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Low-Cost Active Monitoring of Attendance using Passive RFID Technology

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ABSTRACT

In this paper, a smart attendance system for students attending schools is proposed. The proposed attendance system is based on Radio Frequency Identification (RFID) technology to facilitate automation and convenience. The proposed RFID Attendance System (RFID-AS) should be used by school administration to ensure safety for students as well as using it for grading and evaluation purposes. After careful study, passive RFID technology is selected to be used by the proposed system for its reasonable cost. The main components of the system are an RFID tag, an RFID reader, Visual Studio (XAF Tool), and SQL Server to compare the data from the RFID tag with the students' database to record attendance automatically. A Graphical User Interface (GUI) is developed using Visual Studio (XAF Tool) to allow parents and school faculty to log in and browse the students' records. Students will pass the classroom door, which will have an integrated RFID reader device to read their RFID. The paper discusses the design of the solution as well as the testing scenarios.

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1. INTRODUCTION

At present, schools accommodate a huge number of students, and to handle this huge number of students, several problems can occur one of which is taking attendance and ensuring students are attending their classes [1]. Since many students in schools today do not attend classes, it affects their grades and jeopardizes their safety because they could wander off without their parent's knowledge. The main goal of this project is to find a way to ensure the safety of children in schools, make attendance easier, and ultimately raise the learning level in classrooms. Nowadays, most schools use traditional methods for taking attendance such as taking attendance manually using a piece of paper or a computer. The mentioned traditional methods take a considerable amount of class time that can be better utilized by teaching, as an example [2]. Also, one of the weaknesses of such systems is that it isn't accurate all the time, for example, if the instructor makes a mistake while taking attendance and places the student as "present" while he isn't, there is no way to know where the student might be in school or even outside of school [3]. Some students can take advantage of these kinds of systems as they can't ensure the student is in his class as he can simply leave class [4] without the instructor noticing and leaves the school where he is prone to danger [5]. The appropriate solution will be making a system to take attendance automatically using passive RFID technology. The student will have an RFID tag unique to him/her, this RFID tag will function as an ID for each student [6], using this method to take attendance will help to save time and ensure the safety of students during school hours, it is also more precise [7] than using the current methods.

There are several proposed systems in the literature to solve the problems in conventional attendance methods by incorporating advanced technologies to improve these methods [8]. These technologies are RFID [9][10], Bluetooth [11], NFC [12], Biometric (fingerprint) [13], and Iris (face recognition) [8].

The first trial to include technology into the attendance process was using a desktop application developed by Mattam et al. [14], in which the lecturer starts the application that displays the list of all the registered students in a particular course. Attendance is taken by clicking a check box next to the name of the students that are present. The drawback is that human involvement in attendance tracking is still needed.

However, in 2013, Vishal Bhalla et al. [15], have proposed a Bluetooth-based attendance system, in which attendance is taken using the instructor's mobile phone. A software application installed in the instructor's mobile phone, by which the instructor can query the student's mobile telephone via Bluetooth connection and

through the transfer of the student's mobile telephone Media Access Control (MAC) addresses to the instructor's mobile phone, the present status of the student can be confirmed. The main drawback of this proposed technique is that a student's phone is required for attendance which is not a grantee.

In [16], the author describes how an Attendance Management System (AMS) based on Bluetooth and NFC technologies was implemented in a multi-user setting. To verify the user's identification, it uses their fingerprint and the Bluetooth address of their NFC-enabled phone. The NFC tag IDs, along with other data related to the user and their mobile device, are collected by a Java-based desktop program, which then sends them to an analyzer for interpretation of the user's behavior. However, in this instance, as a disadvantage, students must have NFC-enabled phones to sign in to the classroom.

A fingerprint scanner that is utilized in the school attendance system was created by Basheer et al. [17]. The students signify their presence by pressing their fingertips against the sensor of the apparatus. The fingerprint scanner's lack of dependability and frequent damage are disadvantages. Furthermore, it is impractical for recording attendance because students must wait in a long queue to use the fingerprint scanner.

In [18], face recognition technology is used to make the Attendance Management System (AMS) more intelligent. This technique involves installing a CCTV camera at the entrance to a classroom, which automatically takes a person's picture and compares it to a database of faces using an android-enhanced smartphone. Usually, it serves two purposes. First, determining a student's attendance by comparing freshly created facial photos, and second, identifying those who are unfamiliar with their surroundings, such as an illegal person. A recent development in picture verification is the use of 3D face recognition, which promises to match image databases more accurately and be able to identify an individual from various vantage points. Once more, the time-consuming comparison of the collected image with the photos of every student is a challenge in this approach, therefore, it is relatively slow.

To measure student attendance on mobile devices, a student information tracking system for Android is being developed in [19]. This technology lets teachers notify students about the events that the college will host by enabling them to take attendance, update attendance, view student bunks, and distribute key information in pdf formats, such as exam timetables and question banks. This system works on any device. Any mobile device with the Android operating system can have this system loaded on it. The issue with this system is that it was built for the Android platform and cannot be used with iOS or any other mobile operating system. It is also incredibly time-consuming to record student attendance on a mobile device.

According to the survey in the preceding section, the majority of attendance systems are designed in non-practical ways that are costly, unreliable, and time-consuming (slow). Therefore, the goal of this paper is to make school attendance tracking easier, look into ways to cut down on absences, and improve communication between parents and the school to improve safety. Given that school dropout rates are still high in many countries, the current study aims to expand on the previous research by developing an intelligent attendance system using RFID (RFID-AS) for schools and universities. Due to its ability to connect "things" to their online virtual identities [20], RFID technology is essential for the implementation of the Internet of Things (IoT) [21][23]. Finally, the paper will test the RFID attendance system in a few classrooms at a higher level of education to evaluate the effectiveness of our system [24].

The research contribution is to provide 1) active (which means in real-time) monitoring of students and tracking their attendance at schools and 2) with a very low cost. The adopted technology to achieve this goal is passive RFID technology in conjunction with a cloud-based Information Technology (IT) infrastructure. The IT infrastructure is comprehensive enough to allow both teachers and parents to monitor their students in real time and access their records online to ensure safety, provide evaluation, and help in assessment and grading. Currently, these features are provided in the market but at a much higher cost using active RFID [43][44].

2. PROJECT AND DESIGN OBJECTIVES, CRITERIA, AND CONSTRAINTS

The main design objectives of the proposed attendance systems are as follows:

a) Study of how to connect between RFID reader and database, and the way of installation of the RFID readers in the school. The RFID reader will read the data and send it to the interface on the server to compare the data received and the database on SQL.
b) Develop the process of taking attendance by using RFID technology.
c) Develop a database for students using SQL to take attendance automatically.

Several criteria as well as some imposed constraints must be respected during the design process of the RFID-AS, which are summarized in Table 1.

Table 1. Constraints for the School Attendance System Design

Criteria	Constraint
Affordability	Privacy
Accuracy	RFID can be easily disrupted using energy at the right frequency.
Security of the system	RFID tags can be read from far away distances using high-gain antennas.
User-friendly GUI	Using UHF readers can harm students' health.

3. DESCRIPTION OF THE DESIGN

3.1. Proposed Conceptual Design

The first possible design was to build a Real-Time Location System (RTLS) system [22] that tracks and pinpoints a person's location in real-time in indoor locations. It uses active RFID tags [25] as unique IDs for each student, multiple RFID reader devices to pinpoint the location of the tag [26], a database to hold the necessary data, and a code to connect the RFID readers with the database for comparison. The second possible solution is using passive RFID tags as a method of recording attendance with the conjunction of an RFID reader and a database similar to the one for the RTLS system. The third possible solution is using fingerprints [17] rather than RFID tags with the help of a fingerprint scanner to scan the fingerprints of students and create a database for students' fingerprints and use digital signal processing to process the fingerprints of these students to compare [27] them with this database. In this paper, the second solution is selected which depends on passive RFID tags for several reasons that are explained below.

3.2. Reviewing the Chosen Solution and Justification

After comparing the three possible solutions we had at hand, it has been decided to go with the second solution which is to build an attendance system using passive RFID tags. This solution is chosen since it meets the set criteria of affordability. We want to implement this system in different schools and one primary factor for schools accepting this system is cost, our system is not expensive as passive RFID tags are quite cheap (from prices collected from Alibaba.com: 100 RFID tags cost 15 USD and 1 RFID reader cost USD 80) compared to active RFID [28]. Also, passive RFID can last much longer than active RFID tags since it doesn't require a battery for it to be active; instead, it receives the power needed from the reader. Also, readers for RFID tags are cheaper than fingerprint scanners. Also, this system is accurate in taking readings as it recognizes the student through an ID number rather than relying on digital signal processing which requires a high-quality fingerprint scanner and is time-consuming.

3.3. Final Design and Preliminary Cost

Our system consists of a passive RFID tag that holds a unique identification number unique to that tag only as well as not rely on an external battery to function; instead, it gets its power from the reader as the reader will induce voltage and current from its magnetic field. The second is the RFID reader, which is a device that can power up an RFID tag to get the card's unique ID number which will then compare it to the database [29]. For the database, we built a database for students on SQL Server [30] using XAF [31] which allows us to manipulate the database freely and allows us to specify who has permission to edit the database and who can only view specific data. Also, we used Visual Studio 2019 [32] to write a code that can identify the reader and connect the reader with the database to compare. Also, this code is written to specify some cases, for example, our code doesn't allow the scanning of an RFID tag more than once every 10 seconds, this way the student's attendance status won't be taken twice. Lastly, on the XAF tool, we can print a report on the student's grades, attendance status, and any other data we wish to add.

4. HIGH-LEVEL SYSTEM DESIGN

4.1. Attendance and GPA

A study trying to correlate early class attendance and strong academic performance during the academic semester was done at the Technical University of Denmark (DTU) [33]. It was done for two years duration from 2013 until 2015 and included students of different academic years. 78% of the students were male and 22% were female and were from 24 different majors. 60% of sampled students were in freshmen year, 25% in sophomore year and the other 15% were in their junior year. The sampled students were divided into five groups based on their attendance and then measure each group's academic performance or GPA.

In Fig. 1 the upper graph, we can see that 60% of students attended more than 75% of classes and it also shows the correlation between attendance and the term grade of each group. Fig. 1 the lower graph, also shows the variation inside each group. We can observe from this graph that the group with the highest attendance percentage had the highest grades compared to the left-most group which ad significantly lower grades. Also, the rate of failing goes from 23% in the left-most group to only 4% in the right-most group which means that

this study can predict [34] the percentage of failing classes. This study shows that there's a significant correlation (>0.5) between attendance and GPA [33].

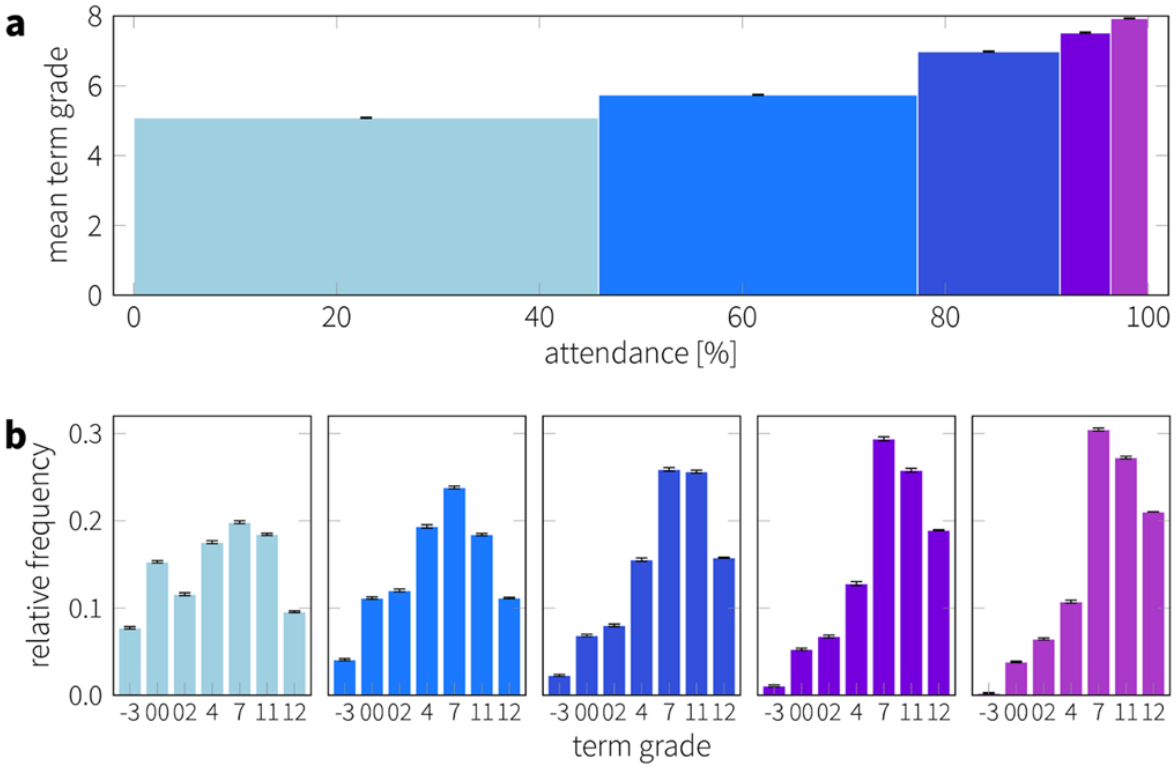

Fig. 1. Attendance and GPA: This figure shows the effect of students attending classes on their grades

4.2. RFID Technology:

RFID or Radio Frequency Identification is a technology that uses small microelectronic chips or tags that have a unique identity that can be detected wirelessly. The first use of RFID was in the 1940s on airplanes to identify friendly ones from hostile ones. Years later the RFID was used primarily in small-scale applications such as automatic registers, electronic toll collection, and anti-theft applications. However, this technology wasn't used as much as these days mainly because the technology was expensive and immature for its time. In the past decade, RFID technology has become more reliable, cheaper, and performed much better due to interest from organizations such as Auto-Id labs and the United States Department of Defense. However, this technology comes with a lot of difficulties which include the issue of large-scale global RFID networks that have the possibility of creating huge amounts of data for a single object and the problem comes from efficiently managing and sharing these huge amounts of data. Another limitation comes from privacy and security fears and should be considered to permit wide-scale real-world acceptance [35].

4.3. RFID Readers

An RFID reader Fig. 2 is consisting of three main components which are: a control section, a High-frequency interface, and an antenna. Then the user end is connected to a host application. The control section of the RFID reader does digital signal processing and procedures on the information received from the RFID transponders. Another rule of the control section is to enable communication with the transponders wirelessly by several methods which include: modulation, anti-collision, and decoding of the information from the transponders. The control section Fig. 3 consists of a microprocessor, a memory block, analog to digital converters, and a communication block for the software application [36]. The High Frequency (HF) interface module of the RFID reader transmits and receives radio frequency signals.

5. POTENTIAL ETHICAL AND/OR ENVIRONMENTAL ISSUES

An ethical problem might arise from this project, which is privacy. It might be invasive to some kids' privacy as the system can tell which classroom the student is in and at what time he entered or left. However, this issue is solved in the sense that only the parents and school management can access this data and they are prohibited from sharing this private data with anyone other than the parents. In addition, since the proposed

system does not deal with materials that could harm people, we currently do not have any environmental issues. A health problem can happen if an ultra-high frequency reader device was used for reading RFID tags at longer ranges so this could limit some applications. This issue should be mitigated by the proper selection of the short-range readers and the mounting locations of these antennas.

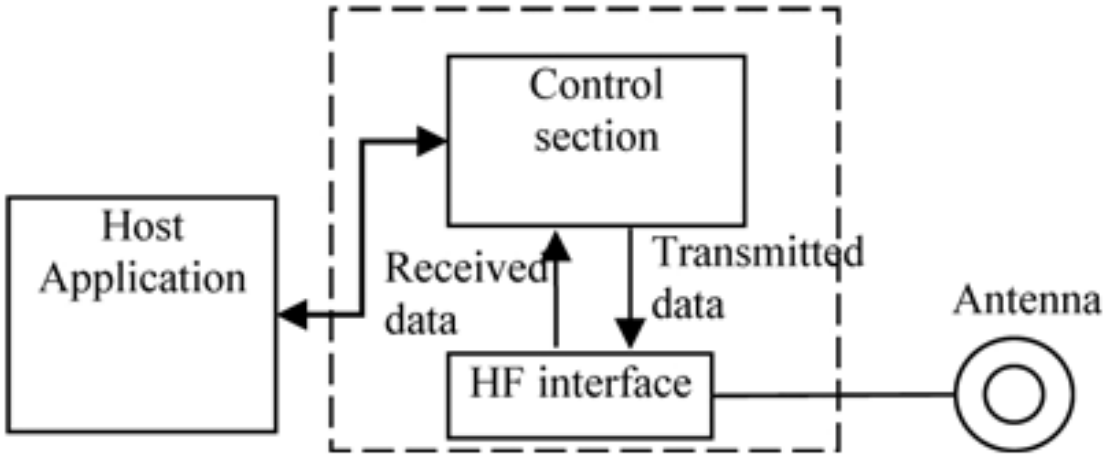

Fig. 2. Shows the components of an RFID reader

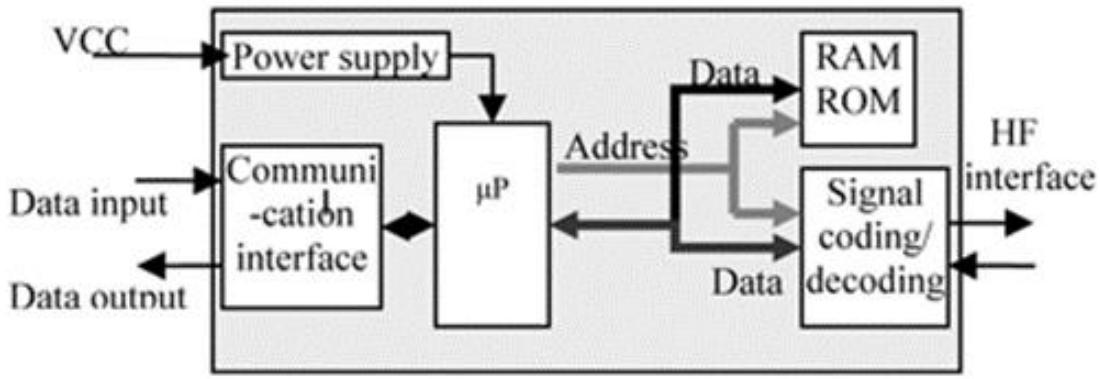

Fig. 3. The components of the control section of the RFID reader

6. DETAILED DESIGN

6.1. Detailed High-Level Specifications

Each student will hold a bracelet that holds an RFID tag, which contains information about each student because it has a small memory that can hold basic information like names and ID numbers, second, in every class, there will be readers that read the information from the RFID tags, it has a short-range so the tag should be very close to the reader then the information that detected by the reader will be sent to a database that contains the information of each student, then update the attendance of a student, after that information of the attendance will be shown online in a webpage, that webpage will be accessible by parents and teachers, the teacher can add extra information for the students like performance, grades, and report, and parents can see the status of their kids if they absent or not and keep tracking of their grades and performance in classes, the last thing, the system will convert data to statistics on charts to observe and track the total attendances at specific time weekly or monthly. The process of the flow of students' information is shown in Fig. 4. Students' information flow.

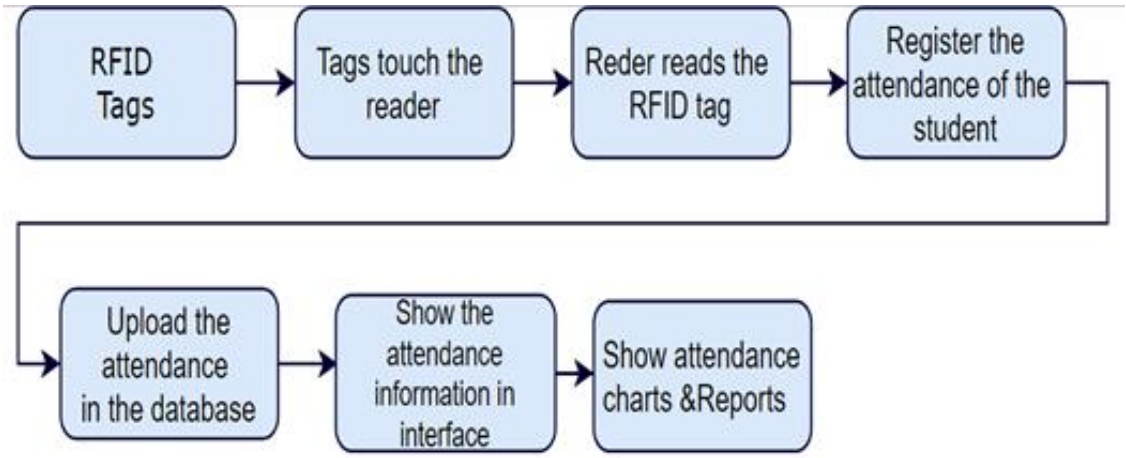

Fig. 4. Students' information flow.

6.2. Detailed Low-Level Specifications

The connection between reader and RFID tags: The connection between RFID and the reader was done using a code that includes the serial number of each tag, each tag's serial number is different than the other tag, so it can't be any conflict between students, after registering the RFID tags, when it touches the reader it will take the attendance for that student if the tag/card was not registered it will show a message that says "card not found" so it should be registered first then specify the information for this card/tag in the database. The flowchart below Fig. 5 shows how the reading process is done and how it repeats itself for each card.

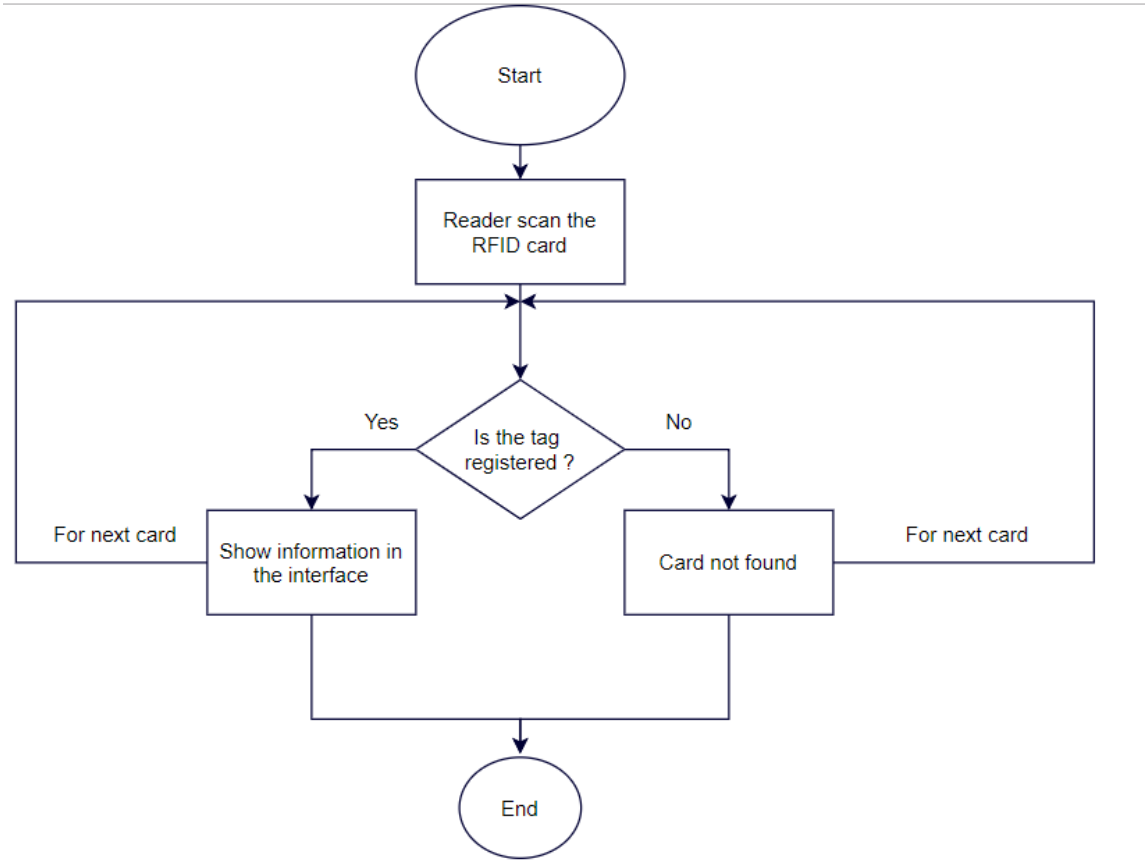

Fig. 5. Flowchart of connection between RFID and reader.

Context diagram of the database in Visual Basic Fig. 6

The students' information system is implemented using Visual Basic (VB) **[32]**. First, the XAF tool [31] is used to build the interface between the RFID hardware and the attendance system database. It will save much

development time instead of programming the interface manually and also setting the access rules as defined in Fig. 7. Initially, the tool should be downloaded and imported into Visual Studio. This tool has ready-made menus that could be imported into VB, the boxes shown below in Fig. 8. are what was chosen so they also will appear in the database. In Fig. 6, the first box is the contact information that will contain all the information of the students like ids, names, birthdays, and other different information, some information will be accessible for specific people so they can modify it, for example, the teacher is connected to grade so they can see and modify them, but the student can only see the grades not modifying them. Each sub-list is expressed by an arrow, so as we can see the teacher box arrow is heading to the grade box which means the grade will be modified by the teacher, also we can see the grades box arrow is heading to the student, that means the grades are only shown to students without modification, the same concept for the different boxes, the last thing is the attendance box we can see the student is the one who is responsible for attendance so the arrow is heading from student to attendance and the attendance will take information from the reader box. Each box can be also modified in the interface with helping of the XAF tool which made the process easy. The accessibility rules which are implemented by the XAF and VB are given in the flowchart in Fig. 7.

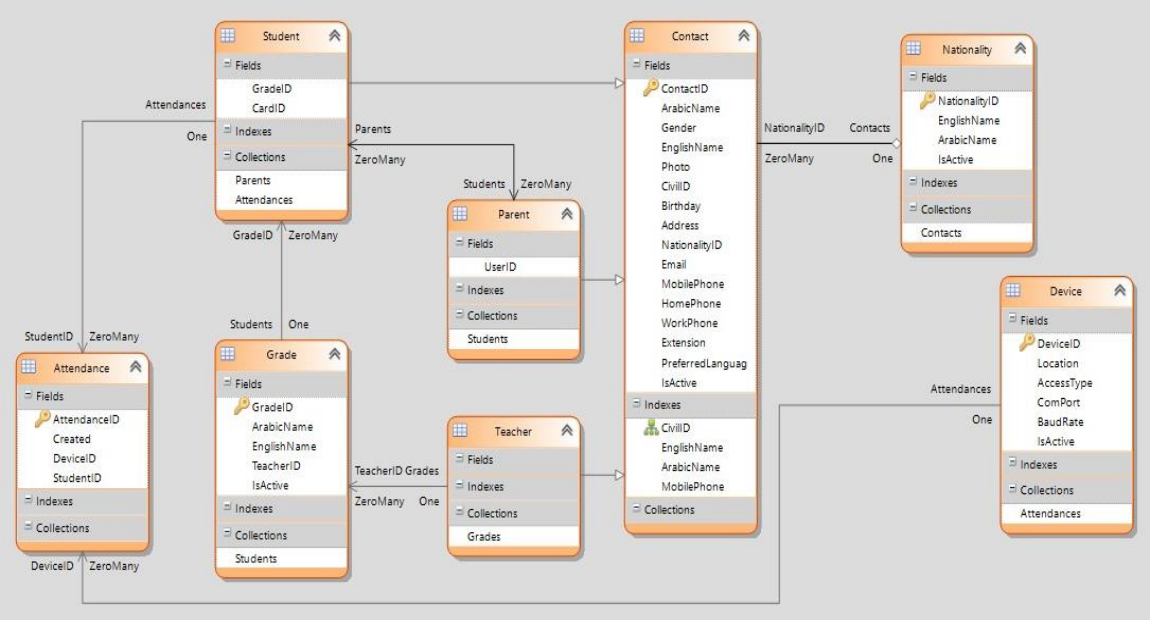

Fig. 6. The context diagram of the attendance database system

7. PROJECT REALIZATION AND PERFORMANCE OPTIMIZATION

7.1. Preliminary Implementation - Analysis and Optimization

First, we implement an application framework that targets both win-forms and .net forms using Visual Basic and the XAF tool. XAF tool will reduce some difficulty in building the system and it will help to create a highly responsive application [37]. XAF tool automatically generates a data model by adding it to the visual basic code and it will generate a data model for our database automatically. We can customize and add more features to our application such as adding a customized dashboard and student weekly report generation. Second, we built an object called (contact) which is the core of the database of our system then we add all the information about students, parents, teachers, devices, attendance, and grade to it. Then we connect all other objects with the users that have teacher roles. They will have their username and password to enter the application. We also consider our security system so it can work with users, roles, and permeation. The student is not allowed to do any modifications to their data. Their access is only for visualization.

The RFID reader is a device to receive information from the Tag. There are a lot of types of readers. In this system, we use passive RFID. This system works with the help of an RFID reader and tag there will be a reader at each gate, the reader is connected to the server to control it, and the reader will send the data taken from the ID to the Visual Basic application to record the attendance. Using Visual Basic and the XAF tool we add three other cases to the reader (Fig. 8, Fig. 10, and Fig. 11). The first one is that the card is not found in the database. The second one is that the student flashed the ID card more than once and the third case is that the card is found in the database.

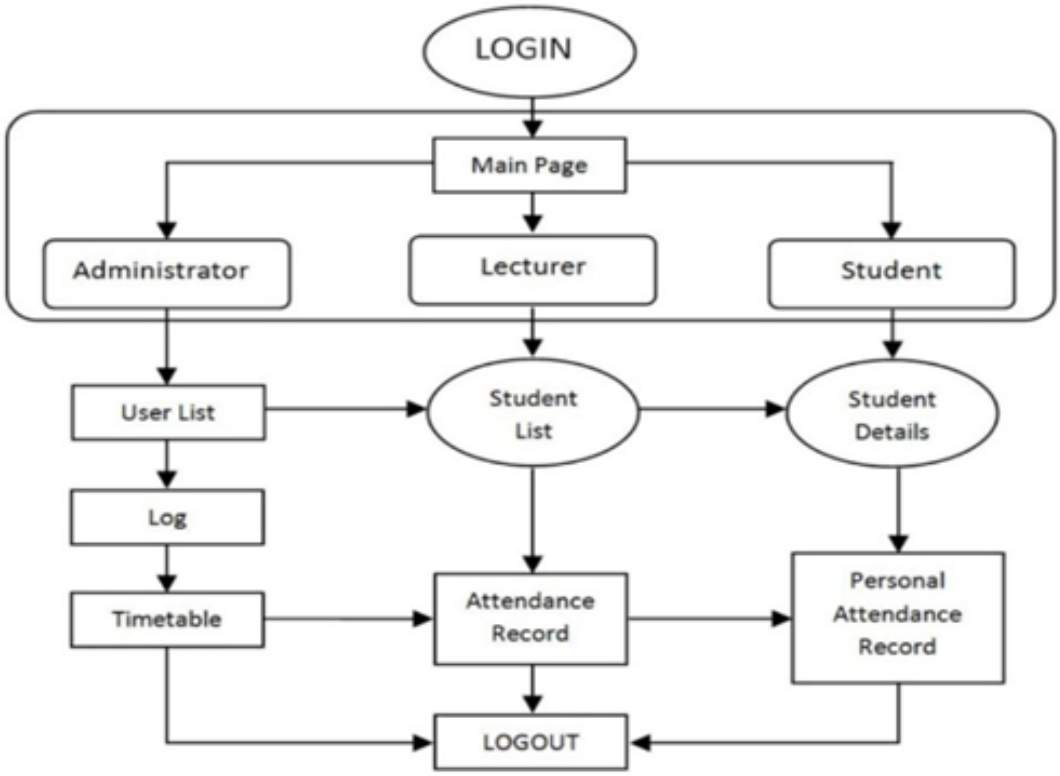

Fig. 7. The accessibility rules flowchart

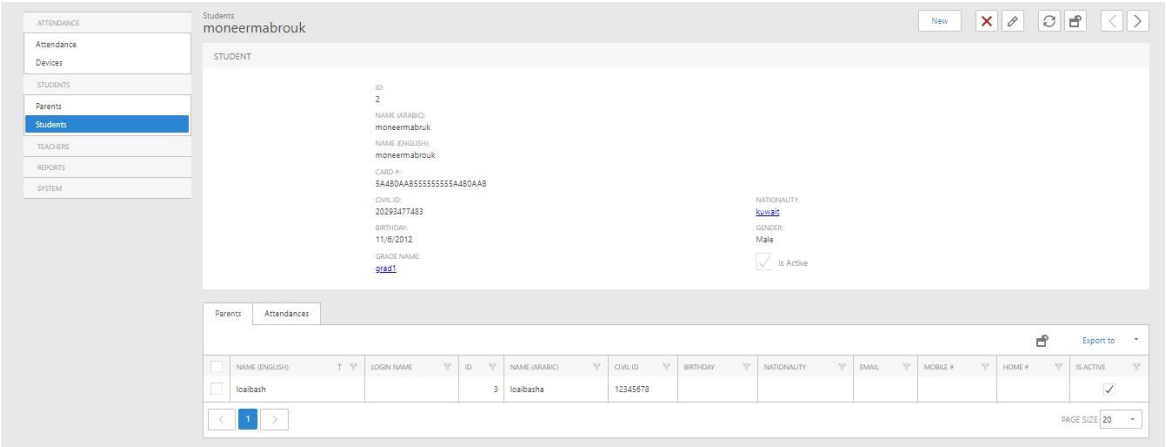

Fig. 8. Interface for XAF on Visual Studio

Since this application is implemented using visual basic and XAF tools. However, there are stages to implementing this application first is to connect the reader with the visual basic program to receive the data taken from the ID. The second is to store the data using an SQL server Fig. 9. The third is to develop and design a web application to check or edit attendance or to add student weekly reports as shown in Fig. 12. Teachers or parents will login to this application using their credentials as shown in Fig. 13.

SQL is a database management system. In our attendance system, SQL is used to perform specific tasks such as updating data and retrieving data from the visual basic code. The data for the student attendance will be stored based on when the student enters the school and flashed the ID at the reader attendance will be stored on the SQL server.

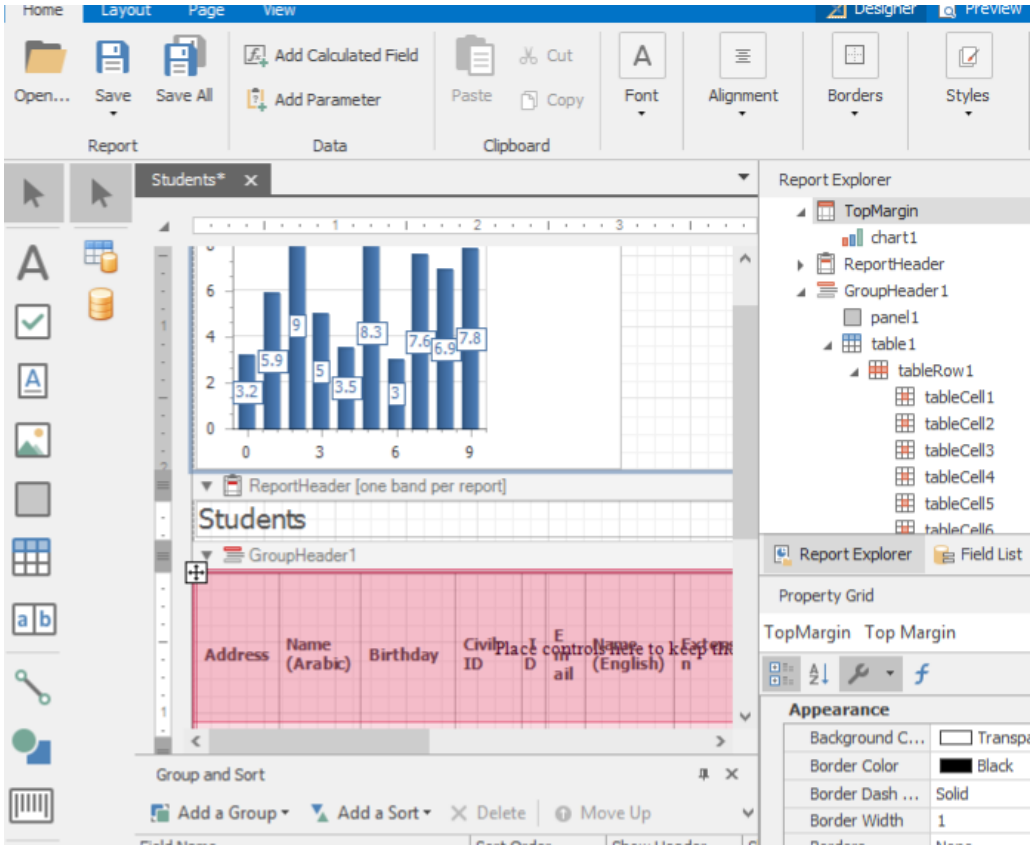

Fig. 9. SQL database

7.2. Discussion of Design's Modifications

A GSM (Global System for Mobile communication) module can be added to the attendance server to be used to send a message to the parents if the student did not attend the classes, we can also add readers for the busses to track [38] the moves of the student to ensure their safety.

7.3. Final Design Construction, Testing, and Improvement

The RFID reader is tested by making it capture ID several times to make sure that the reader read the tag. First, a student with a new tag will be flashed to the reader then the reader will capture this card and save it to the database with the detailed information of the associated student. Then, the student will be able to flash the reader to record the attendance.

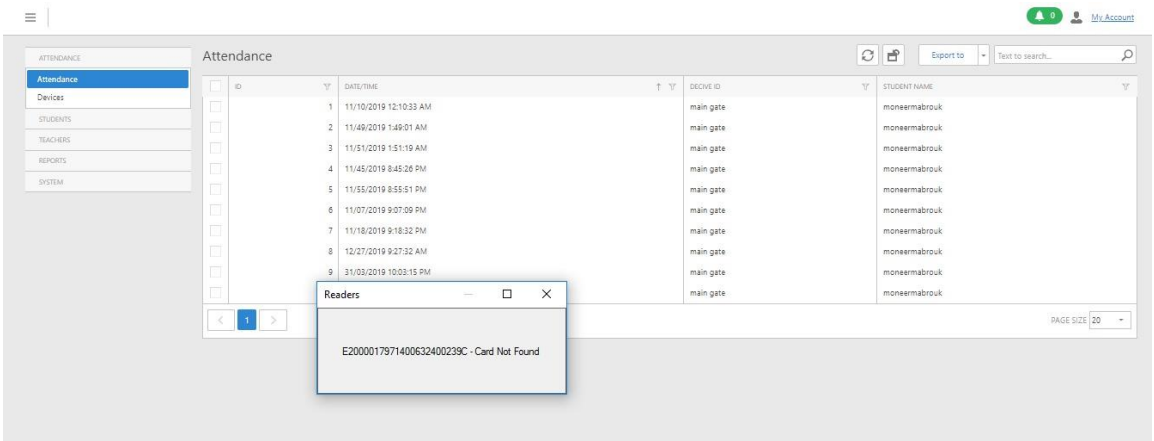

Fig. 10. Reader reads the tag (card not found)

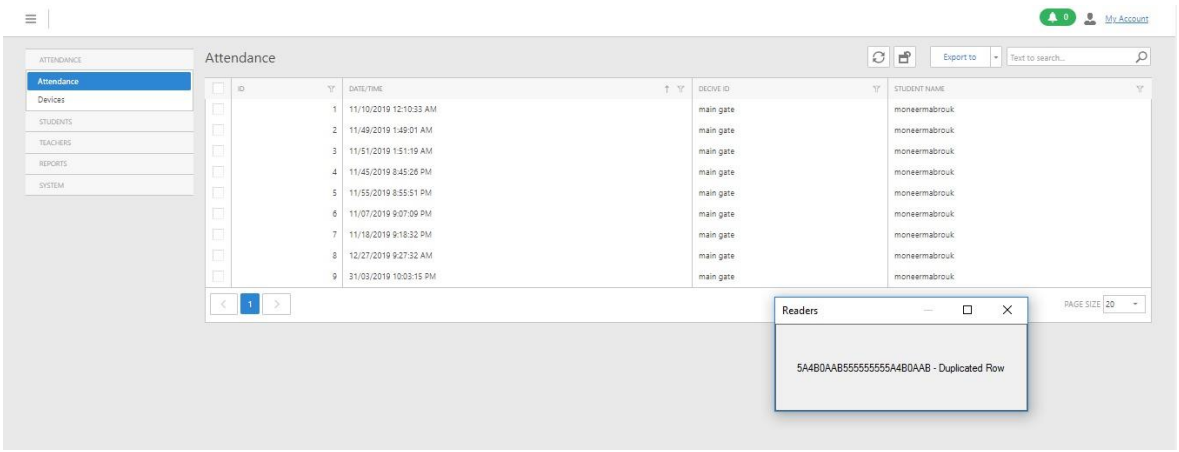

Fig. 11. Reader reads the tag (duplicated row)

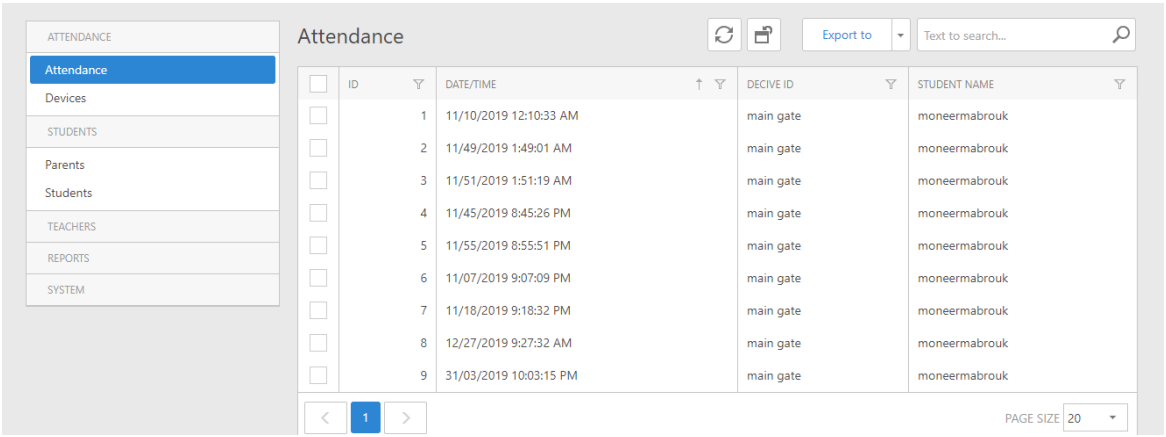

Fig. 12. Sample of attendance record for a student

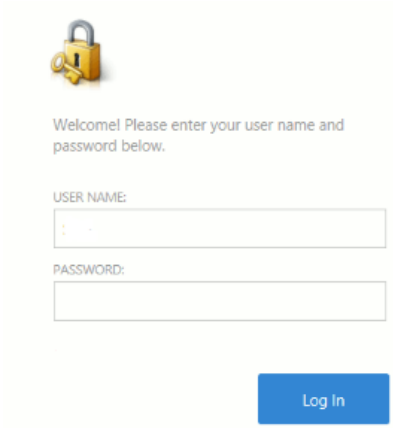

Fig. 13. The Login page for the attendance system

7.4. System Testing

By keeping an eye on the outputs via the web application, we tested the system. Both the reader's ability to transfer data to Visual Basic and the application's ability to track attendance are being tested [39]. The SQL server was subjected to a similar test. Check to see if the SQL server is connected to Visual Basic or if the data was incorrectly returned.

7.5. Analysis and Discussion

The designed system is sustainable [40][41][42] for three reasons: first, it reduced human error; second, it can handle a sizable database; and third, the data will be better organized and simpler to handle. Moreover,

the security aspects were improved. Our system has a large database that can accommodate this enormous number of students and can be scaled up to take attendance for numerous schools simultaneously [45].

The final cost for the prototype of the attendance system was USD 80.33. We bought 5 RFID tags and one RFID reader. We can witness how inexpensive an RFID attendance system can cost which aligned with our first criteria of affordability.

8. CONCLUSION AND FUTURE WORK

The goal of this project is to develop a system that will benefit schools, parents, and teachers while saving time when taking attendance. To accomplish this, we used an RFID tag and reader along with a software program called XAF to quickly take attendance. Additionally, a user will be created for parents to track their child's attendance for classes, grades, and a variety of other features.

In conclusion, by adhering to the decision-making matrix, the criteria, and the constraints that we established and ensuring that they fit with the project, we were able to complete the entire project. As a result, we were able to select the components that matched the project in terms of cost, quality, etc. Additionally, we developed a user-friendly interface for a system that can collect attendance by attaching a reader to the system. Additionally, we were successful in producing a prototype that cleverly illustrates the entire project.

The final design consists of a laptop, reader, RFID tag, and software called XAF. These components can solve the problem of school safety and learning level, so we were able to create a system that can take attendance by touching the RFID tag to the reader and the reader will read the data of the student and take the attendance using XAF tool software, so we connect the reader with the XAF tool software. They can also use the system to track their child's grades. Finally, this system allows parents to ensure that their child learns well and is present in class, and it will save the teacher time from taking attendance by hand.

For future work, this system can be used in schools, universities, and even businesses to ensure that employees arrive on time. It can also be used in buses to track the movement of children returning from school, and we decided to use this system in Kuwait for schools.

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