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IOT based Prison Break Monitoring and Alert System Using Wireless Communication

[1]Ms. G Srilakshmi, [2]Putta Meghana, [3]Chakali Mythri, [4]Kattukuri Samhitha
[1]Associate professor, Electronics and Communication Engineering, BRECW
[2,3,4]B.Tech Students, Department of Electronics and Communication Engineering, BRECW

Abstract

The "Internet of Things-Based Prison Break Monitoring and Alert System Using Wireless Communication" project presents a groundbreaking approach to enhance prison security and prevent escapes. Leveraging Node MCU units in ESP-NOW communication mode, this system establishes a wireless network within the correctional facility, providing continuous monitoring and immediate alerts in the event of a prison break.

Prison security is a top priority, and this project addresses the critical need for robust monitoring systems. Each prisoner wears a Node MCU unit that communicates wirelessly with a central Node MCU hub using ESP-NOW. If a prisoner carrying a Node MCU unit moves beyond the network's coverage area, the system detects the breach and triggers an immediate alert to the jailer. The alert includes the prisoner's unique code, enabling swift action to prevent escapes or unauthorized movement.

The "Prison Break Monitoring and Alert System" project exemplifies the fusion of IoT and wireless communication technology to enhance correctional facility security. By providing real-time monitoring and instant alerts, it significantly reduces the risks associated with prison escapes, safeguarding both inmates and staff.

This project aligns with the growing demand for innovative security solutions in correctional facilities, showcasing the potential of IoT in ensuring safety and preventing unauthorized movements.

1-INTRODUCTION

The concept of a Prison Break Monitoring System emerges from the need to enhance security and oversight within correctional facilities. With rising concerns about inmate escapes, the effectiveness of traditional monitoring methods—such as guards and surveillance cameras—has been called into question. Modern technology provides innovative solutions that can significantly improve monitoring and response strategies.

2 Literature Review

One of the primary components is real-time tracking devices, utilizing GPS and RFID technology to continuously monitor inmate locations. GPS provides data for outdoor areas, while RFID is effective for indoor tracking, allowing for precise monitoring of movements within specific zones of the facility. This real-time tracking is complemented by automated alert mechanisms, which can be programmed to trigger alerts when inmates cross designated boundaries. Such alerts, sent via SMS or mobile apps, enable immediate responses from security personnel.

Another critical feature is the user-friendly interface that includes a centralized dashboard. This dashboard enables staff to visualize real-time data on inmate locations, receive alerts, and manage the system efficiently, facilitating quick decision-making during emergencies. The system's integration with existing security systems, such as

CCTV and alarm systems, further enhances its effectiveness by providing contextual alerts that complement video surveillance.

Remote monitoring capabilities are also integral to the system. Authorized personnel can access monitoring data from outside the facility, allowing for oversight and intervention even when staff are not physically present. This flexibility is particularly vital for managing security in larger institutions. Additionally, the use of Node MCU ensures low power consumption, enabling long-term operation with minimal maintenance, which is especially important in remote areas of a facility.

The system also includes emergency response features that can quickly initiate protocols when an escape is detected. This functionality ensures coordinated responses from security personnel and law enforcement, enhancing overall safety. Continuous data logging allows for the generation of reports that ensure compliance with safety regulations and provide insights into the effectiveness of security measures over time.

Benefits of IoT in Security Systems:

The benefits of IoT in security systems are substantial. Enhanced security measures, coupled with continuous monitoring and immediate alerts, significantly reduce the chances of successful escapes and improve overall safety. Moreover, the automation of alerts and monitoring reduces the burden on staff, allowing them to focus on other critical tasks. The real-time notifications enable quicker reactions to potential incidents, minimizing risks to both staff and the public. Additionally, by reducing the need for extensive manpower and improving resource allocation, IoT systems can lead to long- term cost savings.

3-HARDWARE DESCRIPTION

Block Diagram

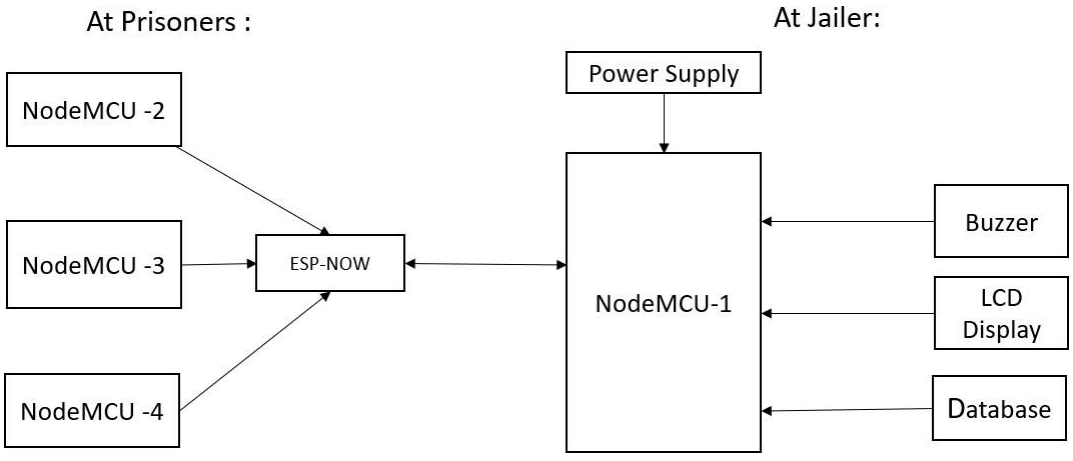

Fig 3.1: Block Diagram Hardware Connection:

In the IoT-based prison break monitoring and alerting system, the hardware components are interconnected to ensure efficient detection, communication, and alerting processes. The Node MCU microcontroller serves as the central hub, interfacing with various sensors, output devices, and communication modules. All components are powered through a regulated power supply, typically delivering 5V or 3.3V to the NodeMCU and other connected peripherals.

The sensors, such as motion detectors, door sensors, or RFID readers, are connected to the NodeMCU's digital or analog input pins, depending on the type of signal they generate. When a sensor detects any event (e.g., motion or breach), it sends an electrical signal to the corresponding input pin of the NodeMCU. The NodeMCU processes these signals, determining whether a breach or unauthorized activity is occurring.

Once an event is processed, the NodeMCU triggers the output devices. The buzzer is connected to a digital output pin and is activated through a pulse when a breach is detected. Similarly, LEDs are wired to output pins to visually indicate system states (e.g., normal operation or breach alerts). The LCD display, typically a 16x2 or 20x4 screen, is connected via I2C or directly to GPIO pins of the NodeMCU, showing real- time system information like breach location or prisoner ID.

Hardware Components

ESP8266 node MCU

It can be used as a standalone device, or as a UART to Wi-Fi adaptor to allow other microcontrollers to connect to a Wi-Fi network. For example, you can connect an ESP8266 to an Arduino to add Wi-Fi capabilities to your Arduino board. The most practical application is using it as a standalone device.

NodeMCU is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.

However, as a chip, the ESP8266 is also hard to access and use. You must solder wires, with the appropriate analog voltage, to its pins for the simplest tasks such as powering it on or sending a keystroke to the “computer” on the chip. You also have to program it in low-level machine instructions that can be interpreted by the chip hardware. This level of integration is not a problem using the ESP8266 as an embedded controller chip in mass-produced electronics. It is a huge burden for hobbyists, hackers, or students who want to experiment with it in their own IoT projects.

LCD Display

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

Fig 3.3: LCD Display

4 SOFTWARE DESCRIPTION

Downloading and installing the Arduino IDE 2

To download and install the Arduino IDE 2 on your Windows. You can easily download the editor from the Arduino Software page.

https://www.arduino.cc/en/software

Requirements:

 Windows - Win 10 and newer, 64 bits The Arduino IDE 2:

2. Installation:

The Arduino IDE 2 is an open-source project. It is a big step from its sturdy predecessor, Arduino IDE 1.x, and comes with revamped UI, improved board & library manager, debugger, autocomplete feature and much more.

1. Download the Editor:

Downloading the Arduino IDE 2 is done through the Arduino Software page. Here you will also find information on the other editors available to use.

Fig 4.1: Website to Download

To install the Arduino IDE 2 on a Windows computer, simply run the file downloaded from the software page.

3. Running the installation file:

Follow the instructions in the installation guide. The installation may take several minutes.

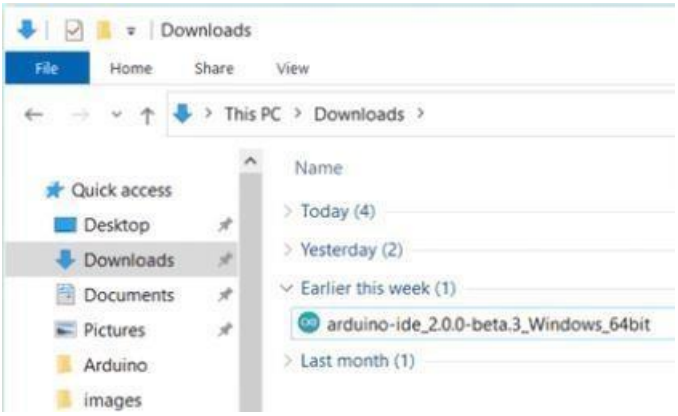

Fig 4.2: Selecting the installed arduino

5- WORKING

The IoT-based prison break monitoring and alerting system can be enhanced with a more detailed working flow by incorporating additional components such as Node MCU, power supply, buzzer, database, LED, LCD display, and using the ESP-NOW protocol. Here's a breakdown of the system's detailed working flow:

Sensor Detection and Data Processing

1. Motion Detection and Tampering Sensing:

   Sensors: Motion sensors (PIR), door/window sensors, and vibration sensors are installed at key locations (doors, walls, windows).

   When a sensor detects suspicious activity (e.g., movement near a secured area, an unauthorized door opening, or vibration indicating tampering), it sends an electrical signal to the Node MCU.

2**. Prisoner Identification:**

Each prisoner has a unique RFID tag or code that is stored in the database.

RFID readers installed at key locations (like gates, cells) scan for prisoner IDs as they move through the facility. If a prisoner without authorization enters a zone or attempts to exit, the system checks the database for their permissions.

3. **Node MCU Processing:**

The Node MCU reads the sensor data (whether it's motion detected, a door breach, or prisoner information) and determines if it exceeds a predefined threshold that indicates a potential prison break.

The NodeMCU then communicates with the database to verify prisoner information and authorized movements. For instance, if a prisoner's unique code is detected at a location they aren't permitted to be in, the system flags this as a security concern.

6-RESULTS

The figure below represents the set up of the Prison Break Monitoring and Alert System

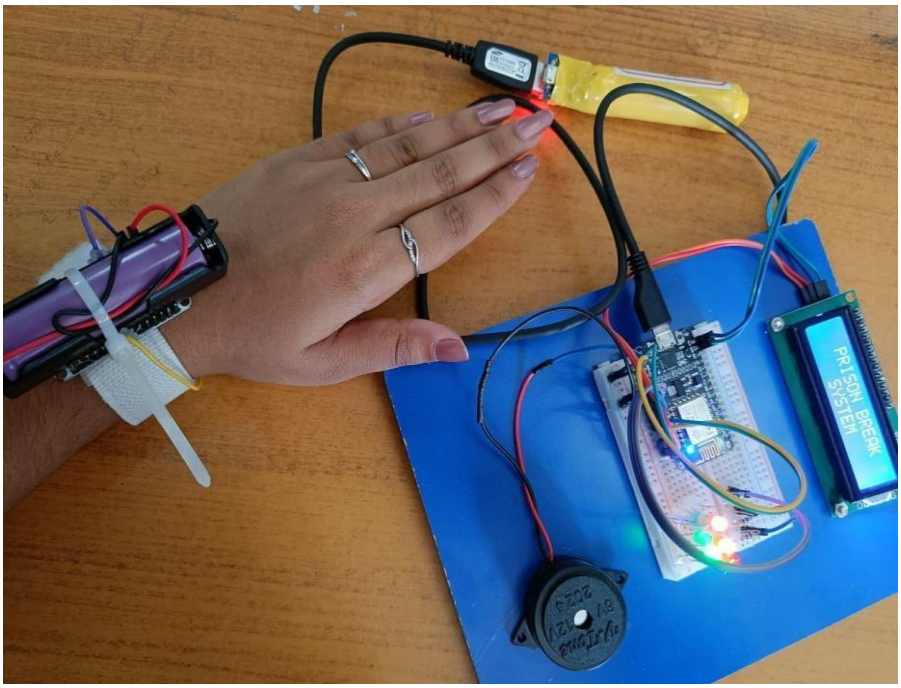

Figure: 6.1 Board setup for the project.

Outputs

6.2.1 Scenario-1

 The figure shows the operation of the system when the prisoner is safe, (i.e.., when the band is connected) and the representation of the data at the jailer database

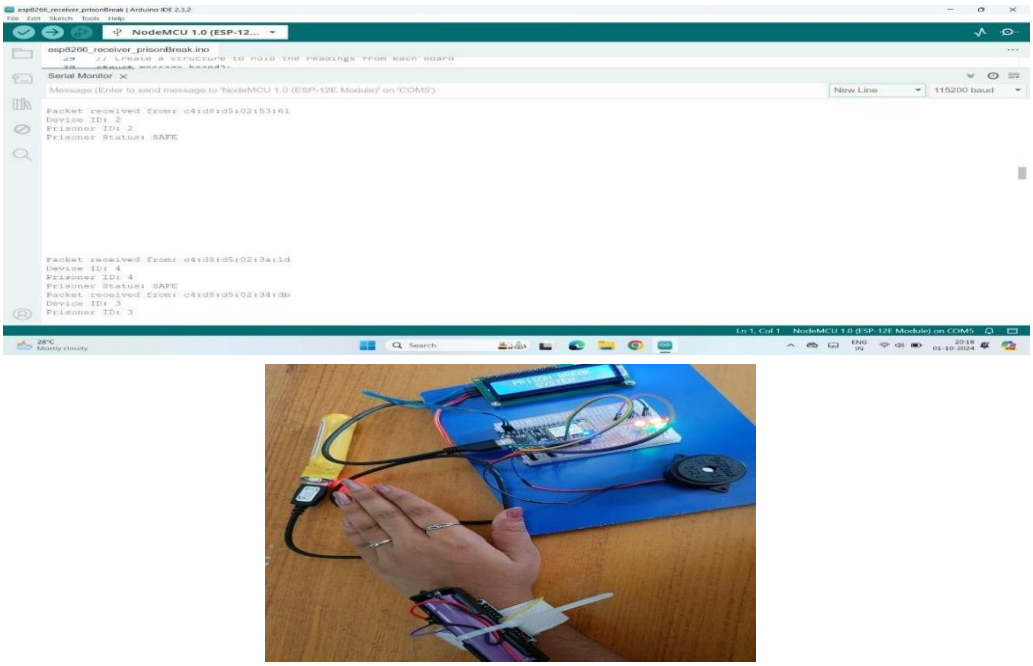

Figure: 6.2 Indicates normal operation, with no detected issues.

6.2.2 Scenario-2

 When the band is broken or removed by the prisoner then, the buzzer is activated to sound a loud alarm, alerting nearby prison staff and the data will be shown near the staff which band is broken as shown in the figure.

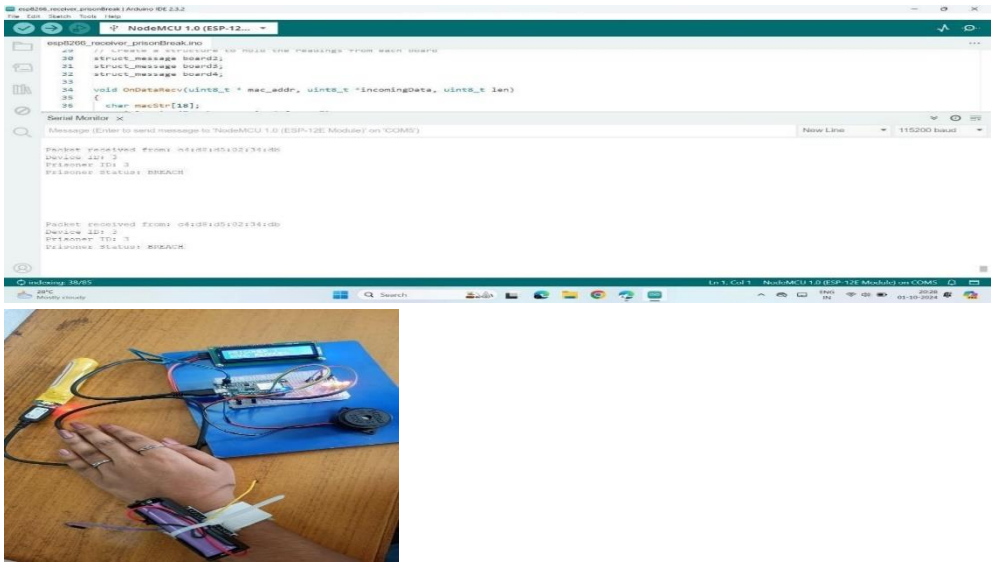

Figure: 6.3 If an unauthorized breach is detected, the buzzer is activated to sound a loud alarm, alerting nearby prison staff.

7-ADVANTAGES AND DISADVANTAGES

Advantages

1. Real-Time Monitoring and Alerts: The system provides instant detection of unauthorized movements or breaches, ensuring that security personnel are immediately notified, allowing for rapid responses and preventing potential prison breaks.

2. Automation and Efficiency: The system reduces reliance on manual surveillance and constant human supervision. Automated alerts and data logging streamline the process of monitoring prisoners and detecting security breaches, minimizing human error.

3. Wireless Communication: Using the ESP-NOW protocol allows multiple NodeMCU units to communicate efficiently across different zones of the prison without requiring external Wi-Fi infrastructure. This makes the system more robust and cost-effective, particularly in large facilities.

Disadvantages

1. Dependence on Technology: The system heavily relies on electronic components and wireless communication, making it vulnerable to technological failures such as hardware malfunctions or software bugs, which can compromise the entire monitoring process.

Initial Setup and Configuration Challenges: Setting up the system may require significant technical expertise to configure the NodeMCU, sensors, and communication protocols properly. This could pose challenges for facilities lacking experienced personnel.

2. Network Interference Issues: Although ESP-NOW allows for efficient communication, it can still be susceptible to interference from other wireless devices or physical obstructions, potentially leading to delayed alerts or loss of critical data.

3. Limited Range of Communication: While the ESP-NOW protocol is suitable for short-range communication, it may face limitations in larger prison facilities where signal strength could degrade over long distances or through thick walls.

8-CONCLUSION

The IoT-based prison break monitoring and alerting system using NodeMCU represents a significant advancement in correctional facility security and management. By integrating various technologies, including real-time location tracking, automated alerts, and data logging, the system enhances the ability to monitor prisoners effectively and ensure their safety within the facility. The use of wristbands equipped with NodeMCU provides a multifaceted approach to prisoner management, allowing for greater oversight and control over movements and access to restricted areas.

One of the core strengths of this system is its capability for real-time monitoring and alerts, which significantly reduces the response time to potential security breaches. This immediacy not only helps in deterring escape attempts but also in managing conflicts or emergencies, thereby improving overall safety for both inmates and staff. Furthermore, the automation of processes such as attendance logging and activity scheduling reduces the burden on staff, allowing them to focus on more critical security tasks and fostering a more organized environment.

In conclusion, the IoT-based prison break monitoring and alerting system utilizing NodeMCU is a forward-thinking solution that addresses the complexities of modern prison management. By harnessing the power of IoT technologies, this system not only enhances security and operational efficiency but also sets a precedent for the integration of smart technologies in correctional facilities. As we move toward a more

technologically driven future, embracing such innovations will be essential in improving prison security, ensuring the safety of all individuals within the system, and contributing to more effective rehabilitation and management of inmates. The continued development and refinement of this technology will pave the way for a safer, smarter, and more humane approach to correctional facility management.

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