ECE445 Senior Design
Group 72 Umbrella Rental System

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Introduction

- Problem: Sudden rain or snow when you need to commute between work or class. Purchasing umbrellas for rare uses is wasteful.
- Our solution:
  - A smart, self-serve, 24x7 umbrella rack which provides umbrella rental service
  - An easy, low cost way for people to rent and return umbrellas
Objective

Technical Capabilities:
- Ability to read RFID cards for user identification
- Communicate with backend database through wifi to maintain rental record and to support real time multi-rack distribution/deployment
- Log damage report in case of accidental or malicious damage
Physical Design & Project Picture
LCD Display
LCD Display Unit

1. 1602 Lcd Display with adjustable backlight
2. Use 5V Power Supply
3. Shows 16 characters x 2 lines
4. Reads ASCII code
RFID Module
RFID Module

- Use RC522 Sensor 13.56MHz
- Only supports 3.3V
- Read information from RFID tag/card
- Send the card information to Microcontroller
- No delay for the read process
RFID work flowchart

1. Start
2. Looking for Card
   - NO: Found a card?
     - YES: Anti Collision
     - NO: Read Card Info
6. Send info to Microcontroller
7. Halt
Lock Module
BYJ - 48 Stepper Motor & ULN2003 Driver Module

- 4 Phase 5V DC Stepper Motor
- Rotation of 5.625° per set of 4 input pulse
- Execute step 1 to 4 for clockwise rotation
- Reverse steps for counterclockwise turn
- Speed control through frequency of input pulse

<table>
<thead>
<tr>
<th>Step</th>
<th>Port Data</th>
<th>Pin 3</th>
<th>Pin 2</th>
<th>Pin 1</th>
<th>Pin 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0x03</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0x06</td>
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<tr>
<td>3</td>
<td>0x0C</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0x09</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
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</tbody>
</table>
Motor - Lock Mechanical Design

- Motor rotation through tension wire triggers spring loaded lock arm on a second axle to eject the lock arm, releasing the umbrella
DEMUX Group for Optimized Motor Signal Pin Usage

- Microcontroller has limited pins accessible, but each microcontroller need to control many motors

<table>
<thead>
<tr>
<th></th>
<th>4 Signal Pin per Motor V.S. 4 Signal Pin with DEMUX Select</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pins Needed</td>
<td>4*n</td>
</tr>
<tr>
<td>Controllable Motor</td>
<td>n</td>
</tr>
</tbody>
</table>

- Current prototype used four 74AC139 DUAL 2 to 4 Demultiplexer, one per motor signal
DEMUX Group for Optimized Motor Signal Pin Usage

FUNCTION TABLE
(each decoder/demultiplexer)

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>SELECT</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>H</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>
WiFi Module
Chip: ESP-8266

- 3.3V supply voltage
- AT Command Set
- Example:
  AT+CIPSTART=<Protocol>,<IP>,<PORT> //Connect to PORT on target IP via Protocol, e.g. TCP
- I/O pin voltage, however...
Control & Server
Software System Overview

Main Server Thread
Wait for new connection

Thread for each connection
Send & Receive Data, close if connection closed

#Slot, Return/Receive/Deny
Rack

Rack Identifier, RFID card number, Damage Report
Rack

Rack
Rack

Database
Microcontroller & Server

1. Wait for user scan
2. Send Message to Server
4. Send Damage Report to Server if there are any
5. Go to Next Iteration when server reply is received
6. Wait for client message
7. Lookup Database for User/Umbrella
8. Change Status of User, Umbrella & Rack
9. Send Reply to Client
10. Rent from/Return to #Slot/Deny Service
11. Change Status of User, Umbrella and Rack
12. Send Reply, Go to Next Iteration
Conclusion

Positives:

- Project works as designed with full functionality
- Every module satisfies the Requirement and had been Verified
- Easy to use with fluent user experience
- Full support for flexible multi rack deployment
- Low Manufacturing Cost and low operation cost

<table>
<thead>
<tr>
<th>Part</th>
<th>Manufacturer</th>
<th>Retail Cost ($)</th>
<th>Bulk Purchase Cost ($)</th>
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</thead>
<tbody>
<tr>
<td>AT89S52</td>
<td>Atmel</td>
<td>$3 each</td>
<td>$1.16 each</td>
</tr>
<tr>
<td>PCB</td>
<td>PCB Way</td>
<td>$3.80 each</td>
<td>$0.559 each</td>
</tr>
<tr>
<td>Motor &amp; Driver</td>
<td>Generic</td>
<td>$20 per 10 pair</td>
<td>$8.50 per 10 pair</td>
</tr>
<tr>
<td>RC522 RFID</td>
<td>Generic</td>
<td>$25</td>
<td>$4.6 per Reader + 10 Card</td>
</tr>
<tr>
<td>ESP 8266 WiFi</td>
<td>Generic</td>
<td>$4 each</td>
<td>$2.20 each</td>
</tr>
<tr>
<td>1602 LCD</td>
<td>Generic</td>
<td>$3 each</td>
<td>$1.31 each</td>
</tr>
<tr>
<td>Rack</td>
<td>Generic</td>
<td>$15 each</td>
<td>$10 each</td>
</tr>
<tr>
<td>Power Supply</td>
<td>Generic</td>
<td>$6</td>
<td>$3</td>
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<tr>
<td>DEMUX IC</td>
<td>Texas Instrument</td>
<td>$8 per 4 pair</td>
<td>$1.152 per 4 pair</td>
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<tr>
<td>Other IC (Inverter, etc)</td>
<td>Texas Instrument</td>
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<td>$1.768</td>
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<tr>
<td>Total</td>
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<td>$91.80</td>
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</tbody>
</table>
Conclusion

Negatives and Future Work:

- Exposed wiring and circuitry on current prototype
- Better protection and waterproof for circuitry
- Improve corner cases in rental database algorithm
  - Reporting damage will cause current user to be banned temporarily, even if the user is not responsible
- User registration interface - Website, Mobile Apps
- Setup payment system for commercial applications
Questions?
Thank you!