



Prince Mohammad University
Department of Electrical Engineering
EEEN Learning Assessment III

Automated Warehouse

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Outline

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- ❖ **Project Objectives**
- ❖ **Project Specifications**
- ❖ **Background and Previous Projects**
- ❖ **Project Architecture**
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Project Definition

Design an automated warehouse; capable of storage and retrieval into/from a warehouse of pre-determined capacity.



Project Objectives

1. **Ease** storage management.
2. **Increase** storage space efficiency.
3. **Minimize** storage errors/misplacements.

Project Specifications

1. Use unique ID tags to identify storage slots.
2. Store/retrieve items from slots.
3. Low power consumption.
4. Use stationary and wireless control terminals.
5. Keep track of in-storage items.

Background:

Problem

- These days, where human error may produce faulty equipment or fail customer's trust, it is imperative to minimize; or better yet, eliminate any room for error.

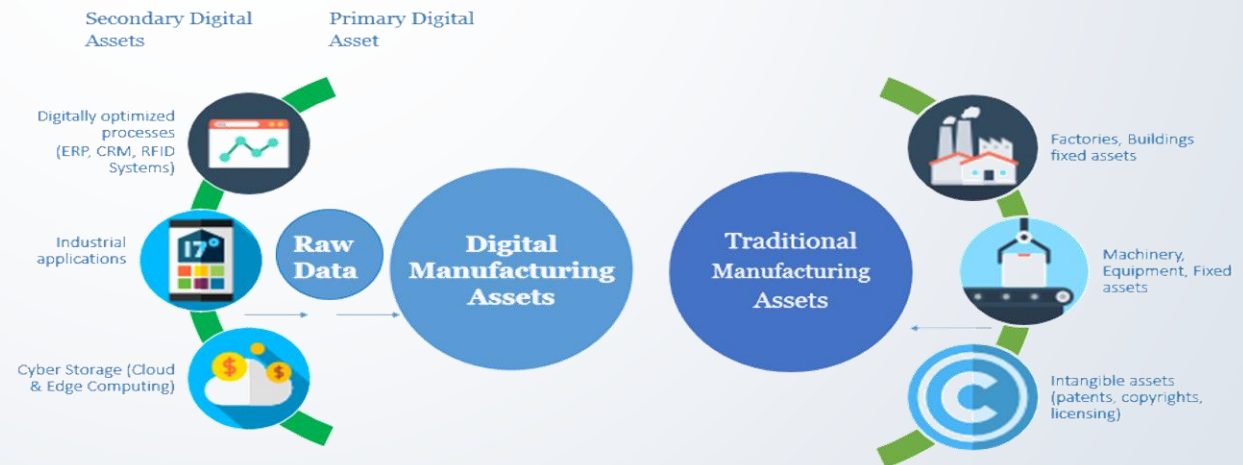
A strong business is only as strong as its weakest link, and the link of storage management can be the lifeblood of a manufacturing facility, or the product provider to the public.



Background:

Solutions

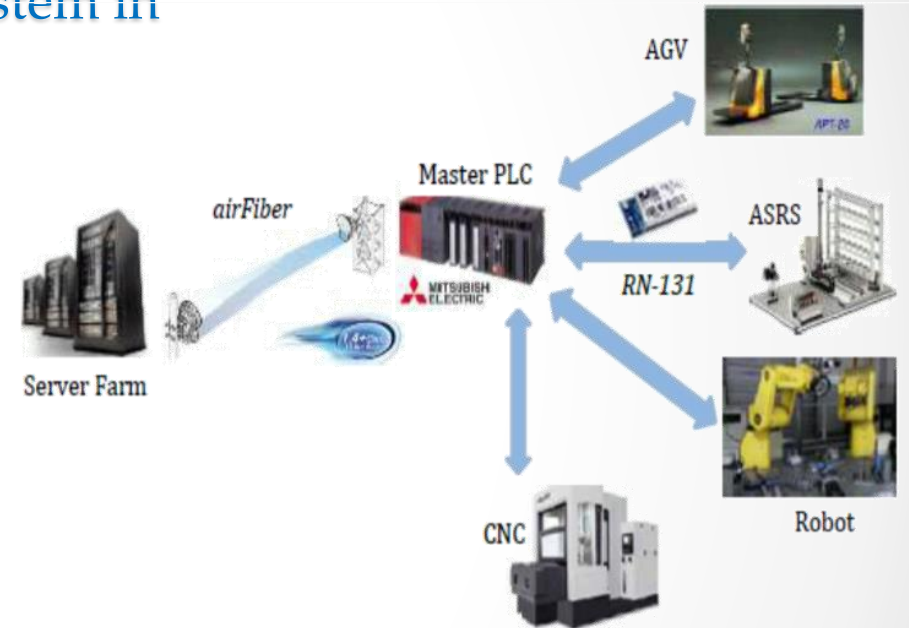
- An automated storage system would leave less room for errors and work more efficiently with respect to time and available space.
- When integrated into a supply chain system, it can send data regarding item availability and demand in real-time, allowing for more seamless business management with fewer hiccups.



Previous Projects (1)

Development of an Automated Storage and Retrieval System in Dynamic Industrial Environment, 2015.

- Rudimentary automation.
- Advanced monitoring and data processing.
- Focused more on improving the system as time goes on, by collecting pick-up data.



Previous Projects (2)

Partially Automated Warehousing System for Industrial Applications, 2017.

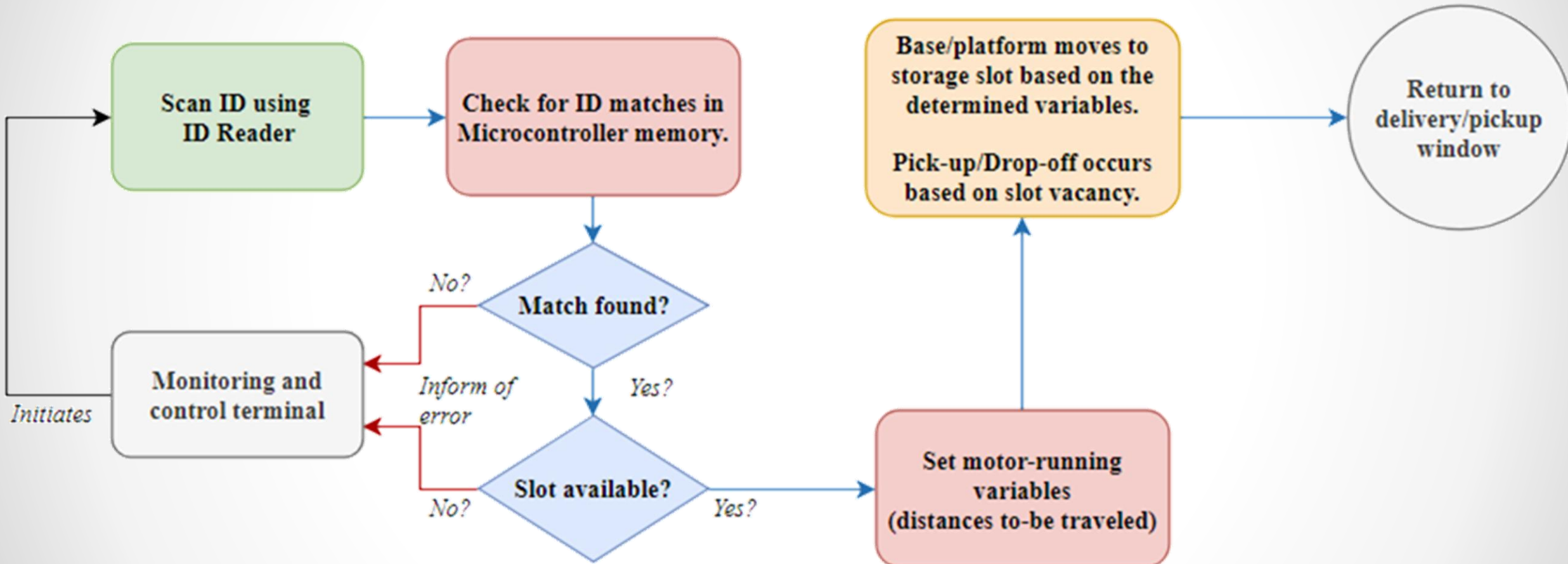
- Works in compliment to current warehouses by augmenting forklifts to keep track of where items are being held.
- Although the movement and delivery process isn't automated, the project augments existing systems, allowing for easier implementation.



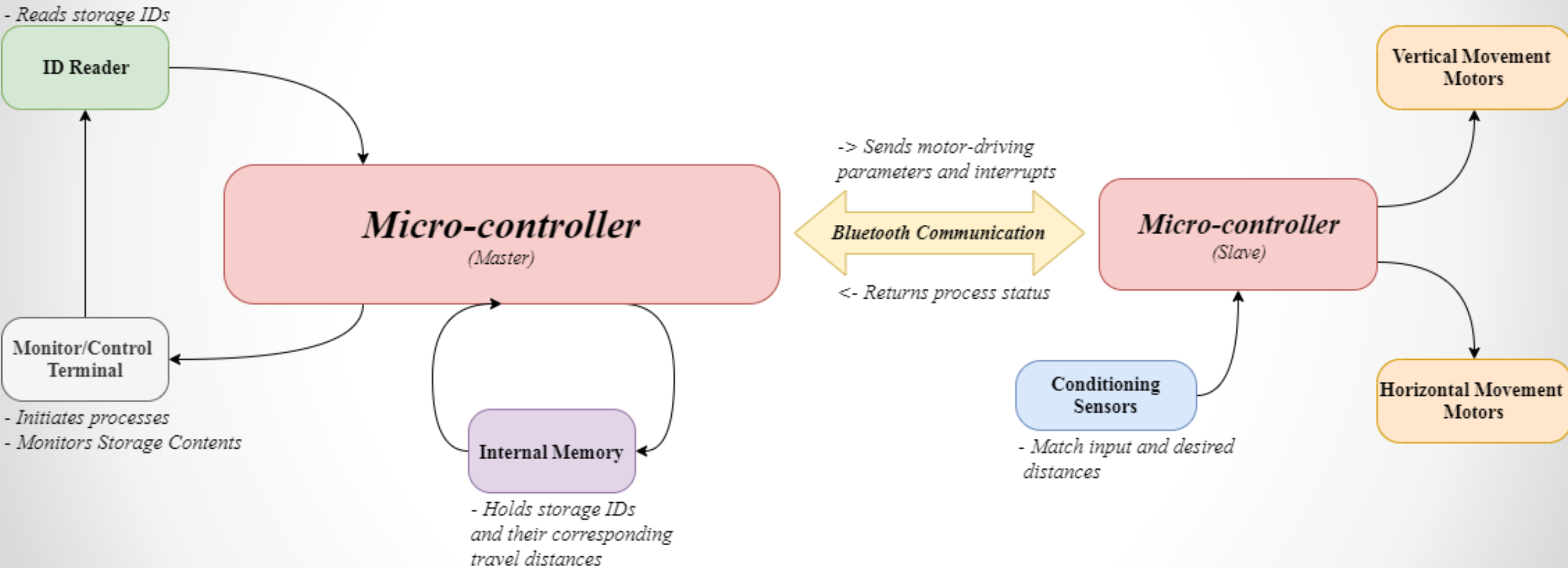
Previous Projects Summary

Projects	1	2	Our Project
Automatic coordination	√		√
Communication method	Wi-Fi and Dataspace	Wi-Fi	Bluetooth
Movement method	Railing	Forklifts	Railing
Storage monitoring	√	√	√
Monitoring method	Sensors/ Dataspace	Sensors/ Dataspace	Dataspace
Operation interruption		√	√

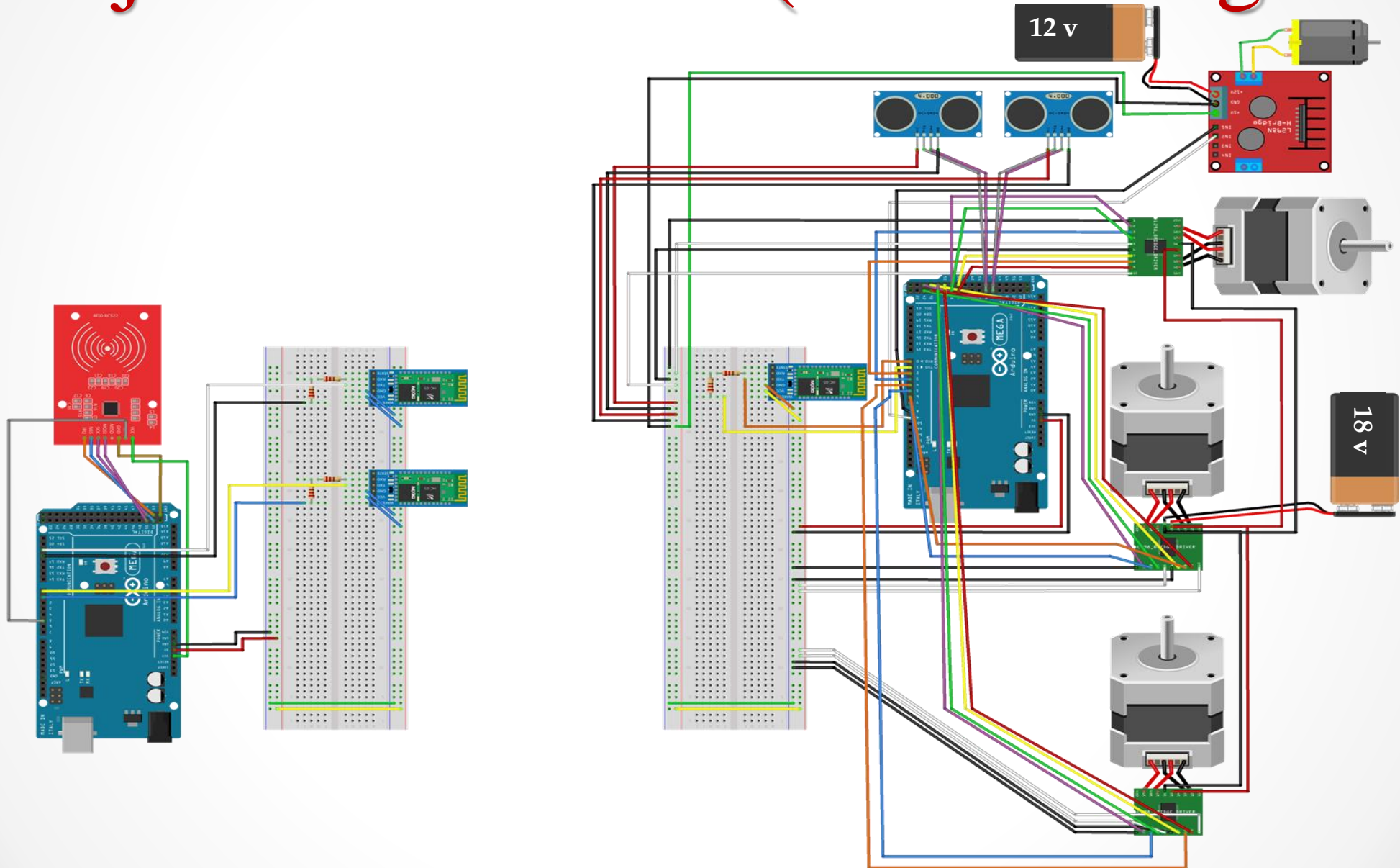
Project Architecture (Behavior)



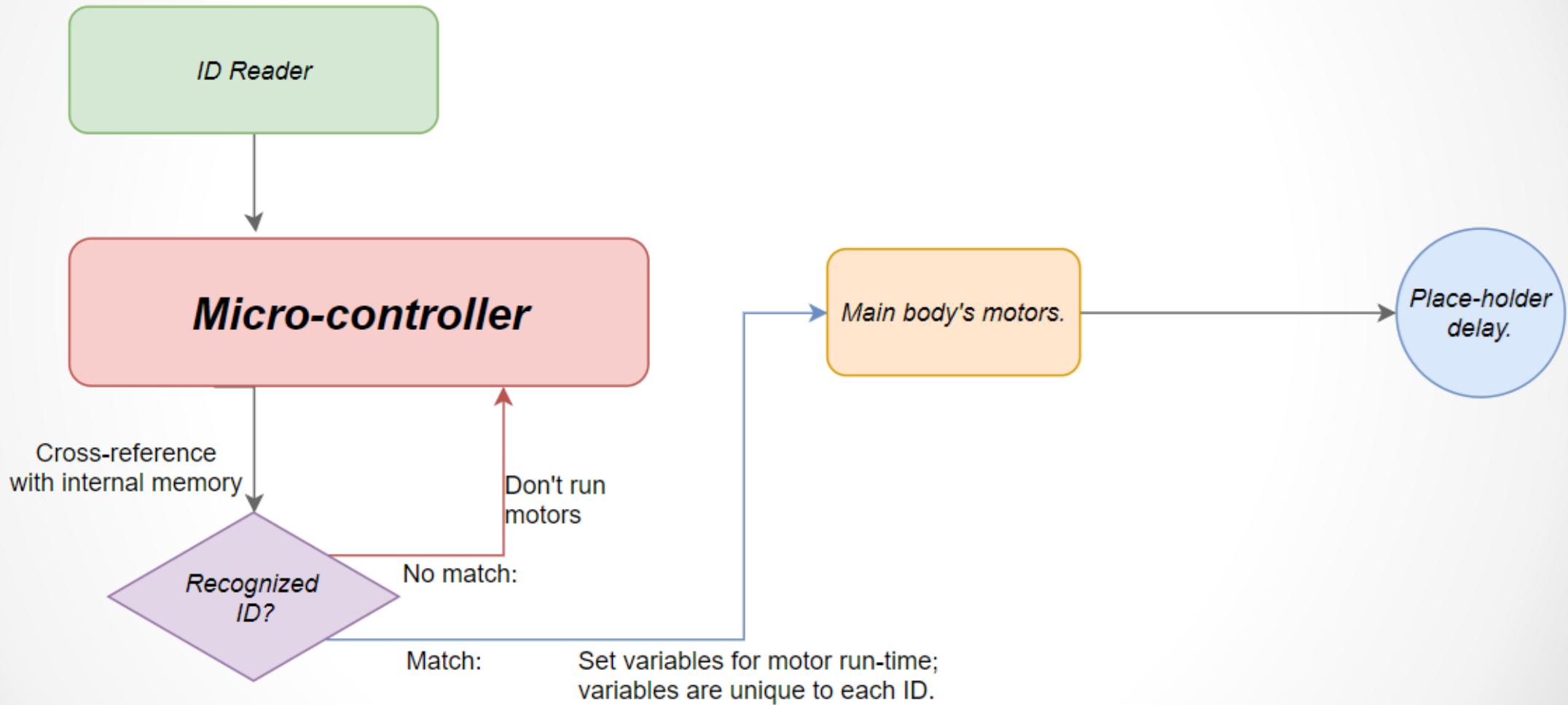
Project Architecture (Components)



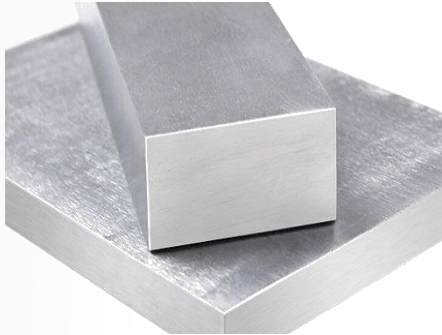
Project Architecture (Circuit Diagram)



Design: Subsystem 1



Design: Sub-1: Body Material Options



Aluminum:



- + Easier to modify
- + Average weight
- + Bends under pressure
- Needs better support
- Needs insulation



Thin Steel Sheet:

- + Easier to support
- + Bends under pressure
- Needs insulation
- Heavy weight



Hardened Wood:



- + Doesn't need insulation
- + Average weight
- Hard to modify
- Breaks under pressure

Design: Sub-1: Body Material Options

Aluminum

Components:

- Vertical-movement platform.
- Platform supports rods.
- Motor-bound screws.
- Storage shelves.

Wood Components:

- Body and forklift.
- Vertical and horizontal end markers.
- Bottom weight support.
- Shelf slot markers.



Design: Sub-1: Motor Options



DC Stepper Motor ★	Servo Motor
Cheaper (175)	Expensive (250)
Smaller	Larger
Used for high torque applications	Used for high speed/accuracy applications

Design: Sub-1: Horizontal Movement

Quad-wheel with IR line-following:

- + Easier to setup and modify tracks.
- Harder to code.
- Vulnerable to dust accumulation.
- Less accurate travel distances.


Double-wheel with physical rails:

- + Easier to code.
- + Less room for overshooting.
- Hard to setup rails.
- Harder to support weight properly.

Quad-wheel with physical rails:

- + Easier to code.
- + Less room for overshooting.
- + Easier weight-support.
- Harder to setup rails.
- Setup becomes immobile after installation.

Linear guide rails:

- + Easier to code. 
- + Less room for overshooting.
- + Much easier weight-support.
- + Setup can be relocated.
- Harder initial setup.
- Slower movement

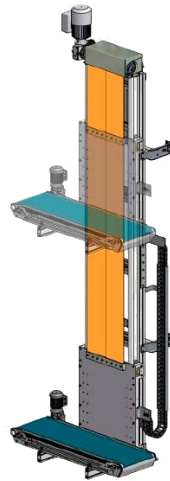
Design: Sub-2: Vertical Movement



Cross-jack:

Lift

Control



Conveyor belt:

Lift

Control



Linear guide rails:



Lift

Control

Re-Designing the Rails

- Stability.
- Accuracy.
- Light weight.
- Axial movement.



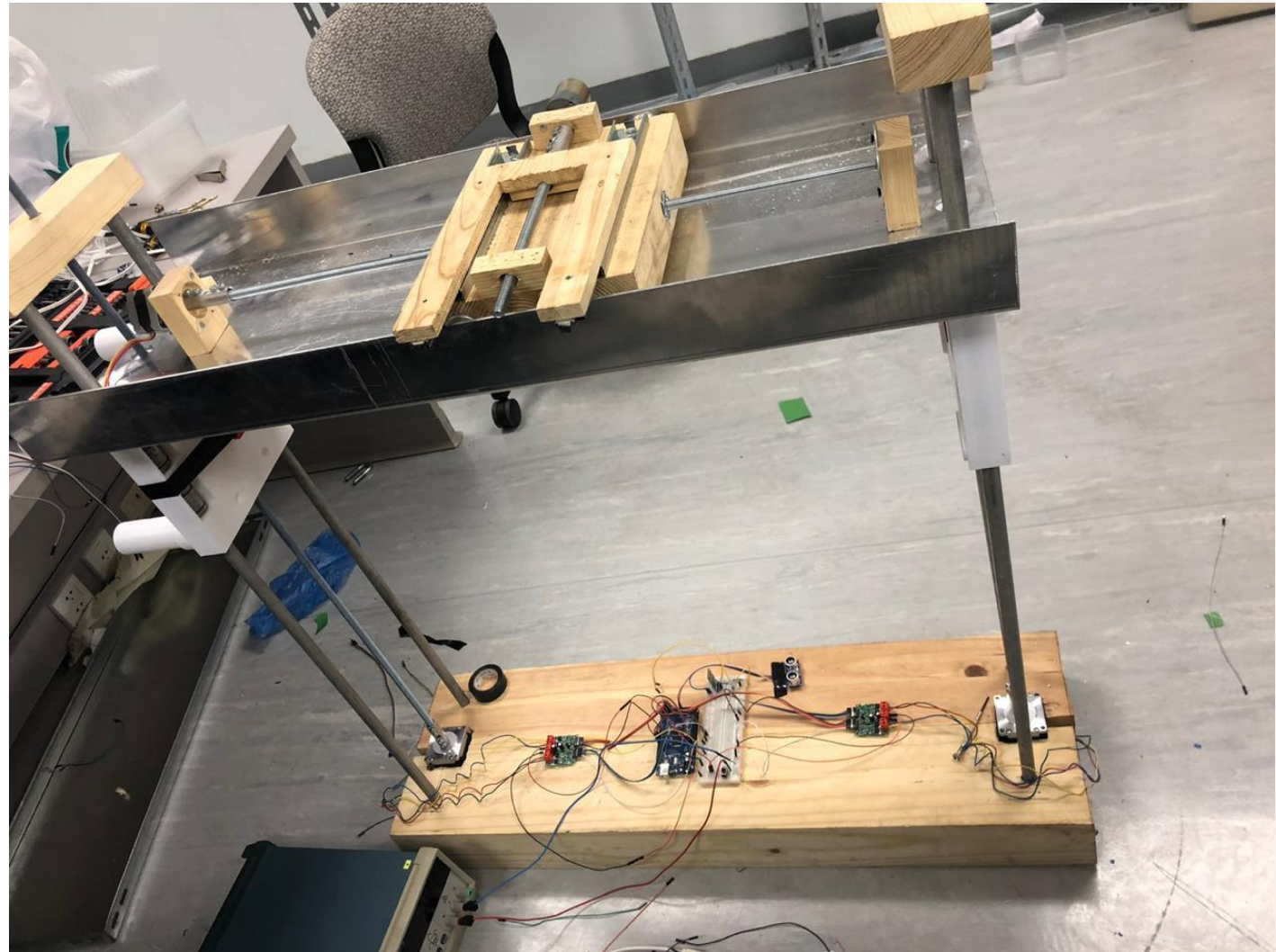
Design: Sub-2: Storage Shelves

- Axial movement.
- Dimensions.
- Accuracy.
- Stability.

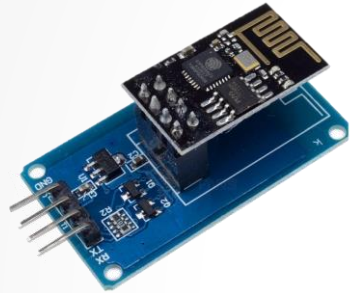


Design: Sub-2: Storage Shelves

- Axial movement.
- Dimensions.
- Accuracy.
- Stability.

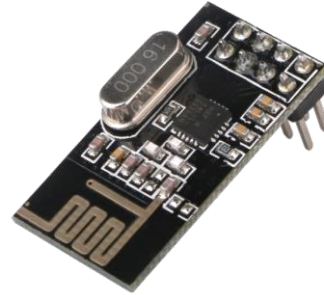


Design: Sub-2: Wireless communication



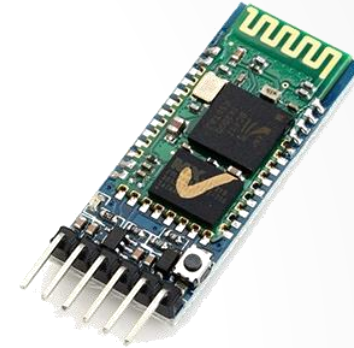
**Wi-Fi
ESP-Series:**

- + Much higher baud rate
- + Wide range
- Needs an established network
- High power consumption
- Overkill



**Radio
(nRF24L01/XBee):**

- + Higher baud rate
- + Much wider range
- + More adaptable to application
- Requires more transceivers for two-way communication
- Harder to test

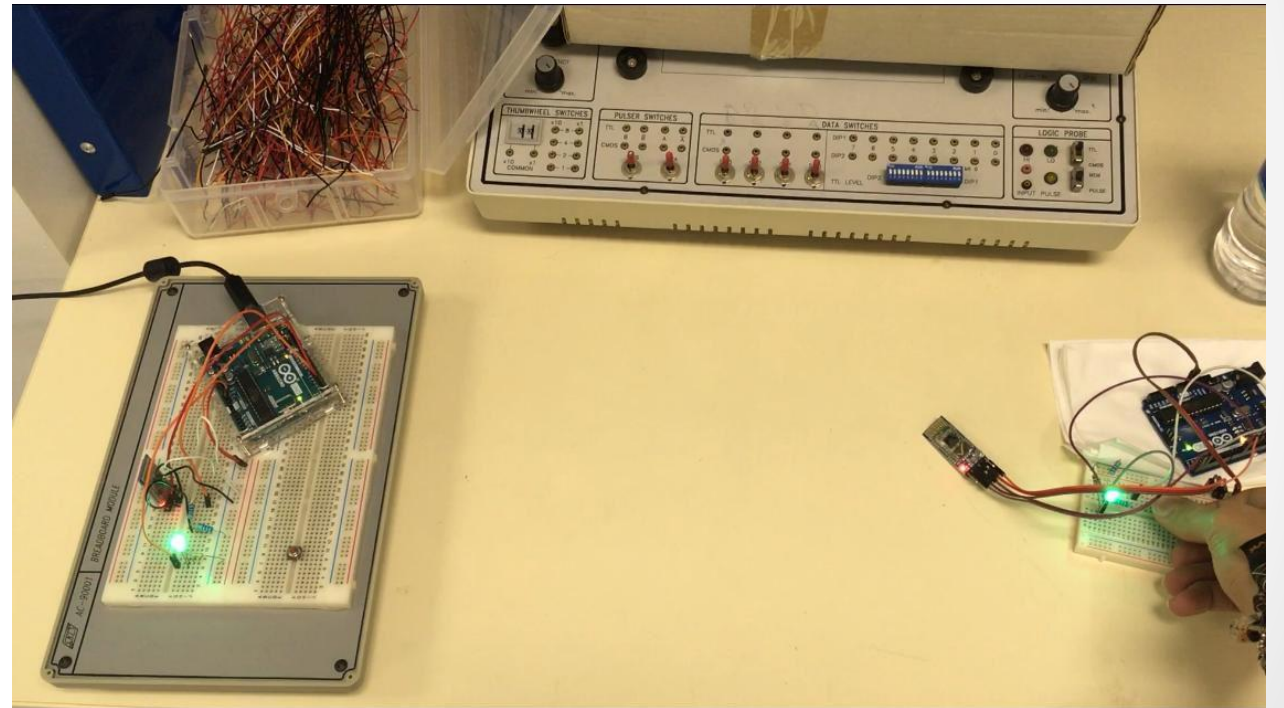


**Bluetooth
(HC-05):** ★

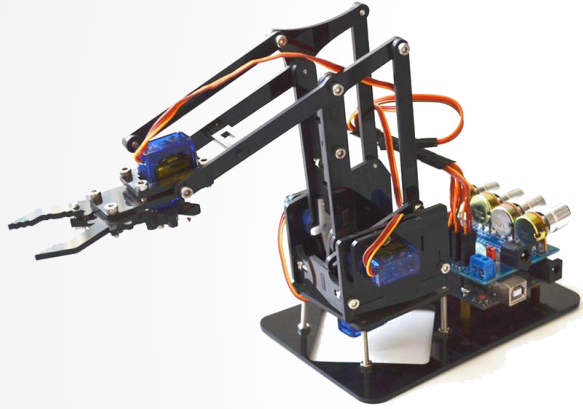
- + Easy two-way communication
- + Easier to test and integrate with serial ports
- + Power efficient
- Shorter Range
- Lower baud rate

Design: Sub-2: Wireless communication

- Secure two-way communication.
- Freedom of movement.
- Low power consumption.
-



Design: Sub-3: Fetching Mechanism



Servo-based arm:

Lift

Control



Sliding shelf:

Lift

Control



Forklift:

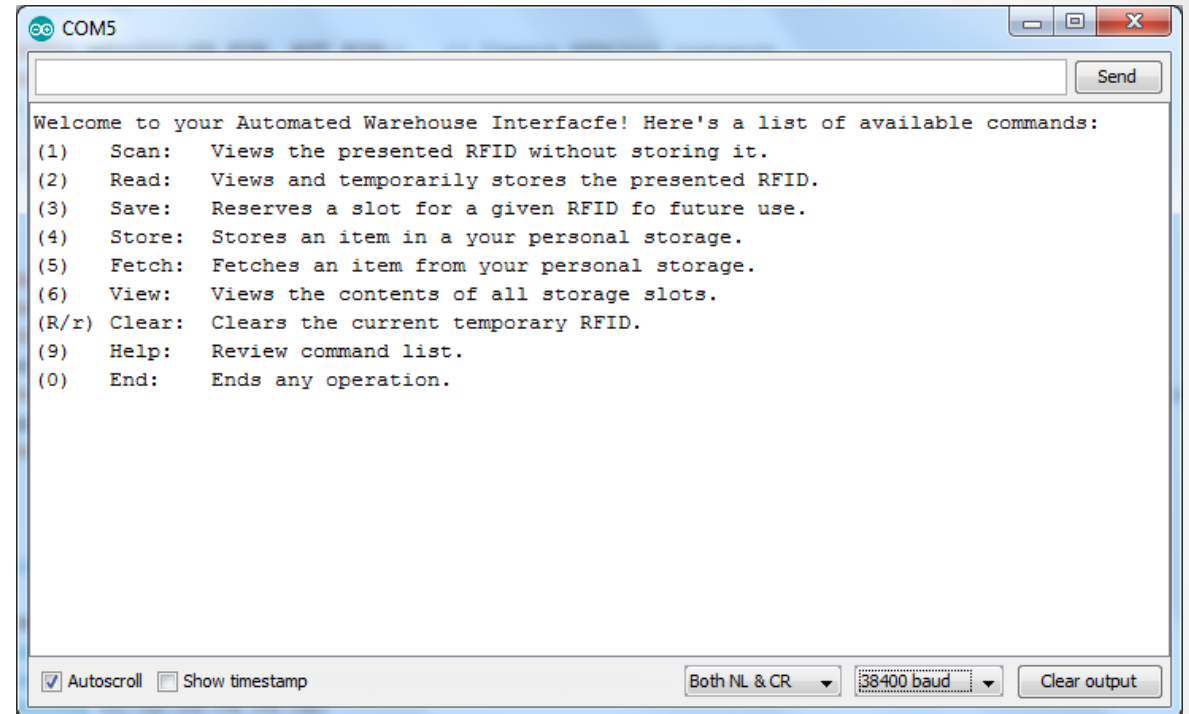


Lift

Control

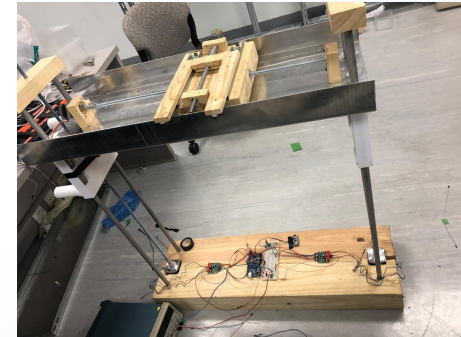
Design: Sub-4: System Refinements

- Coordinating motors.
- Simplifying interface.
- Setting up low-power modes.



Design: Redesigns

- Previous models of vertical and horizontal movement were showing strong design flaws that prevented the project from meeting the goals we had set for it.
- Throughout the semester, we went through several concepts of our mechanical model, costing us over 1700 SAR than the included budget.
- These tests cost more time and money than their outcomes could justify, but we were able to complete one of our models despite the heavy time constraints we caused ourselves.



Design: Challenges

- **As a result of heavy redesigns, we crunched ourselves for time up to the last 3 weeks of the semester, which meant solving any problems as they occurred.**
- **These problems included hardware misfires, component shipping delays, incompatible software, etc.**

Project Budget/Cost

Item	Quantity	Unit Cost (SAR)	Subtotal
Frame	Total	500	500
Robot Body	Total	150	150
Control Unit (Arduino)	2	80	160
Rails + Bearings	Total	300	300
RFID Reader	1	40	40
Bluetooth HC05	3	40	120
DC Battery	1	45	45
Stepper Motors	2+1	175+110	460
Motor Drivers +Sensors	4+2	65+40	340
			Total: 2,115 SAR

Plan (previous semester)

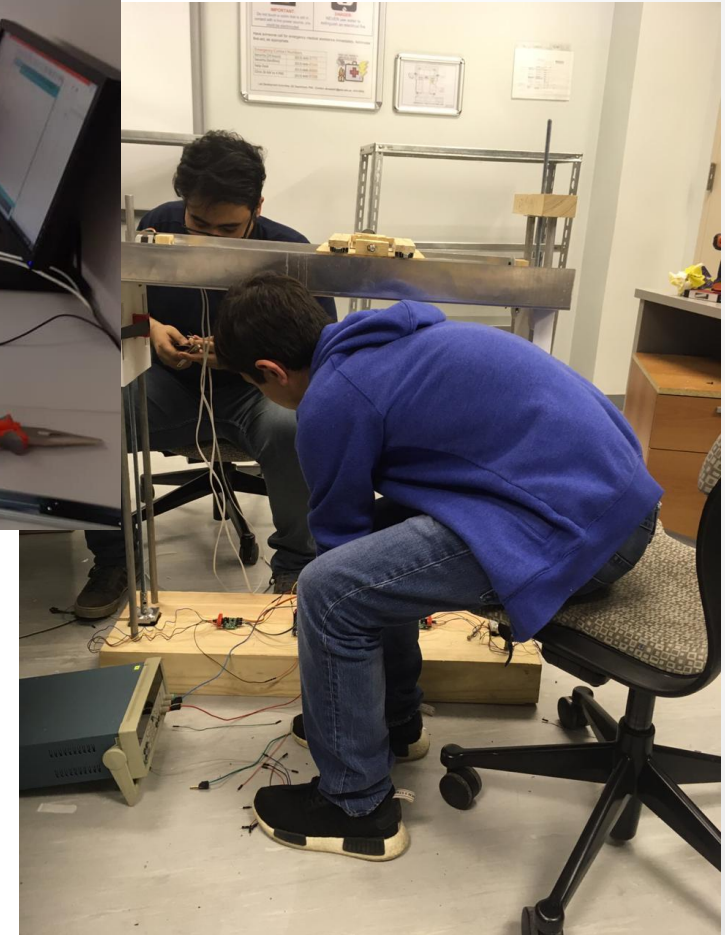
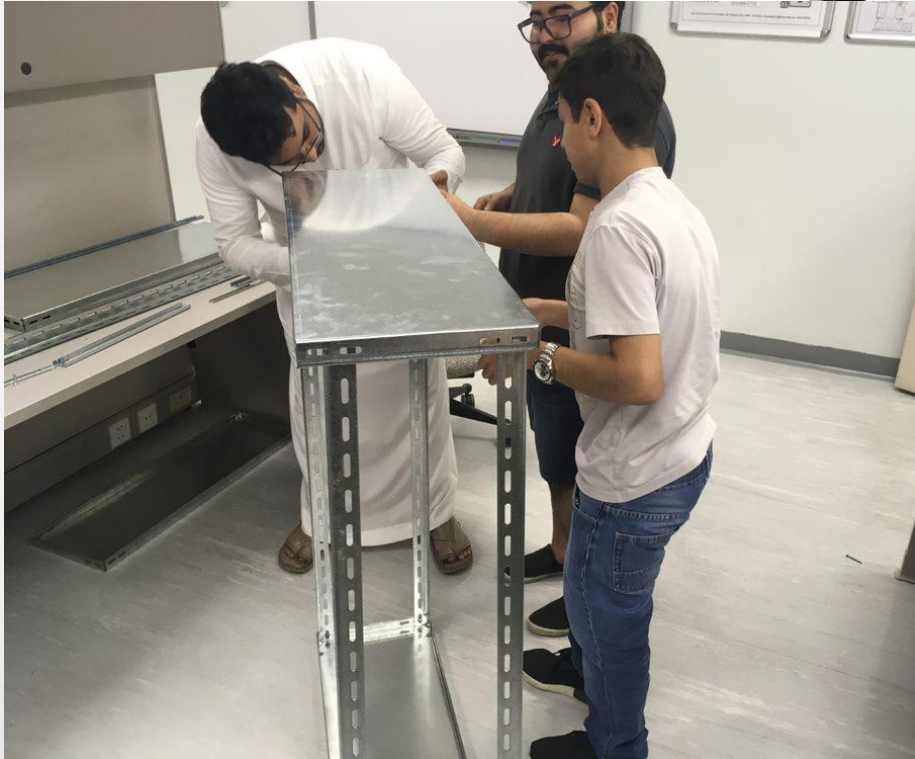
ACTIVITY	PLAN	PLAN	Assigned To	ACTUAL	ACTUAL	PERCENT	Plan		Actual														
	START	DURATION		START	DURATION	COMPLETE	Actual (beyond plan)					% Complete (beyond plan)											
								Periods (Weeks 1-15)															
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Form teams	1	1	ALL	1	1	100%	█																
Select topic & advisor	2	1	ALL	2	2	100%		█	█														
Write proposal and plan	4	1	NY,ME	4	1	100%				█													
Background research & PPT1	4	2	ME,YA	4	2	100%				█	█												
Search and acquire components	5	2	MA,ME,NY	5	2	100%					█	█											
Design subsystem 1 (Storing/Retrieving Robot)	7	4	ALL	6	6	90%						█	█	█	█	█	█	█	█				
Buying/Ordering robot/body components	6	2	YA,MA	6	2	100%						█	█										
Coding initial motor behaviour	7	2	ME	7	2	100%							█	█									
Building the body	8	3	YA,ME	8	3	100%								█	█	█							
Building the track prototype	8	1	YA,MA	8	1	100%								█									
Refining motor behaviour	9	2	ALL	9	3	100%									█	█	█	█					
Prepare midterm Presentation	9	2	ALL	8	3	100%									█	█	█						
Design subsystem 2 (Warehouse movement rail and vertical platform)	11	5	ALL	11	5	25%											█	█	█	█	█	█	
Refining Track	11	2	YA,MA	11	2	60%											█	█					
Buying platform components	11	1	YA,MA	11	1	100%											█						
Coding and wiring vertical motors	11	4	ALL	11	4	0%											█	█	█	█			
Building platform support	12	3	YA,MA	12	3	0%												█	█	█			
Building platform	12	3	YA,MA	12	3	0%												█	█	█			
Refining Vertical movement	13	3		13	3	0%													█	█	█		
Prepapre final report	13	3	NY,YA	13	3	60%														█	█	█	
Prepapre final presentation	13	3	ME,MA	13	3	100%														█	█	█	

Project Management & Team Work

- Team work task division

Task	Mohannad	Mustafa	Nour	Yousif
Search & Acquire Components	30%	10%	20%	40%
Design & Implementation	15%	35%	15%	35%
Research and Problem-Solving	25%	25%	35%	15%
Physical Construction	25%	15%	25%	35%
Circuitry and Power Management	25%	25%	20%	30%
Coding and Testing	10%	40%	10%	40%
Write Reports & Presentations	25%	25%	40%	10%

Project Management & Team Work



References:

1. Free business storage report <http://www.store-it.co.nz/download/free-business-storage-report.pdf>
2. Westfalia Warehouse <https://www.westfaliausa.com/>
3. Development of an Automated Storage and Retrieval System in Dynamic Industrial Environment
<https://www.researchgate.net/publication/307173277>
4. Students Automate warehouse <https://www.zhaw.ch/en/about-us/news/news-releases/news-detail/news-single/students-automate-warehouse/>