ENVOY COMMANDER

Group 32

Team Members

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Problem Statement

There are very few collaborative model-free learning algorithms readily accessible for study

- 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

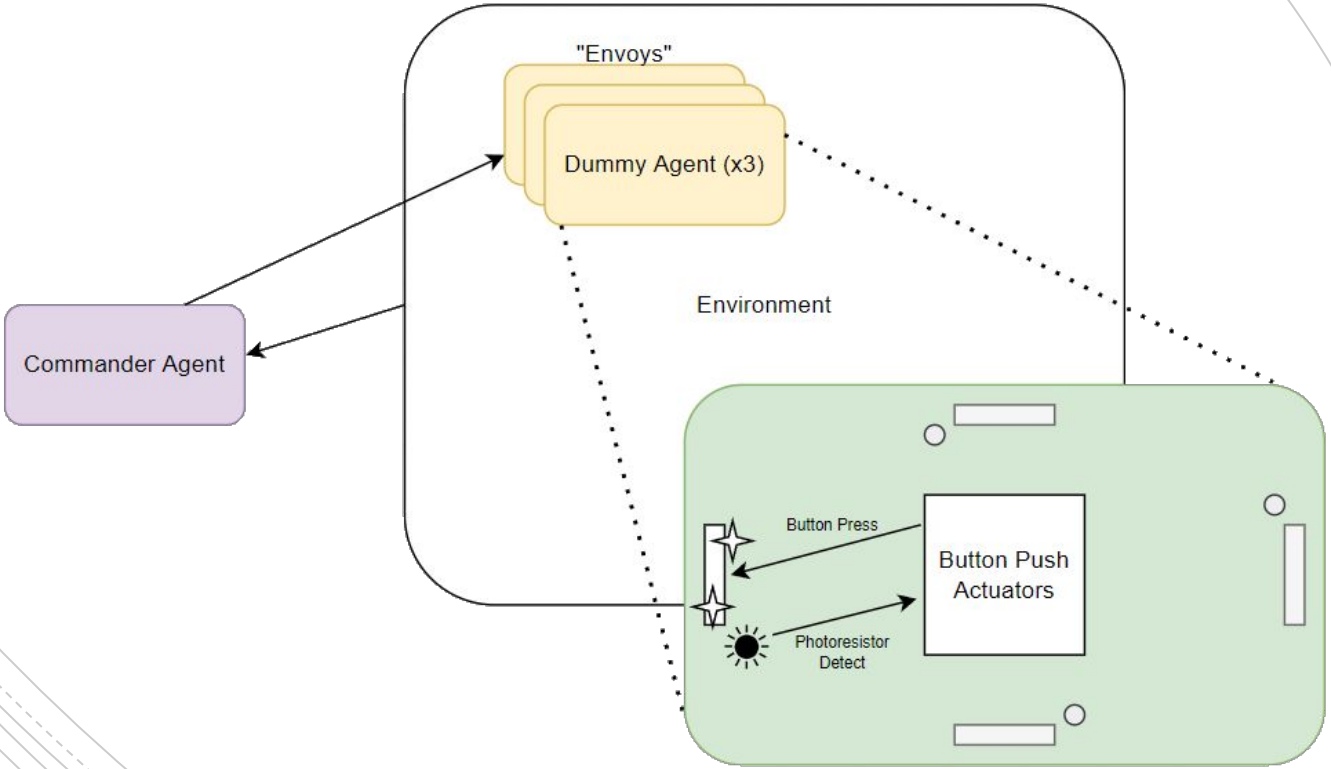
Scalability

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



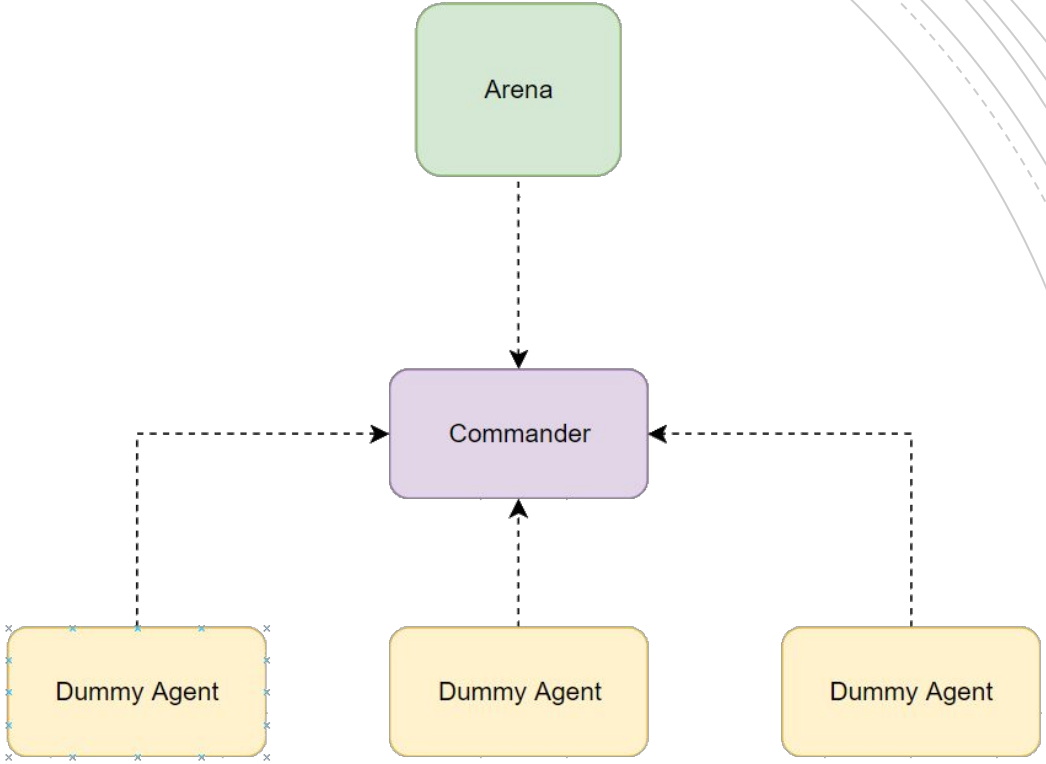
Requirement Specifications

#	Requirement	Specification
1	Episode length should scale linearly	30 sec. per room
2	Sufficiently small project dimensions	3.5 x 3.5ft.
3	Efficient environmental materials usage	< $3ft^2$ 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

Commander Agent

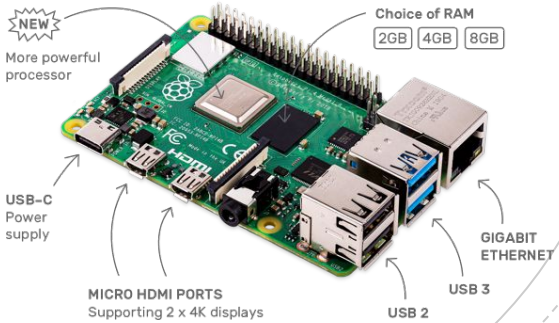
Purpose

- 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


Arena
Commander
Dummy Agent
Dummy Agent
Dummy Agent

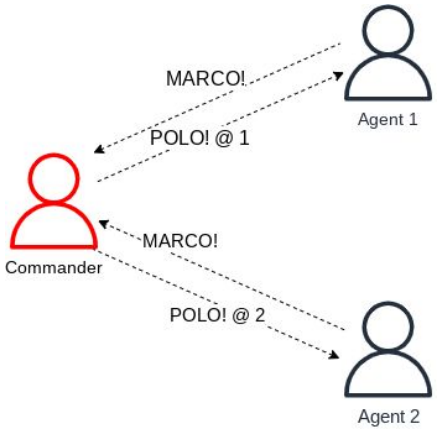
Hardware Decisions

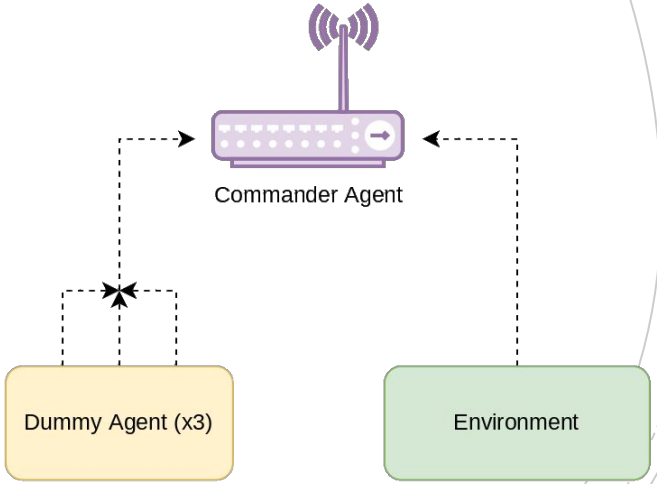
MCU	RPi 4+B	RPi 3	Jetson Nano
Price	$75	$30	$99
Packaged Wireless Communication Protocols	BT5 + Wi-Fi	BT4.2 + Wi-Fi	None
RAM	8 GB DDR4	1 GB DDR2	4 GB DDR 4
Prior Experience	Good	Good	None



Software Decisions

- Python
  - Library availability
    - NumPy
    - Math
  - Familiarity
- Bluetooth vs. Wi-Fi
  - Short communication range
  - Cost tradeoff
  - Network Ability



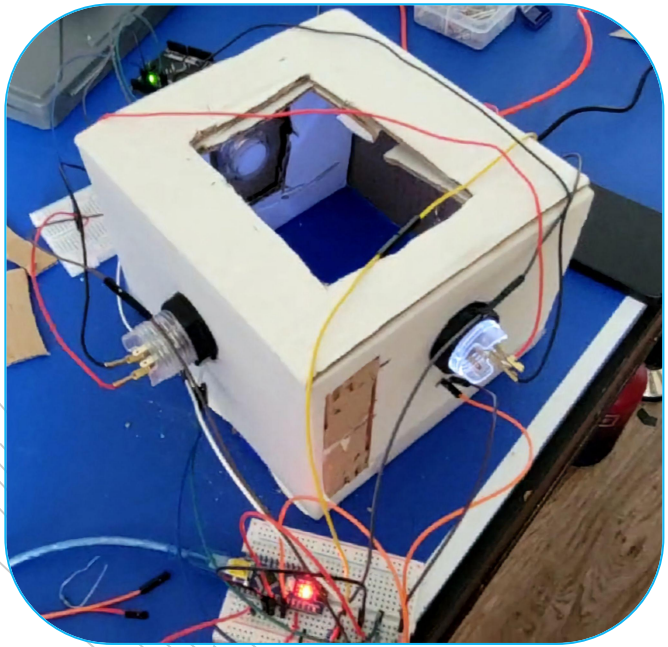


Environment System

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

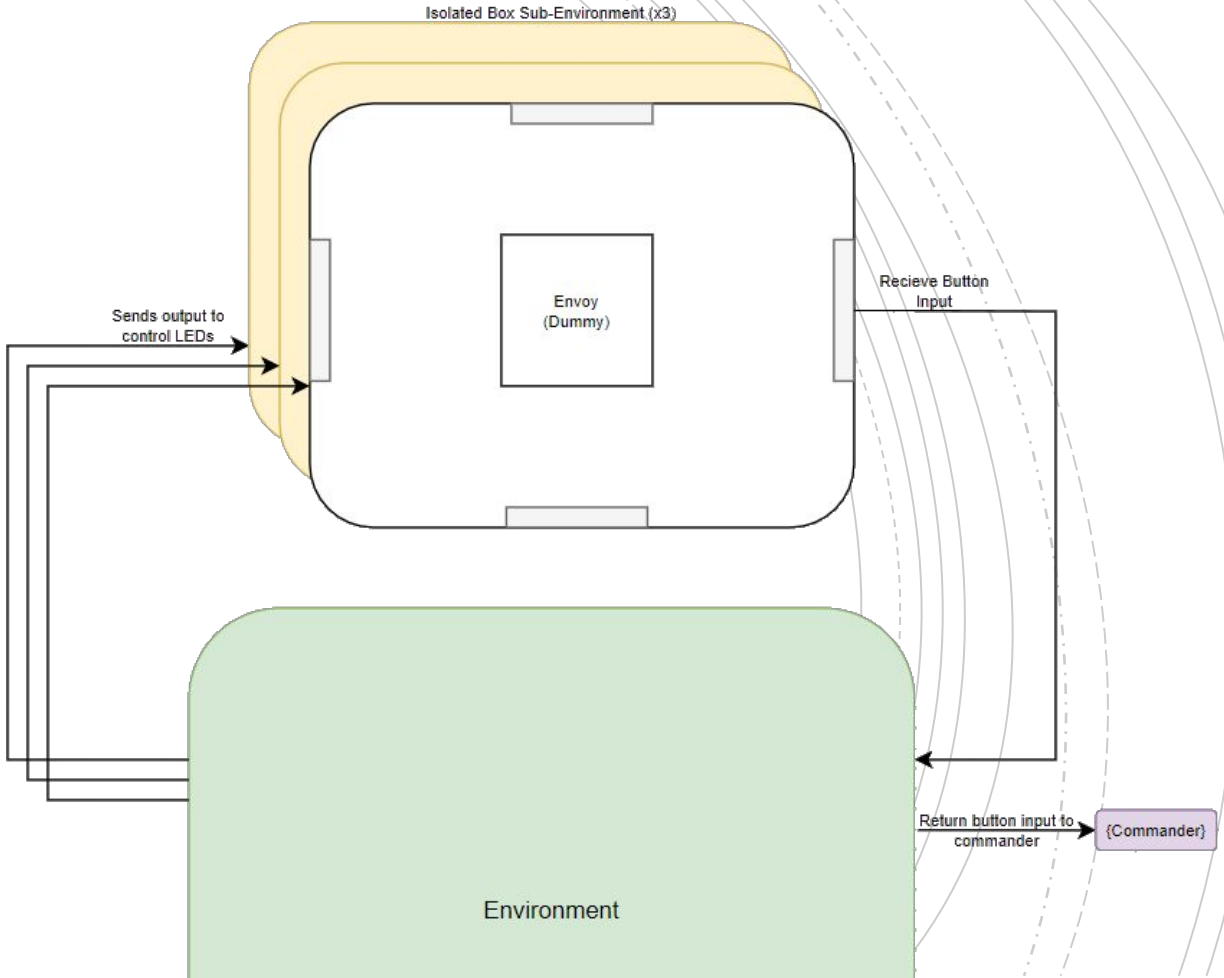


- Key Design Features
  - Anti-interference positioning
  - Button positioning for servo efficiency

Environment Hardware Components

Components List

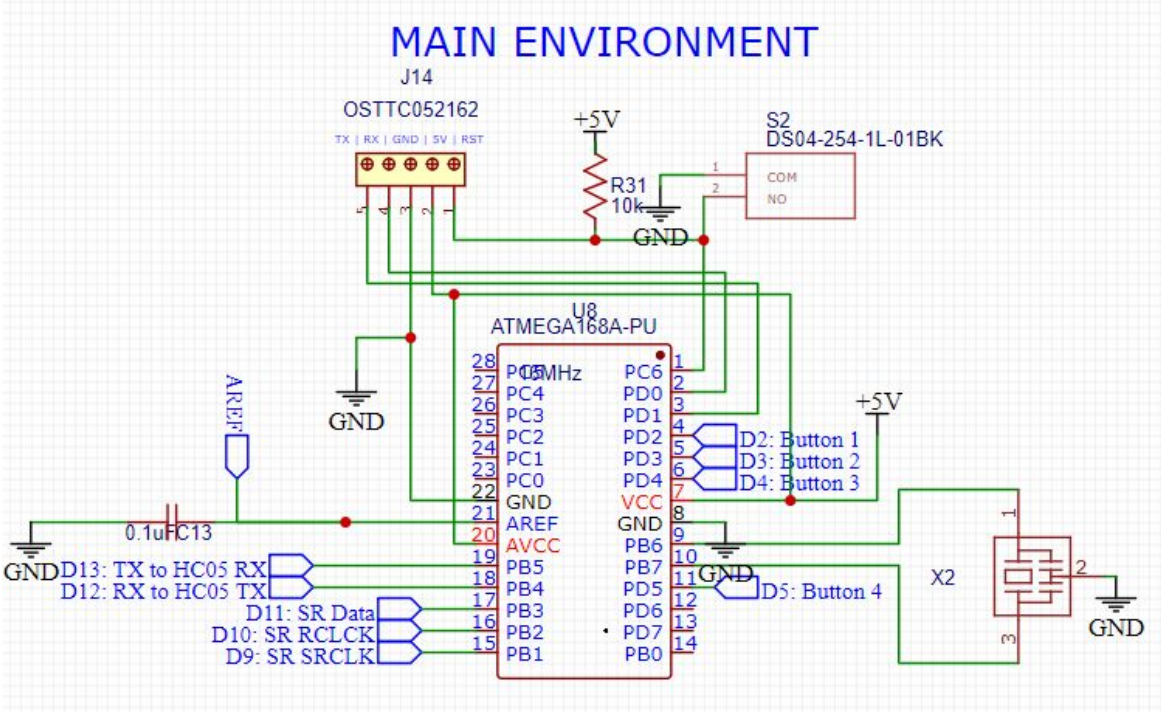
MCU: ATMEGA168A-PU
Bluetooth Module: HC05
VR(s): Buck/Boost and Linear
Power Supply: 3AA/4AA
Interface: 12 Adafruit LED Buttons

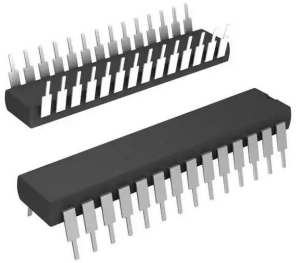


MCU: ATMEGA168A-PU
Purpose: Integrated with Environment's components, which includes the LED buttons and bluetooth.

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





Environment MCU

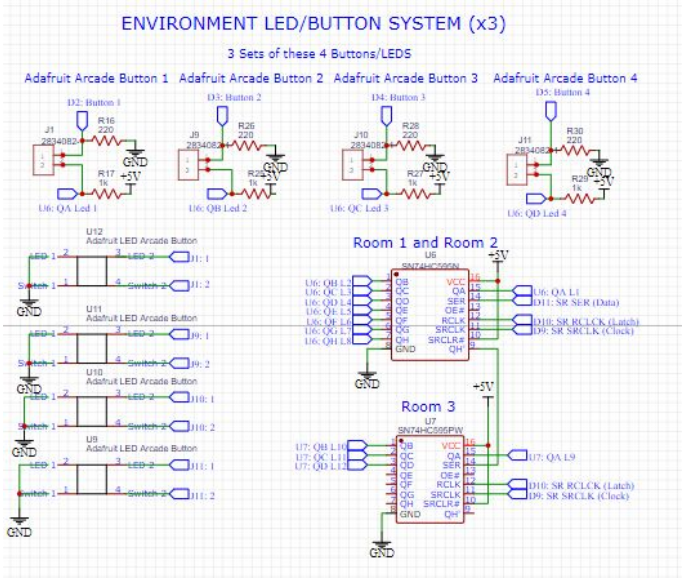
Goal: Scalability Considerations

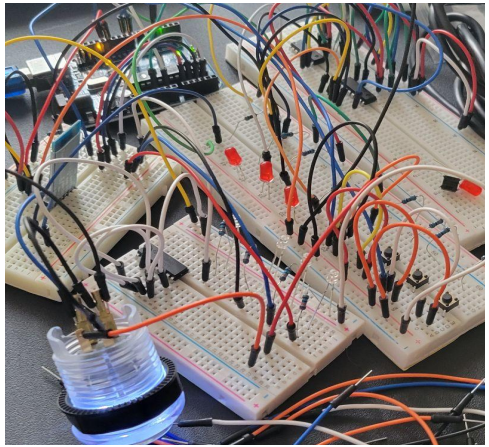
LED SN74HC595 Shift Register:

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

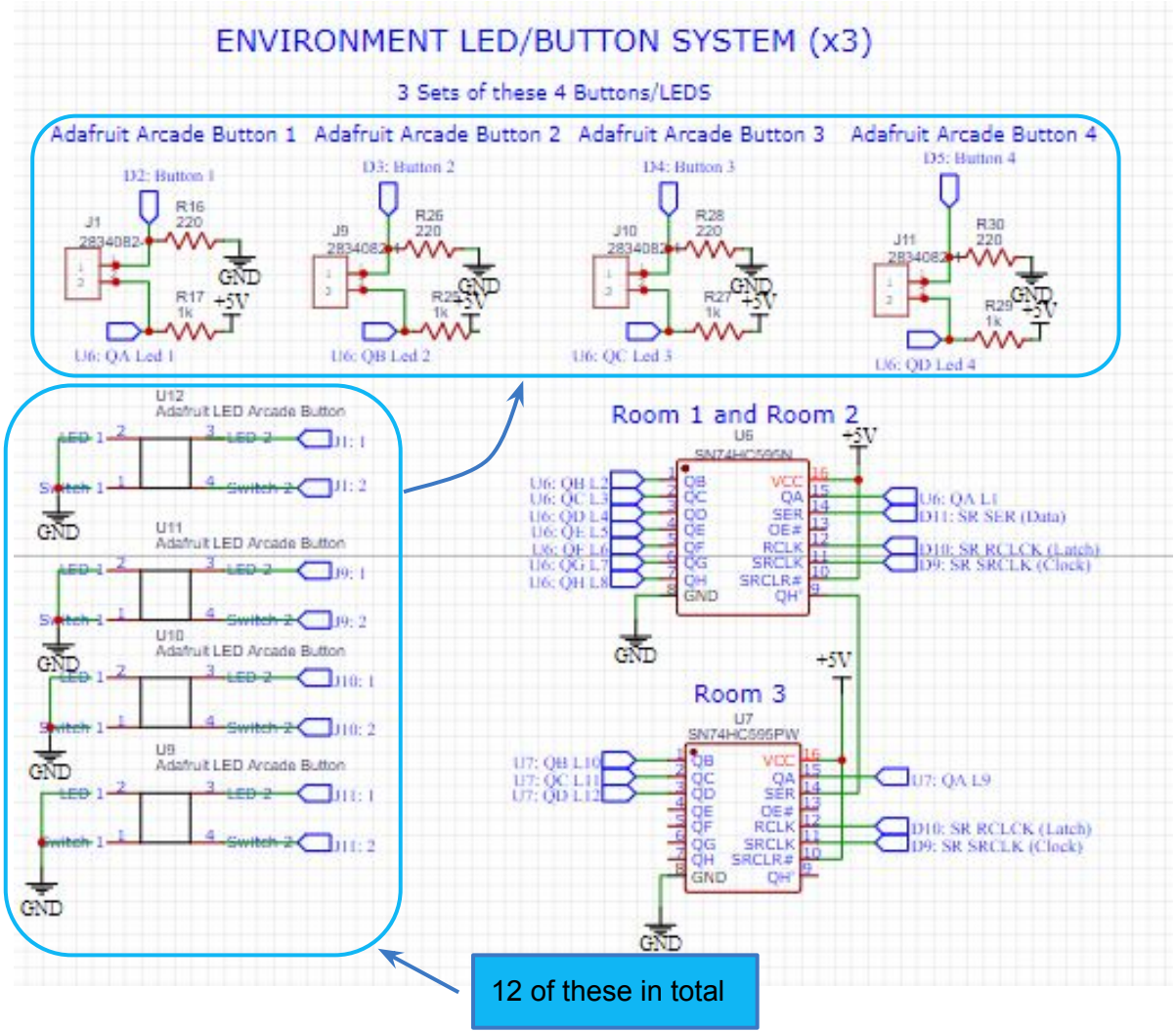
Parallel Button Detection Design:

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





Environment LED Buttons System



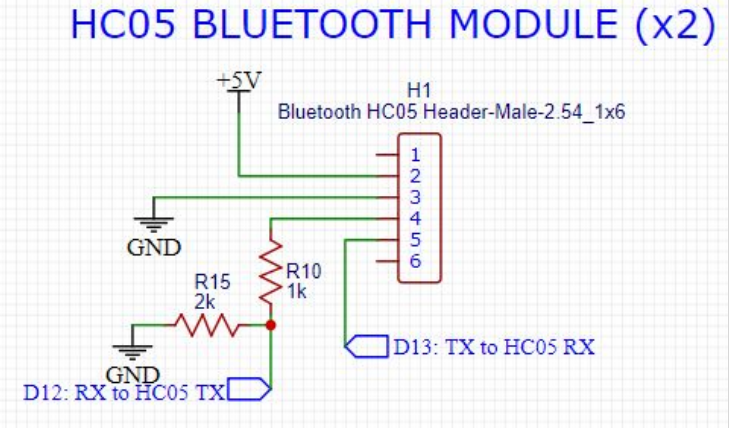
Environment LED Buttons System Focus

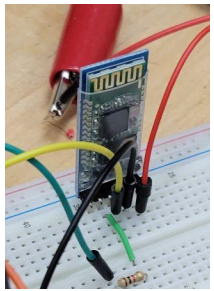
Environment Bluetooth Module

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





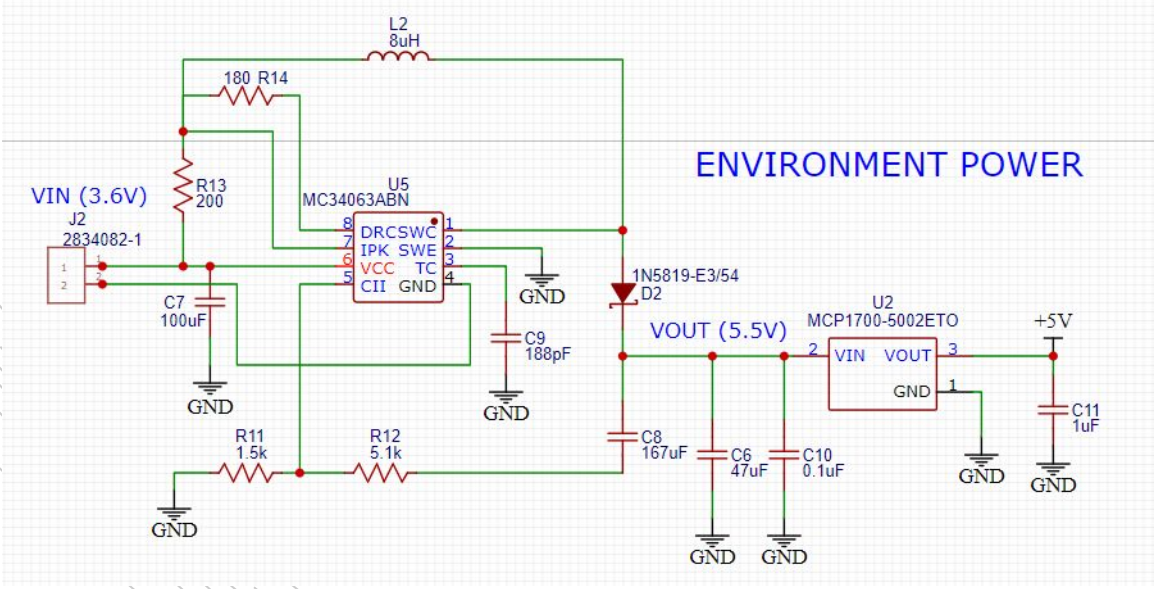
Environment: Power Supply

Goal: 5V of Output at 250mA

3AA Power Supply: Regulated with buck/boost converter to 5.5V → LVR to 5V at 250mA

- Pre-signal processes include the HC-05(5V-30mA)
- Post signal processes include the LED buttons (5V-40mA), and MCU(5V-50mA)

Switch included for battery supply



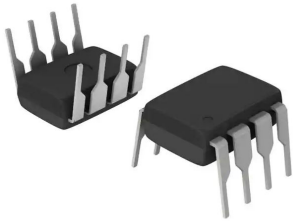
Environment Voltage Regulators

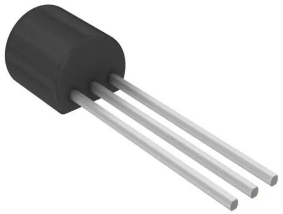
MC34063ABN:

- Raise to 5.5 Volts
- Buck/Boost

MCP1700-5002E:

- Drops Vo to 5V
- LVR





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 voltage regulator designs

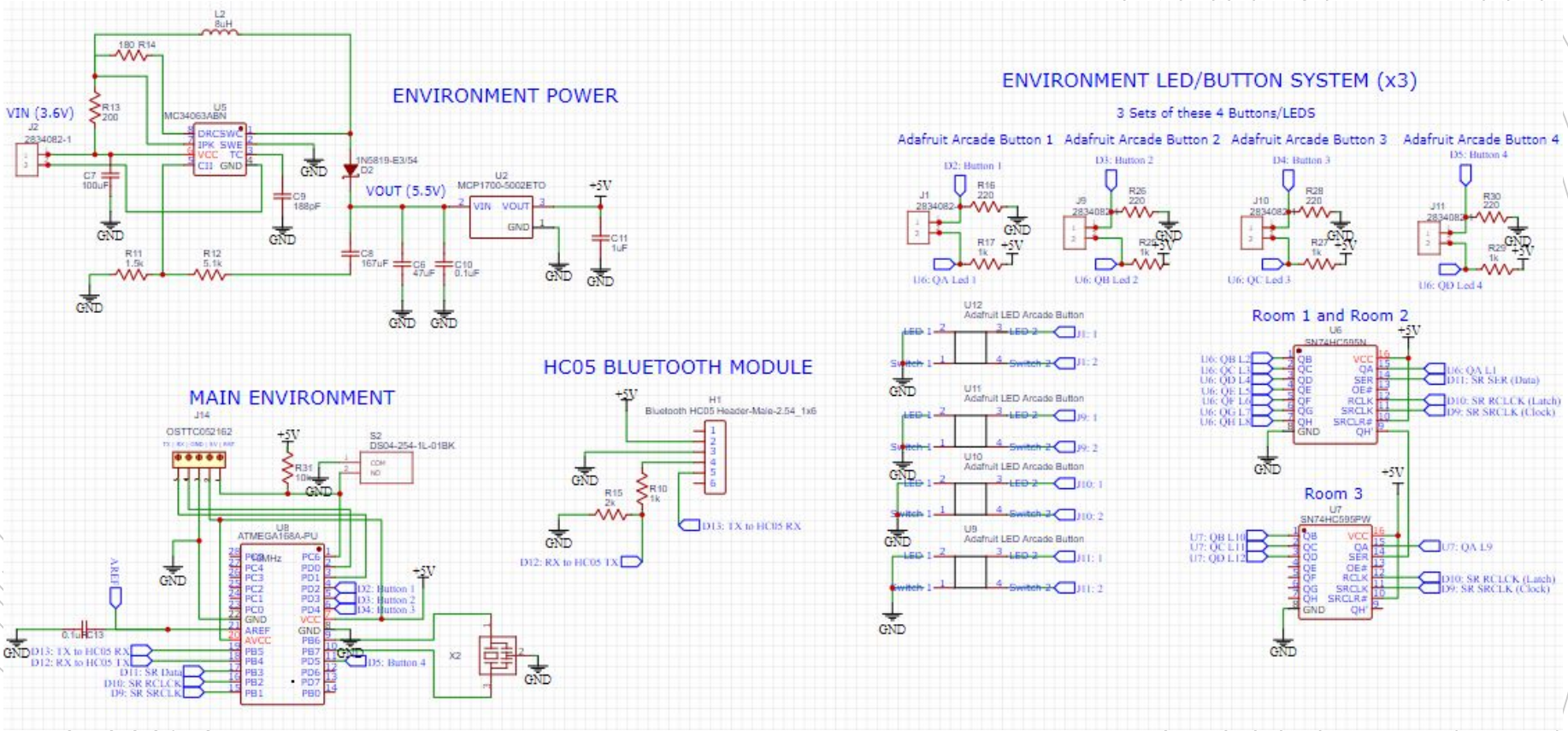
Specifications for MC34063ABN

Min/Max Input/Output	3V/40V 1.25V/38V
Max Current Output	1.5A
Frequency Switching	100Hz - 100kHz
Quiescent Current	2.5mA
Price	$0.97

Specifications for MCP1700-5002E/TO

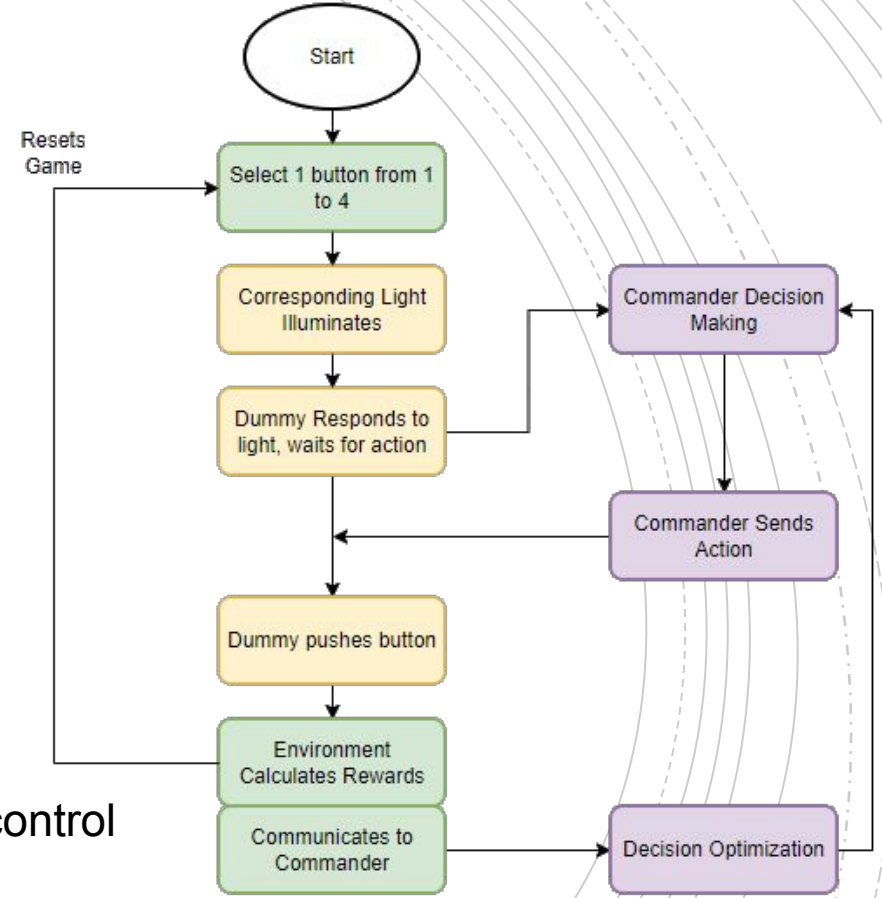
Min/Max Input/Output	2.3V/6V 1.2V/5V
Max Current Output	250mA
Quiescent Current	4uA
PSRR	44 dB for ~100kHz
Price	$0.46

Environment PCB Schematic



Environment Software Components

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



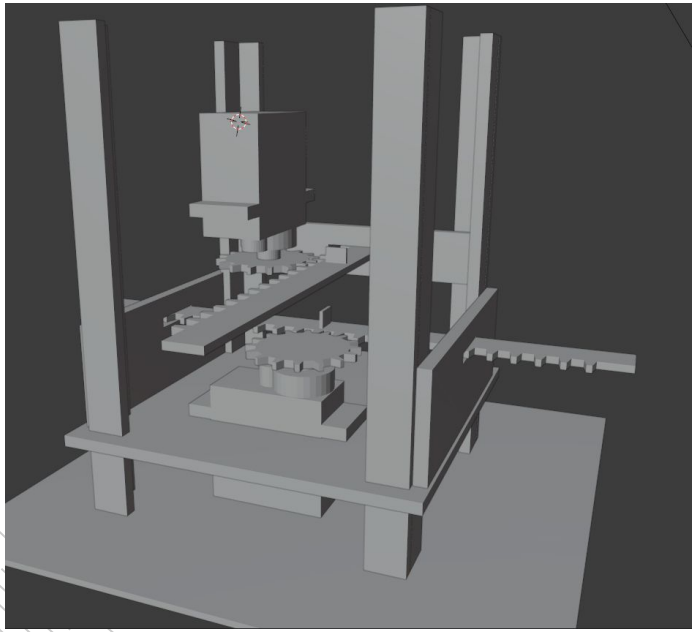
Dummy Agents

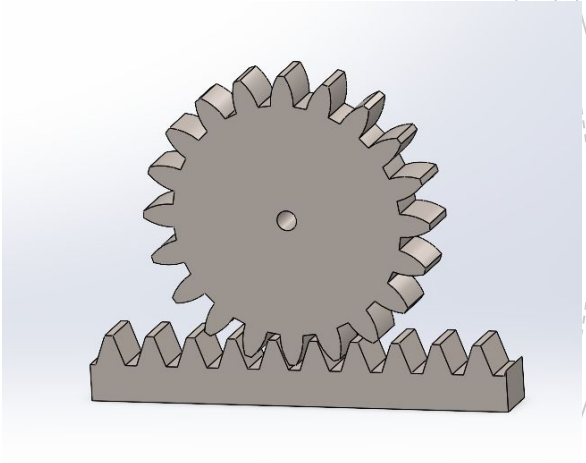
Dummy Agents Purpose

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

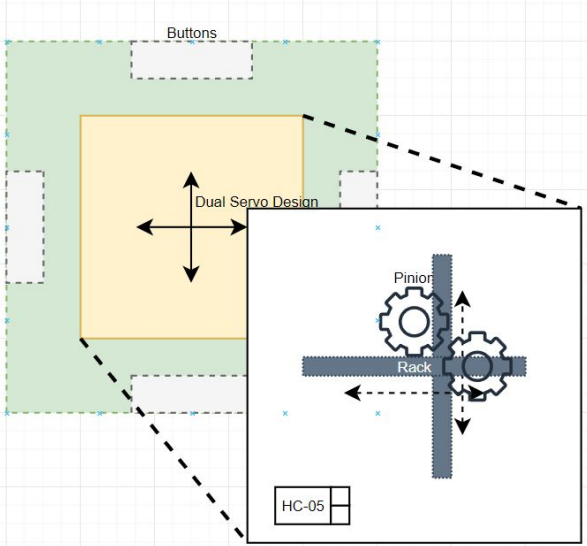
DA Physical Design

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





DA Hardware Components

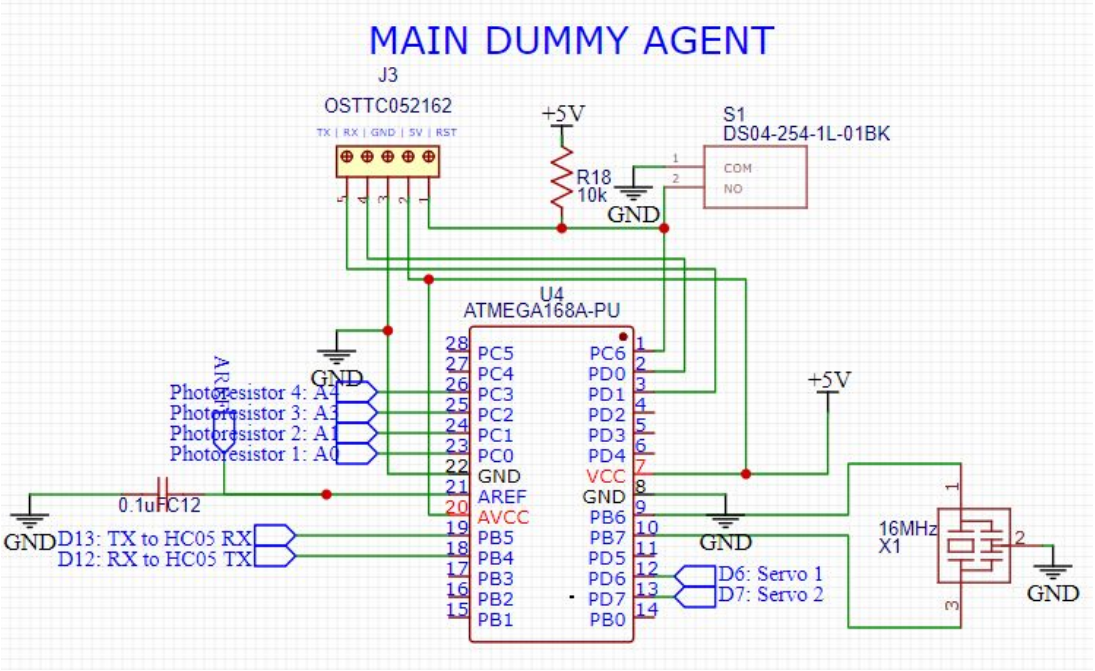


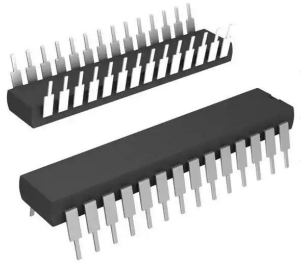
- Dual servos
  - Continuous vs non-continuous
  - Saves power and space
- Photoresistors
  - vs. photodiodes
  - Noise and sensitivity
  - Thresholding
- HC-05
- Power supply

MCU: ATMEGA168PA-AU
Purpose: Same MCU as Environment, but with added features of Servos and Photoresistors.

Specifications

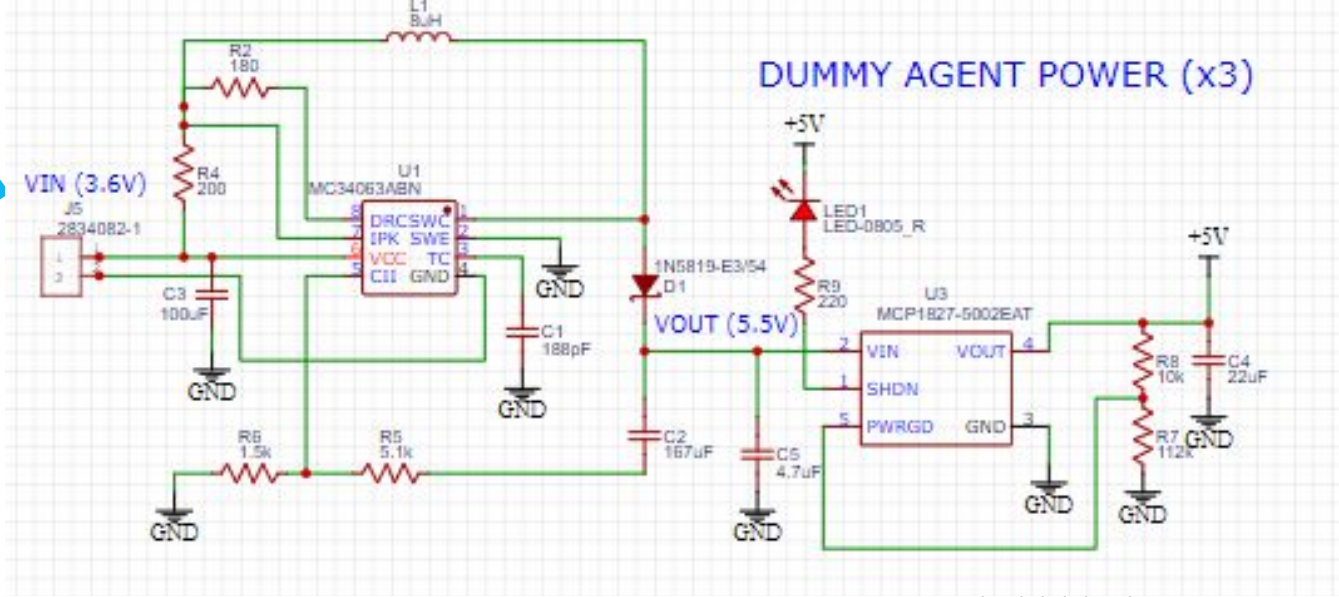
Operating Voltage	1.8V/5.5V	Flash Memory	16KB
I/O Pins (D/A)	20 (14/6)	RAM	1KB
Clock Speed	20MHz	Price	$2.05





DA MCU

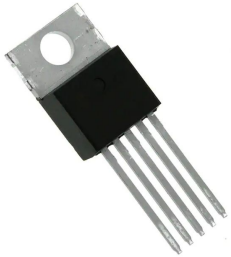
DA: Power Supply Changes



Specifications for MCP1827-5002E/AT

Min/Max Input/Output	2.3V/6V 0.8V/5V
Max Current Output	1.5A
Quiescent Current	220uA
PSRR	60 dB for ~80kHz
Price	$1.47

Similar Voltage Supply

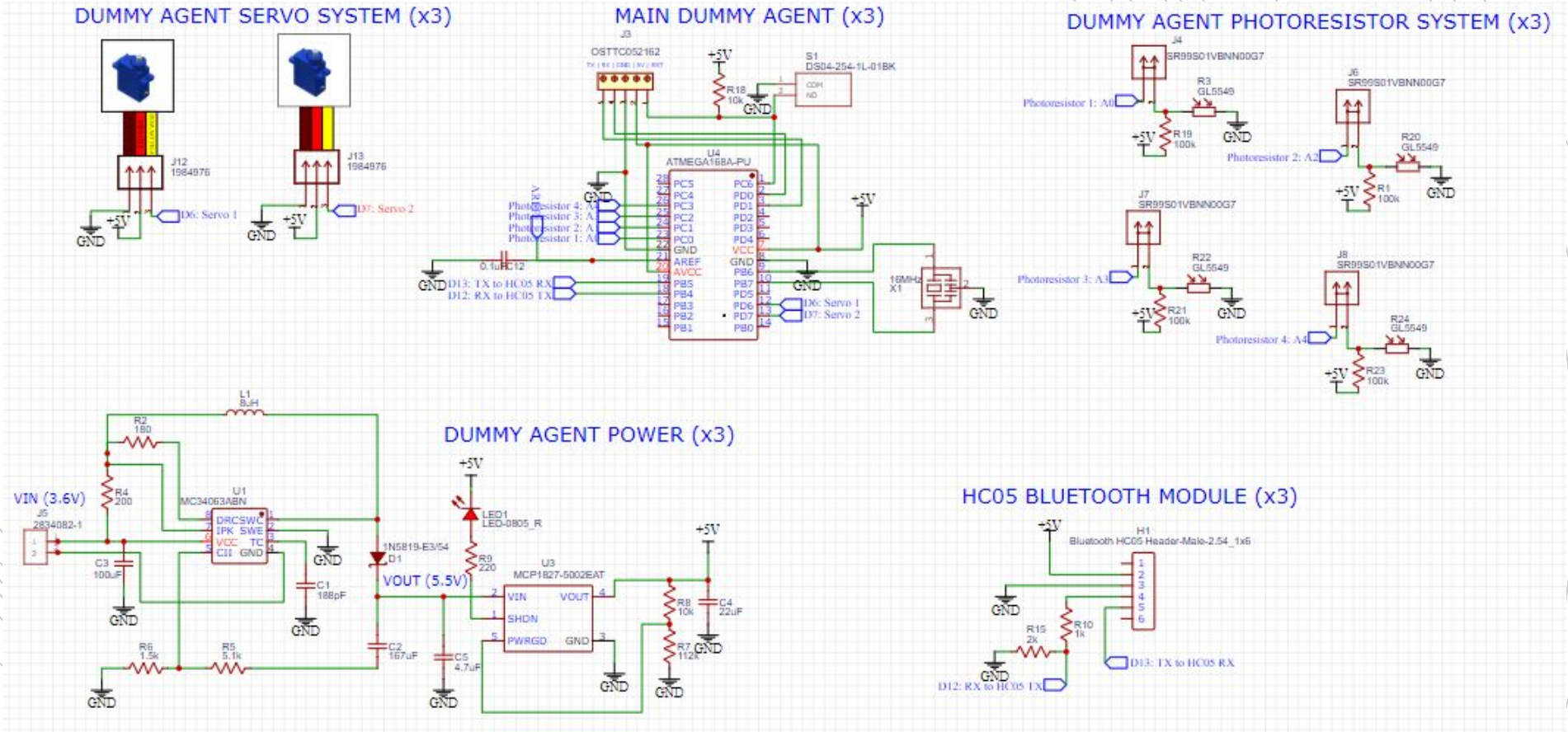


Using 1.5A LVR

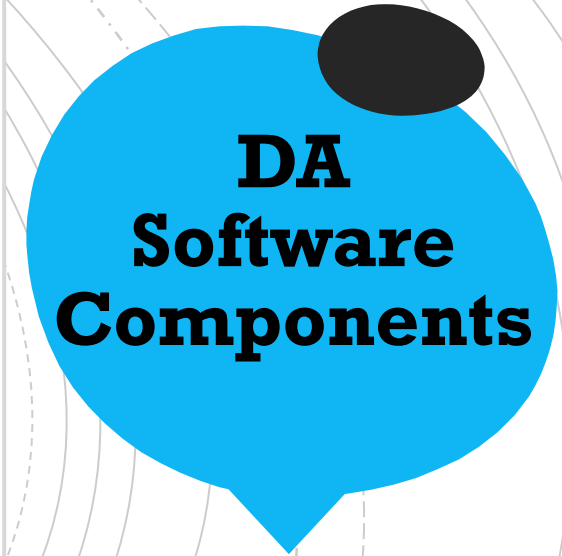
MCP1827-5002E/AT: Used due to issue with servo power draw

- Needed separate power when testing with development Arduino Nano
- Absence causes strange HC-05 behavior

DA PCB Schematic

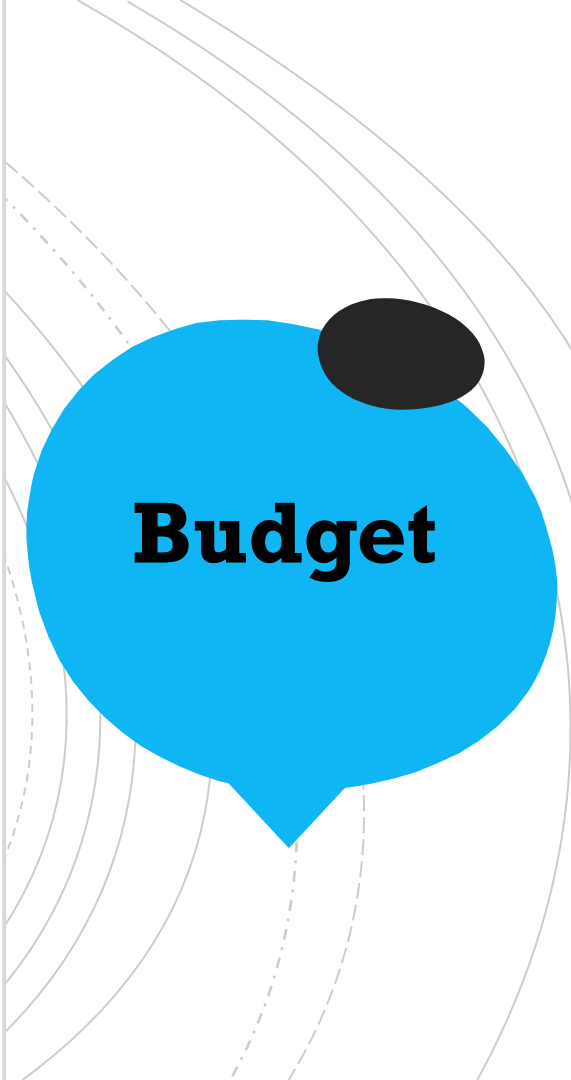


- Simple functionality to maintain scalability
  - Transmit Observations
  - Receive Command, Execute
- Interrupt when detecting a light

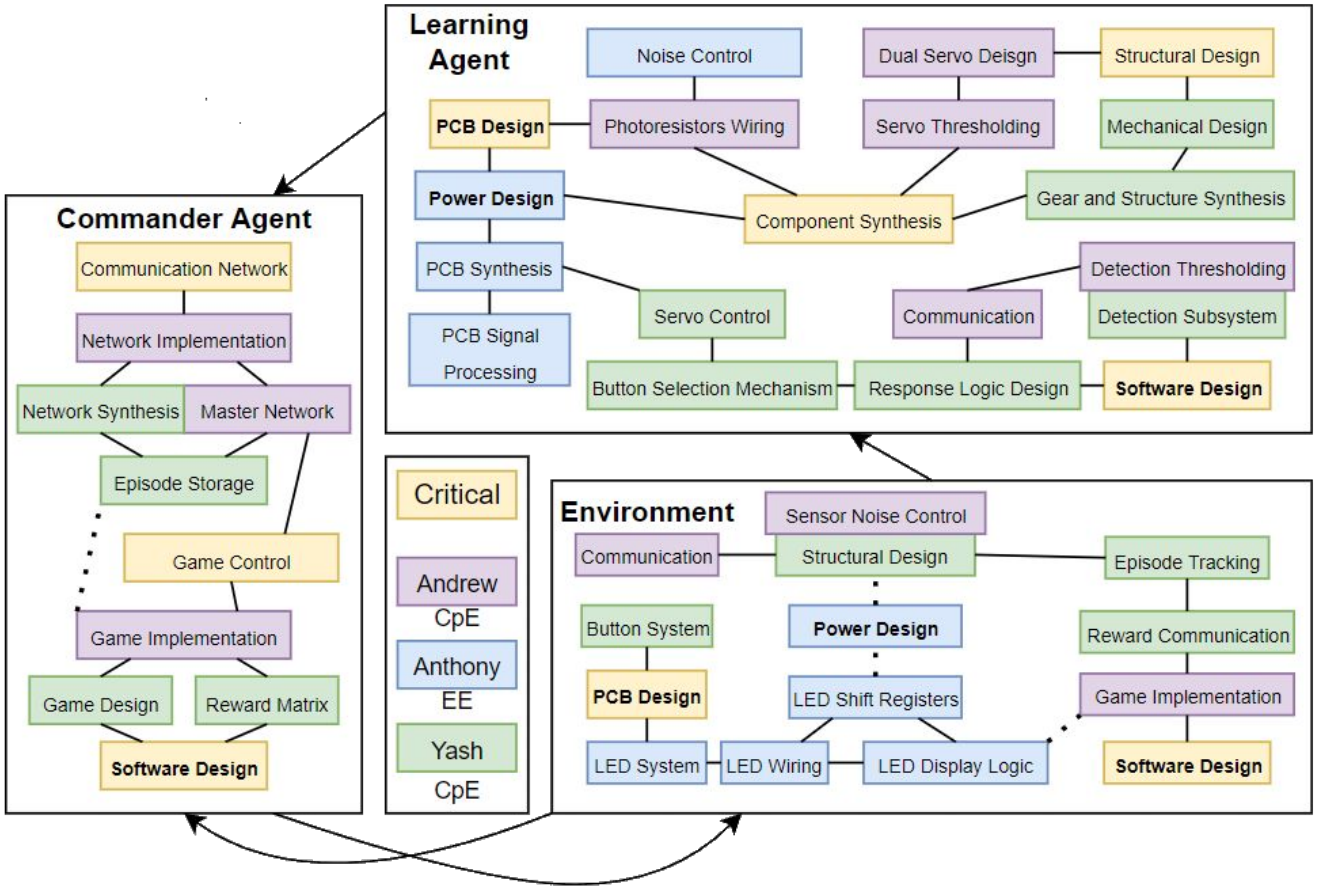


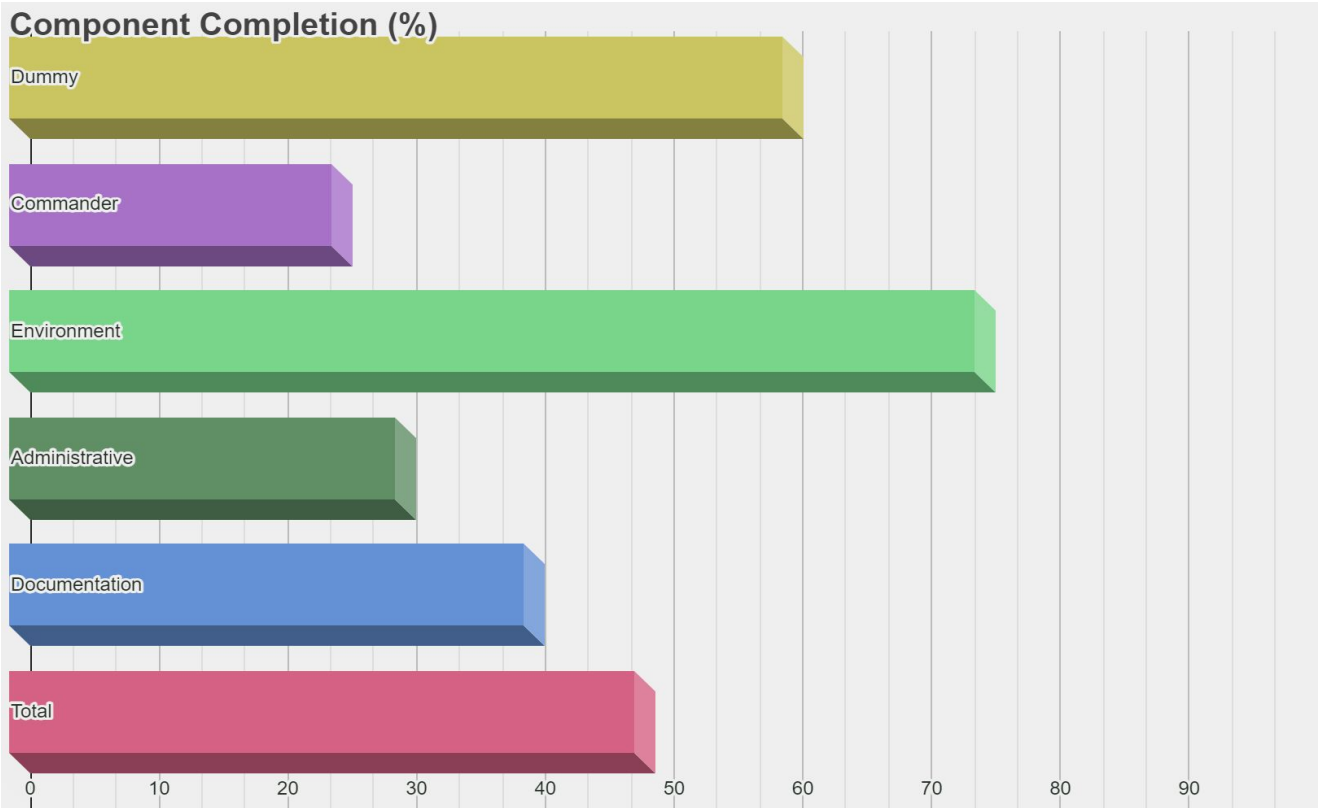
Administrative Content

Description	Price
Raspberry Pi Model 4	$75.00
MCU (10)	$40.00
FS90R servos (6)	$23.00
HC05 Modules (4)	$18.00
Arduino Nano Development Boards (6)	$36.00
Project Wood	$16.00
GL55xx Photoresistor Set	$12.00
74LSxxx/74HCxxx MUX Set	$20.00
Miscellaneous PCB Components (Resistors, Material, etc.)	$65.00
PCB Order(s)	$100.00
Adafruit Button Set	$27.00
Current Total	$432.00
Estimated Total	~$500.00



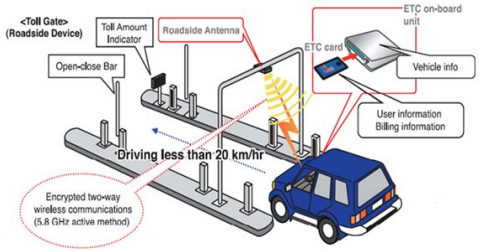
Work Distributions

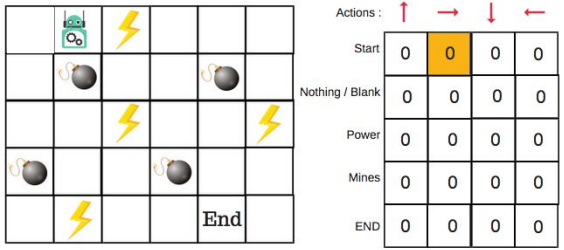




Current Progress

Previous 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

Current Design Difficulties

- Open Socket Bluetooth server
  - Scalability purposes
  - Python Bluetooth libraries on RPi 4 are buggy, won’t accept connection
  - Possible need of threading
- Communication network is still not concrete enough.
  - Asynchronous or Synchronous?

Remaining Steps

- Finish Commander Code
- Construct Environment
- Construct Dummy Agent