# A NOVEL IOT ENABLED AUTOMATED ATTENDANCE REGISTERING SYSTEM USING RFID AND CLOUD AS BACK-END

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**Abstract:** In recent days, Internet of Things, Cloud Computing, Industry 4.0, WSN, are considered to be emerging technologies to solve variety of real-world problems. The main purpose of this paper is to design an automated attendance system using novel technologies such as IoT in IaaS Cloud environment with RFID, providing a unique system design and implementation which enhances the performance, time and overall functionality of the system. This research work concentrates on enhancing the automation computations and processing. As the entire data has to be saved in cloud, the traditional single-user mode limitations can be overcome and through the API, a gateway into the IoT is opened. A hybrid security model solution using SSL and AES is proposed in order to provide authentication and security in handling the data. The proposed model is compared with other existing models based on different parameters.

**Key words:** Automation, IoT, Cloud, RFID, attendance.

## 1. INTRODUCTION

The great development of modern technologies today has made the systems very sophisticated. The Internet of Things today plays a key role in almost all areas of Computer Science so as to create smart cities, improvise the transport sector, the automation sector in agriculture, in health systems, etc. The Internet of Things is an organization of devices, sensors, networks that interact to produce valuable and interchangeable data [1]. Cloud on the other hand allows organizations to maintain an infrastructure remotely, so that applications are fully-functional, faster, centralized on a server [2]. In this research paper we will describe a model that automates attendance by including IoT and Cloud and attached to the data that RFID creates, along with other equipment needed in our model. Automation is a field that is given special importance as it reduces time, increases efficiency, and reduces cost.

At the same time, automation has become a challenge for software engineers, to combine software and hardware, to achieve a completed final result in every aspect as integrating the emerging technologies into systems [3]. Today the technology in revolution is IoT, where devices communicate with their own intelligence based only on raw data received from sensors or other devices on the network [4].

In this paper, different problems are solved. The prime problems consist on the implementation of an attendance system, which is cloud based, and has a gateway into the IoT, so various devices can consume the data. IoT requires special connection so the data can be available. Cloud infrastructure is needed so the data can be centralized, and since the system is security related, a cyber security solution is necessary.

For the mentioned problems, this research paper proposes a model, in a manner of describing in detail the design and the implementation of its methods, consisting in the design of the whole system itself with the required features.

The main objectives of this paper are:

- Describe a modern architecture of a system which includes advanced emerging technologies and the combination of these technologies in precision with each other
- Few such systems are integrated in the Cloud, so the objective is the system to be placed in a Cloud environment
- Since the IoT is revolutionizing the field of Computer Science, few systems can be integrated into such an environment, hence the importance that this paper provides is also the possibility of integration into such devices.
- To provide an adequate modern solution for the register of attendance without physical contact
- Explain the combination and interaction of RFID technology, Cloud environment, and IoT
- Reduce usage time and overall data management
- Increase the overall performance and functionality of the system
- Provide a model of cyber security for such systems

We strongly believe that this model will greatly contribute to the automation aspect, and will also help special actors who will implement this model.
The proposed model is directly implemented in IaaS Cloud, so it can provide that data to the IoT device, using the SQL database, in which the data is stored.

Through the cloud we aim for data to be accessible at all times, and from any device or node, precisely thanks to the components of SQL Server, through which we have several functions such as replication, reflection, where and data can be centralized, and all to be managed by one place. From the cloud the data can be transferred securely using SSL to the IoT Device, through the API we have created, where the data is encoded in JSON format and encrypted in AES 128-bit, and will be accessible with requests from any required device.

## 2. RELATED WORK

In order to achieve an optimal solution for attendance registering automation, a broad approach of technological aspect has been explored by many researchers. When we say broad approach, we mean the various forms and methods that are used to implement and properly design the attendance register which will be practical and fully functional.

Initially, in previous years, [5] have designed a system in which they have described the methods where they have done the identification of who or what is present in connection with the generation of specific contents and then registering it as an attendance. This research in itself contains valuable information about the attendance registering, but at the same time it has many procedures and processes within it. The Research is a motivation for various works to design a relatively good system today.

A complete form of automatic attendance registering through iris recognition is designed [6], which describes the process of identifying the person, which turned out to be very simple and very low cost of implementation, but which creates large data due to the resolution of the camera for iris scanning, the same is worth noting that it is more accurate as the iris is unique to each person

Of course RFID is not something new, as we have mentioned in our research, so there are many attempts to implement such a system, such as the research [7], which is a review, for all possible forms of automatic registration such as face recognition, iris recognition, fingerprint and others, but who have chosen the focus on RFID because they are proven more practical and less time consuming.

An RFID system combined with a GMS modem is designed [8], focusing on the student attendance registering and the students real time location, using the passive RFID tag, which is matched against the database and only finalized once its fingerprint is verified using biometric fingerprint scanner. An SMS is sent to the same flock, using the GMS Modem, to announce whether the student is in the classroom or not.

There are few articles where technologies such as RFID with IoT are integrated. One of those works is [9], where a system for managing teaching has been created using these technologies. This system is based on mobile application, and the same can't be used for many nodes.

A system has been developed [10], similar to what we elaborate in this paper, noting the facilities that are made by implementing RFID and cloud, as well as elaborating the concrete use of RFID and theoretically which devices are used, where it is worth mentioning the algorithm for comparing images, but this paper does not give us a clear idea of how we can concretely implement a system and what form of IoT connection we can use.

One thing that all the works have in common is the facilitation and avoidance of errors of the classical methods of attendance registering, where through numerous attempts implementing such a system, the main idea is to achieve high flexibility, low cost of implementation and reducing time wastage.

## 3. PROPOSED MODEL DESIGN AND IMPLEMENTATION

In this proposed automated attendance registering system, we will develop a system that benefits from the many options offered by Cloud, IoT and RFID technologies so that it will be able to register user attendance automatically without the need for time-wasting classic methods. This research paper covers numerous opinions from different sources which focus on automating attendance and generating very valuable information about it. In this research paper, we develop and describe in detail the development of such a system, which will generate a wealth of information, which can then be consumed by IoT devices. The proposed system, will be easily implementable, and at the same time will be able to meet the needs of users, having many benefits, such as low-cost implementation, and long-term use. The end result will be a novel system through which the design of a model appears where IoT technologies, Cloud Computing and RFID are combined.

In this section, we present the methods and procedures that are used to design our system, which will be as follows: **(1)** General architecture is developed, through which the whole system will work, where each node will be connected to the other node, through hardware, software and network equipment, since through this architecture everyone will be able to implement this system, **(2)** describe the equipment and software that will be used to operate this model, **(3)** develop a database for the automatic registry of attendance which will be launched directly on the Cloud server for easier access, higher security , and easy management, **(4)** the algorithm for automatic attendance registering is developed, where the forms and the way in which the data are recorded in our database will be seen in detail, **(5)** The API is created which will connect the whole system to IoT, **(6)** Security of the model.

The system itself will register user attendance, and at the same time confirm to the user that the attendance registration was successful.

From RFID Reader and the user chip, the user ID is obtained, which will be stored in the cloud database, at the same time performing multiple processes in the background in nanoseconds, registering the current time, ID, a photo of the user and other valid information which will be described in the following chapters.

This data generated by the implemented nodes will be stored permanently in a cloud server, and will be used for further analysis. The information will be able to be used by any IoT Device, and through that information, the devices can perform intelligent functions based on those data.

### 3.1. General architecture

The general architecture of the proposed automatic attendance registration system is divided into several actors which cooperate with each other, but are separate nodes with unique functions.

These actors are: (1) Cloud server, (2) Special computers attached to additional RFID devices, (3) External actors which will carry RFID chips, (4) IoT, which interacts through the API. This architecture is shown in the figure below.

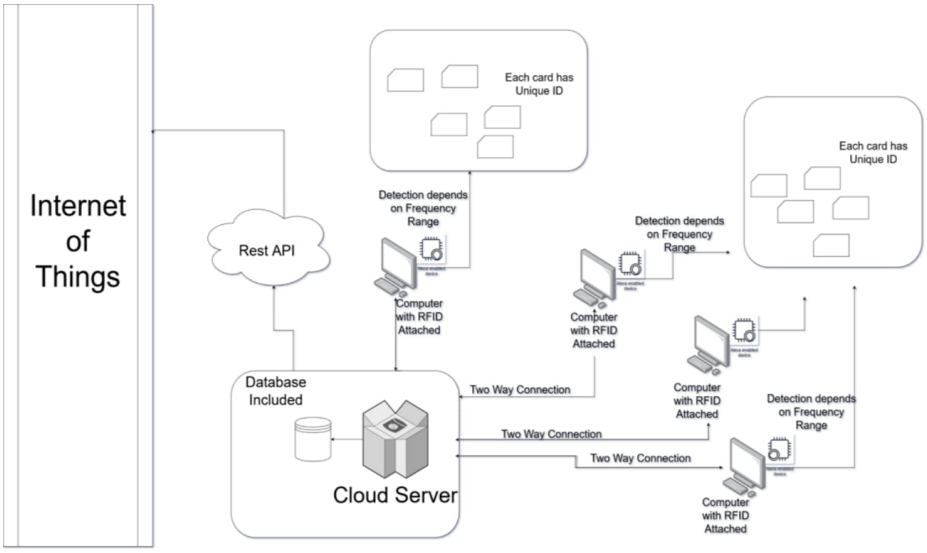


*Fig. 1. System Architecture*

The data created by each computer in different locations will be entered directly into the cloud as this data is centralized there, and so it will be more manageable. At the same time, through the REST API, this data becomes accessible to the IoT devices that want to consume this data, which is why it makes this system so beautiful, its universality.

### 3.2. Hardware interface

For the proposed system to work with all the features described, a range of devices is needed. These devices all perform certain functions for which they are also manufactured. The equipment that will be used are:

a) RFID Reader - The main device that will read the chips that will approach the action reserve. In our case we have an EM4001 Reading RFID with USB interface, which works at 125KHz frequencies. At this frequency, objects in the range of up to 10 cm can be read [11].

b) RFID Tags - Are carried by users, where each chip contains the unique ID of the user.

c) Numeric pad - It is an optional device, which we have integrated in the system, where if they do not have the chip with them, then the user through the pin code which is placed in the database, can be logged.

d) Camera - Which will make images of users at the time they are logged, which will be stored in the database for further use.

We can see how these devices look in the photos below, RFID Reader, Numeric pad, and Camera will be directly connected to any computer. The performance we prefer can be a computer with an Intel Atom / Celeron or AMD A6 processor, 4 GB of RAM and at least a 64 or 128 GB SSD.


*Fig. 2. Hardware components – a) RFID Reader; b) RFID Chips; c) Numeric pad; d) Camera*

### 3.3. Cloud and the database

Today is the era of Cloud Computing in the IT Industry. For an advanced and novel system, Cloud has the best computing architecture. Even in our model we include the Cloud in the form to have a remote server, where the centralization of unlimited nodes is possible, so that all data can be attached to one database.

Infrastructure as a Service is used, as it offers scalability, flexibility and simplicity. Through Cloud Computing with IaaS in our model we benefit:

- Resource Pooling
- Elasticity
- Since the model is automated, the Cloud offers On-Demand storage remotely
- Performance

For permanent data storage, we will implement the relational model using SQL Server. The main reason for this is that access from other nodes via SQL Server is much easier on the network. The structure of our database is developed in five fundamental tables that will work in almost any system, and the good thing about this structure is that it can be modified, fields are added without any difficulty. The tables with the attributes that we have developed are:

*Users – UserID(PrimaryKey), CardID, Name, Surname, Image, EntrySchedule, ExitSchedule, pinCode, Wage.* – The table in which the basic data for each user is stored.

*Transactions – transId(PrimaryKey), userID (ForeignKey), cardID (ForeignKey), dateEnter, Entry, EntryImage, Exit, ExitImage.* In this table we have 1-N links from the Users Table as each user to be logged in will create a new record.

*Annual Leave – AnnualId (PrimaryKey), userID (ForeignKey), DateYearly, Description*- This table stores the annual holidays for users, in which the date and description are marked. It has n-m connection as we have many users with many holidays.

*Medical Leave - MedicalID(PrimaryKey), userID (ForeignKey), DateYearly, Description*- The table is almost identical to Annual Leave, but in which medical leave is stored.

*Official Holidays – HolidayID(PrimaryKey), DateYearly, Description* – The table in which the official leave is stored, which have an impact on all users.

The database scheme and the types of variables that have been used can be seen in the following figure.

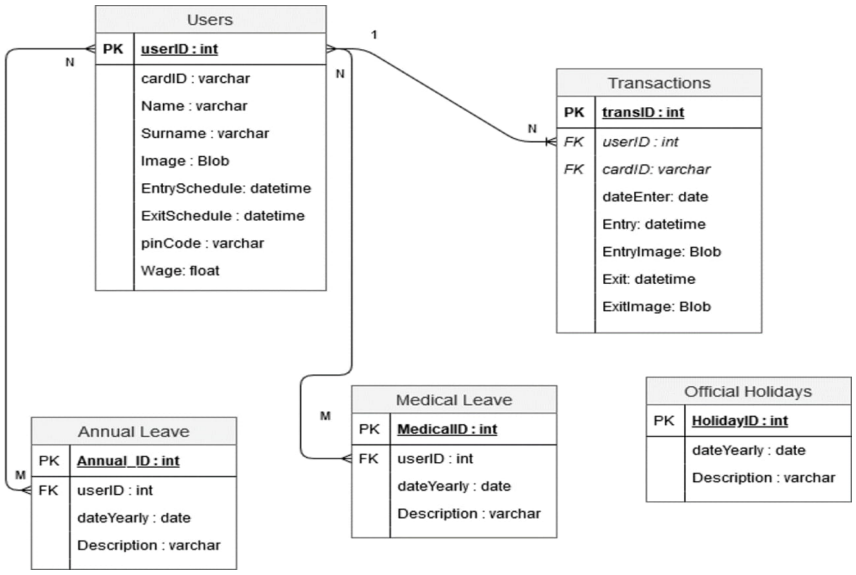


*Fig. 3. Database schema*

Initially we have the user table, where basic information is stored. They are then used for more advanced calculations and reports. For each user we have links to medical and annual holiday tables. This form of data is very stable and maintains integrity.

### 3.4. Algorithm implementation

Without having a proper logic behind the scenes, it is clear that the system cannot function well. In this paper, we have developed an algorithm, through which the attendance of each user who will approach the RFID Reader will be recorded, in such a way that this data will be sent immediately to our cloud database.

The algorithm is as follows:

***input**; reading data from RFID Reader into software*
***output**; sending data into data store which is deployed in a cloud*
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*1. initialize parameters currentTime, EmployeeID, RFID Data, time (null)*
*2. getData from RFID*
*3. if RFIDData exists in DataBase.Employee*
*4. getEmployeeID*
*5. set = currentTime*
*6. getAllTransactions for today*

*7. if (Employee transactions for today == 0)*
*8. set transaction to EmployeeEntered and time = todayTime*
*9. else if (Enter != null && Exit == null) set transaction to EmployeeExited and time = todayTime*
*10. else return Error No Duplicates per day*
*11. else return Error employee doesn't exists*

From this Algorithm we obtain the form through which the system operates in the background, through which the system can be fully-functionalized.

First read the data found in the Chip when approaching RFID Reader, then search the database of users in the cloud to see if there is a user with that ID, if it is successful it will save the current time and id e. users, continue with a query where all today's transactions are required, and if there is no transaction for the current user, then it will save this as input entry, if it does not contain a transaction you will see if there is an output, if there is no exit then it will save it as exit, and in the final if it has both entry and exit, it will not allow the registration duplicates of attendance.

### 3.5. Connection to IoT through API

The data generated by the system can be used by other devices on the IoT.

In order for this data to be sent to the devices, an intermediary is needed. For this issue we implement REST API.

API is an application programming interface, in which a range of rules are found to allow different programs to communicate with each other [12]. REST on the other hand is what an API looks like.

Each URL is called a request, and when data is returned, it is called a response. For our system, we create API which will have a request in the tables which are in SQL. REST architecture allows data to be sent in various formats such as plain text, HTML, XML, YAML, and JSON. We will use the JSON format, as it is very suitable for fast operations. JSON is the abbreviation for JavaScript Object Notation. The creation of the simplified REST API can be seen below.

***input :*** *URL Request*
***output:*** *Data in JSON Format*
*---*
*Initialization: header Content-Type: json ;*
*get Data from Database ;*
*encrypt(data) ;*
*response = fetch data in rows ;*
*json response = json encode(response);*
*print json response ;*

From this code we can understand that first 1) the type of data to be transmitted is determined, 2) the data from the database found in the cloud is called, 3) that data is stored in a variable, 4) the data is encoded in JSON format, and 5) print that data that can be consumed by the API.

### 3.6. Hybrid Security Model

Security is a process that every novel and advanced system should have, as in our era, cyberattacks or possible attack attempts are innumerable. Our model generates sensitive Big Data from multiple nodes in different locations centralized on a Server, such that this model must also have a security system. We propose to implement a hybrid model of cyber security in this model using SSL (Secure Socket Layer) and AES (Advanced Encryption Standard). This hybrid model will operate in two separate processes:

- Secure authentication between the node and the Cloud server
- Encryption / decryption of data after authentication

Secure authentication between the node and the server must be done first, so that data transmission can begin. Here we use SSL, which starts a secure transport level channel for encrypted communication between the node and the server. SSL authentication works when the node is presented with the server certificate, this is called a handshake. During this handshake, both parties generate session keys, these session keys encrypt and decrypt all communication after the handshake.

To make the system even more secure we propose a double cyber security model, where after opening a secure connection, to eliminate Man-In-The-Middle, the data will not be transferred raw, but will be encrypted once again through the symmetric algorithm 128-bit AES. AES works in that form by calculating bytes as opposed to bits. AES considers 128 bits of data as 16-byte blocks. These blocks are organized in four sections and four columns in the form of a matrix. AES depends on a standard process like substitution and permutation. AES utilizes 10 rounds for 128-bit keys. AES is widely adopted and supported by both software and hardware, and today no cryptanalytic attack against AES has been detected, which makes it adequate to implement in such systems.

The data will be stored directly in the Cloud with secure SSL connection, and exactly this data before being stored will be encrypted via AES, so that the data can be transferred securely. The characteristics of AES are:

- It is based on symmetric key
- 128-bit key
- Adequate and faster than Triple-DES
- Can be easily implemented in both software and hardware [13].

Before any transaction occurs between the server and the node, a secure connection will be opened, and then encryption or decryption will occur depending on the requested call.

This model makes the system very secure against cryptoanalysis and unauthorized data transfer, as well as eliminates the practice of raw data storage.

## 4. RESULTS AND DISCUSSIONS

A complete system has been developed using Cloud Environment and RFID, in a way which the system has a gateway into the IoT with a hybrid security model, used to automate the attendance of different type of users, having its back end in a cloud server. Initially, all the necessary hardware and methods are described. CloudSim is used to simulate the Cloud environment. CloudSim is a tool for simulating Cloud scenarios where it offers essential classes for describing data centers, computing resources, virtual machines. Using simulation, we can benefit from new cloud profitability strategies, scheduling algorithms, etc.

We have simulated a Cloud case with resources and a number of brokers. The simulation was successful. The initiation of the broker in the CloudSim environment has represented the Cloudlet together with the creation of the necessary data centers. The result can be seen in the table below.

*Table 1. Representation of Time taken for VM*

| ***Cloudlet ID*** | ***Status*** | ***Data Center ID*** | ***VM ID*** | ***Time*** | ***Start Time*** | ***Finish Time*** |
|---|---|---|---|---|---|---|
| *0* | *Success* | *2* | *0* | *400* | *0.1* | *400.1* |
| *1* | *Success* | *2* | *1* | *60* | *0.1* | *60.1* |
| *2* | *Success* | *3* | *1* | *150* | *0.1* | *150.1* |
| *0* | *Success* | *3* | *0* | *140* | *0.2* | *140.2* |
| *0* | *Success* | *4* | *0* | *140* | *0.2* | *140.2* |

The simulation was performed in a sample of our database where there are 14020 observations. From the represented table we can see that Cloud increases performance through VMs by reducing the transaction completion time from 400 to 140. Apart from the time gained from the simulation, the main benefit lies in the centralization of data from many locations, which is not possible if offline storage is used.

In our model of attendance automation, RFID Reader is a frequency of 125MHz, but other frequencies can be obtained as desired, the labels are the same frequency, the camera is of the simple type 5MP, and the numeric keypad to have an alternative password. The computer and all the cables can be physically hide behind the frame.

Once all these devices are attached, they can be placed in a node fully functional connected to the cloud server. The physical view implemented by us in a real-life case can be seen in the figure below.

Figure 4 describes a node with software and hardware, where we can have countless nodes that interact. All data is located on a cloud, through which the data is accessible from any location and any node. All data is centralized on that server, so synchronizing information is easier.

For the hardware described above, software has also been developed, through which the model is fully functional. The software is written in C #, database based on the SQL relational model. We use two frameworks for the GUI (Graphical User Interface), which are DevExpress and MetroFramework.


*Fig. 4. View of the implemented model in a real life use case.*

The software functions and view can be seen in the following table and figures

*Table 2. Software functions*

| ***Module*** | ***Function*** |
|---|---|
| *Front form* | *Add the automatic attendance in the cloud server for each user getting near the system – RFID Reader by recognizing automatically an entry/exit, add a snapshot for each transaction, represent monthly details for each user in the GUI.* |
| *Users* | *Print, add, edit, delete the attributes of the users which will use the system itself such as Name, Surname, wage, working hours, weekly holiday, picture of the users.* |
| *Transactions* | *Print, add, delete the transactions that the automated system does as entries or exits of the users, see the snapshots for each transaction, see the passive list of users who didn't register attendance, detailed reports for each transaction etc.* |
| *Wage Calculation* | *Calculate Automatic wage for each user by calculating total hours attended, getting the wage for each month, generating a detailed report for each user based on the automatic data generated by the system, print the detailed report.* |
| *Reports* | *Detailed report for the automatic attendance of each user, detailed report for a specific range of users, detailed report for a specific range of dates.* |
| *Official Holidays* | *Add, edit, delete official holidays for the users, adding description for the holidays.* |
| *Medical Leave* | *Add, edit, delete medical leave for the users individually, adding description for the Medical Leave.* |
| *Annual Leave* | *Add, edit, delete annual leave for the users individually, adding description for the Annual Leave.* |


a) b)

*Fig. 5. View of the software – a) RFID Scanning Part and b) Management part*

Figure 5a describes the software part in the implemented physical node where the RFID scan of the users who are supposed to save the attendance is done, while Figure 5b describes the software with the management part, where only authorized users can login, such as managers or the implementer of the software. It is worth mentioning that in the Management part, all the described functions are possible against the scanning part, where only the attendance register happens. Average time for the setup of this system is an average of 1.10 hours for one node. The average time of automatic attendance registering for one person was 1.2 seconds.

We have compared the data recorded for the 60 days of the automatic attendance registering with the data recorded manually, for a different number of users, which can be seen in the tables below.

*Table 3. Automatic and manual attendance registering*

| ***Frequency (user)*** | ***Automatic attendance (seconds)*** | ***Classic Attendance (seconds)*** |
|---|---|---|
| *1* | *1.2* | *4.5* |
| *50* | *68.4* | *225.8* |
| *200* | *230.2* | *980.2* |
| *500* | *535.1* | *2901.9* |

*Table 4. Report Generating*

| ***Frequency (user)*** | ***Automatic attendance*** | ***Classic Attendance*** |
|---|---|---|
| *1* | *1 second constant* | *10 minutes* |
| *50* | *1 second constant* | *2.40 hours* |
| *200* | *1 second constant* | *12.10 hours* |
| *500* | *1 second constant* | *38.14 hours* |

*Table 5. Fail/Mistake Rate*

| ***Frequency (user)*** | ***Automatic attendance (seconds)*** | ***Classic Attendance (seconds)*** |
|---|---|---|
| *1* | *0 fails* | *0 mistakes* |
| *50* | *0 fails* | *3 mistakes* |
| *200* | *0 fails* | *14 mistakes* |
| *500* | *0 fails* | *21 mistakes* |

Based on the above tables, we can see that the automated system for the attendance registering is exceptional in terms of time, increasing the efficiency as well as the time spent for the attendance register. With the increase of users, manual registering time is too high and inefficient also leading in mistakes that have consequences, from which results that automation is very valuable in this aspect. A comparison between different attendance register systems has been made. In this comparison different aspects of the systems have been identified, which can be seen in following table.

*Table 6. Comparison between known systems and our model*

| ***Comparsion Metrics*** | | ***Iris Recognition based attendance [6]*** | ***Smart Attendance System using RFID and Face Recognition [7]*** | ***RFID based Logistic Management System using IoT [14]*** | ***Our Model*** |
|---|---|---|---|---|---|
| *Functionality* | *No. Reports* | *1* | *1* | *1* | *>40* |
| | *Accuracy* | *82.2%* | *N/A* | *NA* | *100%* |
| *Security* | | *No* | *No* | *No* | *SSL & AES* |
| *IoT Enabled* | | *no* | *no* | *yes* | *yes* |
| *Time* | | *N/A* | *N/A* | *N/A* | *1.2 sec* |
| *Multiple Nodes* | | *no* | *no* | *no* | *yes – Cloud based* |
| *Trustworthiness* | | *100%* | *80%* | *30%* | *90%* |
| *Ease of use* | | *easy* | *medium* | *easy* | *easy* |
| *Maintenance* | | *hard* | *hard* | *very hard* | *very easy* |

From the comparison of the systems [6], [7], and [14] compared to our model we can easily notice the advantages that this model has, where it is worth emphasizing the inclusion of the technologies that gives the greatest priority, since that none of the related systems allow multiple nodes in many locations, as well as the amazing speed of cloud access, through which we have a gateway to the IoT with the implementation of the proposed API. The functionality of the proposed model is

much greater than the systems mentioned. None of those systems provides a proposal for data security, which in our work is the proposal of SSL and AES. Trustworthiness is at the same level as ease of use, and the maintenance of our system compared to other models is very easy, mentioning also the number of reports and functions which are incomparable with our model.

## 6. CONCLUSIONS

IoT is considered a valuable field of study when applied in conjunction with Cloud Computing, as both are highly interrelated.

Through this work, we have developed a sophisticated system, mentioning the functions and the construction of the system.

This research mainly focuses on the application of IoT and Cloud together in a proposed new model of attendance automation. The system will automatically generate valuable data in distance with the help of RFID, which will then be sent to the Cloud, and processed in the IoT having API as a gateway. Implementing the system gives full control over the data, and numerous reports can be generated.

The data generated by our model will be secured with a hybrid SSL and AES solution. The main objective of the research is to propose a novel model of automatic attendance register, which has a unique construction, system related benefits and lots of functionalities, so as to have access to the IoT, and the data to be computerized in the Cloud IaaS environment from multiple nodes in different locations. Taken together, this model offers a novel perspective on combining variety emerging technologies such as Cloud, IoT, and RFID into the proposed model.

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