

ENVOY COMMANDER

Group 32

Team Members



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Problem Statement

There are few accessible collaborative model-free learning frameworks

- Distributed ML (Machine Learning) implementations are expensive
- Communication model
 - Real World tasks are cooperative
 - Data is noisy
- Simulated Controlled environment
 - “Secret Simon Says”

Motivations

Goals

Manifest Centralized Learning

Practicality of Model-Free Learning

Potential Application in Research

Principles

Affordability

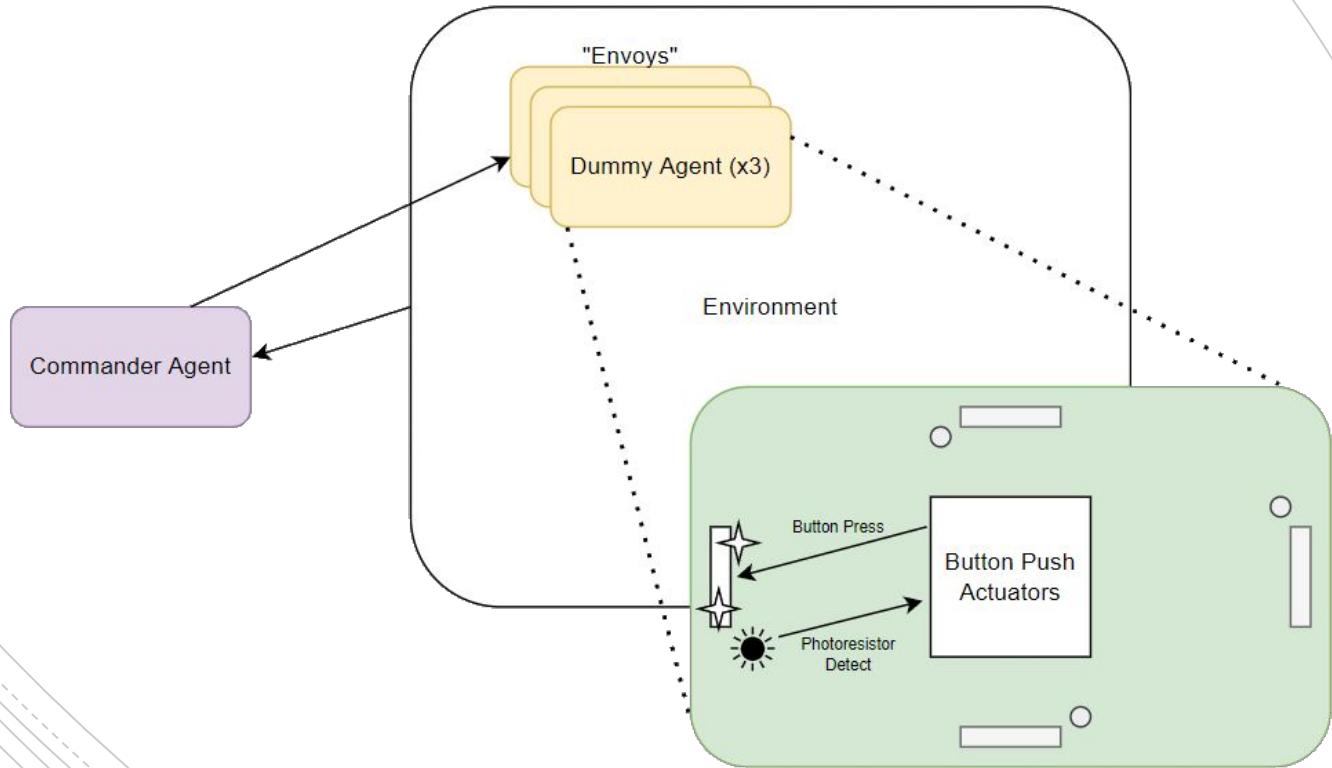
Scalability

Expansibility

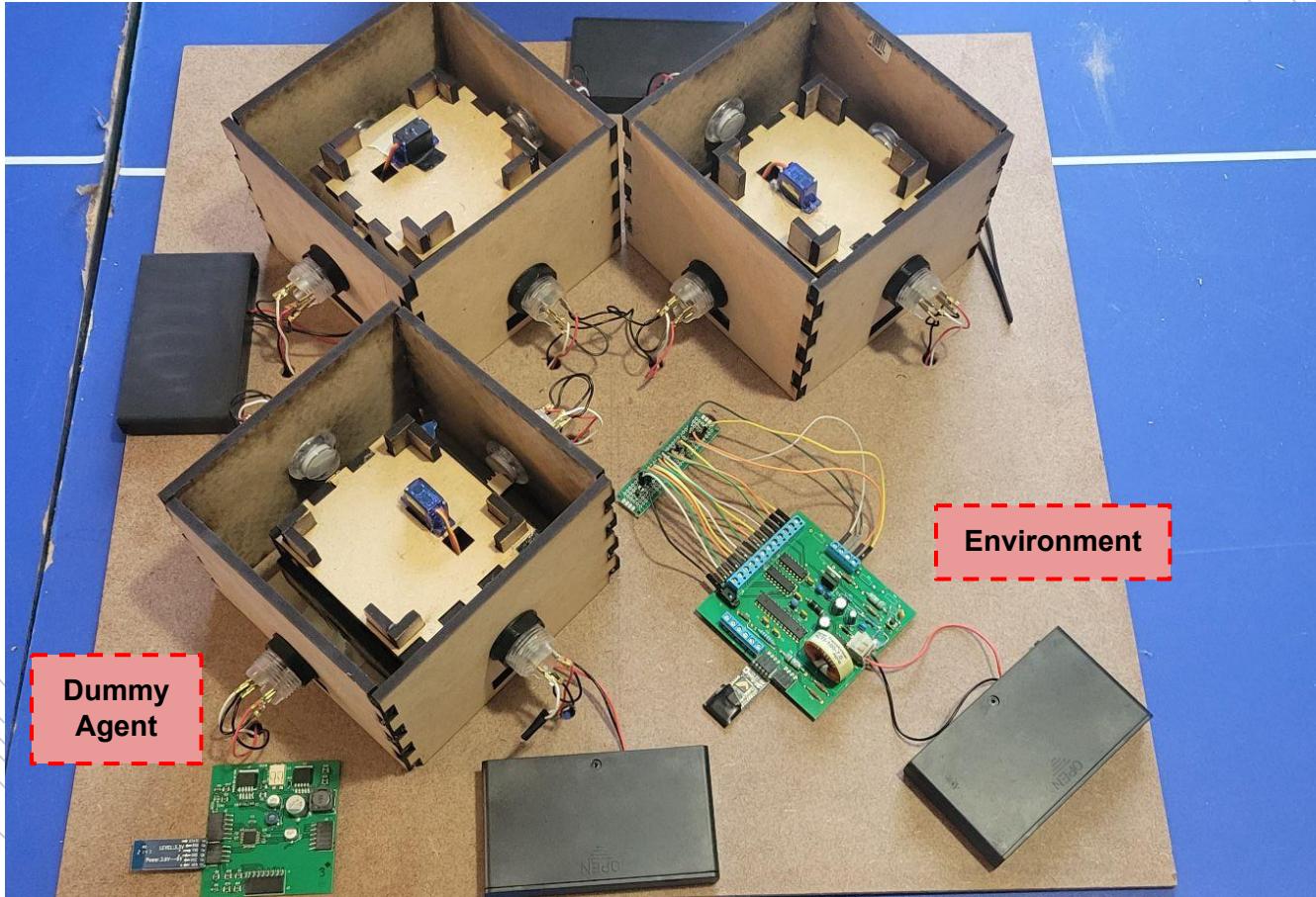
Proposed Solution

- Project Summary
 - 3 Main Components
 - Commander
 - Dummies
 - Environment
 - Assumptions
 - Uniform sensor noise
 - Single observations
 - Discreteness
 - Unlimited resources
 - “Secret Simon Says”

Sample Visualization



Finalized Visualization



Requirement Specifications

| # | Requirement | Specification | Status |
|---|--|------------------|--------|
| 1 | Episode length should scale linearly | 30 sec. per room | |
| 2 | Sufficiently small project dimensions | 2.5 x 2.5ft. | |
| 3 | Efficient environmental materials usage | < 6ft^2 per room | |
| 4 | Dummy Agents should function for sufficient time to conduct learning process | 2 Hrs. | |
| 5 | Environment runtime should exceed dummy agent runtime | > 2 Hrs. | |
| 6 | Affordable project budget scaled to room number | < \$500 | |
| 7 | Project should have enough rooms to demonstrate collaborative learning | > 2 rooms | |
| 8 | Project should display significant learning | 50 Episodes | |

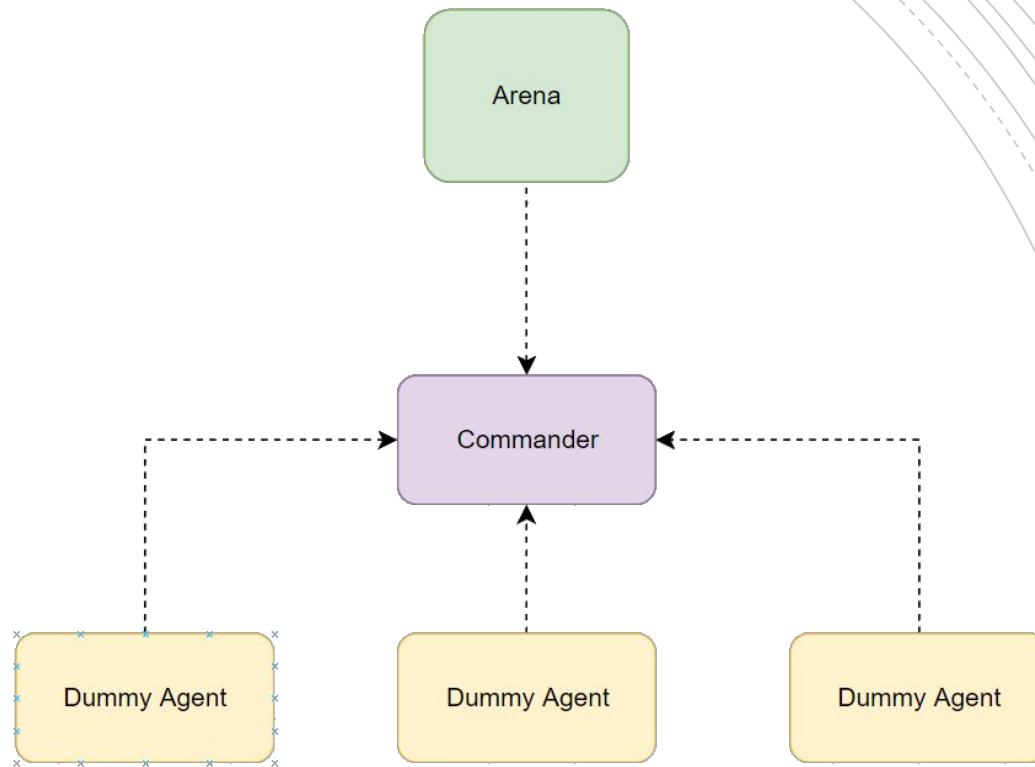


The background features a central blue circle containing the text "Commander Agent". This central circle is surrounded by several concentric, semi-transparent circles in shades of light blue and white. The entire composition is set against a dark gray background with faint, curved, dashed gray lines that resemble architectural or technical drawings.

**Commander
Agent**

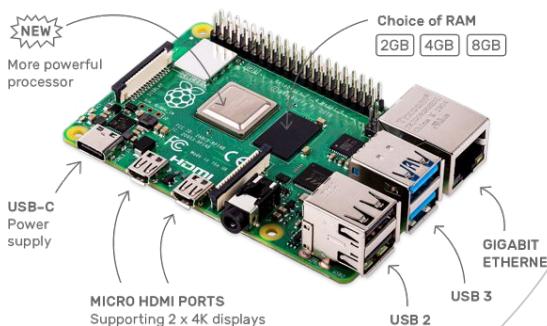
Purpose

- Central Learning Agent
 - Model-free Q-learning
- Receives inputs from dummy agent
 - Processes observations
 - Communicates optimized decisions to the dummy agent
- Receives inputs from environment
 - Process rewards for later optimization
 - Learns from environment

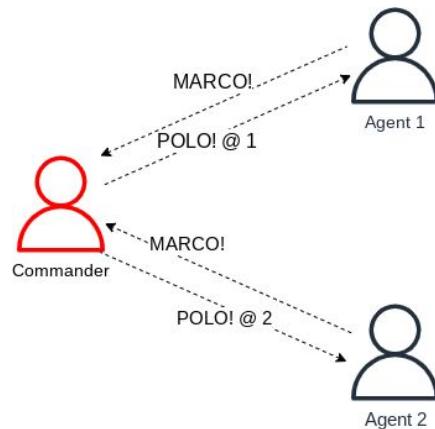


Hardware Decisions

| MCU | RPi 4+B | RPi 3 | Jetson Nano |
|---|-------------|---------------|-------------|
| Price | \$75 | \$30 | \$99 |
| Packaged Wireless Communication Protocols | BT5 + Wi-Fi | BT4.2 + Wi-Fi | None |
| RAM | 8 GB DDR4 | 1 GB DDR2 | 4 GB DDR 4 |
| Prior Experience | Good | Good | None |

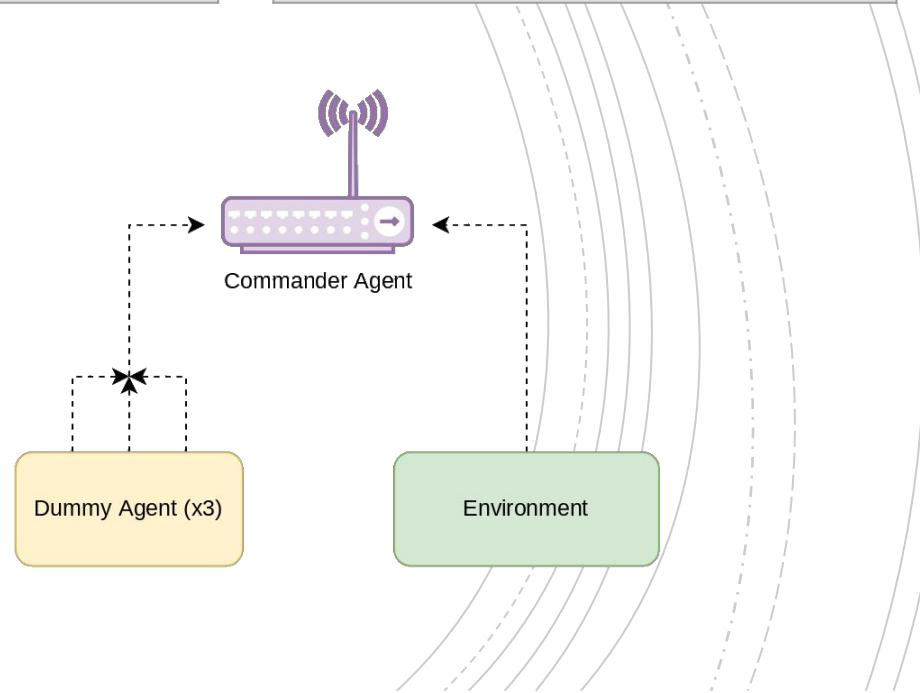


Software Decisions



- ## Python
- Library availability
 - NumPy
 - Math
 - Familiarity

- ## Bluetooth instead of Wifi
- Short communication range
 - Cost tradeoff
 - Network Ability



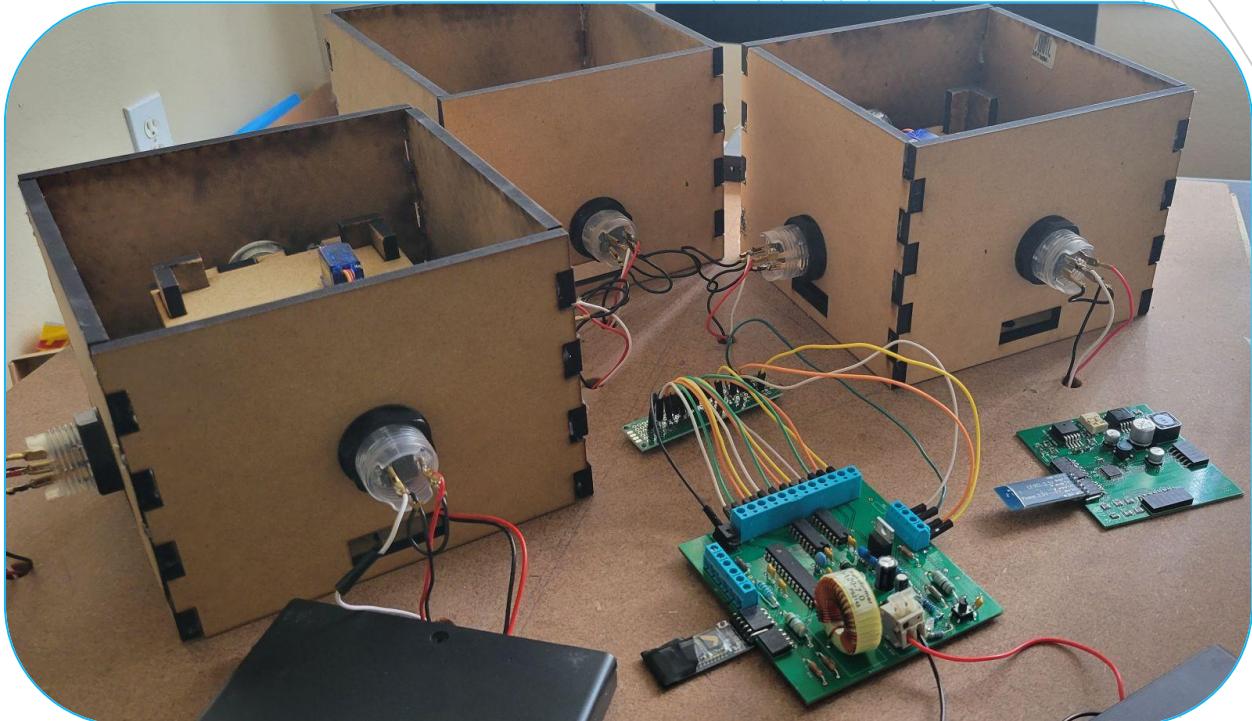
Environment System

Purpose

- Physical interface to simulate environment
- Reward Assignment
 - Omnipotent
- Presents Slipperiness
 - Things can happen even if they aren't supposed to
 - Affects learning rate
- Modular relative to dummy agents

Environment Physical Design

- Key Design Features
 - Anti-interference positioning
 - Button positioning for servo efficiency



Environment Hardware Components

Components List

MCU: ATMEGA168A-PU

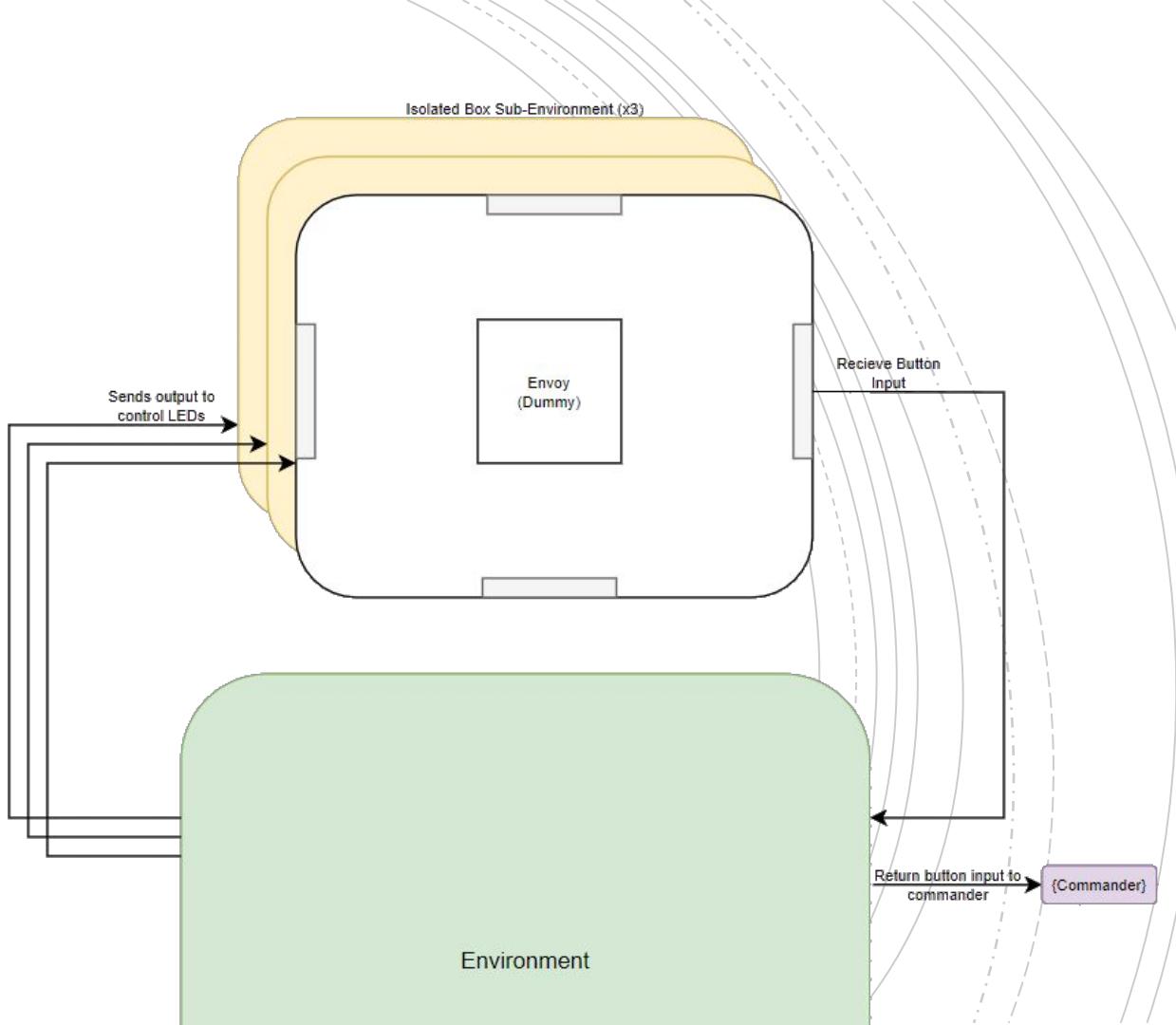
Bluetooth Module: HC-05

VR(s): Buck/Boost and Linear

Power Supply: 8AA Pack

Interface: 12 Adafruit LED Buttons

Board Type: Throughhole



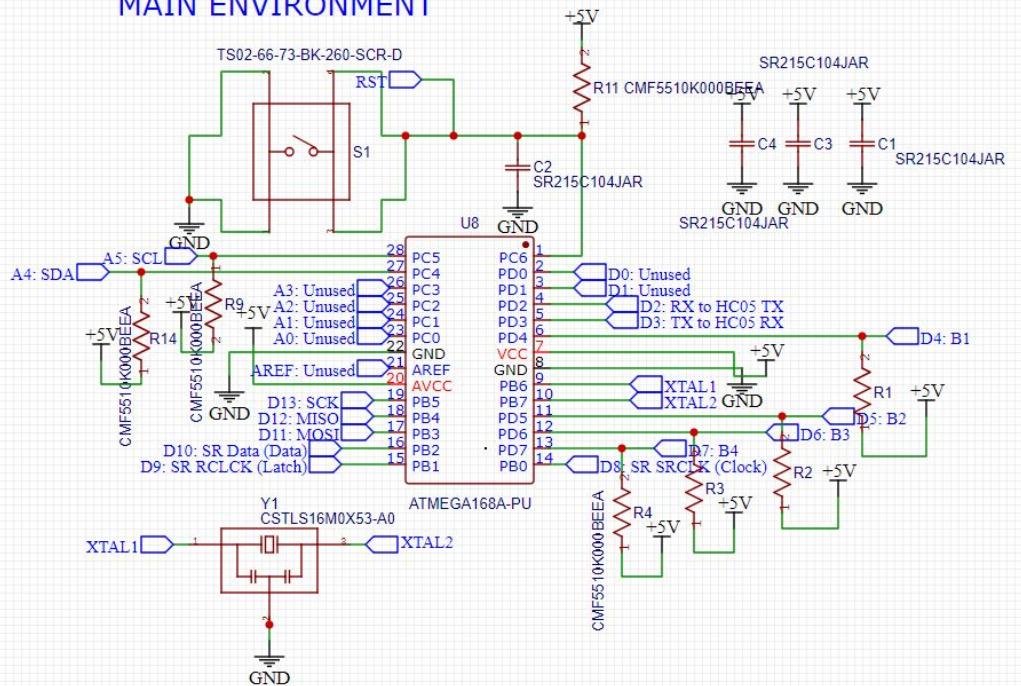
MCU: ATMEGA168A-PU

Purpose: Integrated with Environment's components, which includes the LED buttons and Bluetooth.

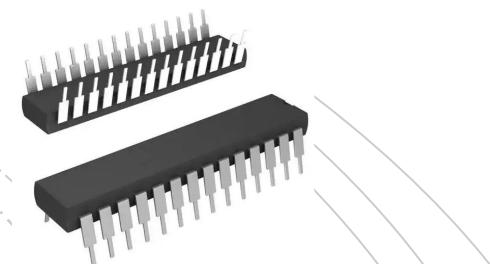
Specifications

| | | | |
|-------------------|------------|--------------|--------|
| Operating Voltage | 1.8V/5.5 V | Flash Memory | 16KB |
| I/O Pins (D/A) | 23 (14/6) | RAM | 1KB |
| Clock Speed | 20MHz | Price | \$2.88 |

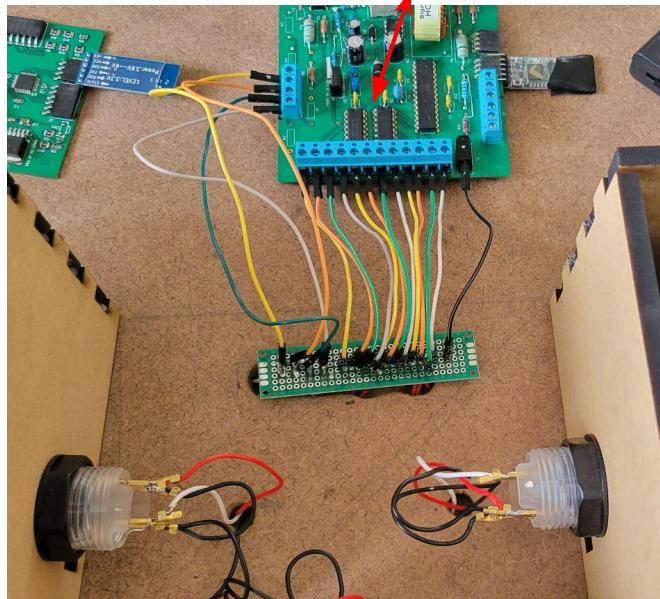
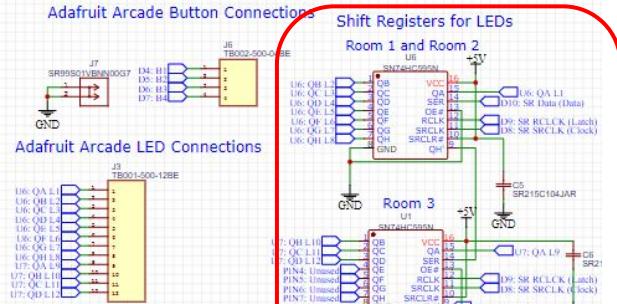
MAIN ENVIRONMENT



Environment MCU



ENVIRONMENT LED/BUTTON SYSTEM



Environment LED Buttons System

Goal: Scalability Considerations

LED SN74HC595 Shift Register:

- Daisy-Chained Design utilized less pins used for multitude of controlled LED outputs
- Capable of 16 buttons (4 rooms) in current iteration.

Parallel Button Detection

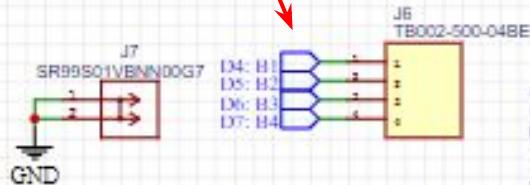
Design:

- Rooms run in sequence to know which button is being pressed
- Possible since only focused on one room at a time.

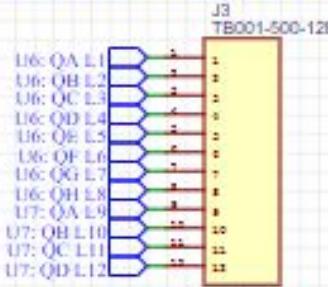
Paralleled Buttons for All Rooms

ENVIRONMENT LED/BUTTON SYSTEM

Adafruit Arcade Button Connections



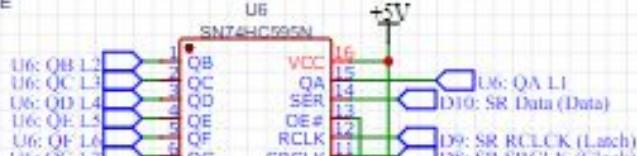
Adafruit Arcade LED Connections



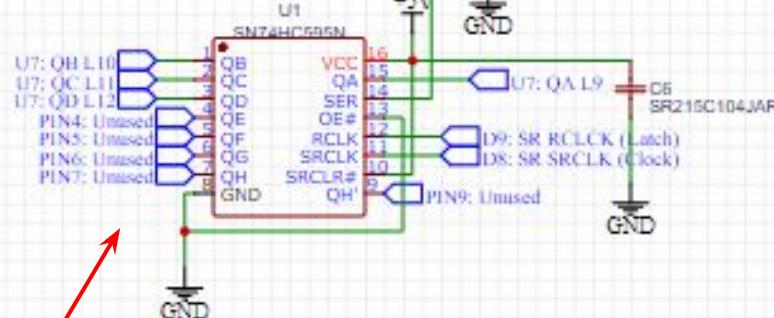
For 3 Rooms

Shift Registers for LEDs

Room 1 and Room 2



Room 3



Shift Registers Daisy-Chained for Serial In/Parallel Out

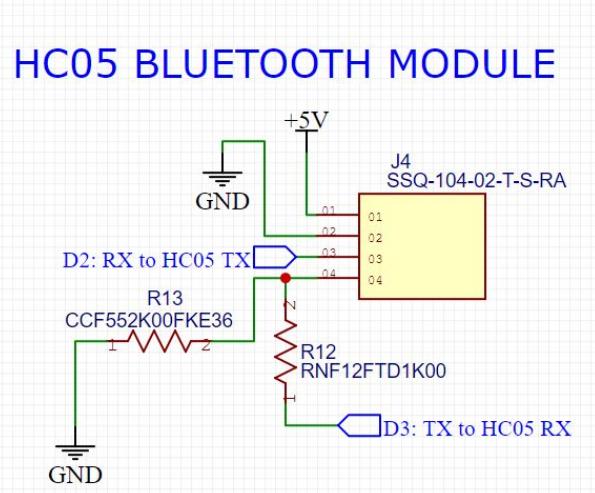
Environment LED Buttons System Focus

Goal: Used to communicate fixed reward that is known by Environment PCB based on room position in game.

HC-05 Module:

Used for reliability and familiarity, as well as cheap and effectiveness

- Serial Communications
- 2.45Hz frequency band
- Master Mode to RPi4.
- Used in Environment and Dummy Agents



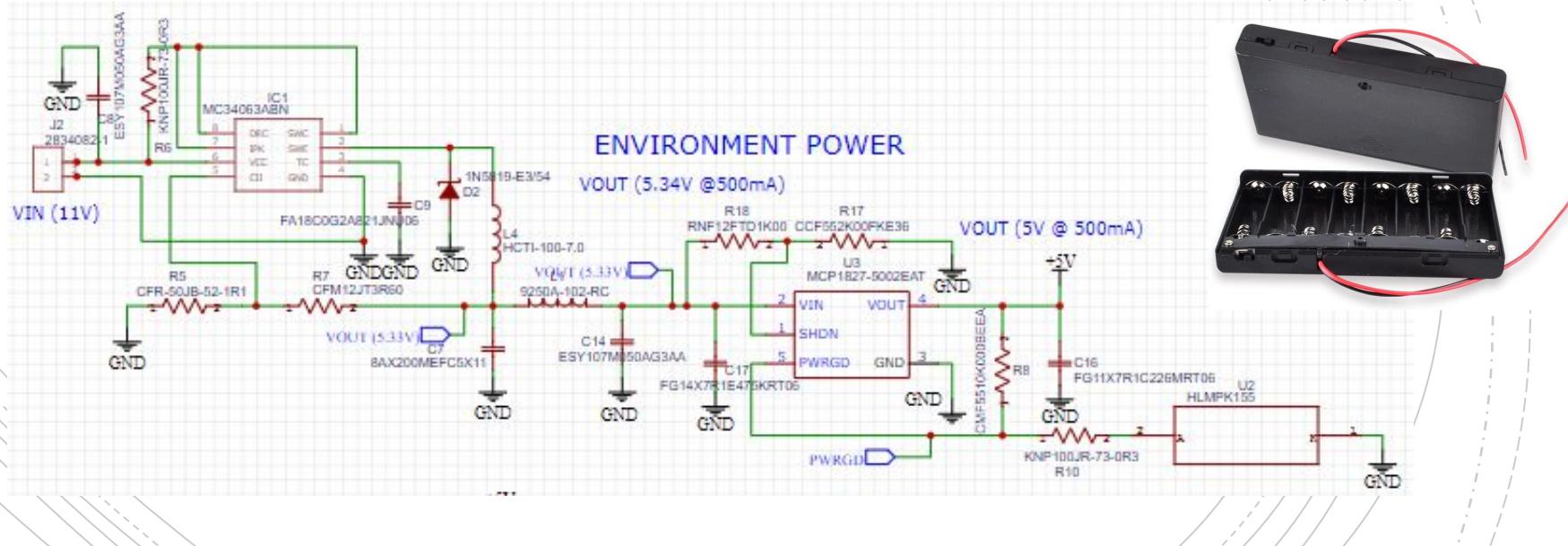
**Environment
Bluetooth
Module**

Environment: Power Supply

Goal: 5V of Output at 500mA

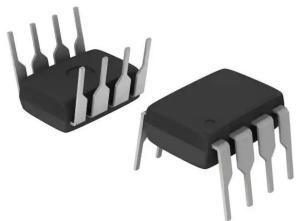
8AA Power Supply: Regulated with Buck/Boost converter in Step-down mode to 5.34V → LDO Linear VR to 5V at 500mA

- Pre-signal processes include the HC-05 (5V-30mA)
- Post signal processes include the LED buttons (5V-40mA), and MCU (5V-50mA)
- Used 8 Ni-MH Rechargeable AA Batteries at 2200mAH



MC34063ABN:

- Step-down 11V to 5.34 V
- Buck/Boost



MCP1827-5002E/AT:

- Drops 5.34V to 5V
- LDO Linear VR

Voltage regulation from LVR frequency regulation produces a clean signal and with a reduced noise due to PSRR matching

Prevents over-voltage

Difficulties:

- New to PCB design
- Difficult to test switching voltage regulator designs
- Finding available small parts to lower costs

Specifications for
MC34063ABN

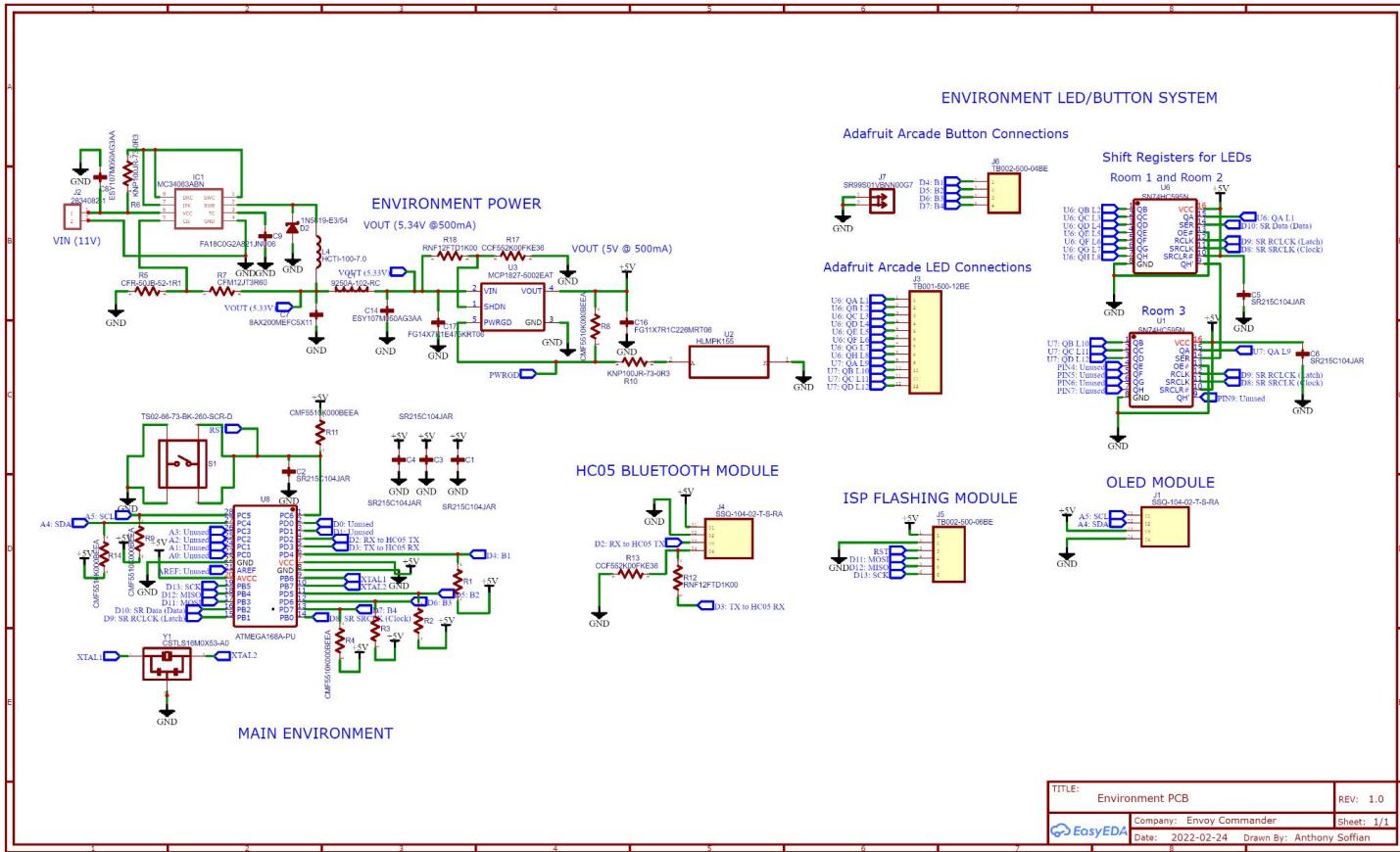
| | |
|-------------------------------|---------------------|
| Min-Max Input Variable Output | 3V/40V 1.25V/38V |
| Max Current Output | 600mA |
| Frequency Switching | 100Hz - 100kHz |
| Quiescent Current | 2.5mA |
| Price | \$0.97 |

Specifications for
MCP1827-5002E/AT

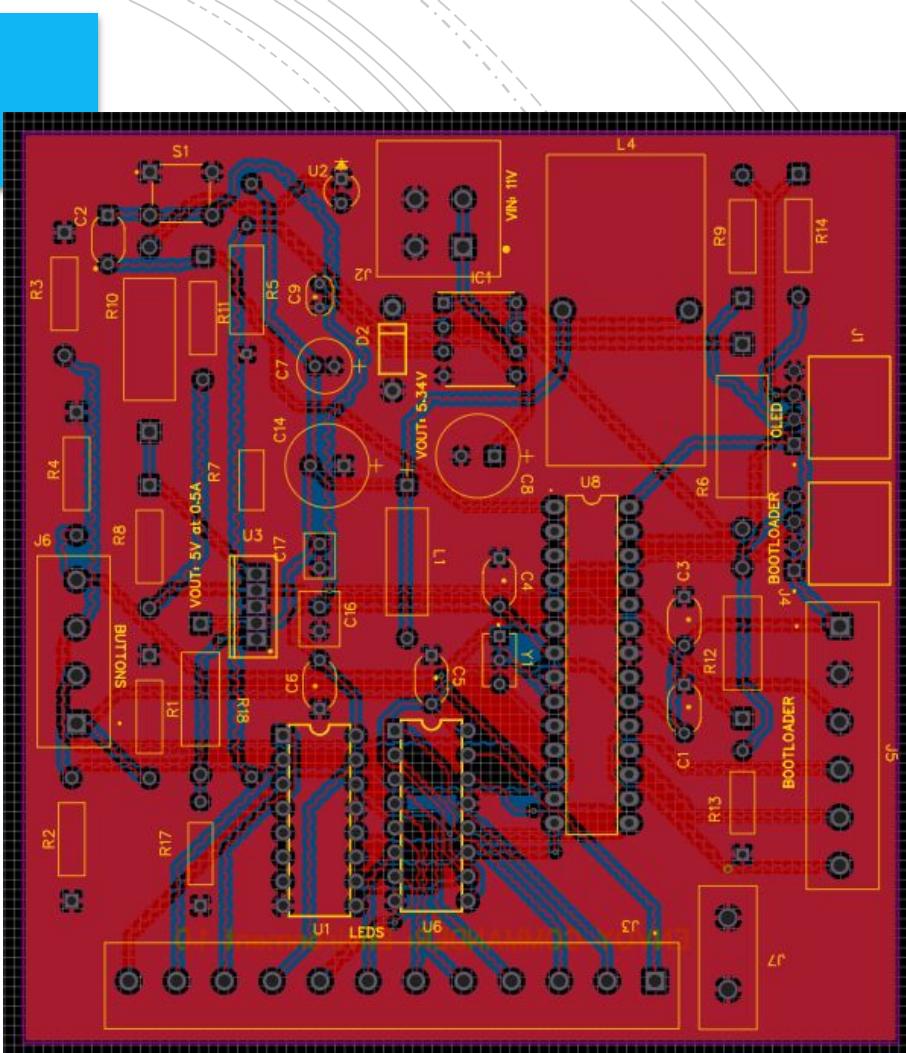
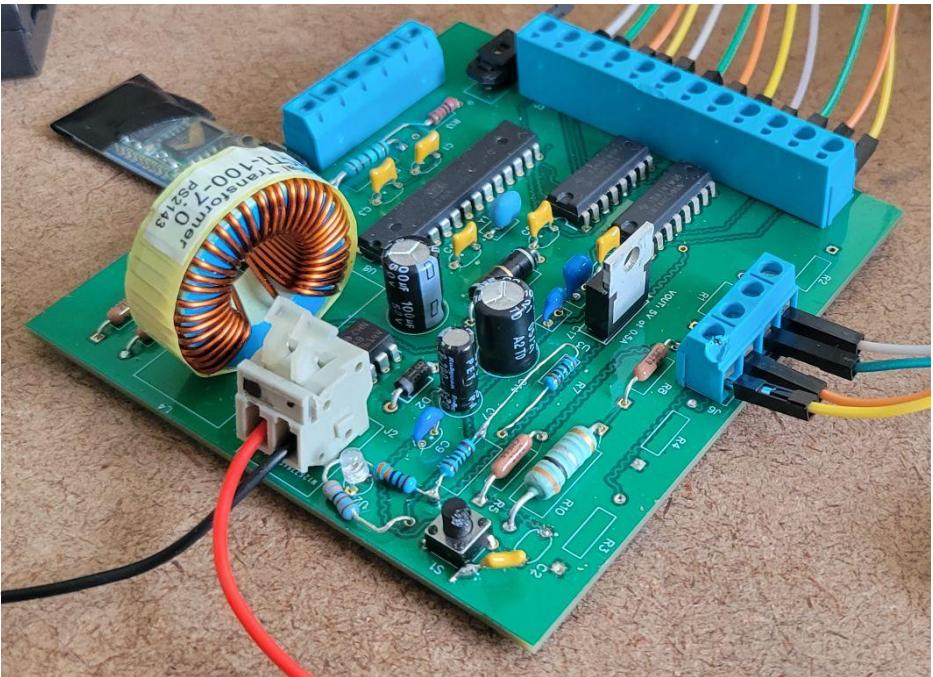
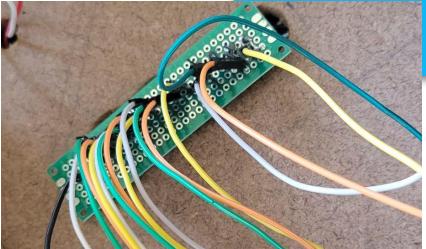
| | |
|----------------------------|---------------------|
| Min-Max Input Fixed Output | 2.3V/6V 5V Fixed |
| Max Current Output | 1.5A |
| Quiescent Current | 220uA |
| PSRR | 60 dB for ~80kHz |
| Price | \$1.47 |

Environment Voltage Regulators

Environment PCB Schematic

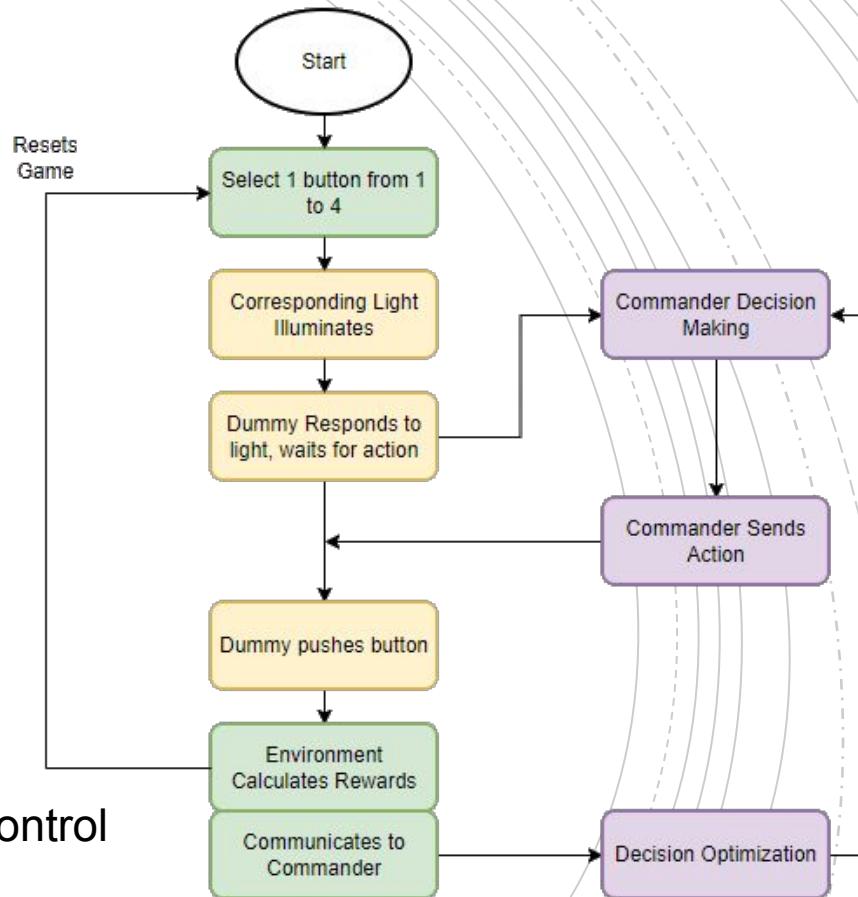


Environment PCB Design



Environment Software Components

- “Secret Simon”
 - $1 \rightarrow 2 \rightarrow 3$
 - Cascading game design
- Benefits
 - Simple and Discrete
 - Linear and Scalable
- Scalable using code and bitshift led control



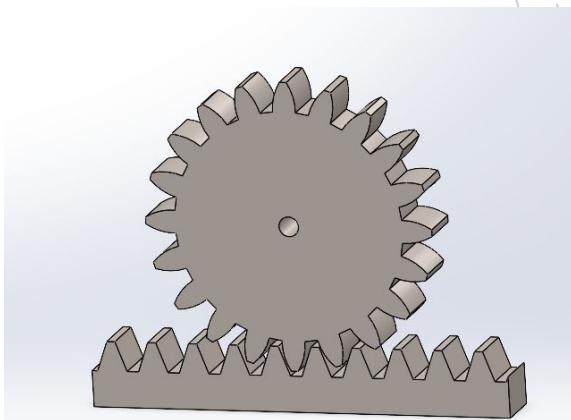
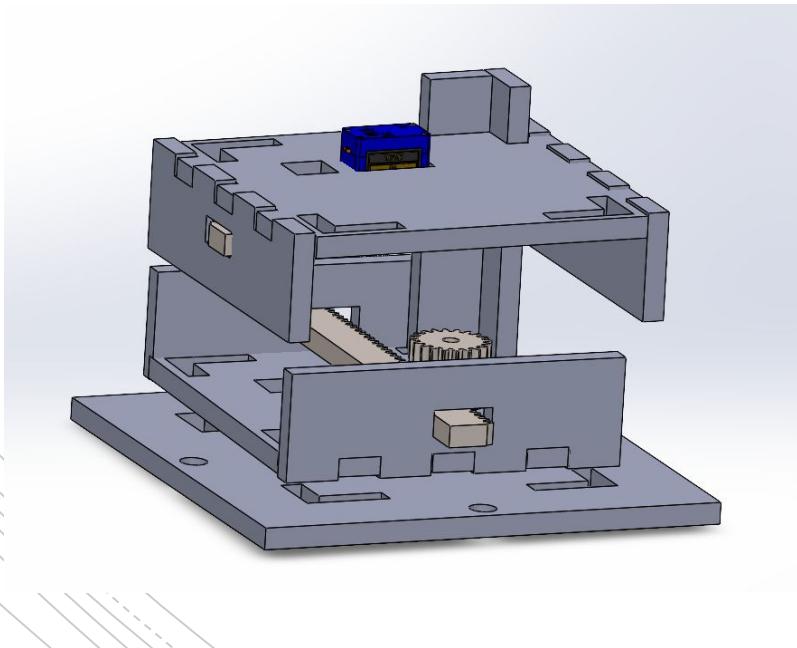
Dummy Agents

Dummy Agents Purpose

- Receive and Execute Commands
- Transmit Observations
- Scalability and Standardized

DA Mechanical Design

- Linear actuators (rack and pinion)
 - Travel distance of 3 inches from center
- 216 in³ constraint (6 inch cube)
- Wood construction to cut costs



DA Hardware Components

Components List

MCU: ATMEGA168PA-AU

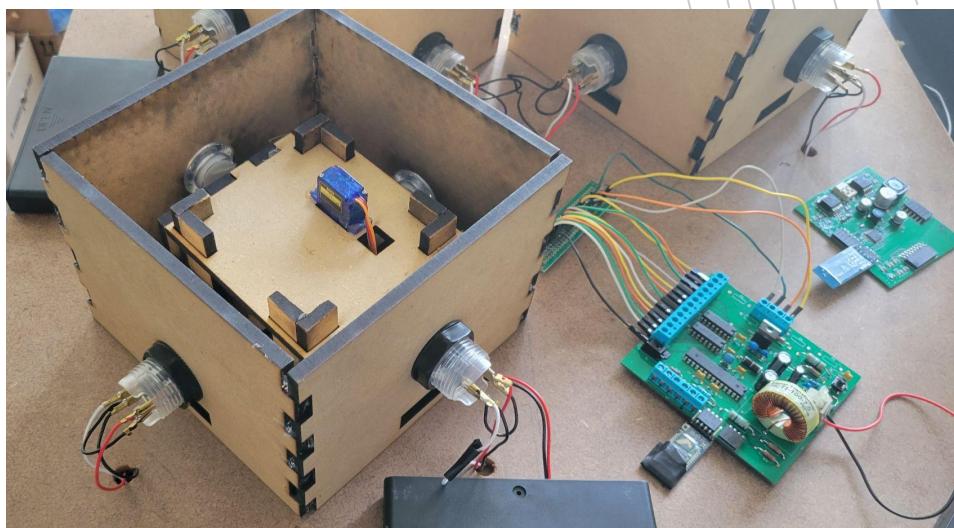
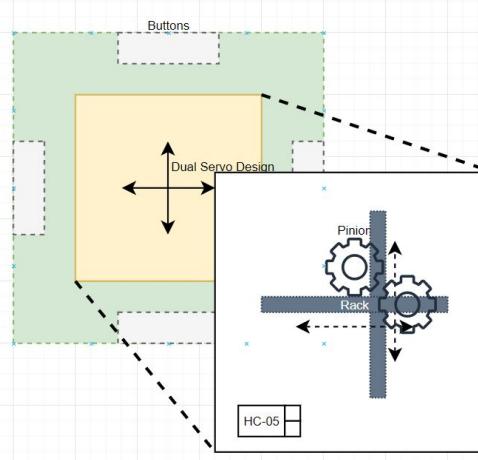
Bluetooth Module: HC-05

VR(s): Buck and Linear

Power Supply: 8AA Pack

Interface: 2 Servos and 4
Photoresistors

Board: SMT for Size Constraints of
Mechanical Design

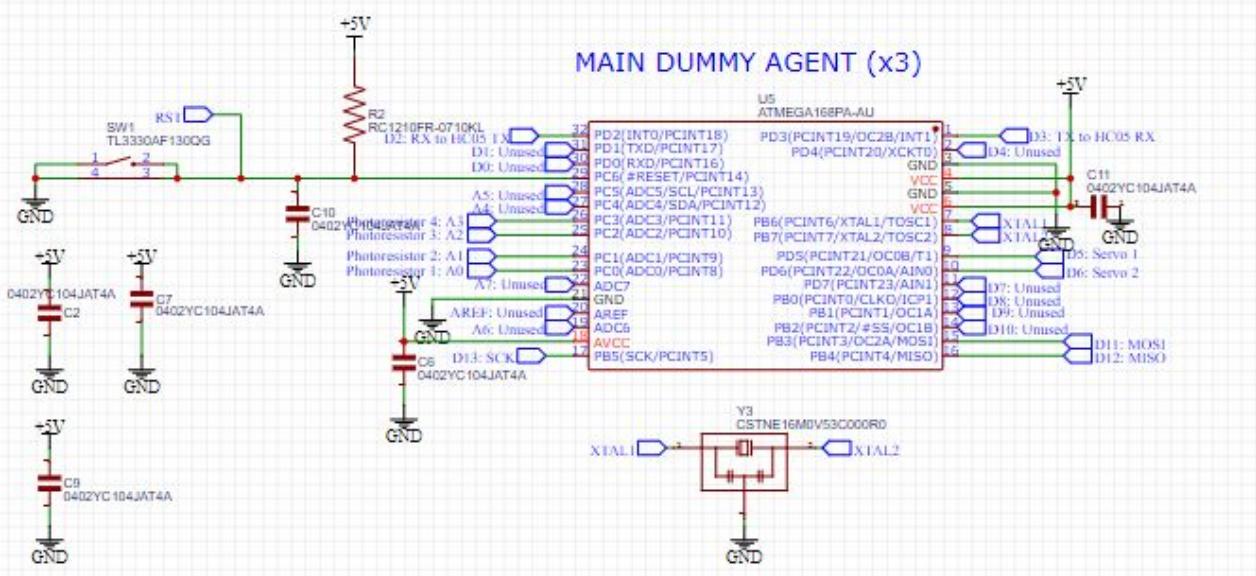


MCU: ATMEGA168PA-AU

Purpose: Same MCU as Environment, but with added features of Servos and Photoresistors and in TQFP package for SMT board.

Specifications

| | | | |
|-------------------|-----------|--------------|--------|
| Operating Voltage | 1.8V/5.5V | Flash Memory | 16KB |
| I/O Pins (D/A) | 20 (14/6) | RAM | 1KB |
| Clock Speed | 20MHz | Price | \$2.05 |

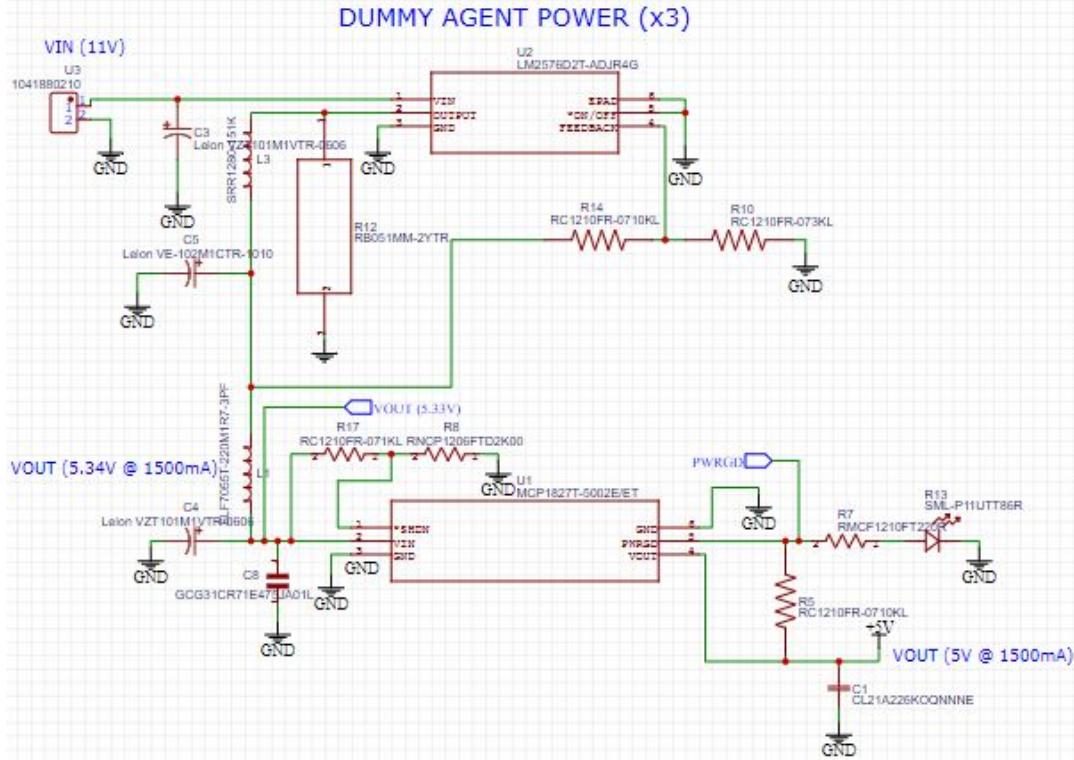


DA: Power Supply

Goal: 5V of Output at 1500mA

8AA Power Supply: Regulated with Buck converter to 5.34V → LDO Linear VR to 5V at 1500mA

- Pre-signal processes include the HC-05 (5V-30mA) and 4 GL5549 Photoresistors to sense Environment
- Post signal processes include the 2 SG90 9g Micro Servos (5V/1.3A in Standby mode)
- Used 8 Ni-MH Rechargeable AA Batteries at 2200mAH



LM2576D2T-ADJR4G:

- Step-down 11V to 5.34V
- Higher Current Buck



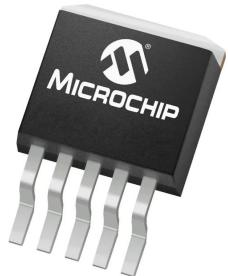
MCP1827T-5002E/ET:

- Drops 5.34V to 5V
- LDO Linear VR

Same Switching regulator and LDO Linear VR combination idea to produce clean 5V at a higher current supply of 1.5A.

Difficulties:

- Fitting Ind/Caps into Size Constraints led to Increase in Voltage Supply at 1.5A.



Specifications for
LM2576D2T-ADJR4G

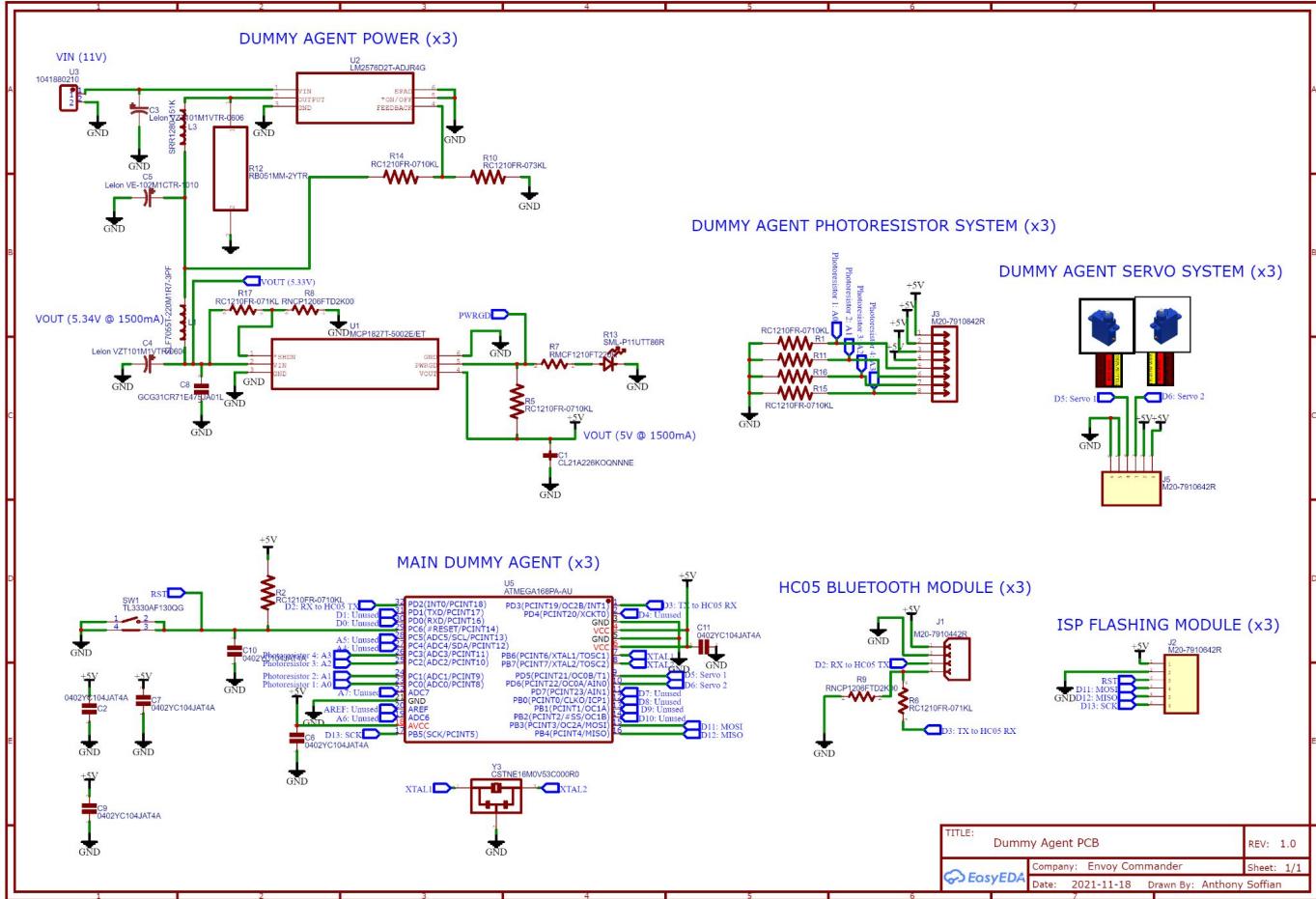
| | |
|-------------------------------|---------------------|
| Min V _{d0} | 2.3V |
| Min-Max Input Variable Output | 3V/40V 1.23V/37V |
| Max Current Output | 3A |
| Frequency Switching | 52kHz |
| Quiescent Current | 16mA |
| Price | \$2.92 |

Specifications for
MCP1827T-5002E/ET

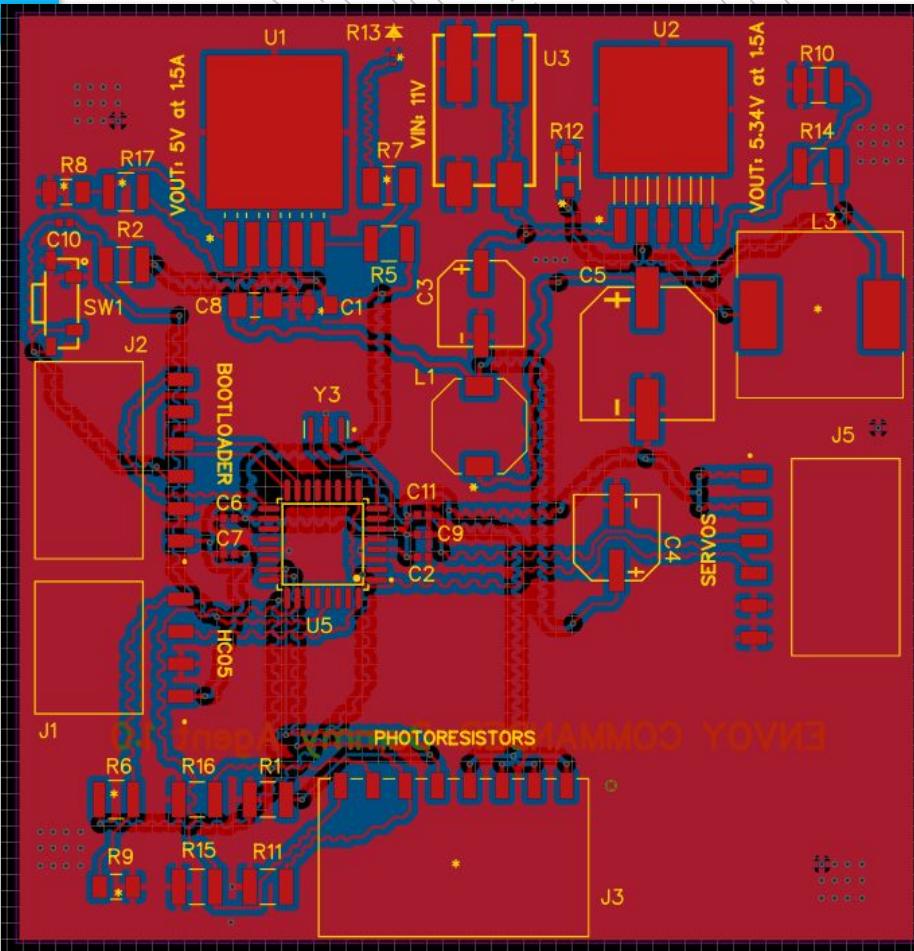
| | |
|----------------------------|---------------------|
| Typical Dropout Voltage | 330mV |
| Min-Max Input Fixed Output | 2.3V/6V 5V Fixed |
| Max Current Output | 1.5A |
| Quiescent Current | 220uA |
| PSRR | 60 dB for ~80kHz |
| Price | \$1.71 |

DA Voltage Regulators

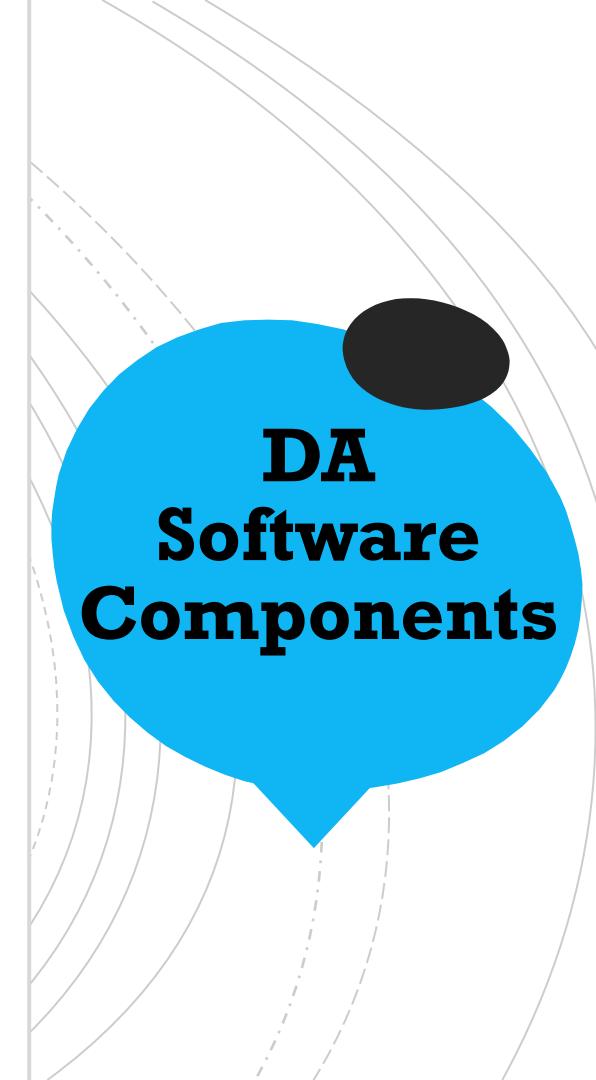
DA PCB Schematic



DA PCB Design



- Simple functionality to maintain scalability
 - Transmit Observations
 - Receive Command, Execute



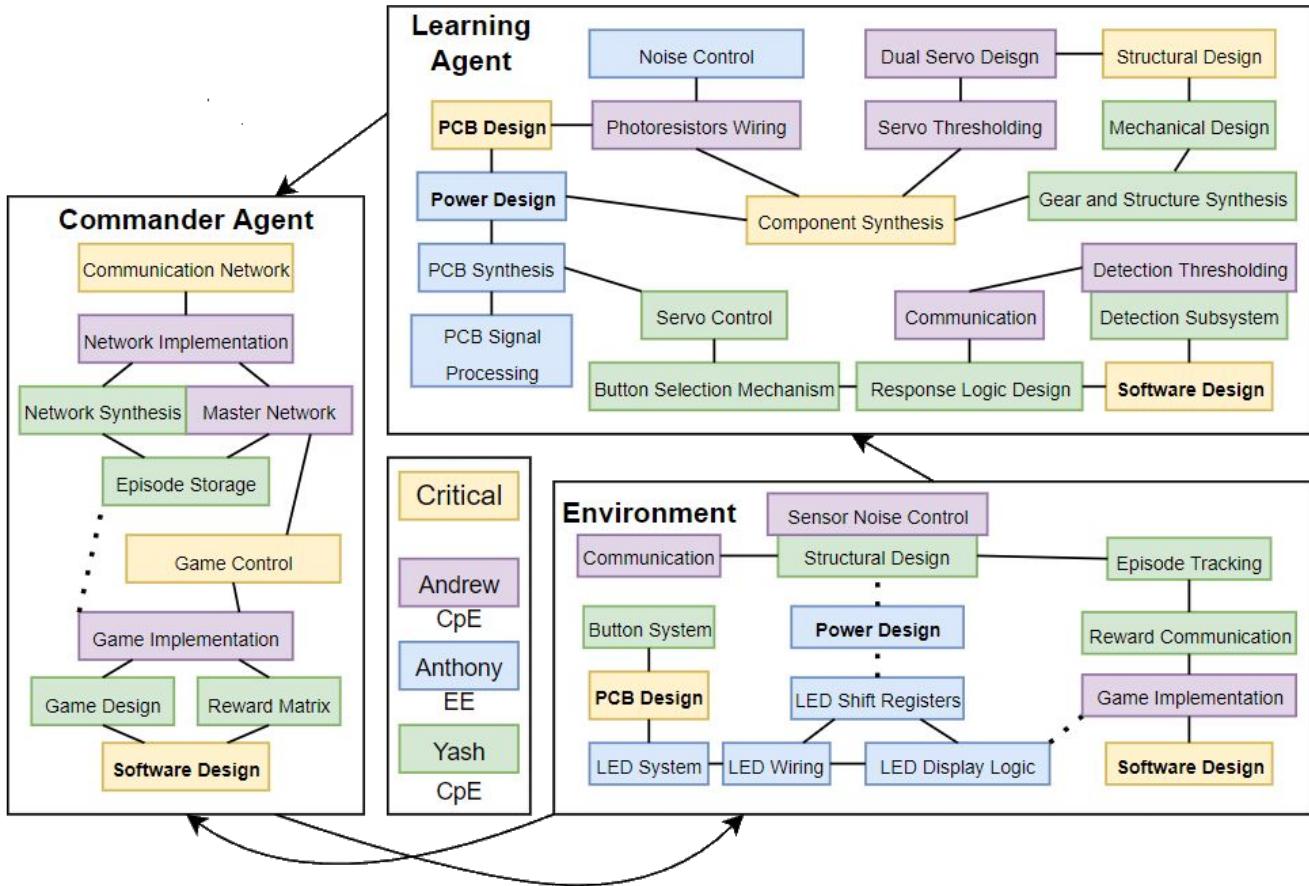
DA Software Components

Administrative Content

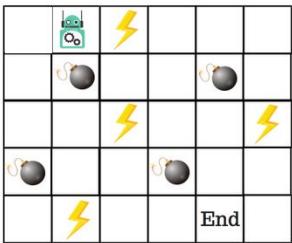
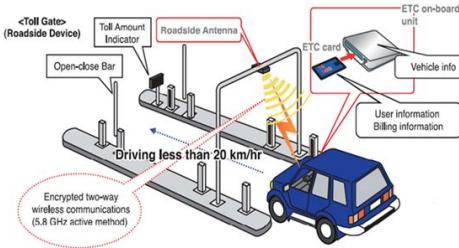
| Description | Price |
|---|-----------|
| Raspberry Pi Model 4 | \$75.00 |
| MCU (10) | \$40.00 |
| SG90 servos (6) | \$12.00 |
| HC05 Modules (10) | \$40.00 |
| Arduino Nano Development Boards (6) | \$36.00 |
| Project Wood | \$16.00 |
| Misc. Components (IC's, Material, etc.) | \$107.00 |
| TH/SMT PCB(s) and Stencil Orders | \$124.00 |
| Adafruit Button Set | \$27.00 |
| Current Total | \$477.00 |
| Estimated Total | ~\$500.00 |

Budget

Work Distributions



Initial Design Difficulties



| Actions : | | ↑ | → | ↓ | ← | |
|-----------------|--|-------|---|---|---|---|
| | | Start | 0 | 0 | 0 | 0 |
| Nothing / Blank | | 0 | 0 | 0 | 0 | |
| Power | | 0 | 0 | 0 | 0 | |
| Mines | | 0 | 0 | 0 | 0 | |
| END | | 0 | 0 | 0 | 0 | |

- Building the maze
 - How do we track progress in the maze?
 - Toll booth idea
 - Different colors along the way
 - Camera tracking
 - Continuous rewards
 - How large should it be?
- Field Agent movement
 - Can't precisely control movement in maze
 - Communication ranges
 - Sensor noise
 - Power issues
- Too many sub projects, low budget, low time

Final Design Difficulties

- Open Socket Bluetooth server
 - Out of order connection
 - Timeout issues
- Dummy Agent
 - Redesign to have better access to the PCB
 - Standardized power connectors
 - Agent to room ratio
- Power safety features



Remaining Future Steps

- Vary sensor parameters
 - Amount, Fidelity, Type
- Investigate error and uncertainty
- Make other algorithms integratable
- Advanced communication