

RFID-based access control system with automated employee attendance tracking

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Abstract

The purpose of this paper is to develop an access control with employee attendance registration function based on RFID technology. In addition to the increased demand of automation of personnel accounting systems from the one side, there is a challenge to propose a reliable access control system with provided secured access control and an enough precision of course attendance of personnel as for the presence detection, as for the calculation of actual work hours. The major part of currently available systems of time attendance registration are using the ones of abovementioned variants or combination of them. Such systems and solutions that are combining the manual work time registration with automation, are lacking in either the accuracy or security or both of these properties resulting in double work load of user and administrative staff. The proposed variant of system exploiting the RFID identification of users together with architecture based on client-server model for the integrated environment including validation, event registration, processing and tracking office presence administration is designed. These components of architecture based on server-FastAPI, client: Arduino (controller + the reader MFRC522), database-MySQL, admin interface-web are used to illustrate server-side event registration of the RFID readers; forming the session of attendance; determining the actual work time and clarifying the problem work-time. Such approach allows for central personnel registering, their RFID Cards/fobs, reservation of right for persons access to particular locations, the work attendance management. Collected and analyzed data from the experiments showed in practice the effectiveness of security measures and a sufficient reliability of calculation of presence and actual work hours for the proposed variants of RFID based time-register system. The study demonstrated the efficiency of applying the RFID-technology for implementation of integrated solutions for design and construction the access controlling and attendance registration systems for office buildings, industrial enterprises, training institutions with the purpose of increasing the precision of personnel accounting and automation of business operations increasing.

Keywords

client-server architecture, RFID, access control system, attendance tracking, employee identification, event processing, FastAPI, MySQL

1. Introduction

1.1. Background information

As digital infrastructure proliferates, a need for enormous automation has arisen to one 'set and forget' even the physical access and attendance audit. Organizations require a powerful and accurate tool to authenticate employees, provide access and accurately record attendance data without imposing additional administrative overhead. The insurmountable gap in most organizations lies in the fact that attendance recording and access management functions are executed separately (one for managing authorized users and the other for auditing working hours), leading to double entries in the employee database and additional resources managing the information [1].

With the development of automatic identification, a fully integrated system merging access verification with attendance control into a central data system can be now implemented. As a result of several

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identification techniques available; radio-frequency identification (RFID) provides a best solution for the identity element in an organization such as an office, schools, research laboratories and factories where the access needs to be identified (achieve, exist, lets in) an uncountable number of times per day, because of its contactless feature, fast data processing and relatively low cost [2, 3].

As requiring of centered work force, would consume opportunity of integrated RFID solution because provides access, event registration, attendance together, thus ultimately does improved performance that reduces the human intervenes that will record of human resource.

1.2. Access control and attendance management challenges

The deployment of the integrated access control and attendance management systems presents a number of technical and organizational difficulties. The data consistency challenge is one of the most critical problems to overcome. Access events and attendance records are typically handled by a number of disconnected databases and software components in organizations. In a large number of companies duplicated records are often stored and are hard to keep synchronized [4].

Another challenge concerns reliable processing of identification events. One identification process provides proof that an RFID tag or similar has been brought near the readers. However further processing must be undertaken before it becomes obvious that the identification event represents an entrance, an exit or another type of action performed by a particular employee [5].

System maintainability and scalability is also an aspect to be taken into account when the system is put into operation. For a larger number of employees and entries the system must provide a solution able to handle large amounts of identification events whilst allowing for central monitoring and control of all hardware units. In both cases it seems the role of the servers is important separating hardware activities from software related processes. All the discussed issues make evident the necessity for an information system able to manage both identification methods, event and time attendance processes in one cohesive environment.

1.3. Practical significance and implementation prospects

Real world implementation: why such an integrated system is required is because the demand of an automatic personal management system is rapidly increasing. Firms of all kinds are interested in gaining real time information on employee attendance, working hours and accesses without much effort from humans and by avoiding the manually feeding and updating data, to time sheets. This is now achievable through modern identification techniques that provide more accurate solutions for registering staff with better control over accesses, but new questions are arising on how to assure confidentiality with such constantly monitored identities [6].

The solution presented herein provides the RFID integrated system with personnel recognition, access verification, access, entrance, and exit recording capabilities, through its database. When the data on RFID tags and access times is processed centralized the amount of data required for administrative purposes decrease, eliminating discrepancies between the access lists and attendance registers and allowing the firm the flexibility required when high volumes of ID checks per day are being done.

Our RFID solution can be deployed in various offices, universities, labs, plants and government agencies requiring both access control and tracking of staff. Its client-server design allows a centralized management of staff, ID card, level authorizations and time sheets with flexibility for further amendments.

A key advantage is that many areas can be developed and that many ways of extending the RFID application with for instance multi-access point support, improved security features, an ERP integration or even a simple analyzing module could result in the evolution of the system to become a complete personnel management tool.

Our research focuses on raising the level of efficiency, the quality of information, and alleviating the burden of managing employees through RFID ID technologies and a central event handling system and time management.

2. Modern literature analysis

2.1. RFID-based identification systems

RFID (Radio Frequency Identification) popular for automated identifications of people or things and of location of them. With the use of RFID technology, radio frequency waves are utilized for bidirectional transmission to carry identification information such as ID numbers encoded in the RFID tag to a compatible reader. In general, RFID provides more advantages over a traditional barcode, the foremost of these advantages being the capability to speed up identifications and simplify systems because it does not necessarily require a straight line between the tag and the reader [7].

RFID technology has been developed and applied from many industries both on every aspects such as transportation, stock control systems, health care organization, logistic organization along with certain security systems.

RFID receives the intention from industry in consequence of contactless, low price and automatic detection of events and it causes the reader tag systems to replace the bar code identification systems. Access Control systems is a physical security measure that works with the intent to prevent Unauthorized physical access to areas, computer systems (including network servers, and company databases). Access control systems can prevent certain users access to restricted areas, doors or windows, rooms, files, computers [8]. Various kinds of researches demonstrate that compared with other identification systems, a RFID identification systems would provide one or two of the greatest value proposition and reasonable balances on installing cost, operational efficiencies and extendibility.

Low-cost reader devices and RFID tags provide opportunities to several Small & Medium-Sized Companies to start deploying of RFID systems in early stages [9].

However, it still faces limitations to integrate RFID in typical attendance systems or human supervisions without human interpretation, for the reason that identification and logging events needs to be first analyzed and processed to support better management decision-making, so RFID-based application was developed which comprises central management application helping to manage identification events, to manage stored data and to compile reports.

2.2. Alternative identification technologies

In the modern world today, many identification technologies are used for access control and attendance management systems. The selection of an identification method among the existing technologies is the outcome of the consideration of several parameters such as: -the required security level, the implementation cost, the ease of operation and the scalability of the solution. Low-cost solutions using QR- and bar-codes; they can be used with conventional mobile phones or scanners. They are not that difficult to install, but they require that the readers have visual communication with the tag. The weak point of solutions based on printed code is that they are not unique, two people may have the same printed barcode and one can share it with somebody else, this makes the system less secure [10, 11].

PIN based systems has not physical credential, but it is purely use up memory of user, habits of user and code memory; that is it can be predicted, observed or passed to other persons [12]. And this explains PIN code is just complements for all identification technologies.

Examples of biometric solutions are the fingerprint and facial recognition. Biometric solutions normally provide a higher level of personalization of credentials, reducing the chance of their misuse by other person, but normally are more expensive (hardware/ software) and need of computational power and need to follow the legislations that protect personal data [13, 14], this could be a problem for small/medium companies.

On the base of all the solutions we already presented, we consider that RFID is the more attractive technology because of its ability to be operating 'easy to implement', low in term of deployment cost, contactless and easy to integration. These features make them well suited.

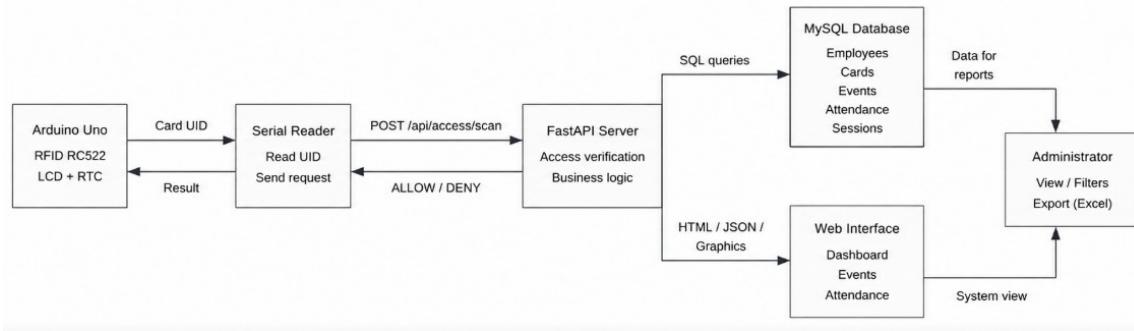


Figure 1: General architecture of the developed RFID-based access control and attendance management system.

3. Proposed system

3.1. System architecture

Our solution is an integrated client-server system, using RFID identification, central event processing, and a Web client-based administrator environment. Therefore, access control and employees' attendance are performed in a single information system [15].

The Hardware: consists of Arduino Uno microcontroller, MFRC522 RFID Reader, LCD and RFIDs for employees. When you show a card to the reader its UID is read and sent to the server through an HTTP request. The server also process this information and acts as a decision maker.

The main business logic: management of RFID events, access validation, creation of the user sessions, management of the database, is made by the FastAPI. All information related to employees, RFIDs, accesses and attendances are stored into a MySQL database.

Figure 1 below represents the overall architecture of the RFID based access control and attendance management system that we have built. Figure 1 presents the general architecture of the developed RFID-based access control and attendance management system.

As can be seen in Figure 1, FastAPI server is in the middle of the whole system. It takes RFID ID requests from Hardware subsystem, does the access control, records the events into database and forwards all data to the admin web interface.

3.2. Hardware subsystem

Hardware subsystem is mainly to get the RFID credentials and to give the main contact point for employee and system. Hardware is based on Arduino Uno, a micro-controller and an MFRC522 RFID reader, which communicate with the RFID card and extract the unique number associated with the card. This card UID is then used as input to the server to check authorization and mark attendance.

The main function of the Arduino Uno is to manage the RFID reader and send to the server the identifier received. The architecture of the system proposed is such that the physical layer does not decide by itself the access or not. It is just an identification and communication component because the real business logic is used by the server. It is easier to administer because access rights, employees or cards records may be changes directly in the database without the need of alter a firmware or anything else in the microcontroller.

The popular implementation of MIFARE by using the low-cost cards and the functionalities of the native hardware sub-system to realize the prototype systems for access control systems [16], the use of MFRC522 module is justified. For give a indication of the incoming access query, such a granted or refused, the local display embedded to hardware sub-system.

3.3. Server-side implementation

Processing is done at server-side that's monitoring RFID event, checking access permission, attendance record and Data storage. FastAPI has fast request handling, REST API support etc. Incorporation any external hardware component and database [17, 18] is supported by our Server.

Whenever any RFID card is scanned then the hardware layer make an HTTP request sending the card UID and the reader data to the server, where it validates it and compare against the data we already stored in our database. The server determine whether the RFID token is available, and enabled, who owns the employee who owns it, and whether said person is allowed access [19].

All necessary data are stored in a MySQL database to handle employees, RFID tokens, access events, attendance periods, readers and entry points [20]. The entity 'employees' is related to RFID tokens, access events and attendance periods, while the table 'events' logs all identification attempts and acts as the driving table for attendance reports.

A different 'attendance_sessions' table is used for storing processing attendance data (check-in/out time, break time, worked time). Storing raw RFID events and processed attendance data separately makes it easy to perform historical analysis on the events or to speed up queries on this monthly attendance data.

The REST API exposes the interaction between the hardware, database, and admin interface. Configuring the server side allow the access control and attendance management separate from the hardware, and facilitates expansion of the system.

3.4. Attendance processing algorithm

Attendance data will be generated automatically from the RFID identification occurrences. The system developed, rather than carrying out registration processes, obtains information from the occurred events of entry/exit and generates attended session with presence, including working time and rests [21, 22].

On identity of an employee, server retrieves the open session of employee attendance. If an open session does not exist, server then creates a new attendance record and records the current timestamp for check-in. Else, server detects the current event when an employee leaves or returns to the working session, or terminates a working session.

Figure 2 displays the attendance processing algorithm of the system.

The system's algorithm will envisage role as per flexible entrance and exit norms and will handle Break for employee during working day. Short DMG departures will be treated as breaks and will be associated with current presence session, while longer DMG bouts will trigger to close the session and will computed the employee working time duration [23].

With the given approach they can be generated from the access control events without the registration of sessions, providing more accurate personnel accounting and reducing of the attendance control administrative duties.

3.5. Working time calculation

When the attendance sessions have been created based on the RFID sessions, Indicators are created for the sake of salary calculation and for the attendance analysis. A working day, for each of the attendance sessions, includes employee check-ins, check-outs and short absences [24].

At first time for an employee, a new session is started and the first time that has been recorded is considered as the time of arrival. Subsequently on the same working day additional incidents of this worker's mobility in the workforce lend new information to this session of attendance [25]. Depending on the order of these events and length of employees breaks, this attendance session might be interrupted by breaks or it might be ended. This procedure automates attendance information creation without the need for extra registration processes [26].

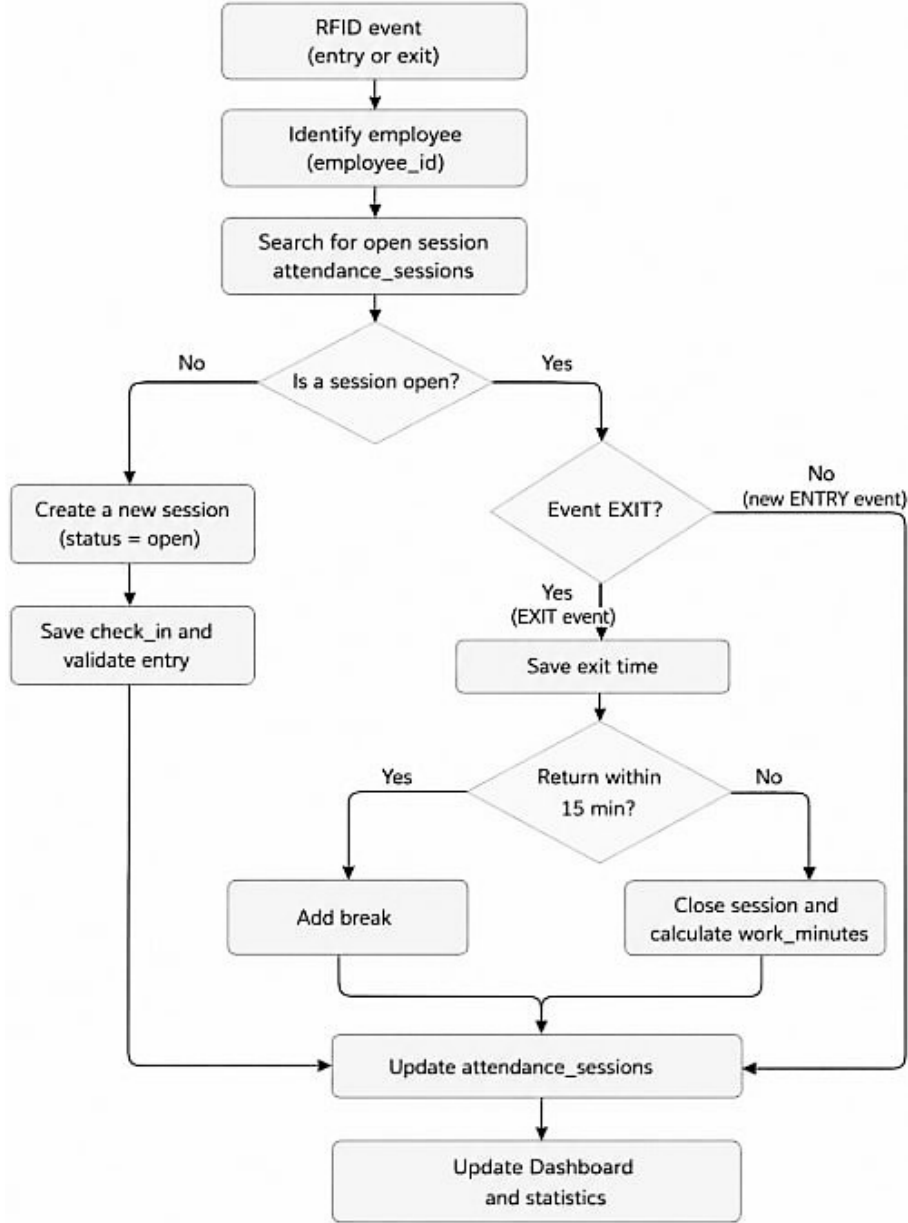


Figure 2: Attendance processing and work time tracking algorithm..

The length of effective working time is calculated as the difference between the recorded arrival time and departure time, taking into account any registered break periods as described in the following expression:

$$T_{work} = T_{out} - T_{in} - T_{break}, \quad (1)$$

where T_{work} is the effective working time, T_{out} is the employee check-out time, T_{in} is the employee check-in time, and T_{break} represents the total duration of breaks during the attendance session.

This is to separate the time which an employee actually spends physically within the premises (attendance interval) from the actual hours worked. Because employees could go out of building on breaks and enter again, still within the same attendance.

Furthermore, employee lateness is automatically registered as soon as an employee checks in. The clocking time will be cross referenced against the working day start time designated by the administrator and lateness to the work place will be entered on to the system as:

$$L = \max(0, T_{in} - T_{start}), \quad (2)$$

where L is the lateness duration, T_{in} is the actual arrival time, and T_{start} is the scheduled beginning of the working day.

The values are recorded on the attendance session and can be accessed in order to support reports, dashboard summaries, and further employee activity analysis [27].

4. System testing and evaluation

The system designed has been implemented and tested in real organizational environment. The test consisted of RFID tag identification and access detection, session creation for the presence and the working time, the data base management during normal activity with citizens [28].

In operation, operator identification in and out of working place was based on RFID cards. All RFID events were transmitted to server, where they have been handled by algorithms and stored in the database. The tests proved that the communication between hardware part of the system and server was stable [29].

The procedures for user identification and access using RFID cards were tested successfully. Any valid card was correctly recognized, access rights were verified, and a corresponding access decision was return. Invalid credentials were denied, and all access attempts were logged in the event log for further traceability of accesses [30].

The attendance management subsystem was tested in normal enterprise operation. Employee entry and exit and of any short period absences were recorded automatically and did not require any additional manual registration. Attendance sessions were created properly and the derived values of working time fit the employee presence. The operation of the database proved to be working in the right way. Employee data, RFID information, access events and attendance data were stored without any errors and continued to be accessible for any other elaboration or report generation. No loss or inconsistencies occurred between RFID events log and attendance sessions generated by the system operation [31].

It was proved that combining access control with employees' attendance management in one information environment is a practically possible thing. As attendance records drew from RFID events automatically, the attendance records could closely reflect the real attendance records system, which could ease the management pressure and error rate [32].

Calculation methods have been successfully tested and calculated effective working time, break time and lateness parameters. The tested statistics would give system administrators organized data of each employee activity and attendance discipline. The results have proved applicability of the solution in enterprise environment where digital access control and Attendance Management are required. Modular architecture offers extension to two (or more) access points, intelligent reporting facilities and connection with enterprise information systems [33].

5. Conclusions

This paper presented the development of an RFID-based access control system with integrated employee attendance tracking functionality. The following were united in a single information space of one information environment, RFID identification device, centralized data processing through server based, escape management of attendance and administration environment based on web application. The information system was built on RFID hardware based on Arduino, FastAPI and MySQL database. It supports a facility entrance and registration to events, creation of Attendance session, impacts the actual working hours and observing facility personnel attendance.

Direct translating RFID recognition events to formatted attendance records without registration of the employees as the participator of this event is considered as the highest project.

The algorithm of Attendance tracking process has been designed for: automatic calculation and recording attendance sessions (automatically generated), calculation and recording works effective

hours, recording break-time and find out the initial time of working, find out the time of leave the facilities or building. The architecture of integrating access control system and attendance managing system within the view of one integrated information system is preferred for better administrating structure, which decreases the working volume of workers for HR administration. The trial test on the different typical environment operation conditions of this system indicated the high analyzing degree for recognizing RFID identities, access control, attendance time counting and database manipulation. Finally, the proposed solutions have good future for some companies that have workers' attendance and building and hardware facility controlling demands.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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