Team 38
Good2Go Automated Token Exchanger (GATEr)
ECE 445

John Kim, Henry Guan, Ariocie Liang
# Table of Contents

1. Project Rationale  
2. Objectives  
3. Project Overview  
4. Original Design & Changes  
5. Requirements & Verification  
6. Project Build  
7. Functional Test Results  
8. Video  
9. Design Decisions  
10. Successes & Failures  
11. Challenges & Learning  
12. Future Work  
13. Ethics  

ECE 445/Team 38
● **Good2Go (G2G)** is a service used by U of I dining halls

● Old container -> redeemable token -> new container

● **Current problems**
  ○ Lacks unification
  ○ Relies solely on human supervision
Objectives

- Automate service with 2 key functions
  - Exchange token for a clean container
  - Exchange old container for either token or new container
- Complete exchange process within 15 seconds
- Dispense exactly 1 new container at a time without jamming
- Correctly detect invalid G2G containers via 2 verification processes:
  - Overweight containers (>10g)
  - Invalid G2G QR codes
- Physical tokens -> digital tokens
  - Added convenience and security
Original Design

OVERALL DESIGN

USED CONTAINER DEPOSIT MECHANISM

CLEAN CONTAINER DISPENSING MECHANISM
Changes from Original Design

- Downsize overall size of contraption
- Utilize a conveyor belt style of dispensing rather than have 2 mechanical arms retract
- Use of LEDs for status of machine rather than an LCD display
Requirements & Verification - Power Subsystem

Requirements
1. Power all components in accordance with their rated voltage within 5% variance

Verification
1. Probe voltage running through each component, ensuring that measured voltage is within 5% of rated voltage
• Left side of PCB supplies expected voltage to each component
• Able to convert 12V from power supply into voltage value within 5% of 5V for AtMega328P
● Right side of PCB initially had a voltage drop
● 12V delivered from power supply does not convert into a value within 5% of 5V for ATTiny85
● Cause of drop was a corroded voltage regulator and a missing capacitor
Requirements & Verification - Power Subsystem cont.

**Requirements**

1. Power all components in accordance with their rated voltage within 5% variance

**Validity**

1. Yes!

**Verification**

1. Probe voltage running through each component, ensuring that measured voltage is within 5% of rated voltage

- Able to power all components on PCB properly after fixing the issues
Requirements

1. Keep track of user’s token count
2. Correctly keep track of user input

Verification

1. Check invalid tokens, storing tokens, using tokens
2. Execute specific action based on user selection
Validity

1. Yes!
2. Yes!

- Tokens are stored and updated successfully
- User cannot dispense a new container if they have no tokens
- Buttons execute correct action based on user input
Requirements & Verification - Sensing Subsystem

Requirements
1. Able to scan QR code and measure weight on G2G containers
2. Execute retrieval and dispensal for valid G2G containers

Verification
1. Check if QR code enables a correct scan and load cell measures mass properly
2. Reject containers that are overweight or have an invalid/no QR code, while executing retrieval or dispensal for valid containers.
Validity

1. Yes!
2. Yes!

- Valid QR codes pass and weight is able to be read
- Machine rejects invalid containers properly, continues in state machine for valid containers
Requirements & Verification - Control Subsystem

**Requirements**

1. Machine should complete exchange within 15 seconds from start to finish
2. Dispense exactly one container upon a dispense request without any mechanical issues

**Validity**

1. Will be validated in the video!

**Verification**

1. Repetitively time how long it takes to complete the exchange from start to finish
2. Repetitive tests, check if only one container is dispensed
G2G system at U of I dining halls is only a service, not a product

- **Physical Design:**
  - Downscale
  - Retrieval & Dispensing mechanism
  - QR scanner continuous mode & Field of View
  - Transparency of containers
  - Needed a retrieval system + accurate weighing scale
    - Load cell with two arms beneath
State Machine
Servo Motors

- Non-continuous motor: RPM & angle tuning
- Continuous motor: RPM & duration tuning
  - Using PWM: pulse of ~1.5ms to stop motor
  - Calibration (adjustment screw & potentiometer)
  - 0 (CW full speed), 90 (stop), 180 (CCW full speed)

Issue: erratic behavior when powered

Solution: separate power supply, 470uF capacitor, software
Card Reader (iCard)

- Interfacing with HID device, debugging driver code

- Failure with MSR 123
  - USB protocols (Product ID)
  - Device Descriptor

- MSR 90
  - Modify to handle only key-down interrupts
  - 3 tracks (header, data, unused)
QR Scanner

- Reading/ Writing to address of QR
  - Mode change to continuous
  - UART scan commands
  - timeout value

- Dynamic vs Static QR
  - Dynamic: encoded information changes
  - Static: fixed information (may become obsolete)

Issue: UART serial port buffered upon failed container return due to multiple scans

Solution: clear serial buffer if invalid
Functional Test Results 4

Load cell

- Strain gauge load cell & Amplifier
  - Convert load into electric signals
  - Degree of voltage change -> digital reading as weight

- Calibration process:
  - Software to set to 0 and place known weight
  - Adjust calibration factor (-7500)

Issue: easy fluctuation in measurement when first inserted

Solution: delay measurement until QR scanner validation completes
Video

Link: https://www.youtube.com/watch?v=p8fdRb78moU&t=1s
Design Choices

- **LED vs Display (LCD)**
  - Imitate behavior of a vending machine
  - User information abstracted
  - At most 1 token needed

- **Stepper vs Servo motor**
  - High torque at high speed
  - Feedback (closed loop)

- **QR vs Barcode**
  - Barcode for small data
  - QR for human error
  - Orientation

- **RFID vs Magnetic Card Swiper**
  - iCard
  - Reduced layer of identification
Successes & Failures

● Success:
  ○ Physical solution to current G2G system ✓
  ○ Integration with iCard ✓
  ○ Full functionality achieved ✓

● Work in Place:
  ○ Power supply component
  ○ PCB modification
    ■ USB Shield
Challenges & Learning

- **Hardware**
  - Separate power supply for motors
  - Wiring in downscaled container

- **Software**
  - Integration: USB task and UART communication

- **Parts & Components**
  - Machine shop

- **Learning:** soldering, abstraction details
Future Work

- **Database**
  - Store more information (different containers, date)
  - Limited write cycles for on-chip memory
  - Scalable if using several G2G machines

- **Display**
  - Allow multiple choices and selection
  - Display non-sensitive account information (token)
  - Easy use with on screen instructions
Potential Ethical Issues

- Security
  - No layer of security
  - Data loss

- Safety
  - Mechanical jamming
  - Lack of warnings/alerts
  - Motors at high speed
Thank You For Listening!

Any Questions?

Contact Information:

John Kim: jaehank2@illinois.edu
Henry Guan: henrgy3@illinois.edu
Ariocie Liang: arliang2@illinois.edu