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Fingerprint Lock with LCD Display

Computer Architecture

University of Basel, Fall 2024

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Project Goal

Ambition

To build a secure access system that uses biometric authentication with a fingerprint sensor, controlled by an Arduino, to ensure a secure lock

- **Secure Access**: Biometric system using fingerprint recognition to control entry
- **Real-Time Feedback**: LCD display shows status (e.g., "Access Granted" or "Access Denied")
- **Modular Design**: Easily adaptable for various access control applications

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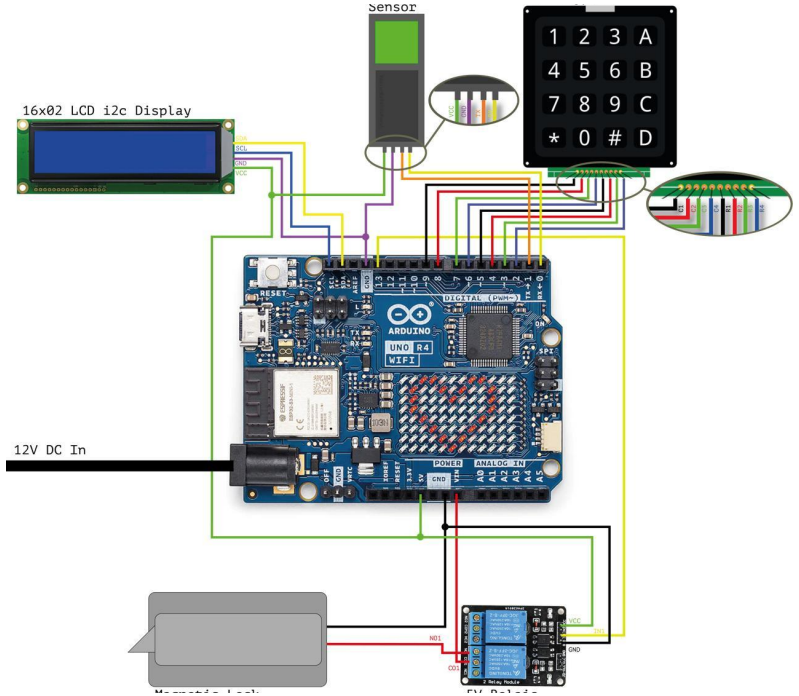
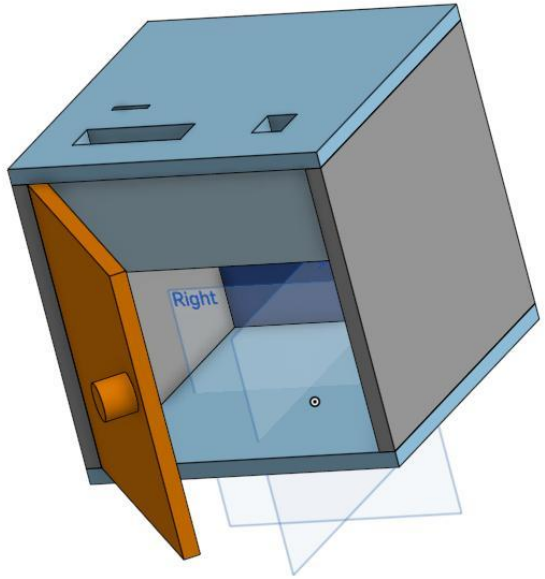
- **Real-Time Feedback**: LCD display shows status (e.g., "Access Granted" or "Access Denied")
- **Time-Based Access**: Feature to restrict or allow access based on specific time intervals, enhancing security and operational flexibility
- **Modular Design**: Easily adaptable for various access control applications

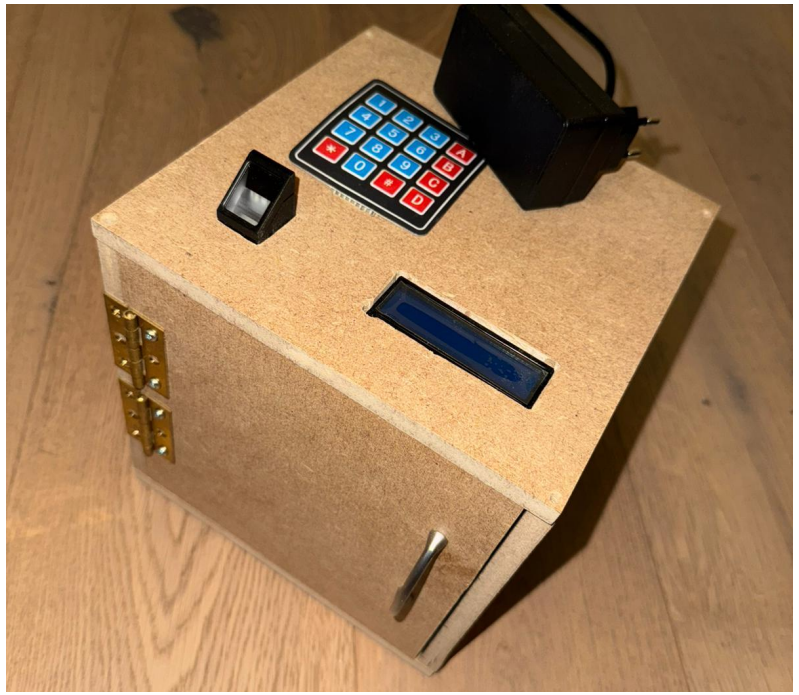
System Overview



Circuit Diagram



CAD Visualization

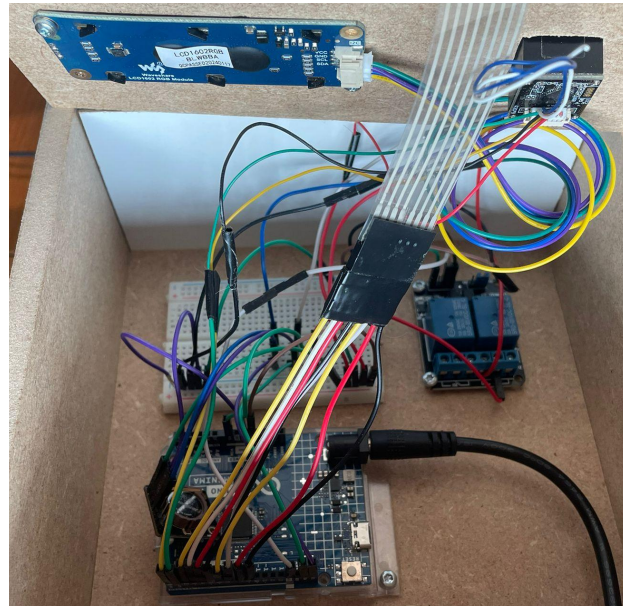


Final Result

Hardware Implementation

Hardware

- Arduino UNO R4 Minima/WIFI
- R307 Fingerprint Reader
- 16x2 I2C LCD Display
- 12V DC Electromagnetic Lock
- 2-Channel Relay Module
- 12V DC Power Supply
- Jumper Wires & Breadboard
- RTC SD3031
- Keypad 4x4 Matrix
- Wood, Hinge, Door Handle



Total HW Costs: 236.66 CHF (initially Planned: 106 CHF)

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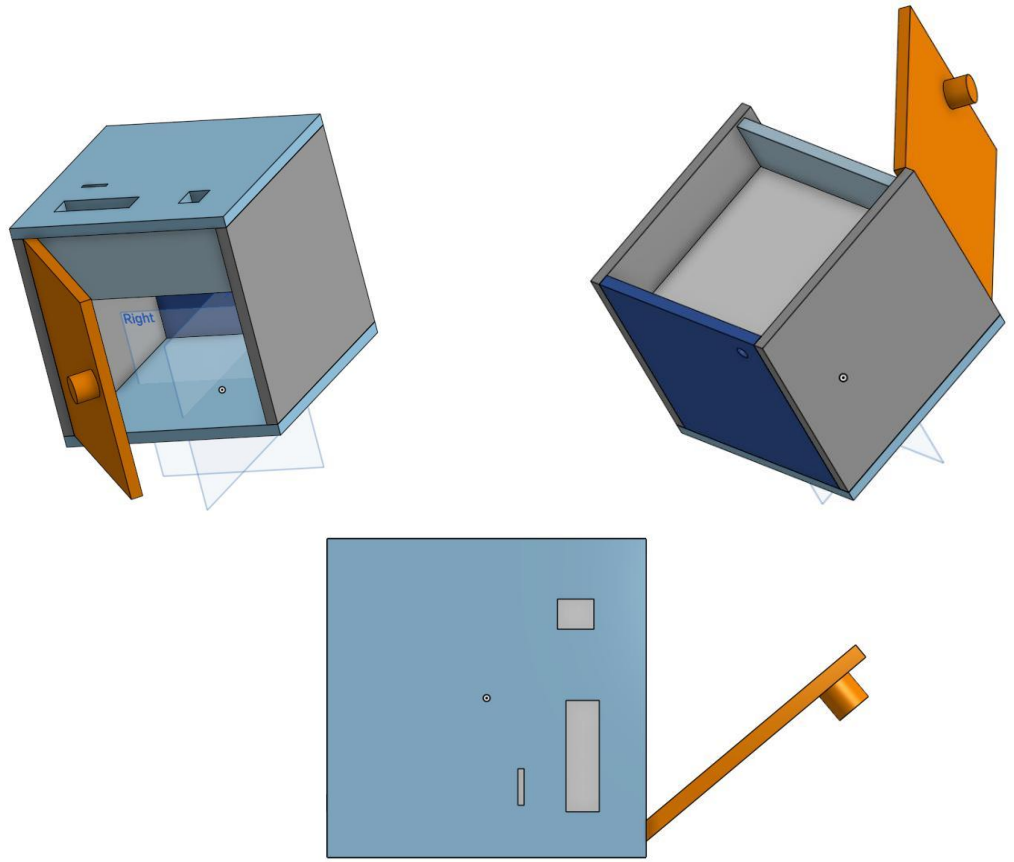

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Software Implementation

Programming Environment

➔ Developed using Arduino IDE (C++)

➔ Serial communication for debugging

Core Functionalities

➔ Fingerprint Enrollment and Verification

➔ Time-Based Access Control

  – *Access to predefined time slots*

➔ LCD Display Handling

  – *User Feedback Messages*

➔ Relay Control

  – *Lock Activation upon Verification and Time*

```
bool fingerEnroll(int id) {
    // Enroll a fingerprint for the given ID
    for (int i = 0; i < 2; i++) {
        if (i == 0) {
            lcd.clear();
            lcd.send_string("Scan Finger");
        } else {
            lcd.clear();
            lcd.send_string("Scan Finger");
            lcd.setCursor(0, 1);
            lcd.send_string("Again");
        }

        // Wait until a finger is detected
        while (finger.getImage() != FINGERPRINT_OK) {
            // Stay here until a finger is detected
        }

        if (finger.image2Tz(i + 1) != FINGERPRINT_OK) {
            lcd.clear();
            lcd.send_string("Error Capturing");
            delay(2000);
            return false; // Error transferring the fingerprint image
        }

        if (i == 0) {
            lcd.clear();
            lcd.send_string("Remove Finger");
            delay(2000); // Allow time to remove the finger
        }
    }

    // Create and store the fingerprint model
    if (finger.createModel() != FINGERPRINT_OK) {
        lcd.clear();
        lcd.send_string("Error Creating");
        delay(2000);
        return false; // Error creating the model
    }

    if (finger.storeModel(id) != FINGERPRINT_OK) {
        lcd.clear();
        lcd.send_string("Store Failed");
        delay(2000);
        return false; // Error storing the model
    }

    return true; // Successfully stored
}
```

Software Implementation

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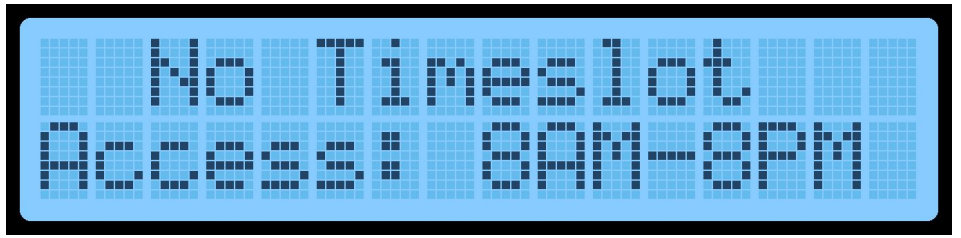
Core Functionalities

- ➔ Fingerprint Enrollment and Verification
- ➔ Time-Based Access Control
  - – *Access to predefined time slots*
- ➔ LCD Display Handling
  - – *User Feedback Messages*
- ➔ Relay Control
  - – *Lock Activation upon Verification and Time*

```
1  void loop() {
2      // Update time from NTP server
3      timeClient.update();
4      String currentTime = timeClient.getFormattedTime();
5      int currentHour = timeClient.getHours(); // Get the current hour
6
7      // Display default screen if not in menu mode
8      if (!inMenu) {
9          ...
10     }
11
12     // Read keypress from keypad
13     char key = keypad.getKey();
14
15     // Handle keypress actions
16     if (key == '*') {
17         // Enter menu mode
18         ...
19     } else if (key == '#') {
20         // Attempt to unlock
21         if (currentHour >= 8 && currentHour < 20) {
22             // Check fingerprint during allowed hours (8 AM - 8 PM)
23             startFingerprint();
24         } else {
25             // Display time restriction message
26             lcd.clear();
27             lcd.send_string("  No Timeslot   ");
28             lcd.setCursor(0, 1);
29             lcd.send_string("Access: 8AM-8PM ");
30             delay(3000);
31             lcd.clear();
32             showDefaultScreen(); // Return to default screen
33         }
34     }
35 }
```



Challenges Faced

1. **Keypad Sensitivity Issues**
   Problem: Keypad produced ghost inputs and was overly sensitive
2. **RTC Module Challenges**
   Problem: Difficulties in getting the RTC Module to function correctly
3. **Power Supply Issues**
   Problem: Wrong power supply caused multiple failures; components stopped working, Arduino board was not recognized by the computer
4. **LCD Backlight Failure**
   Problem: LCD backlight stopped functioning at full potential

1. **Solution:** Switched to a more stable keypad library, which resolved the issue and improved input accuracy
2. **Solution:** same as 3.
3. **Solution:** Purchased a new Arduino board with a Wi-Fi module, allowing us to fetch time from the network instead of relying on the RTC module
4. **Solution:** Replaced the LCD screen with a new one, which resolved the problem

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Demo

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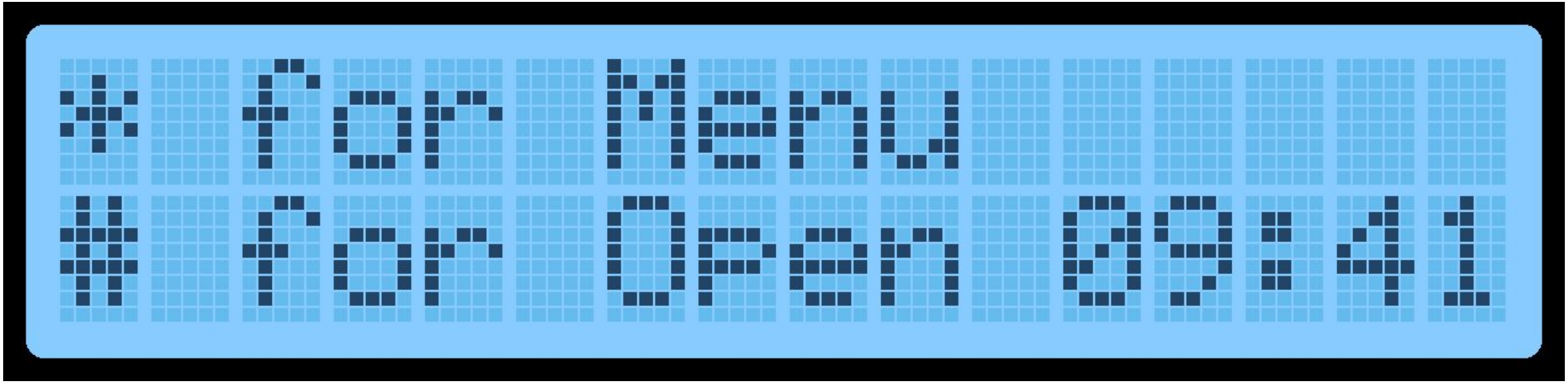

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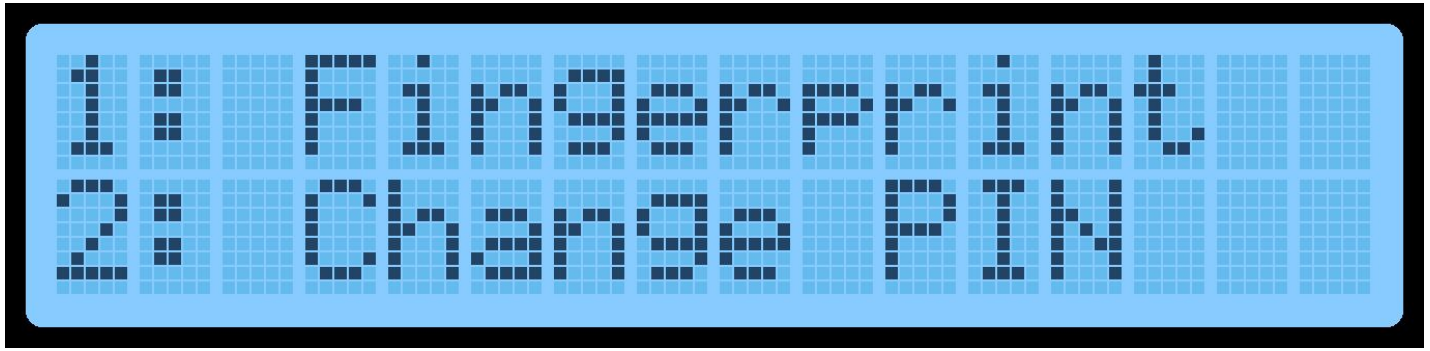

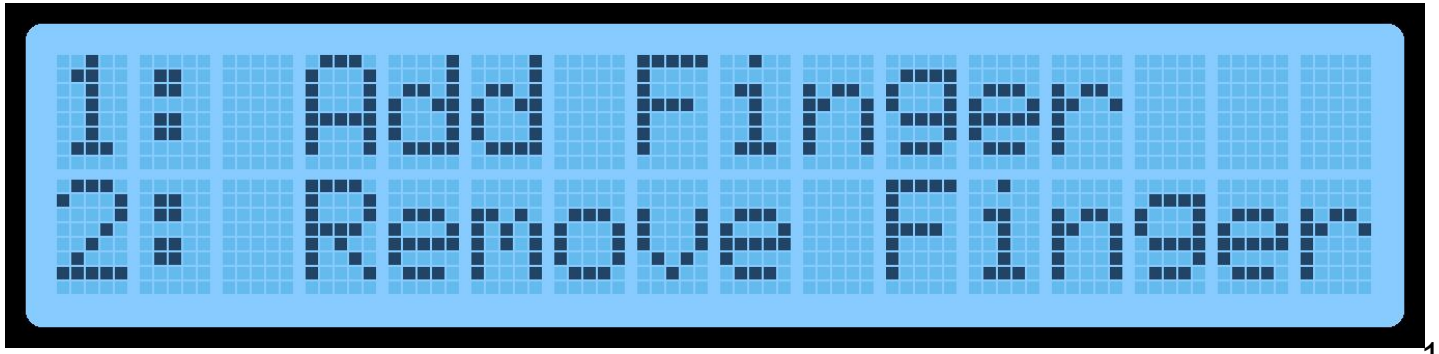

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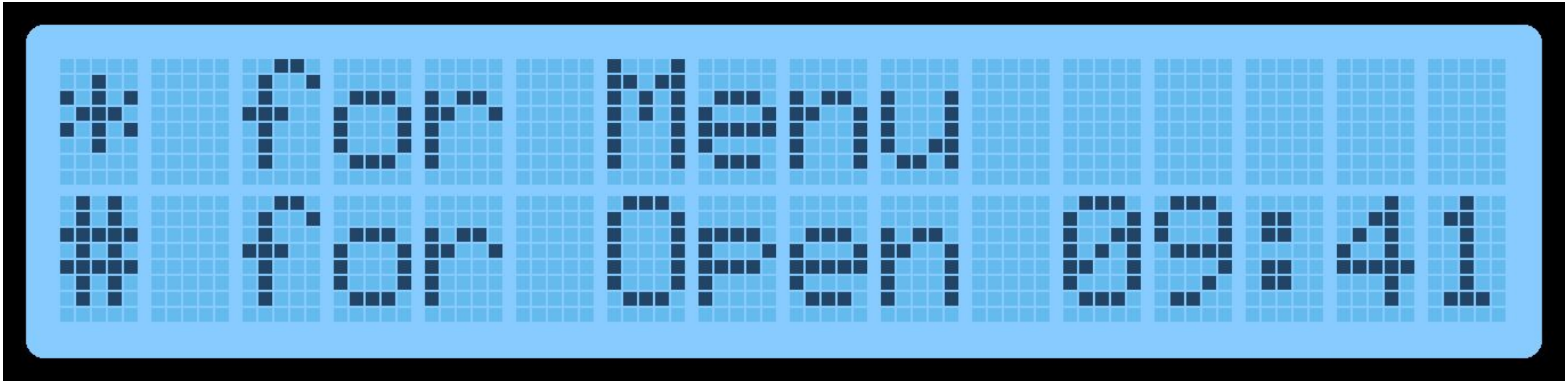

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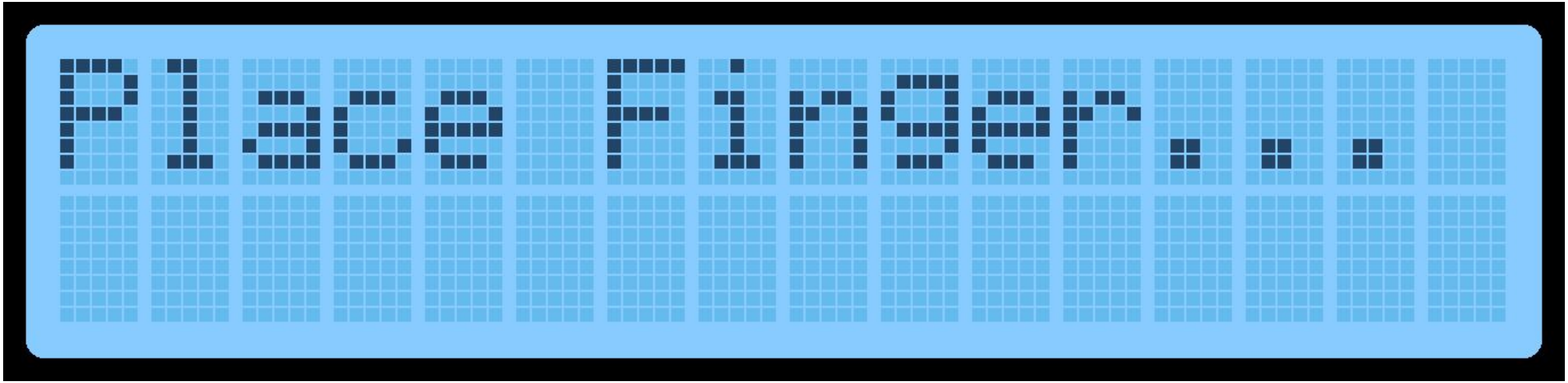

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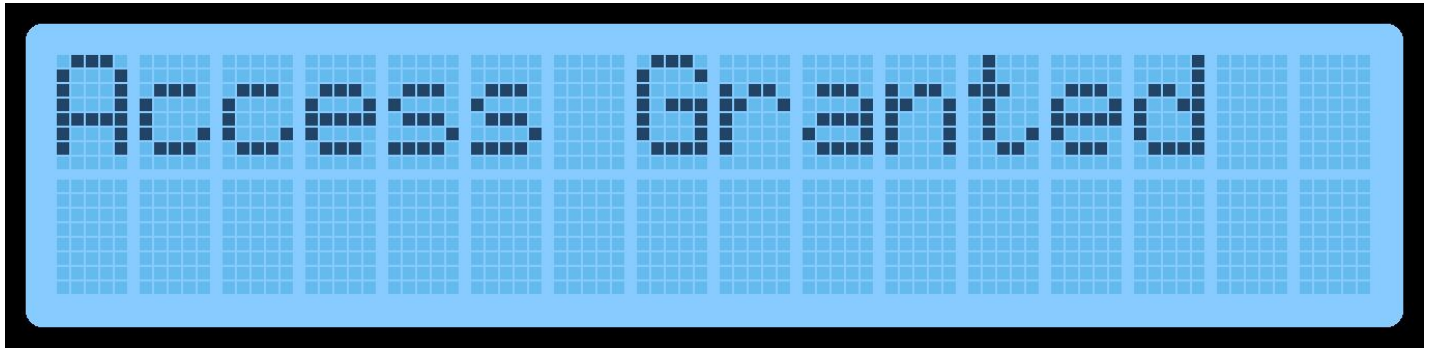

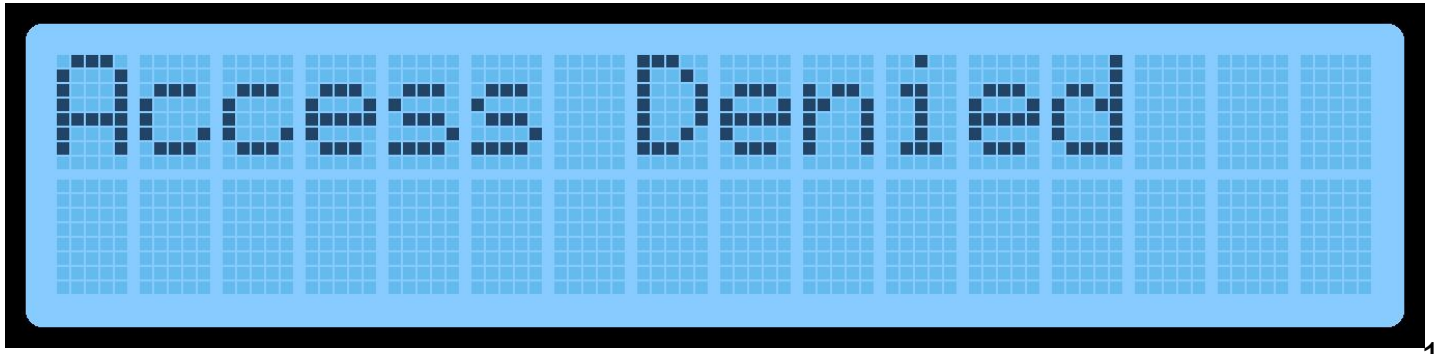

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Q & A

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Thank you!