Prison Break and Prisoner Monitoring System

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by

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Thesis Approval

This thesis entitled **Prison Break and Prisoner Monitoring System** by **Yashvi Shah and Idika Mittal** is approved for the degree of **Bachelors of Technology**.

Examiners:

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Declaration

I hereby declare that
i) the thesis comprises of my original work towards Internet of Things course in the degree of Bachelors of Technology in Information and Communication Technology at Dhirubhai Ambani Institute of Information and Communication Technology and has not been submitted elsewhere for a degree,
ii) due acknowledgment has been made in the text to all the reference material used.

Date: May 2020

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Abstract

Very recently certain allegations aroused regarding the security system within the prisons. Prisoners are reported to be indulging in various malpractices even inside the jail boundary that require immediate attention. The traditional methods for getting the appropriate report usually take long time to process which helps the prisoner to escape. It is observed that applications which require high traceability can very well use RFID (Radio Frequency Identification) technology. This system is developed for high security prison management using the RFID along with the buzzers and real time tracking system to ensure 100% safety.

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Chapter 1

Introduction

1.1 Current Scenario and Observation

Indian prisons today hold 14% more people than they should. That's the average. But occupancy can reach 200% on a state level and 500% in some of the jails. Inmates –innocent until proven guilty - awaiting trial outnumber convicts two to one. Prisoners can be locked into often old and dilapidated barracks for up to 14 hours for security reasons. Violence, corruption, exploitation, criminality, disease and discontent pervade. Every five and a half hours a prisoner dies in jail. The suicide rate is one and a half times higher inside than outside. Across India there are 53009 prison staff and 1401 prisons; one correctional officer for every 703 prisoners; one guard for every nine prisoners; one medical staff for every 225 prisoners and one psychologist/psychiatrist for every 23000 prisoners.

These horrible figures brought out every year by the National Crime Record Bureau (1) are not a new development nor are they getting better. They point to the everyday misery and wretchedness of life in prison for both inmates and staff. They also underline the absence of any system of prison supervision by the administration and the ministries in charge.

At present, the prison has surveillance cameras and few security guards are employed to monitor the illegal movement of prisoners approaching the perimeter wall with the intention to escape from prison. In addition the officers perform head counts of all the prisoners 3-8 times a day to keep a check on the number of prisoners.These approaches can be easily botched by the prisoner to escape from the prison. To control this undesirable situation, techniques like implanting pressure sensors in the perimeter wall, CCTV surveillance with image processing based solutions, Drones etc are used. Deployment of these techniques incurs high cost and does not give exact location of the prisoner. Hence, IoT based prisoner escape detection technique has been proposed in this work.

1.2 Aims and Objectives

In this thesis we propose a solution to trace the prisoner getting outside a specific boundary. It allows the prison management authority to keep track of prisoners based on RFID (Radio Frequency Identification) technology. This system assigns a unique ID to each and every prisoner with in prison to access the information about him/her.The cost effectiveness and efficiency make the system reasonable. The following are the functions mainly handled by the system:

1. The system notifies the authority about an escape with the help of buzzer when a prisoner tries to cross a predefined boundary.
2. Maintain details of each prisoner like interrogation and citation details, date of custody and remand, parole or bail details, visitors list etc., and manipulate the same using his RFID.
3. The system also maintains a track of health of each prisoner like pulse count on a cloud service platform.
4. The system is capable of tracking the position of each prisoner using the RFID technology, The authority in the control room can keep a watch on the movement of prisoners and notify in advance if there is any suspicious movement.
5. RFID typically facilitates the investigation process. RFID reduces inmates' violence and property damage since everything is recorded in the system which in return reduces maintenance costs in the prison.

The central prison officials can check the criminal background of a person. The crime department can check the travel history of a citizen at the time of prison break, if needed. All data related to a person are stored under the RFID of that person.

Aditionally the system can also be set up to do meal counts. Each wristband also has a RFID tag on it. As each prisoner enters the cafeteria, he scans his bar code in front of a reader. If the same prisoner attempts to come back and get a second meal, an alert sounds.

The RFID tag can also be scanned every time an inmate is given prescription drugs, so the institution knows who got what and when. It can even be tied into the phone system, so prisoners are only able to dial certain numbers based on the unique serial number in their wristband.

Chapter 2

Survey of similar project

2.1 Calipatria State Prison Survey

Calipatria State Prison, a maximum-security facility tucked in the desert in the southeast corner of California, has been testing the system since last October. It foiled at least one escape, identified prisoners involved in a riot and provided other benefits.

A transmitter, which looks like a large industrial wristwatch, is strapped to the wrist of each prisoner. The device holds a 900 MHz RFID transmitter with a battery that sends out a signal every couple of seconds. The transmitter is housed in a tamperproof casing and strapped with screws with tamper-resistant covers. If the band is cut or a prisoner manages to slide the band off, an alarm is automatically triggered at a central monitoring station.

Readers with antennas are set up around the prison yard and throughout the interior of the building. For example a prison in California has about 60 readers, which pick up signals from every transmitter in the facility. At least three readers may pick up a signal from each inmate, but its usually many more to provide redundancy in the system. The signals are sent to a collector node, which calculates the person's location to within a few feet and puts a time of arrival stamp on the information and forwards it to computers software, which is used to establish the conditions for alerts. A TSI software could be used for processing data. The system can handle up to 24,000 units, according to TSI. The readers can process hundreds of signals virtually simultaneous, because the signals are transmitted up so quickly.

2.2 Case Study of the Early Implementation of Active Radio-Frequency Identification in One Facility

A case study(3) of one large jail facility in the process of installing an active RFID system to manage its inmate population. This case study capitalized on an opportunity to gather contemporaneous information about the issues and lessons learned of a facility in the process of designing, installing, and preparing the system for operation. At this facility, a site visit was conducted to observe the retrofitting of the existing facility to accommodate the installation of the RFID equipment, as well as semistructured interviews with key staff involved in all phases of the acquisition, installation, training, and other activities in preparation for system's operations.

Specifically, the case study site was the Central Detention Facility (CDF) operated by the District of Columbia Department of Corrections (DC DOC). The CDF has a full-time correctional staff of nearly 700 officers and a male-only population that averages 1,900 inmates per day.

DC DOC intends to use the RFID system as an inmate management tool and as a tool for enhancing the security of correctional officers and other staff in the jail. When the RFID system is ready for launch, DC DOC intends to fit each inmate with a tamper-resistant wristband containing an RFID transmitting device during the jail booking process. Communication between the jail's information management system and the RFID system software allows the signals from a specific bracelet to be linked to a specific inmate. The bracelet is removed from each inmate at the time of facility discharge. Each correctional officer is also required to wear, on his or her belt, an RFID device during his or her shift that will help in identifying his or her location and generate safety-related alerts. The RFID monitoring function will be integrated into a correctional surveillance center, or CSC, which is being established in the facility. The sole function of the CSC personnel will be to monitor the RFID signals and alerts, as well as other surveillance technology, such as the closed-circuit television (CCTV) system and a telephone monitoring system.

Chapter 3

Components

3.1 Hardware

The required hardware of the system includes RFID card reader and an RFID tag, ESP32, Pulse sensor and buzzers. ESP32 is a single-board micro controller with Wifi module. We mainly used this board in order to ease up the process of storing data about the prisoner on cloud. The wristband with RFID tag, on the prisoners wrists acts as a tamperproof transmitter, each transmitter constantly sends off a unique signal that's captured by the antenna and then processed through a computer software or on cloud, which determines where the subject is at every two seconds. The system installs a RFID card reader on the boundaries of the security region to enable the administrator to track the security break. This design will also monitor a moving person and report the status of the person on demand.

3.2 Frontend

Frontend is supported by an web application. The website would contain an google map of the prison and its boundaries along with real time tracking of the prisoners. The frontend would be developed mainly using Javascript and React. The access to the website would only be given to the main authority of the prison in order to avoid security breaches.

3.3 Backend

Backend will be supported by NoSQL database as it supports variety of data structure. NoSQL databases compared to traditional database are more scalable and provide superior performance and their data model addresses several shortcomings of the the relational model. Although there are various alternatives of database, but using NoSQL database will help integration of our model to Google Maps with an ease. The RFID data would be send to AWS for processing and then it would be stored in database.

3.4 Amazon Web Services

Amazon web service (AWS) is a platform that offers flexible, reliable, scalable, easy-to-use and cost-effective cloud computing solutions. For our project we would be using Amazon DynamoDB (It is a fast, fully managed NoSQL database service. It is a simple service which allow cost-effective storage and retrieval of data. It also allows you to serve any level of request traffic), IoT Core (It is a managed cloud AWS service. The service allows connected deviceslike cars, light bulbs, sensor grids, to securely interact with cloud applications and other devices), IoT Analytics (This AWS IOT service is helpful to perform analysis on data collected by your IoT devices)

Chapter 4

System Design

4.1 Architecture for Prison Break System

The system is mainly composed of the active electronic tags, along with RFID readers.

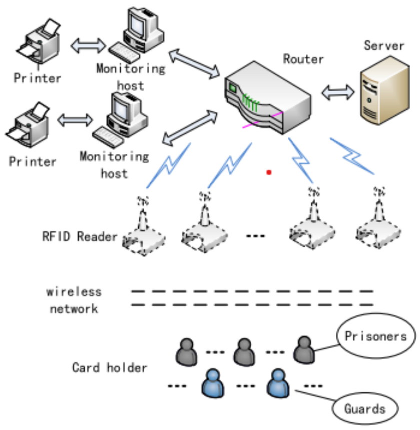

Figure 4.1: Architecture for prison break system

4.1.1 Design of Tag

Personnel information is stored in RFID tag for identification of a prisoner. Taking into account the particularity of the prisoners, RFID tags in this system are in a non-detachable bracelet form.

Electronic tag is an important part of RFID system, which is mainly composed of the antenna and the chip. The chip is composed of a memory, a controller, an encoder and a modulator. Tag uses 433MHz band, and its maximum identification distance is 150m, effective distance 80m. The electronic tag hold the personal information.

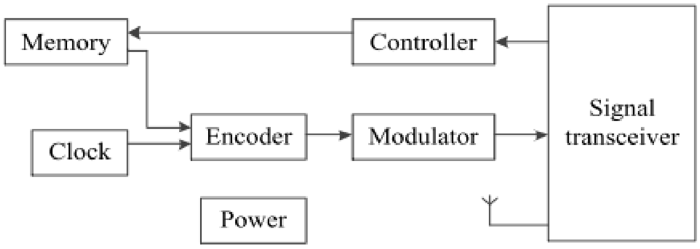

Figure 4.2: Design of Tag

4.1.2 Design of Readers

The reader is the key terminal of the RFID system, which transmits the radio frequency modulation signal to the electronic tag by the antenna and receives the radio frequency modulation signal which containing information returned from a tag by the antenna. The signal is transmitted to the application system after be processed. The typical reader terminal consists of antenna module, radio frequency module, control module, interface and so on.

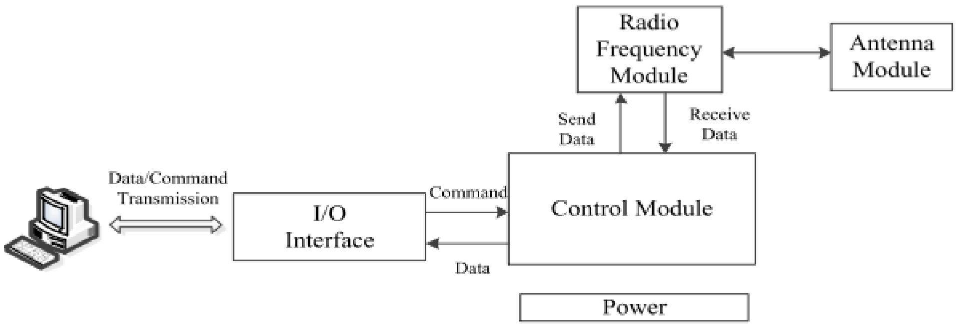

Figure 4.3: Design of Readers

For this system we would be using the following RFID reader as shown in the diagram.

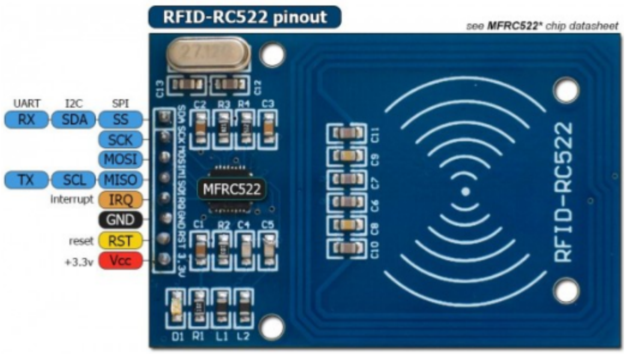

Figure 4.4: RFID-RC522

4.1.3 Position of Reader

For tracking the prisoner using the RFID technology we implement the following strategy to place the readers. The area of prison is generally approximated as a rectangle. Put a reader at coordinate (80, 80), and put other readers according to the principle that the span of adjacent two readers is 80 meters. The recognition range covers the whole prison.
When the person wearing the tag enters the reading range of the reader, the reader reads the information in electronic tag, calculates the position information and updates the data. For calculating the position of the reader localization algorithm can be used.

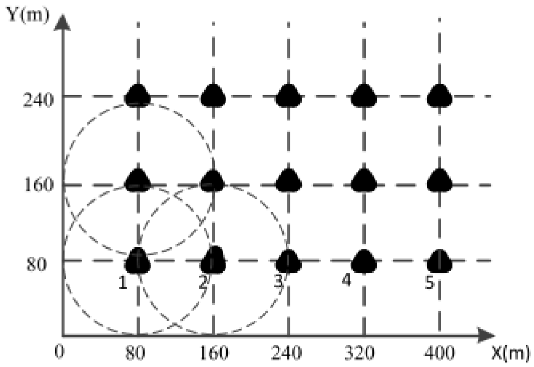

Figure 4.5: Position of Readers

4.1.4 Connection of Reader with ESP32

Using the following connections listed below we can read the data of RFID tag. The link contains the algorithm to read and write to the RFID tag with the help of

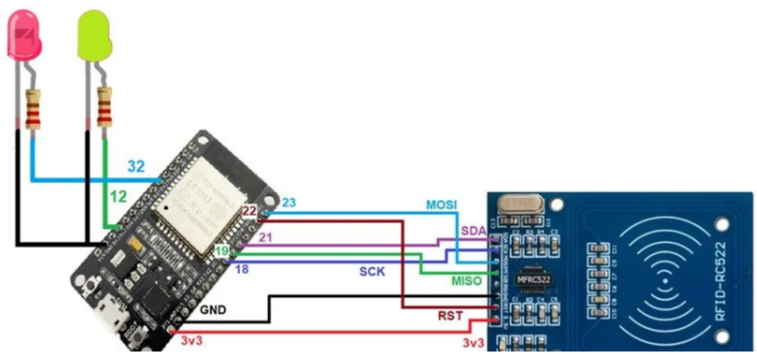

Figure 4.6: Connection of Reader with ESP32

RFID Reader and ESP32. Useful information about the prisoner like the ID, no of meals, medical prescription are stored in the tag of each prisoner.

https://github.com/YS4100/IoT/blob/master/CodeForRFIDReader

4.1.5 Connection of Buzzer with ESP32

When the RFID readers near the perimeter of the wall receive a signal implies that the prisoner is trying to escape as he is in the forbidden region. In such scenario the buzzers connected to the ESP32 will generate an alert to notify the prison management authority of the escape. The below diagram shows the connection of a buzzer to the ESP32.

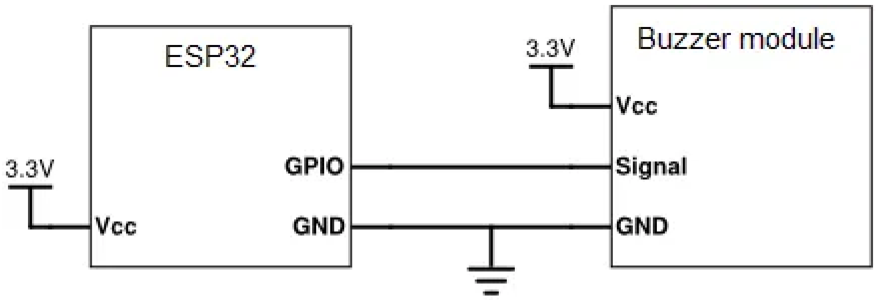

Figure 4.7: Connection of Buzzer with ESP32

4.1.6 Connection of AWS with ESP32 to store data

We need to connect ESP32 to AWS to store the data monitored by the system. For this ESP32 needs an active internet connection, so the code mentioned in the link is required for storing data collected by esp32 to the cloud.

`https://github.com/YS4100/IoT/blob/master/CodeToSendDataToAWS`

By importing a library to make JSON files in the Arduino IDE we can directly upload files in JSON format to AWS.

4.2 Architecture for Prisoner Monitoring System

4.2.1 Monitoring Position and Details about Prisoner

Active RFID technology possesses the sensing ability between label and reader, interaction ability between label and reader, anti-collision ability, ability of avoiding the influences from human body, metal and fluid, ability of loading sensing technology and data security, etc.

The positioning computation of active RFID technology is conducted by maximum likelihood method by the formula $\hat{X}=(A^TA)^{-1}A^TB$. RFID tag worn by the prisoner would contain the information as shown in the below table.

Field name	Content	Type	Length	Remarks
ID	Card no.	Text	5	NOT NULL
DoorID	Gate no.	Text	4	NOT NULL
InDate	Entry date	Date	8	NULL
InTime	Entry time	Time	6	NULL
OutDate	Exit date	Date	8	NULL
OutTime	Exit time	Time	6	NULL
State	Access control state	Yes/No	2	NULL
Alart	Alarm	Yes/No	2	NULL

Figure 4.8: Data that can be stored in RFID of prisoner

4.2.2 Monitoring the health of the prisoner

For monitoring the health of the prisoner we use a pulse sensor which is present on the bracelet worn by the prisoner. Sensor would collect data after a fixed interval of time. This data would be stored on AWS database for monitoring the continuous health of the prisoner. Below circuit shows the connection of the pulse sensor to the ESP32.

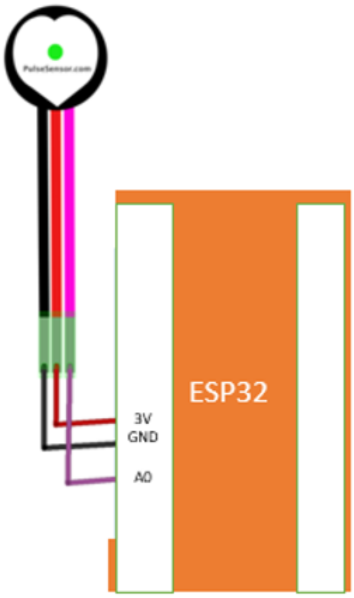

Figure 4.9: Pulse Sensor

Chapter 5

Correctness and Performance Measurement

5.1 Testing Parameters

Based on the following parameters our system could be tested:

- The system should produce an alert when a prisoner tries to go out of the cell.
- When alert is received the system should switch on the buzzer.
- The system should correctly monitor the prisoner's heartbeat and other data.
- The performance of our system can be checked by measuring the speed of monitoring and accuracy in storing the data.
- Our system should detect the prison break before it gets too late.

5.2 Challenges

The following were the challenges faced while designing the prison break and monitoring system using RFID technology:

- Main challenge in deploying this module is battery life. Therefore, power to the wearable device can be derived through solar energy, kinetic movements wireless charging etc.
- We were not able to figure out how to reduce the size of the bracelet. However we could use an Arduino Programmable Smart Bracelet that features ESP32-PICO-D4 SiP(it includes ESP32, 4MB SPI Flash, Crystal Oscillator, Passive components)

5.3 Constraints for real time deployment

Since this system is deployed in the real time there are some obvious constraints that cause problem while executing.

- The first constraint is the internet system. The system needs strong internet connection to be executed so if we lose the internet connection the system needs to be reset.
- The front end interface should never be closed. If the window is closed the system loses connection making it lag behind.

Chapter 6

Future Works

6.1 Web Application

For tracking the prisoners in real time, we would be developing a a website(6) which would have a google map view of the prison along with the defined boundaries. The information about the location of prisoner obtained through the RFID tag would be converted to latitude and longitude format on the AWS platform.This information would be used to track real time position of the prisoner.

6.1.1 Google Earth

Google Earth is a virtual map, globe and geographical information program and it is enable scientists around the world to data communicate and findings in an intuitive three dimensional (3D) global that was originally called Earth Viewer 3D. Virtual globes are low cost and easy to use in data collection, exploration and visualization It maps the Earth by the superimposition of images taken from satellite imagery.

Google Earth makes us travel through a virtual globe and view satellite imagery,3D buildings, terrain, maps. The options within Google Earth are endless, such as discover the earth, jump in the ocean, visit moon and mars, , explore the sky, create custom image and hikes on handheld GPS devices.

6.1.2 Coordinate System and Projection

A geographic coordinate system (GCS) defines locations on the earth using a three-dimensional spherical surface. Every location on the Earth can be specified by a set of numbers using GCS

6.1.2.1 Latitude:

It is an imaginary circle they are total 180. In the spherical system, ‘horizontal’ or east–west lines are lines of equal latitude or parallels i.e. the lines joining points of the same latitude trace circles on the surface of Earth.

6.1.2.2 KML File:

All information and coordinates which Google Earth deal with it they are created in KML file using JavaScript and iFrames. KML is standard for Keyhole Markup Language .

KML is used to display geographic data in an Earth browser such as Google Earth and Google Maps, it is a file format. It uses a tag-based structure with nested elements and attributes, i.e. these files are XML-based scripting files; require the use of an extremely verbose tag-based language.

6.1.3 System Design and Working

The first part of the system work depends on the work of the RFID, which is an electronic device consists of RFID reader, antenna and tag. The RFID reader reads the tag number (ID associated to a individual person) when the tag being in the coverage zone of the reader antenna, then RFID reader sends this information to the computer (PC), the software program in the computer takes this information then updates it's Database and sends the (longitude/ latitude) to the Google Earth program. When Google Earth receives (longitude/ latitude) it finds the person location then displays that location on the screen of the that computer .

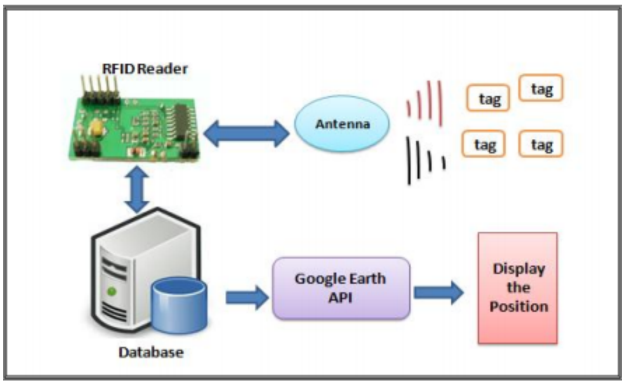

Figure 6.1: Block Diagram of System

To complete implementation of this system we use the following programming language:

6.1.3.1 Database:

This system need a Database system to store, update information, etc we use Dynamo DB here .

6.1.3.2 Javascript

We use java script language to manage Google earth API, also to control and change the setting of required features and how to display it.
The link to the javascript code for geolocation is present in the link below(5):

`https://github.com/YS4100/IoT/blob/master/GeoTracking`

6.1.3.3 Google Earth API

Google Earth API standard for Google earth application programming interface. The Google Earth applications can be embedded into web pages by using Google

Earth API with JavaScript code. With this API plug in installed, the applications can work interactively in web browsers. Javascript code need to be written to implement the Google Earth API applications in the web pages. In order to run the applications in browsers, developers and end users need to install the Google Earth plugin. The API can display lines, placemarks, overlays, polygons, and 3D models on the imagery.

The working steps of the system are defined as follows:

1. Display the location of the current/dedicated person:
   When the person who carries the Tag move in the location which contained the RFID Reader its position will be displayed.

2. So the Data Base will be update in the same time:
   In addition to display the position of the current person, the exact time and date of person's existence in that position and other information of this person will be recorded in the data base.

3. Searching for any person and show the information dedicated to him or her:
   We can show the information about any person we need, with the help of the person Tag ID and information recorded in the Data Base.

Figure 6.2: Map Marker showing the location of prisoner

6.2 Results

At the end of implementation, we would get a fully functional website which would be accessible only by the warder or the prison authority. By looking at the website from his room he would be able to track every movement of each prisoner and would be able to take precautionary measures if any suspicious movement is encountered.

Chapter 7

Conclusion

The conclusion of the thesis is that if this system is implemented in our prison system it would add a new level to the security rules of our country. This system will bring some difference in the number of jail breaks happening per year. Thus overall we can say that correctional facilities have benefited plenty from integrating RFID technology within their system. RFID has definitely proved its worth as a security tool for prison management systems. With prisons having to deal with overcrowding, RFID could be a necessary piece of equipment in the future to track and monitor the health of the prisoners.

Appendix A

Overview

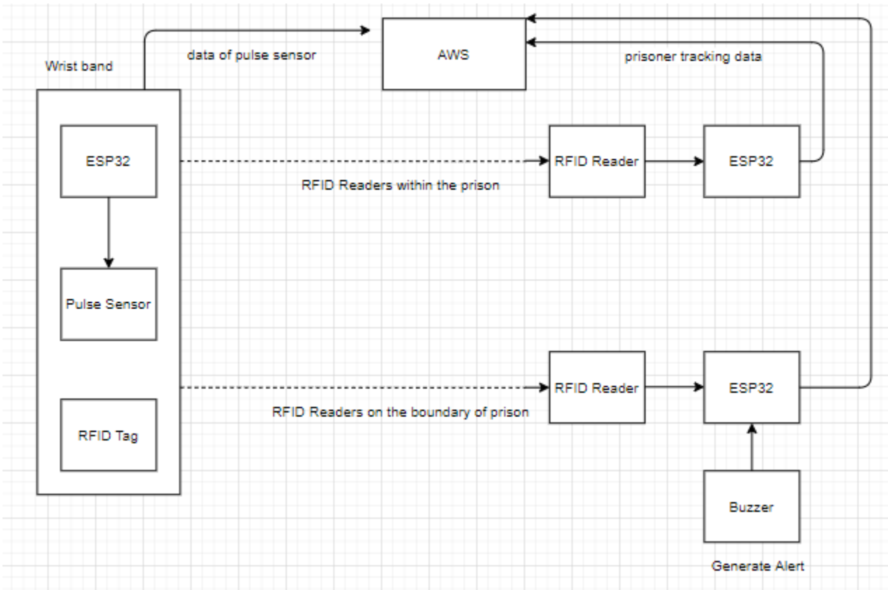

Figure A.1: System Design

Facility Name	Location	Vendor	Installation Began	Specific Use
Riverside Regional Jail	Hopewell, Va.	Elmo-Tech	2009[a]	500 staff
Sacramento County Probation and Parole Services, Youth Detention Center	Sacramento, Calif.	TSI PRISM	2009[a]	450 staff
DC DOC CDF	Washington, D.C.	TSI PRISM	2008	2,000 inmates and 700+ staff
Minnesota Department of Corrections, Minnesota Correctional Facility, Lino Lakes	Lino Lakes, Minn.	TSI PRISM	2007	1,300 inmates
Marion County Superior Court Juvenile Division, Marion County Juvenile Detention Center	Indianapolis, Ind.	TSI PRISM	2007	150 inmates and 200 staff
Ohio Department of Rehabilitation and Corrections, NEPRC	Cleveland, Ohio	Elmo-Tech	2006	580 inmates
Southern Nevada Correctional Center	Jean, Nev.	Elmo-Tech	2006[b]	500 inmates and 100 staff
Virginia Department of Corrections, Marion Treatment Center	Marion, Va.	TSI PRISM	2006	225 inmates and 180 staff
State of Minnesota Department of Human Services, St. Peter Regional Treatment Center[c]	St. Peter, Minn.	Elmo-Tech	2005	75 inmates
Ohio Department of Rehabilitation and Corrections, Ross Correctional Facility	Chillicothe, Ohio	TSI PRISM	2004	350 inmates
Illinois Department of Corrections, Logan Correctional Center	Lincoln, Ill.	TSI PRISM	2003	1,900 inmates and 100 staff
Michigan Department of Human Services, W. J. Maxey Training School for Boys	Whitmore Lake, Mich.	TSI PRISM	2002	240 inmates and 200 staff
Minnesota Correctional Facility, Faribault	Faribault, Minn.	Elmo-Tech	2002	95 inmates
California Department of Corrections and Rehabilitation, California State Prison, Corcoran	Corcoran, Calif.	TSI PRISM	1997	200 staff

NOTE: DC DOC = District of Columbia Department of Corrections. CDF = Central Detention Facility.

[a] Full operation expected in 2010.

[b] Facility closed due to state budget cuts in 2008.

[c] This secure mental health facility is included because it houses sex offenders.

Figure A.2: U.S. Correctional Facilities That Have Acquired Active Radio-Frequency Identification Systems

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[1] "Prison Statistics of India, National Crime Record Bureau and National Human Rights Commission"

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