displays an interface as presented in Figure 4.

After the soft codes for the API access interface are created, various additional interfaces are added by modifying the general API Java codes. The API shows how the “set database connection” is designed by modifying the general API Java source codes.

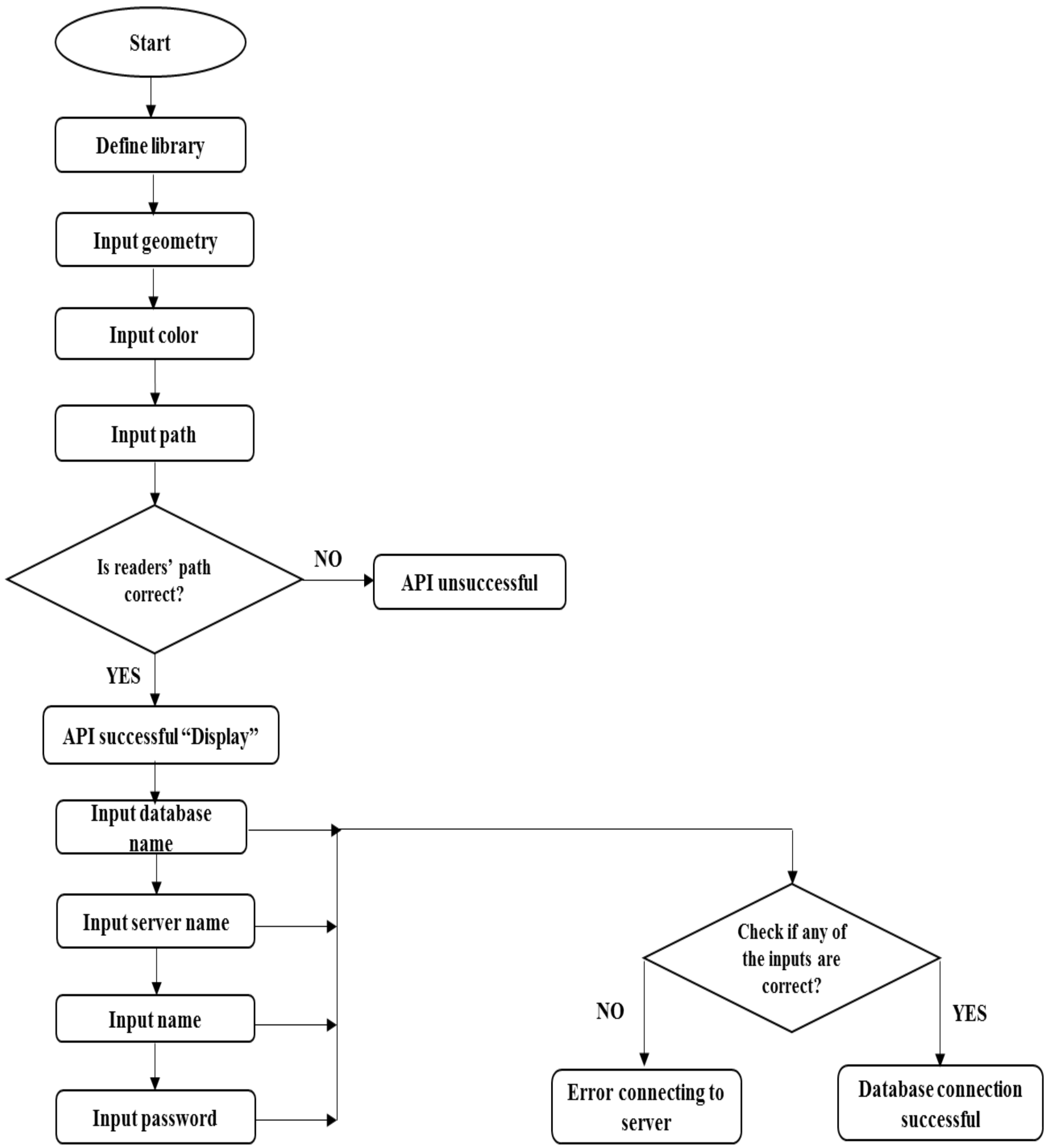

Figure 3: Merging API with the database connection

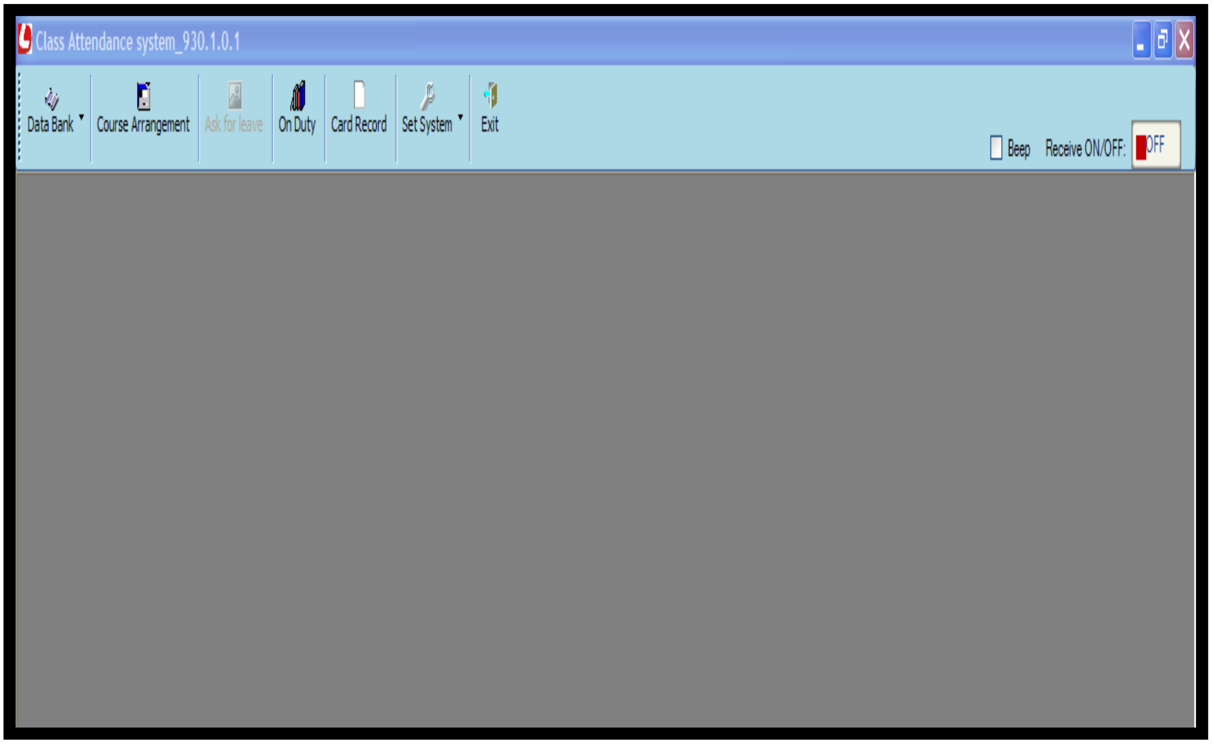

Figure 4: API display of the database

3. ***Server Connection Design:***

After synchronizing the hardware parts, there was a need to design a database that stores all the readings received by the system. An algorithm for the database was designed to create guidelines for how the database would function. A network system that links the reader to the server was needed in order for the user (the class instructors) to have access to student records on the instructors' computers.

The algorithm for the server connection is shown in Figure 5. The source code for the algorithm is written in C#. The system is designed in such a way that the reader (device) will query the local network (host) for an Internet Protocol (IP) connection. The device is directly connected to a host's network port. The IP addresses of the device and the host belong to the same network, with the addresses identified as 192.168.1.xxx and the mask as 255.255.255.0. The designation "xxx" must be specified by the network provider, along with a mask number which is set to 255. This allows the bandwidth range between 1 and 225 to activate and link the system to the server.

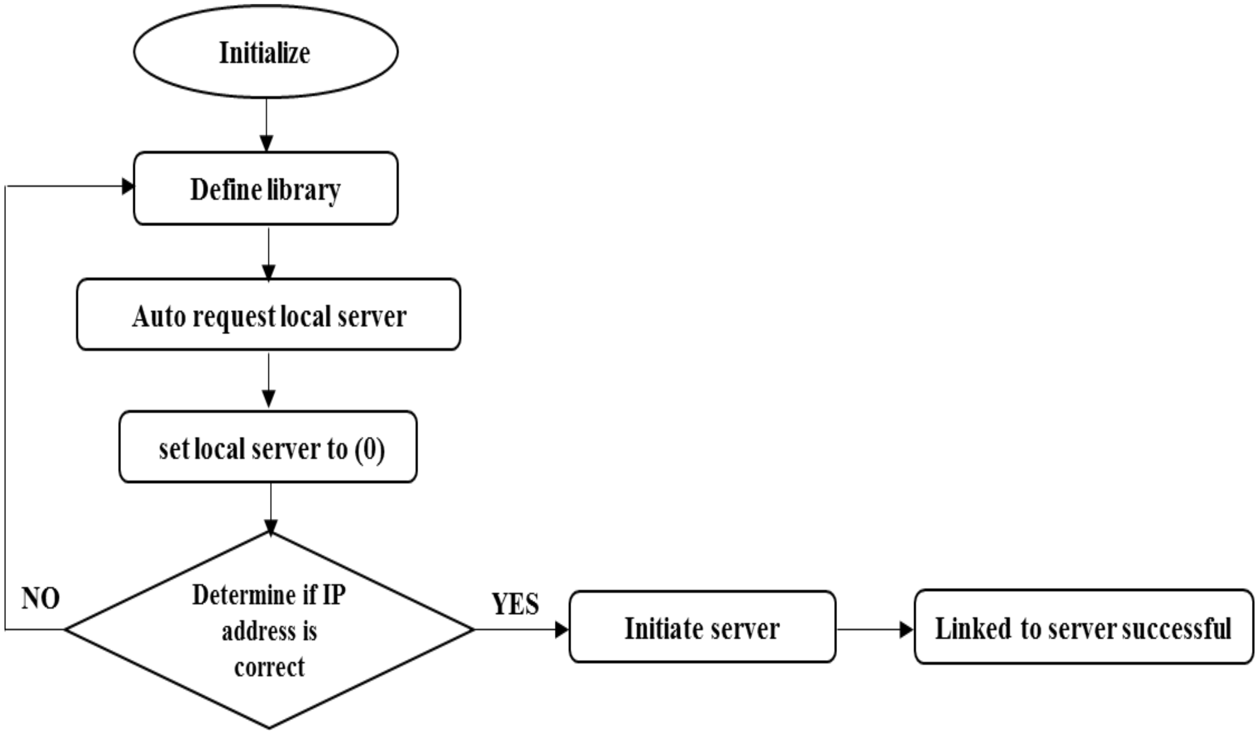

Figure 5: Server connection algorithm

In order to connect the system wirelessly to the database, the prototype device (hardware) needed to be connected to the network socket of the host using a cross-connection cable. The DS Manager software was set to identify parameters of the TCP/IP interface by searching for the server of the host's IP address. "DS Manager" is a server management software program that offers a unique solution for hosting automation and management needs.

After data has been read by the reader, it is important to store the data in a place where it can be queried. Therefore, this necessitated the design of a database that would be compatible with the RFID system. The database had to have various features that would allow for simple querying of data.

In order to design a database that meets these needs, a C# program was used with Structured Query Language (SQL). An open-source "Tibbo" database program was used to create a standard database for this project. The algorithm for the database connection is shown in figure 6.

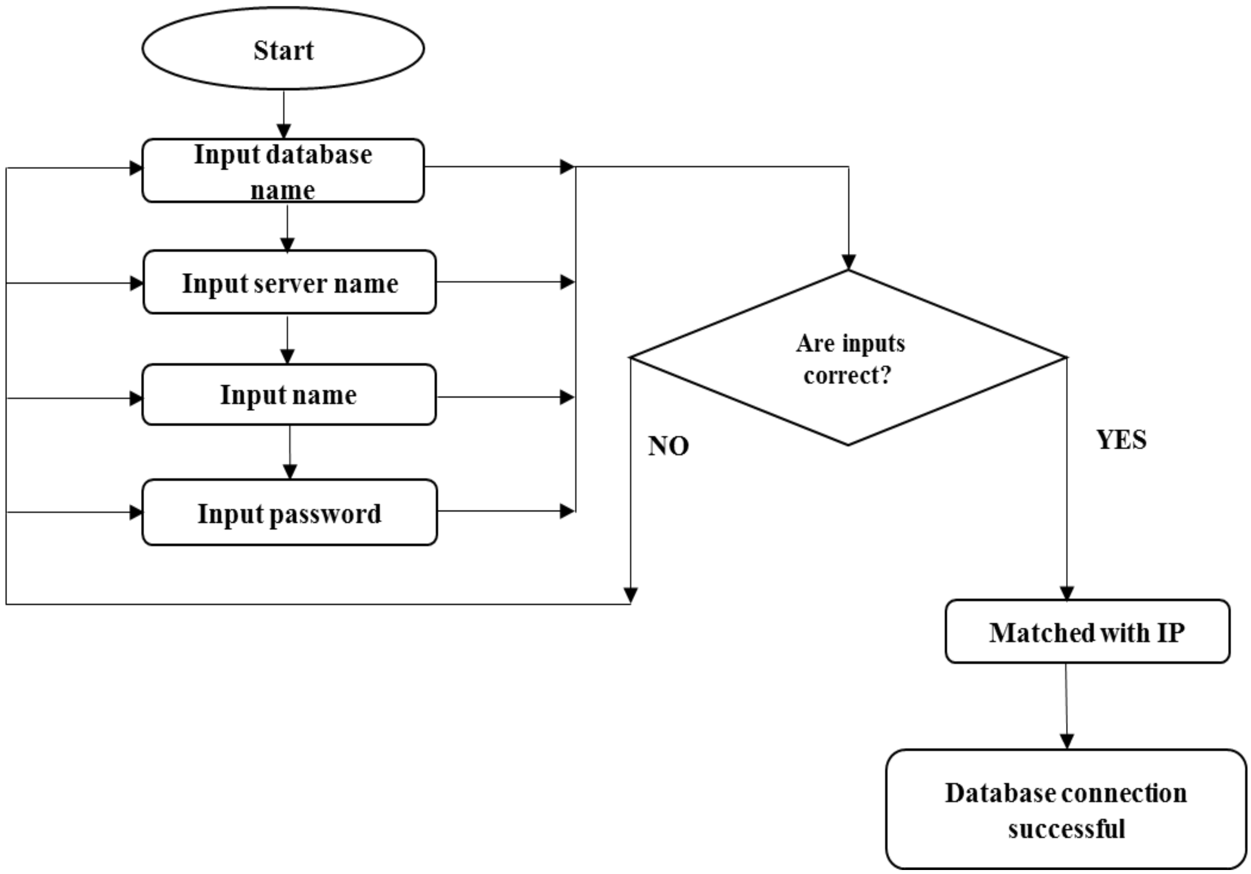

Figure 6: Algorithm for database connection

4. ***Database Design:***

As shown in figure 7, the first step in designing a database was to create a simple table in the form of a spreadsheet. The database was programmed to accommodate various features required for the design. Figure 8 shows output of the spreadsheet that was designed for database.

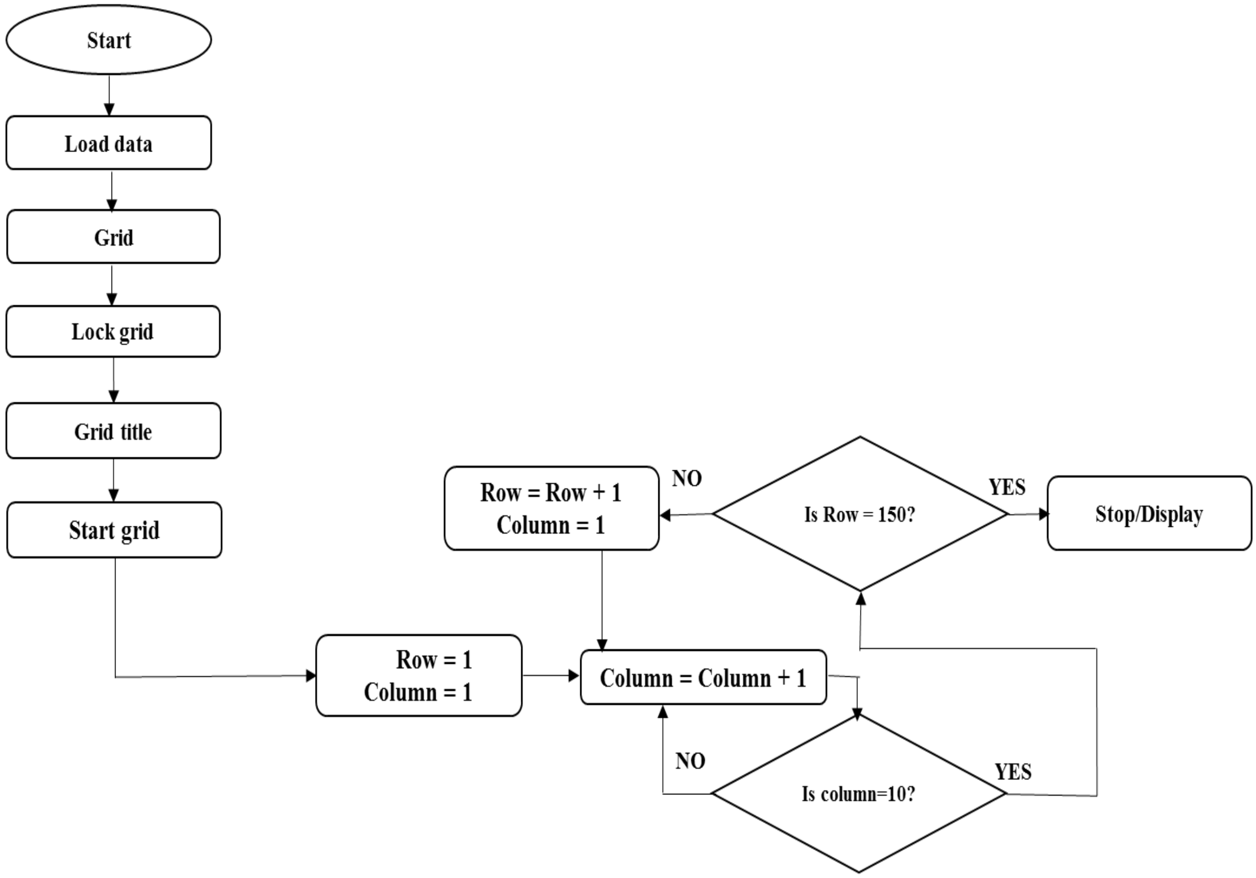

Figure 7: Database table algorithm

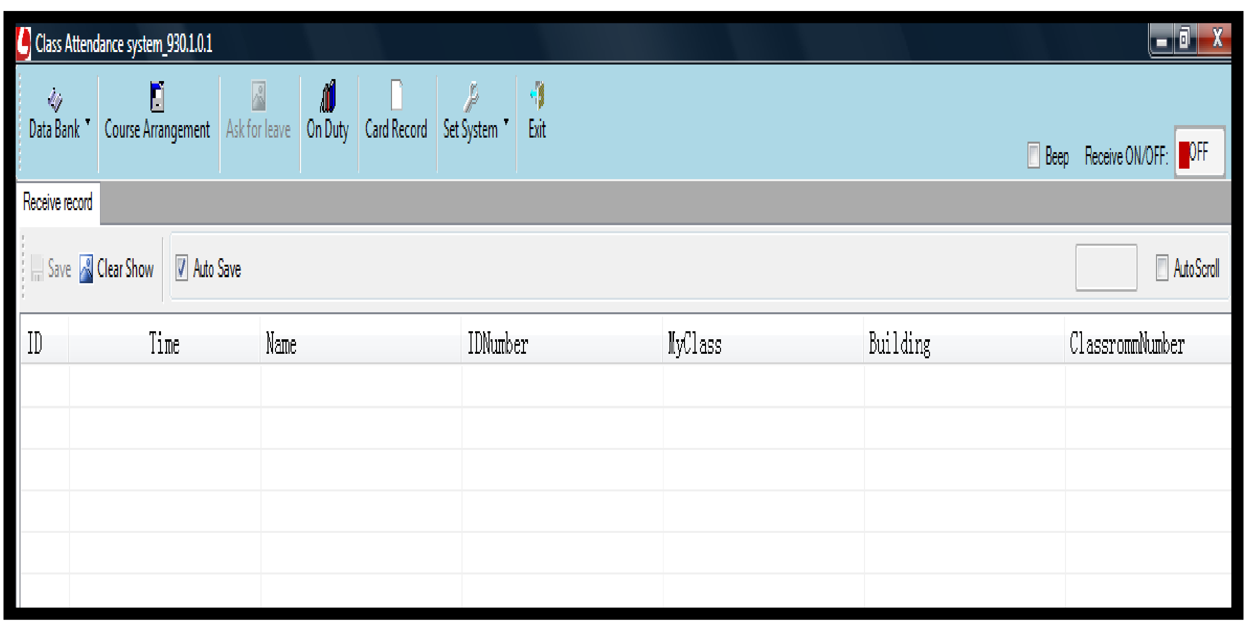

Figure 8: Output of database spreadsheet

Data Entry Allocation

An algorithm was designed to create the path used to assign the information being read, as it is being read by the reader (device). The databank is designed to handle the storage of the entries while a place holder places each entry into the assigned rows and columns.

The database design was divided into two sections of Administrator's Interface and Instructor's Interface as shown in figure 9. The administrator's interface was designed to have five basic parts. It was designed to request the user for a login password to access the database and also for securing the data within the database. The first phase of the database was designed to handle student registration. Each tag has a unique binary number identification. The numbers are merged with each student's name in the database. As each student is crosschecked in the database spreadsheet, the time is recorded, each tag is noted and it is saved in the database. The instructor's interface was designed to handle how classes are viewed by each instructor and also for allowing instructors to query student records.

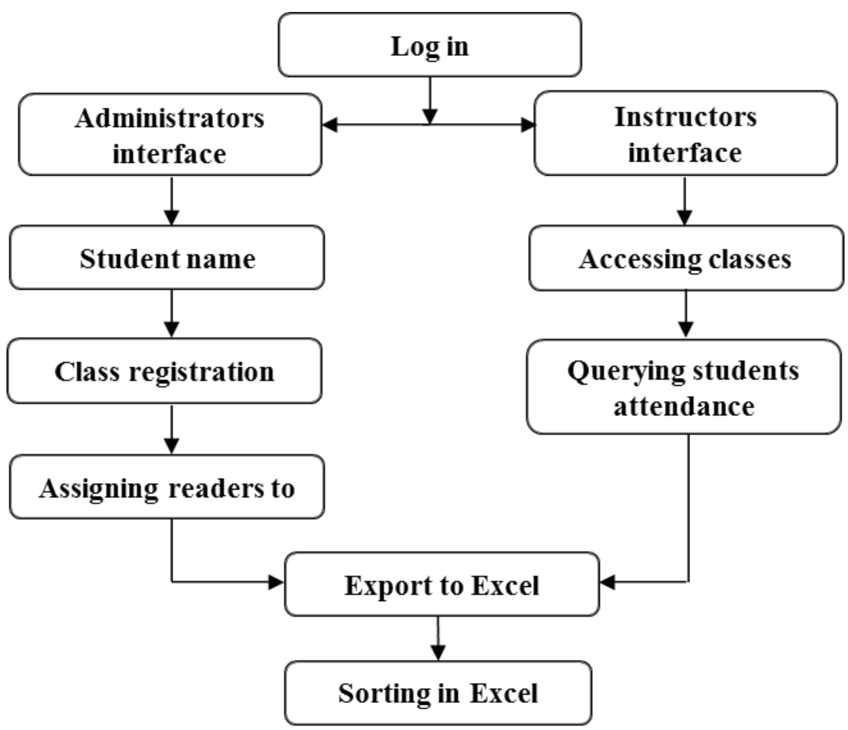

Figure 9: Database design structure

An interface where data is queried was designed to open when an instructor is logged into the system as shown in figure 10. This interface was designed to be compatible with many query functions, which helps instructors to query records for various semesters, years, classes, and student names. It also offers additional space for comments and remarks related to each student, which can be added by the instructor. Finally, the attendance data that are recorded and stored in the database is transferred to an excel spreadsheet.

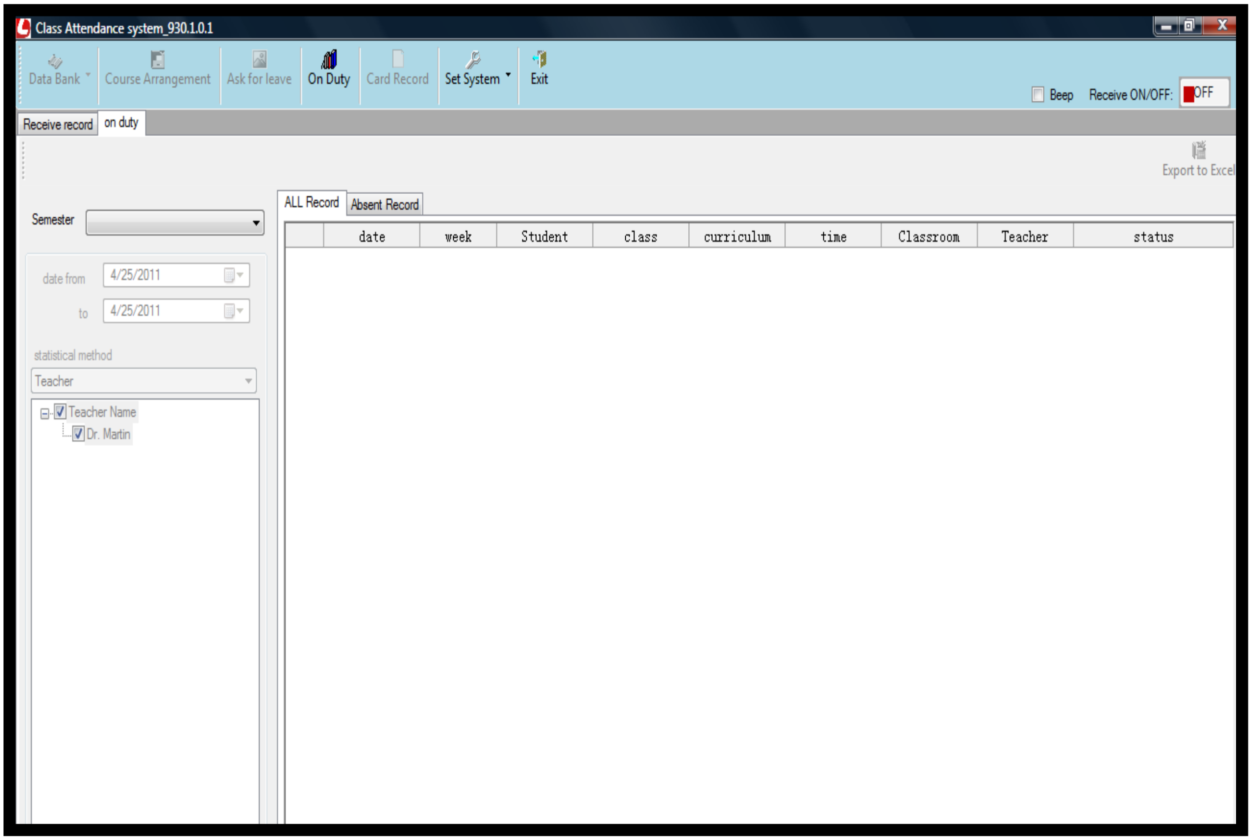

Figure 10: Instructors Query Page

After the system was designed and implemented, the student conducted a number of testing to validate the design. Numerious mock students were registered in the system through administration access. The testing proved the system full capability of reading students information from the tags and recording students attendance in the designed database. The design requirements had all been completely met with satisfactory performance of the system.

Student Learning Outcomes

The student learning outcomes of this project both in hardware and software designs can be summerized as follows:

- The student learned how to modify a developmental board to create an RFID reader for harware communications.
- The student learned how to design different application interfaces to allow a user, administrator or teacher, to interact with the system.
- The student learned how to program the system so that the hardware gets connected wirelessly to the server on a network.
- The student learned how to program the system so that the database communicates with the server.
- The student learned how to design a compatible database that accomodates both administrator and instructor’s needs for the RFID attendance system.
- The student gained extensive hands-on experience in C programming, Java programming, and SQL.
- The students had the opportunity to build a working prototype and validat the design through numerous testings.

Conclusion

In this project, an undergraduate student had the opportunity to use his learned hardware and programming knowledge in design and implementation of an automated attendance system by modifying a developmental board into an RFID reader. Through this design and implementation process, the student gained invaluable experience by engaging in design of different application interfaces for the users, design of a compatible database, and design of a wireless system for communication between the hardware, server and database.

The student was also involved in the process of test and verification of the designed system by building a working prototype and performing a number of testing to validate the performance of the designed system.

This system is flexible and can be used in every class type setting and does not require any paperwork to collect class attendance. The system automates all of the manual processes and saves time in recording class attendance.

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