ECE 445 Smart Inventory System

Team 10

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Team

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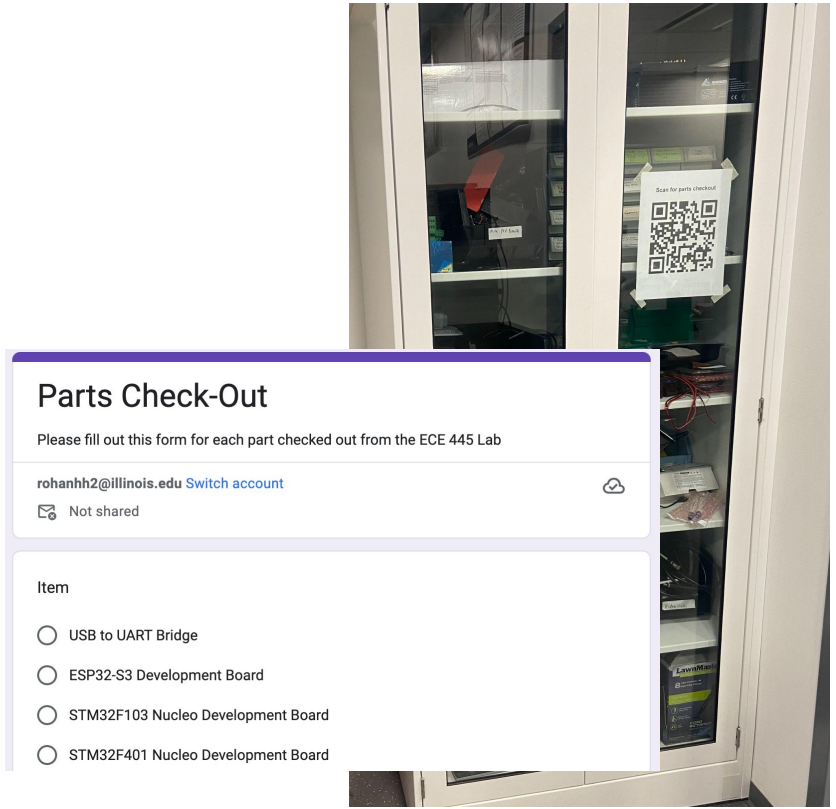
Agenda

1. Introduction
2. Objective
3. Project Design
4. Successes & Challenges
5. Further Recommendations
6. Conclusion

Introduction

Problem

- Time-intensive, manual process for borrowing and returning components in ECE 445
- TAs have to manually check out components, record which students have them, and track down missing items
- Students have to wait for office hours to be able to access project components, delaying workflows



Solution

- Implementation of a smart tagging system using QR codes for components
- Secure storage within a locked container accessible via iCard scanning
- Exterior camera for quick identification of QR-coded components during borrowing
- Backend system logging transaction data initiated by the camera and microcontroller
- Same streamlined process for returning components, enhancing efficiency and accountability

Objective

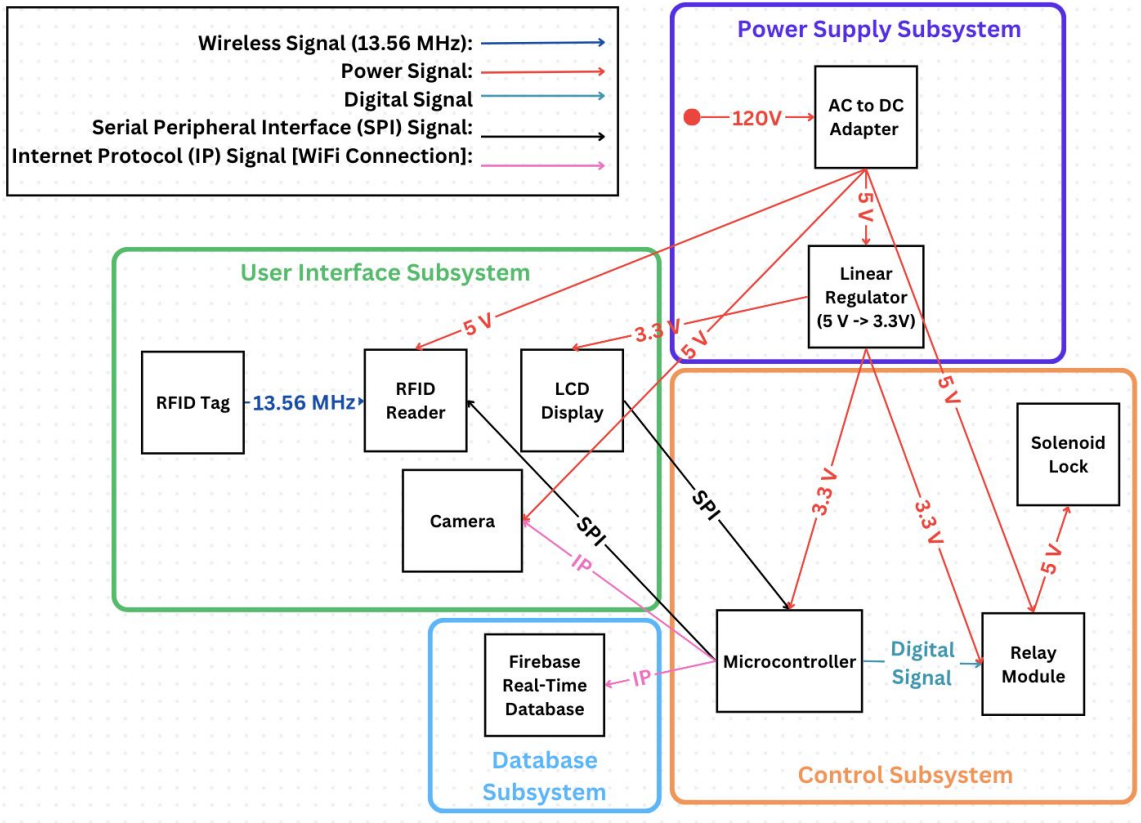
High-Level Requirements

1. The system should unlock the tool cabinet in less than 7 seconds from when a student first taps their iCard on the RFID reader
2. The system should be able to scan and recognize each component's QR code in less than 6 seconds of first appearing in the frame
3. The system should correctly update the database in less than 6 seconds when a student borrows or returns a tool after receiving its unique identifier from the QR code

Evidently, the project aims to modernize component management in ECE 445 through an automated camera-inventory system, streamlining processes, enhancing efficiency, and boosting accountability.


Design

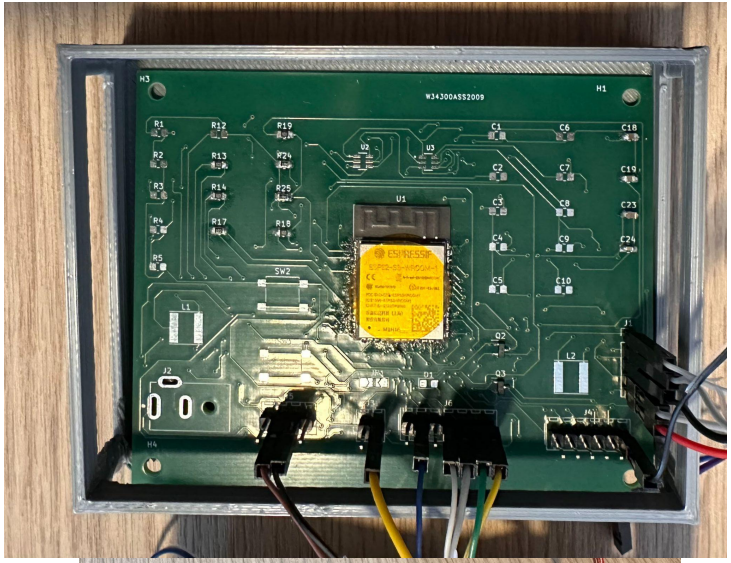
Block Diagram



Control Subsystem

Subsystem Components:

- ESP32 Microcontroller: Core control unit for communication and authorization
- Relay Board: Controls the container-locking mechanism
- Electric Solenoid Lock: Secures the container



Control Subsystem

Access Authorization Sequence:

- Student Identification
- Database Verification
- Container Unlocking
- Transaction Logging

Component Borrowing/Returning Process:

- Component Identification
- Database Recording
- Container Locking

Control Subsystem

Requirements:

- The UID obtained from the RFID reader should be mapped to a student within 3.5 seconds
- When an authorized user taps their iCard, the relay should enable, closing the circuit with the solenoid and unlocking the box
- When an unauthorized user taps their iCard, the box should remain locked

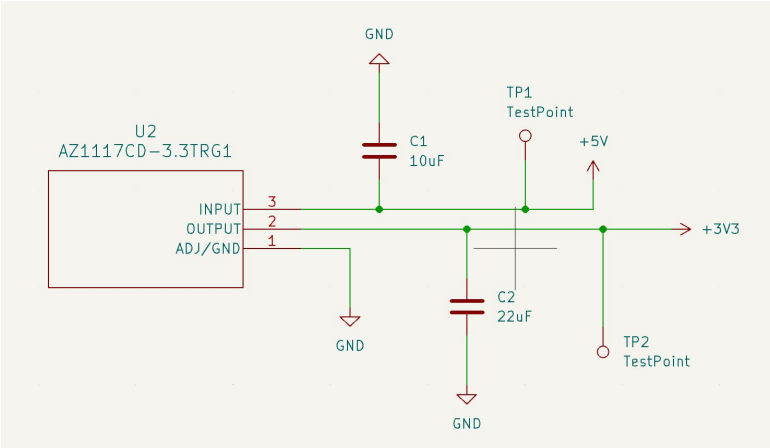
Power Supply Subsystem

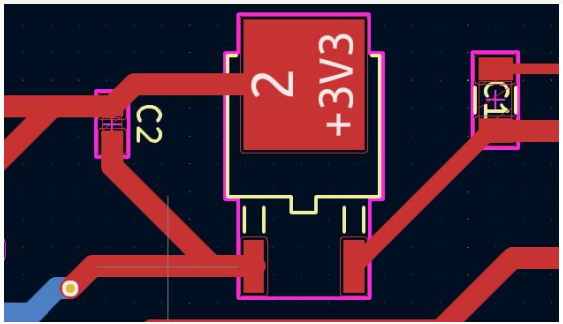
Requirements:

- The linear regulator circuit should drop the 5V input to 3.3V ± 0.5

Trial	Measured V_{Out}
1	3.2935
2	3.2874
3	3.2966

Oscilloscope Readings



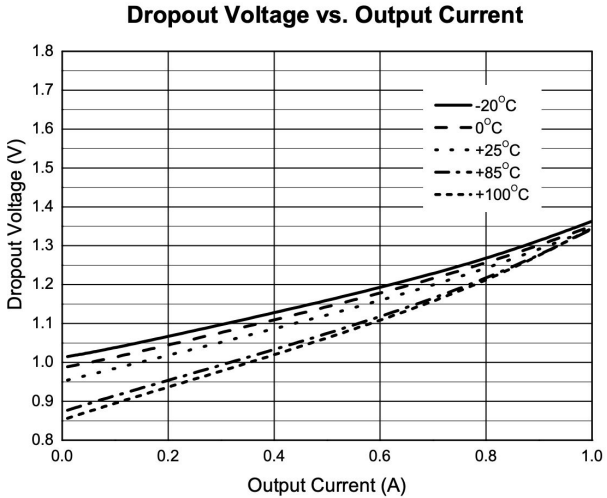


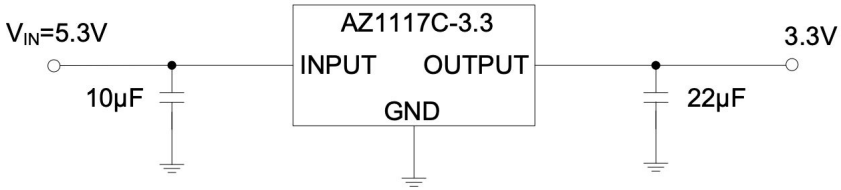
Tolerance Analysis

3.3V Linear Regulator:

- Operating Temperature: 150 °C
- Vin = 5 V, Vout = 3.3 V
- Current Draw = 397 mA
  - ESP32 WiFi = 355 mA
  - LCD = 30 mA
  - Relay = 12 mA
- Junction-Case TR: 29.1 °C/W, Case-Ambient TR: 112.2
- Ambient Temperature: 38 °C

Max Temperature: 125 °C

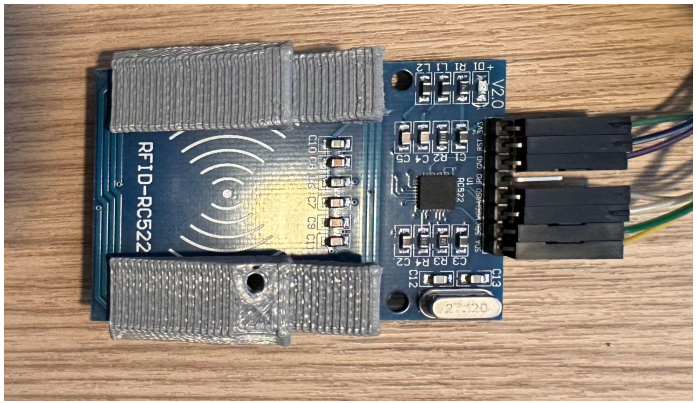




User Interface Subsystem

System Components:

- LCD Display: Provides real-time system status updates
- RFID Reader: Students use their iCard to access the system
- ESP32-CAM (Barcode Scanner): Identifies QR-coded components



User Interface Subsystem

Student Interaction Flow:

1. Initiation: scan iCard
2. Authorization: student access verified by checking database
3. Container Access: control subsystem sends signal to unlock container
4. Component Selection: student selects needed components
5. Transaction Recording: QR code reader decodes selected components
6. Database Logging: student, component, and time are recorded in database
7. Container Securement: container is locked once transaction is complete

User Interface Subsystem

Requirements:

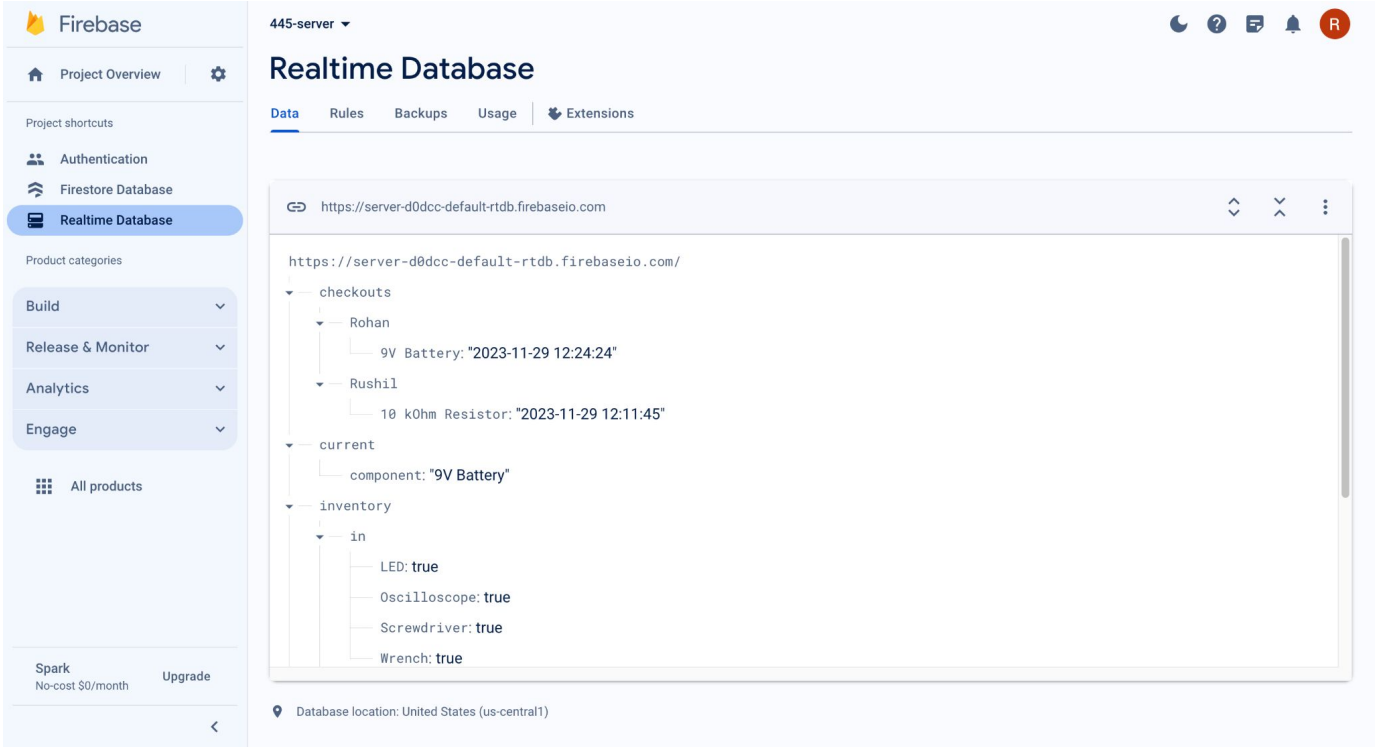
- Verify that the camera system can detect & decode QR codes within 4 seconds
- Verify that the LCD indicates that the box has been unlocked after tapping authorized iCard

Trial	QR Decoding Duration (sec)
1	3.54
2	2.21
3	3.78

QR Code Decoding Timings

Database Subsystem

- Google Firebase serverless, no-SQL database
- Easily read and understood by any course staff without the need for SQL queries
- Allows individual authentications from each microcontroller for security



Database Subsystem

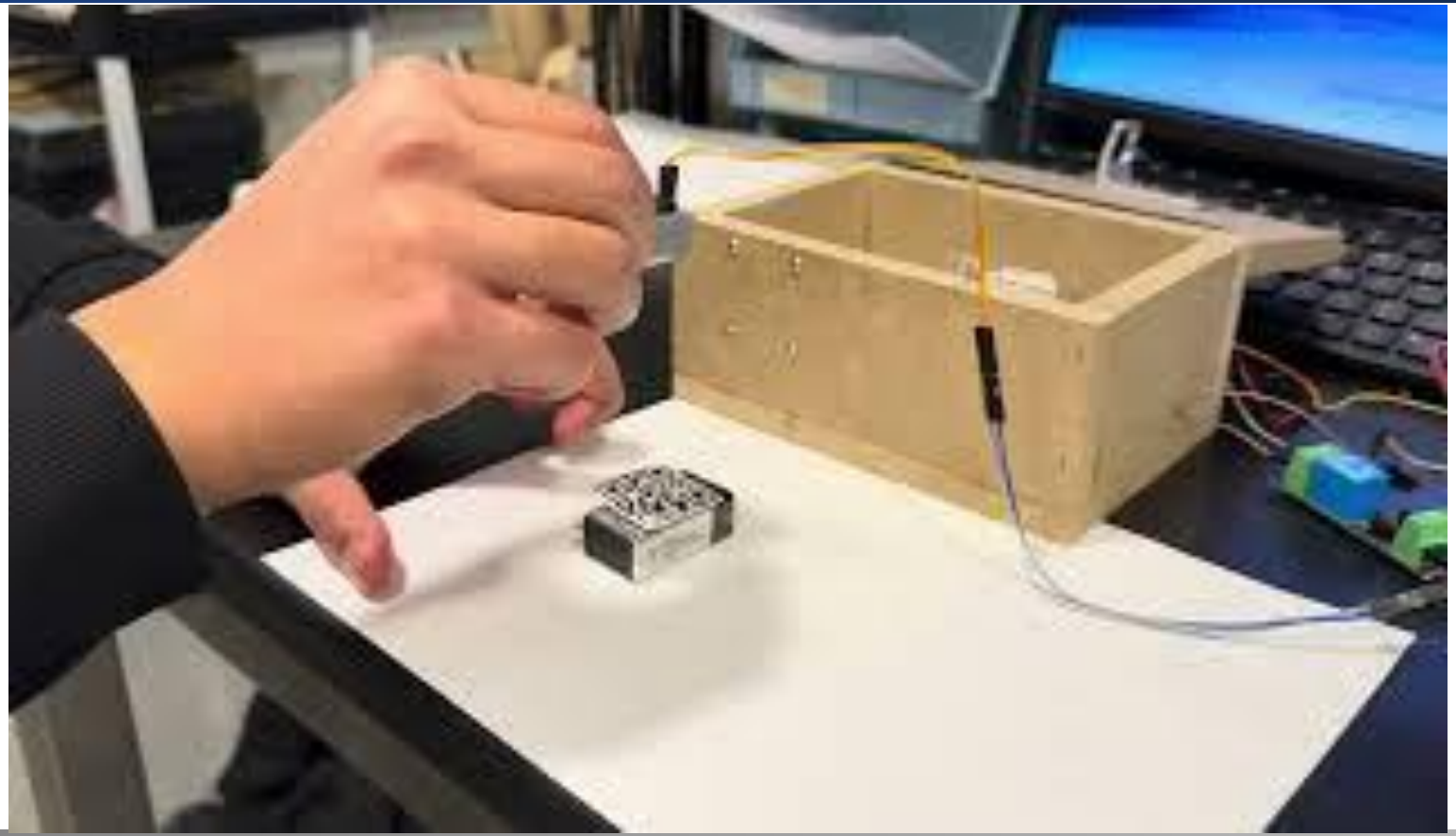
Requirements:

- The database should correctly update to reflect component checkout, including the student name, component borrowed, and time checked out
- The database should correctly update to reflect component return
- The system should not allow a student to borrow or return a component already checked out to another student

```
def set_inventory():
    try:
        data = {
            "in"  : {
                "Wrench" : True,
                "Screwdriver" : True,
                "10 kOhm Resistor" : True,
                "Oscilloscope" : True,
                "9V Battery" : True,
                "LED" : True
            },
            "out" : {

            }
        }

        db.reference("inventory").set(data)
        print("success")
    except Exception as e:
        print("Database push failed")
        print(str(e))
```

```
def set_users():
    try:

        data = {
            "authorized"  : {
                "Rohan" : True,
                "Rushil" : True,
            },
            "unauthorized" : {
                "Krish" : True,
            }
        }

        db.reference("users").set(data)
        print("success")
    except Exception as e:
        print("Database push failed")
        print(str(e))
```

Demonstration Video



Successes and Challenges

Successes

Secure Components

The components are securely locked in a container and are only accessible once a valid iCard is tapped

QR Code Recognition

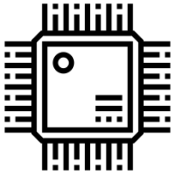
The camera is successfully able to scan the QR Code on the components and identify them by name

Database Records

With each code scanned, the database updates the borrowed/returned component from the student's records

Challenges

MCU Interaction



We needed to send image recognition data from one MCU to the other and needed to generate a wireless communication method

12V Power Supply

Our initial 12V supply burned the PCB and we had to identify potential issues in our PCB design to redesign the power subsystem

3D Printing

The resolution of the 3D printer we used wasn't precise enough to insert our components with ease

Further Recommendations

Further Recommendations

- Utilizing a mount for the ESP-32 camera so scanning does not need to be done manually by a student
- Allowing an additional user input interface to allow students to initiate multiple checkout/return transactions at once
- Create a web interface to consolidate the checkout data stored in the database for easy access by ECE 445 course staff

Conclusion

Conclusion

Technical Skills

- Computer-Aided Design, Programming an ESP-32, Printed Circuit Board Design, Soldering, Using external devices with a microcontroller, Google Firebase

Project Management and Communication

- Understanding and addressing potential risks early on to mitigate project setbacks
- Keeping open and clear communication amongst team members to complete a project
- Creating clear block diagrams to explain critical parts of a technical design

Questions?