IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, March 2025
Impact Factor: 7.67

ArsenalSync: A Smart Firearm Security System

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Abstract: *Unauthorized access to firearms is a critical security threat, leading to misuse, theft, and accidents. ArsenalSync is an advanced gun security system designed to prevent unauthorized usage while ensuring seamless access for authorized users. The system integrates a RFID sensor, ESP32 microcontroller, Bluetooth communication, and a motorized locking mechanism to enhance firearm security. Upon activation, the RFID sensor verifies the user's identity and sends authentication data wirelessly via ESP32 modules. If an unauthorized individual attempts to use the firearm, the system notifies the registered owner through a mobile application, offering options to lock, disable, or apply countermeasures to the weapon. The motorized locking mechanism ensures that the firearm remains inoperable until authorized access is granted. Additionally, the system features an automatic locking mechanism post-usage, enhancing security in high-risk environments. ArsenalSync is specifically designed for military, law enforcement, and personal firearm safety, ensuring robust security while maintaining accessibility for legitimate users.*

Keywords: Gun security, ArsenalSync, firearm safety, RFID authentication, ESP32, Bluetooth communication, motorized locking, unauthorized access prevention, real-time notification, defense technology

I. INTRODUCTION

The increasing misuse of firearms due to unauthorized access has become a critical security concern worldwide. Whether in military environments, law enforcement agencies, or civilian firearm ownership, ensuring that only authorized individuals can operate a weapon is essential for preventing theft, misuse, and accidents.[1]Traditional firearm security measures, such as manual locks and safes, have limitations, including the risk of lost keys, forgotten passwords, or physical breaches. To address these challenges, ArsenalSync introduces a smart firearm security system that leverages RFID authentication, ESP32-based wireless communication, and a motorized locking mechanism to ensure advanced gun safety.The ArsenalSync system is designed to prevent unauthorized access by using RFID technology, where only users with a registered RFID tag can activate the firearm. The ESP32 microcontroller facilitates secure wireless communication between different system components, ensuring seamless authentication and control. If an unauthorized attempt is detected, the system instantly alerts the registered owner via a mobile application, providing real-time options to lock, disable, or apply countermeasures to the weapon. The motorized locking mechanism ensures that the firearm remains completely inoperable unless authenticated. This project aims to enhance firearm security, particularly in military, law enforcement, and high-security environments, where unauthorized access could lead to severe consequences. By integrating IoT-based smart security with firearms, ArsenalSync offers a modern, reliable, and efficient solution to prevent weapon misuse. ArsenalSync introduces a smart firearm security system that integrates RFID authentication, Bluetooth communication, GPS tracking, and a mobile application to ensure only authorized users can access and operate firearms. By leveraging IoT technology, ArsenalSync enhances firearm security, reduces the risk of misuse, and provides real-time monitoring capabilities.

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DOI: 10.48175/568

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II. LITERATURE SURVEY

Firearm Security Mechanisms

Traditional firearm security primarily relies on **mechanical locks**, such as trigger locks and gun safes, which prevent unauthorized access. However, studies have shown that mechanical locks can be bypassed with physical tools or brute force. To overcome these limitations, **smart gun technology** has emerged, integrating biometric authentication (fingerprint recognition) and RFID-based access control. While biometric security offers strong protection, it may suffer from reliability issues in extreme environmental conditions or when hands are dirty or injured.

RFID-Based Access Control Systems

RFID (Radio Frequency Identification) is widely used for **secure authentication** in various applications, including access control, inventory management, and vehicle security systems. Research has shown that **RFID-based firearm locking mechanisms** improve security by ensuring that only authorized users with valid RFID tags can operate the weapon[2]. However, some studies highlight vulnerabilities such as RFID cloning and signal interception. To mitigate such risks, encrypted RFID communication and multi-factor authentication methods have been proposed.

IoT and Bluetooth-Based Smart Locking Systems

The integration of **IoT (Internet of Things) in security systems** has led to the development of smart locks controlled via mobile applications and cloud-based platforms. Bluetooth Low Energy (BLE) and Wi-Fi are commonly used for remote access control, offering flexibility and enhanced security. However, some research points out the risk of **Bluetooth hacking and signal jamming** in unsecured environments. By combining **RFID authentication with Bluetooth control**, systems can achieve multi-layer security, ensuring **both proximity-based and remote access verification**. ArsenalSync leverages this dual authentication method to enhance firearm security.

Firearm Inventory and Usage Tracking Systems

Firearm tracking systems are crucial for **law enforcement agencies, military organizations, and personal firearm owners**. Research has shown that digital databases, such as **cloud-based or blockchain-based inventory management**, can improve firearm accountability. Traditional paper-based record-keeping is prone to human errors and manipulation, making digital tracking solutions more effective. ArsenalSync incorporates **Firebase database management** to track **firearm type, bullet usage, and user activity**, ensuring reliable firearm inventory control.

III. SYSTEM DESIGN AND IMPLEMENTATION

3.1 Hardware Components

RFID SENSOR

Model Used: RC522 RFID Module

Purpose: Used for authentication by scanning RFID tags assigned to authorized users.

Working: The module reads the RFID tag's unique ID and sends it to the ESP32 for verification. If the tag is valid, the gun is unlocked; otherwise, access is denied[3].

Features:

- Supports 13.56 MHz frequency
- Detects RFID tags within a few centimeters
- Low power consumption and fast response time
- Real-Time Authentication Process
- Unique Tag Authentication

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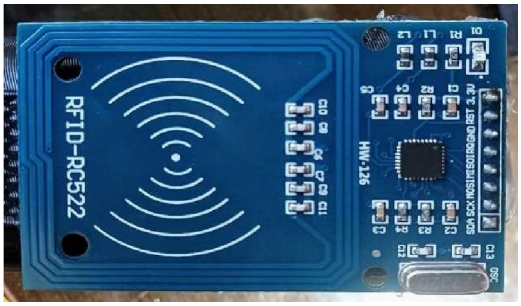

Fig 1. RFID SENSOR

ESP32 Microcontroller

Model Used: ESP32 NodeMCU

Purpose: Acts as the processing and communication unit for the system.

Working:

One ESP32 module is connected to the RFID sensor to authenticate users[4].

The second ESP32 receives authentication data wirelessly and controls the motorized locking mechanism.

Features:

- Dual-core processor for efficient data handling
- Wi-Fi & Bluetooth support for wireless communication
- Low power consumption, making it suitable for battery-powered systems

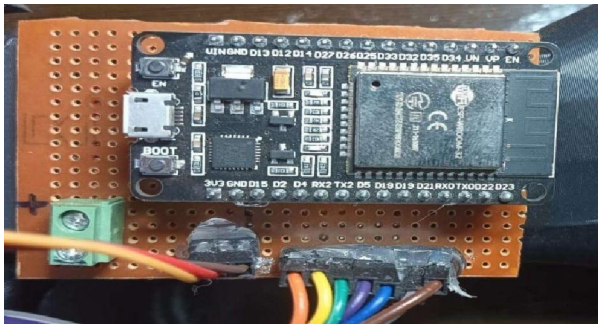

Fig 2. ESP32 Microcontroller

SG90 Micro Servo Motor

Purpose: Controls the **locking mechanism** of the firearm.

Working:

If an authorized RFID tag is detected, the ESP32 activates the servo motor to unlock the firearm[5].

If an unauthorized attempt is detected, the servo motor remains in the locked position.

Features:

Small and lightweight, suitable for compact integration

Operates on 5V power.

Precise movement for locking and unlocking

Functions.

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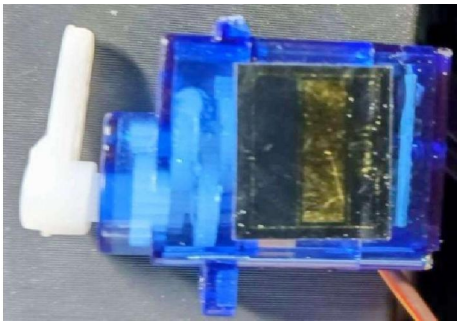

Fig 3. Micro Servo Motor

Li-ion Battery

Purpose: Provides power to all components, ensuring portability.

Working:

Supplies power to the ESP32, RFID module, and servo motor.

Ensures uninterrupted operation, even in field conditions. Features:

High capacity (3.7V - 7.4V) for extended operation.

Rechargeable and Lightweight.

Fig 4. Li-ion Battery

3.2 Mobile Application Features

The ArsenalSync system is integrated with a mobile application that provides authentication, firearm control, legal information, and firearm management[6]. We also used firebase database for storing user credentials[7].The app consists of multiple modules, ensuring secure access and seamless operation. The key components of the application are as follows:

User Authentication and Login

- The application includes a secure login page, where users authenticate themselves using their Gmail ID and password.
- Only registered users can access firearm controls and management features, ensuring restricted access to authorized personnel.

User Role Selection and Dashboard

- After logging in, users are directed to a role-based selection page, where they can choose from three different categories:

Public User:

- Provides general firearm-related information, including laws, regulations, and safety guidelines.
- Educates users about responsible firearm usage, ownership, and licensing procedures.

Private User:

- Allows registered firearm owners to lock and unlock their firearms securely.

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- Displays the current firearm status (locked/unlocked) and provides options for remote access control.
- Sends real-time alerts in case of unauthorized firearm access attempts.

Arsenal Manager:

- Designed for firearm inventory managers responsible for maintaining multiple firearms.
- Displays detailed service history, including maintenance schedules, last service date, and upcoming service reminders.
- Provides bullet usage calculations, tracking the number of bullets fired and remaining ammunition count.

Security and Connectivity

- The app uses encrypted communication to securely transmit firearm status and commands.
- The Bluetooth or Wi-Fi module in the firearm system ensures real-time connectivity with the mobile application.

Real-Time Notifications and Alerts

- The application sends notifications when the firearm is locked or unlocked.
- Arsenal managers receive timely updates on firearm service requirements and ammunition usage.

3.3 Technology Used

Component	Technology Used	Purpose
Microcontroller	ESP32	Controls authentication, Bluetooth, and servo motor
Authentication	RFID Sensor	Verifies authorized users via RFID tags
Locking Mechanism	Servo Motor	Physically locks/unlocks the firearm's selector lever
Power Source	Lithium-Ion Battery	Provides portable power for standalone operation
Mobile Application	MIT App Inventor	Interface for unlocking, user management, and firearm tracking
Communication	Bluetooth (ESP32)	Connects mobile app with firearm locking system
Database Management	Firebase Database	Stores user credentials and firearm tracking data
Hardware Integration	Custom PCB	Connects all hardware components efficiently
Prototype Model	3D-Printed AK-47 (PLA+ Filament)	Simulates real firearm operation for testing

3.4 Security Features and System Reliability

1. Multi-Factor Authentication

ArsenalSync ensures multi-layer security by combining RFID authentication, Bluetooth communication, and mobile app-based login credentials. This prevents unauthorized users from bypassing the system.

2. Remote Monitoring and Logging

The mobile app logs access attempts and system activity, allowing the owner to monitor firearm usage in real time. Future implementations may include cloud storage for access logs and intrusion detection.

3. Emergency Lock and Override System

In case of emergency situations, ArsenalSync can be designed to remotely disable firearm access or implement an emergency override system for authorized personnel.

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4. GPS-Based Tracking and Geo-Fencing

The integration of a GPS module enables real-time location tracking of firearms. The system can also implement geo- fencing, triggering alerts if the firearm moves beyond a predefined safe zone

IV. RESULT

Fig 5. AK-47 Replica

Fig 6. Hardware setup

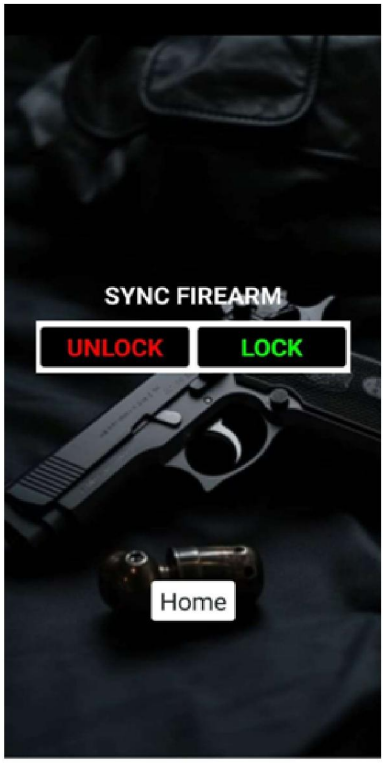

Fig 7. Sync Firearm

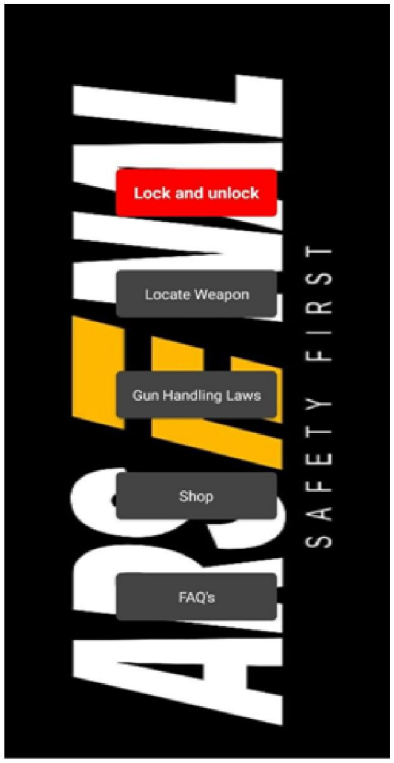

Fig 8. Home Page

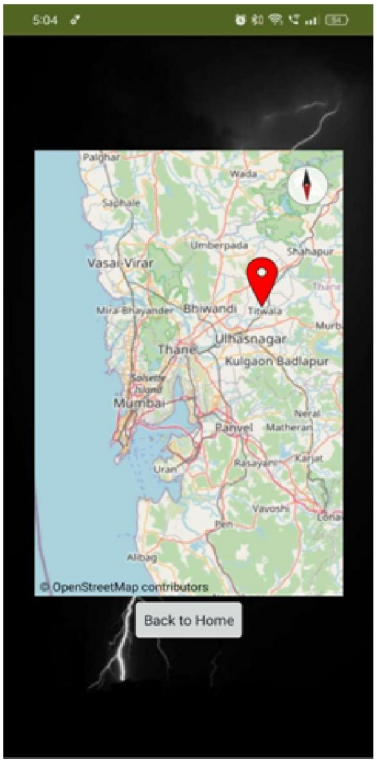

Fig 9. Locate Weapon

V. CONCLUSION

ArsenalSync provides an innovative and robust firearm security solution by integrating RFID, Bluetooth, and IoT technology. The system effectively restricts firearm access to authorized users, reducing the risk of misuse and

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enhancing safety. The inclusion of the Gun Manager feature and Firebase-based User Management further strengthens security and firearm tracking[8].

The successful implementation of RFID-based authentication, mobile app integration, and real-time firearm status monitoring demonstrates the system's efficiency in preventing unauthorized access. ArsenalSync's multi-factor authentication, tamper detection, and remote control capabilities make it a reliable choice for modern firearm security.

ACKNOWLEDGMENT

We express our sincere gratitude to everyone who contributed to the successful development of ArsenalSync. This project would not have been possible without the invaluable guidance, support, and encouragement of several individuals. We extend our heartfelt thanks to our project guide and faculty members, whose insights, constructive feedback, and technical expertise played a crucial role in shaping this system. We are also grateful to our college and the Computer Technology department for providing the necessary resources, knowledge, and opportunities that enriched our learning experience. A special thanks to our mentors and project evaluators for their valuable feedback, suggestions, and assistance in testing, which helped refine the system's usability and efficiency. Lastly, we deeply appreciate our families and friends for their unwavering support, patience, and encouragement throughout this journey. Their belief in our capabilities kept us motivated to accomplish this milestone.

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