Light Energy Harvesting for Sustainable Internet of Things Devices

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Presentation Outline

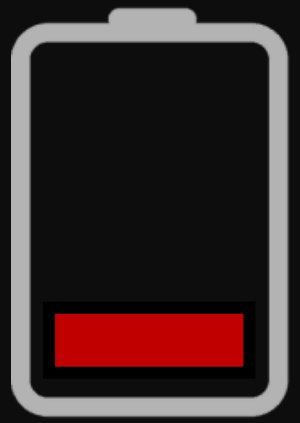
- Project Background
- Problem Statements
- Objectives
- Literature Review
- Scope of Study
- Methodology
- Results
- Conclusion

Project Background

- Internet of Things (IoT) refers to a system of connected devices that transfer data over a network

- Light energy harvesting is the practice of extracting and storing ambient light energy sources

Problem Statement



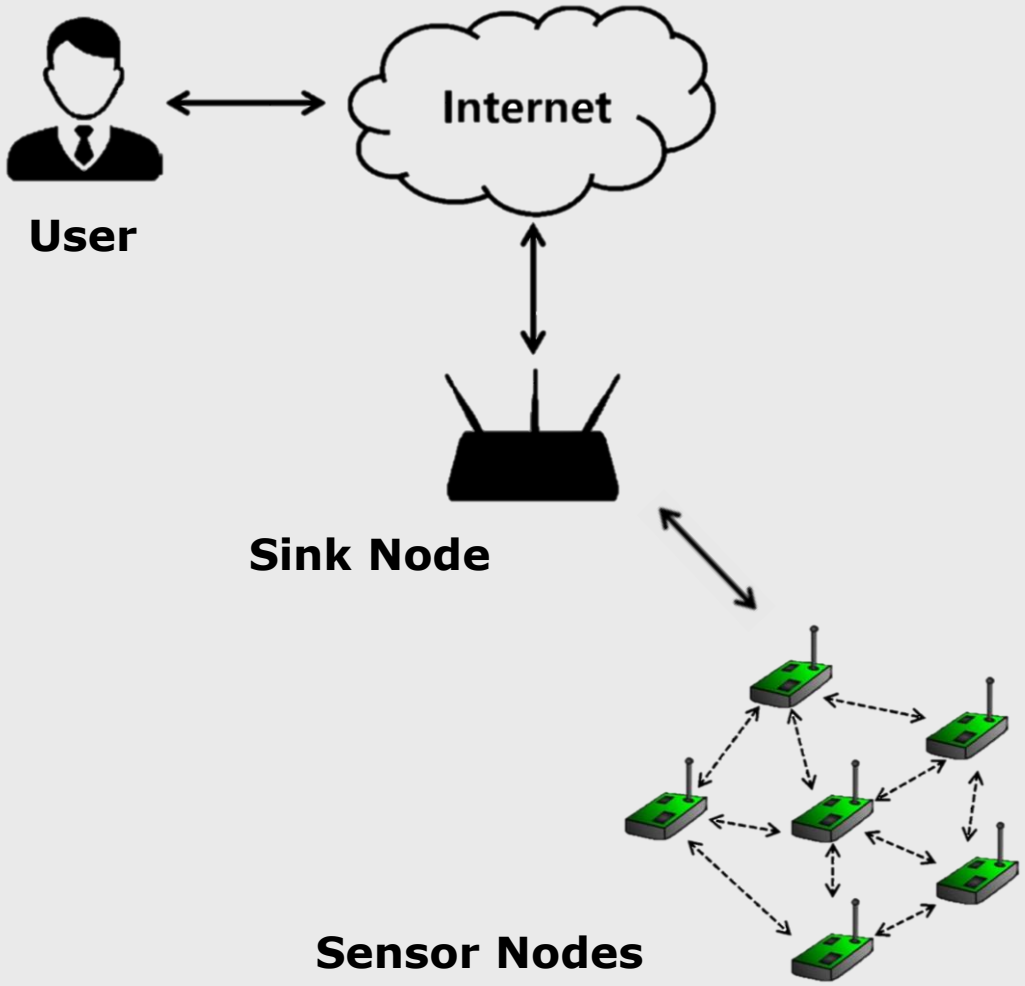
- Most IoT devices use disposable batteries
- Short operation lifetime
- Requires regular maintenance
- Maintenance can be dangerous & expensive

Objectives

To develop a Light Energy Harvester for Internet of Things (IoT) devices

To test the devices to ensure their sustained operation over a prolonged time

Literature Review



Wireless Sensor Networks (WSN)

- A network of dispersed sensors
- Monitor and record physical conditions of an environment
- Consist of sink nodes and sensor nodes

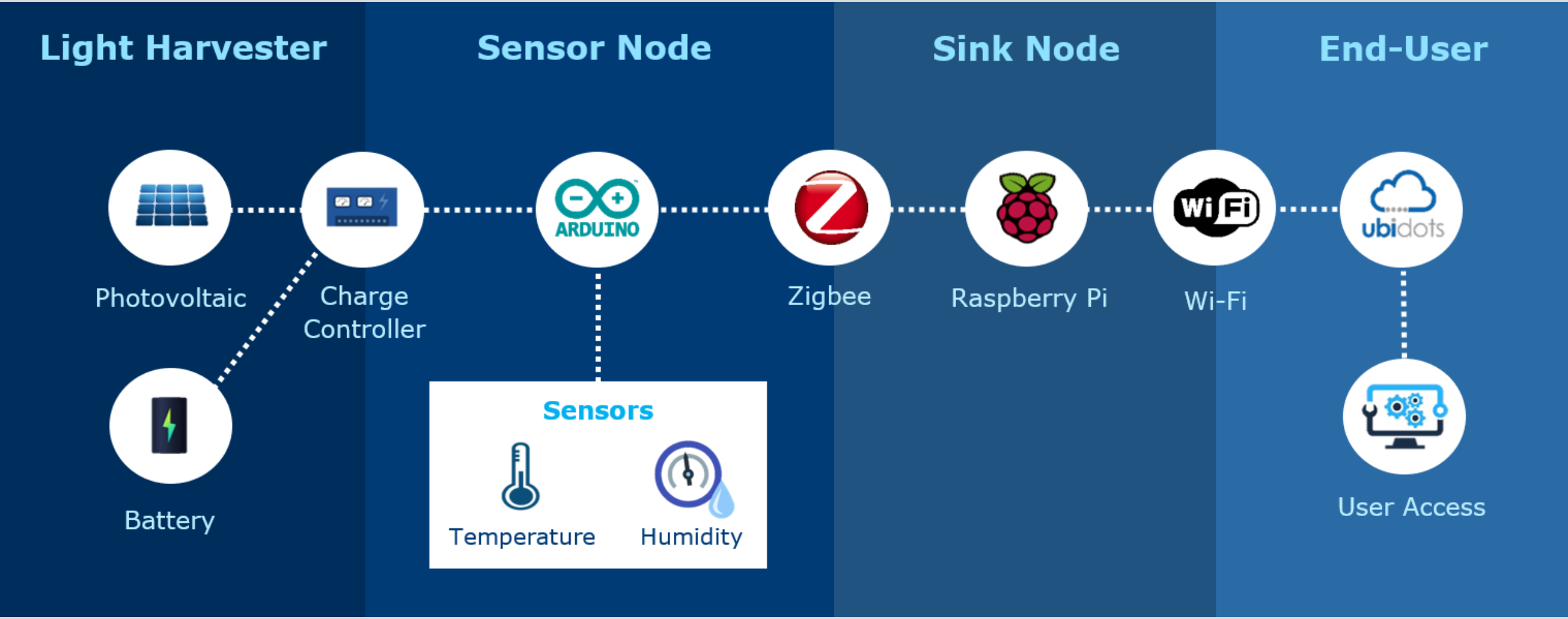
Related Works

Title	Intermittent Lighting	Low Power Consumption	Include Sensors	Long Operation Lifetime
Indoor light energy harvesting for battery-powered sensors using small photovoltaic modules (2021)	No	Yes	Yes	Yes
Wireless technologies for smart agricultural monitoring using internet of things devices with energy harvesting capabilities (2020)	Yes	No	Yes	No
luXbeacon—A Battery-less Beacon for Green IoT: Design, Modeling, and Field Tests (2019)	Yes	Yes	No	Yes
Solar-Powered Smart Agricultural Monitoring System Using Internet of Things Devices (2018)	Yes	No	Yes	No
Self-powered IoT Device based on Energy Harvesting for Remote Applications (2018)	No	Yes	Yes	Yes

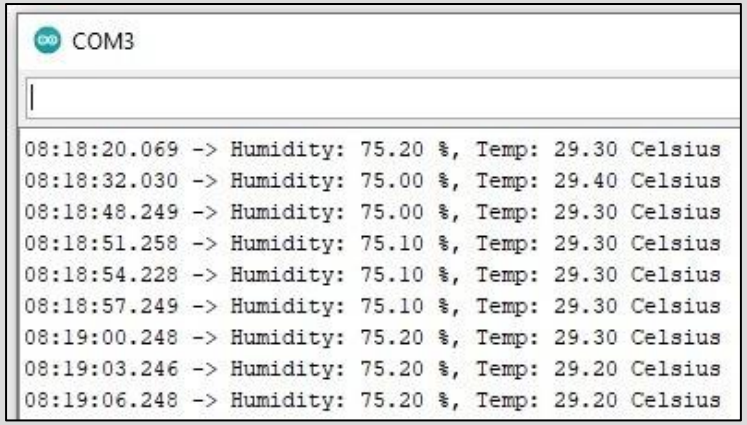
Scope of Study

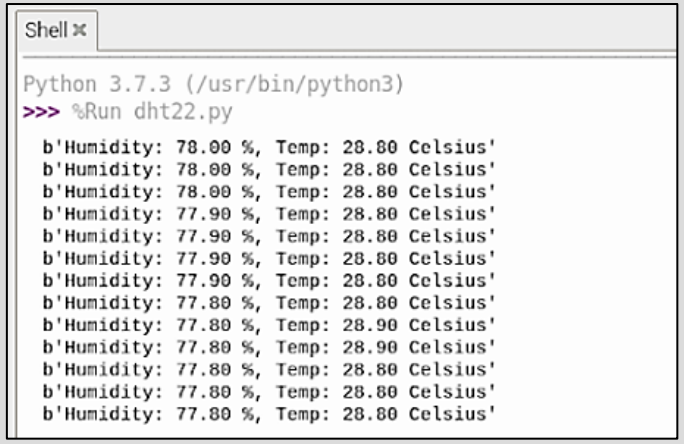
- Design a light energy harvester prototype for Sensor Nodes in Wireless Sensor Networks (WSN)
- Incorporate low power consumption devices
- Intermittent lighting test condition
- Include multiple sensors
- Ensure long operation lifetime

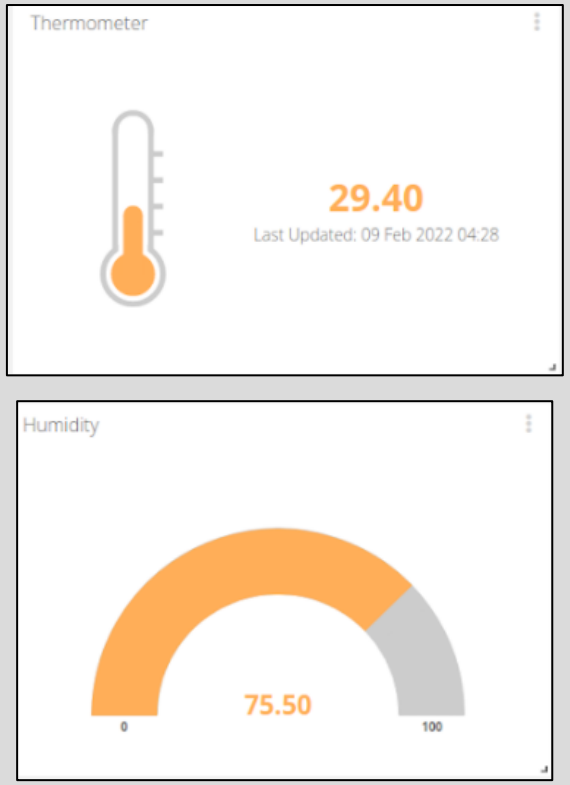
Overall System Architecture



Data Flow







Sensor Node

Sink Node

Ubidots

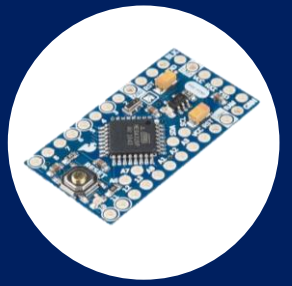
Sensor Node & Sink Node

Sensor Node

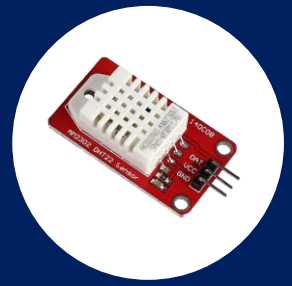
Photovoltaic

3400mAH
Lithium Ion

Charger Module



Arduino Pro
Mini 3.3V



DHT22
Sensor

Xbee Pro
Series 1

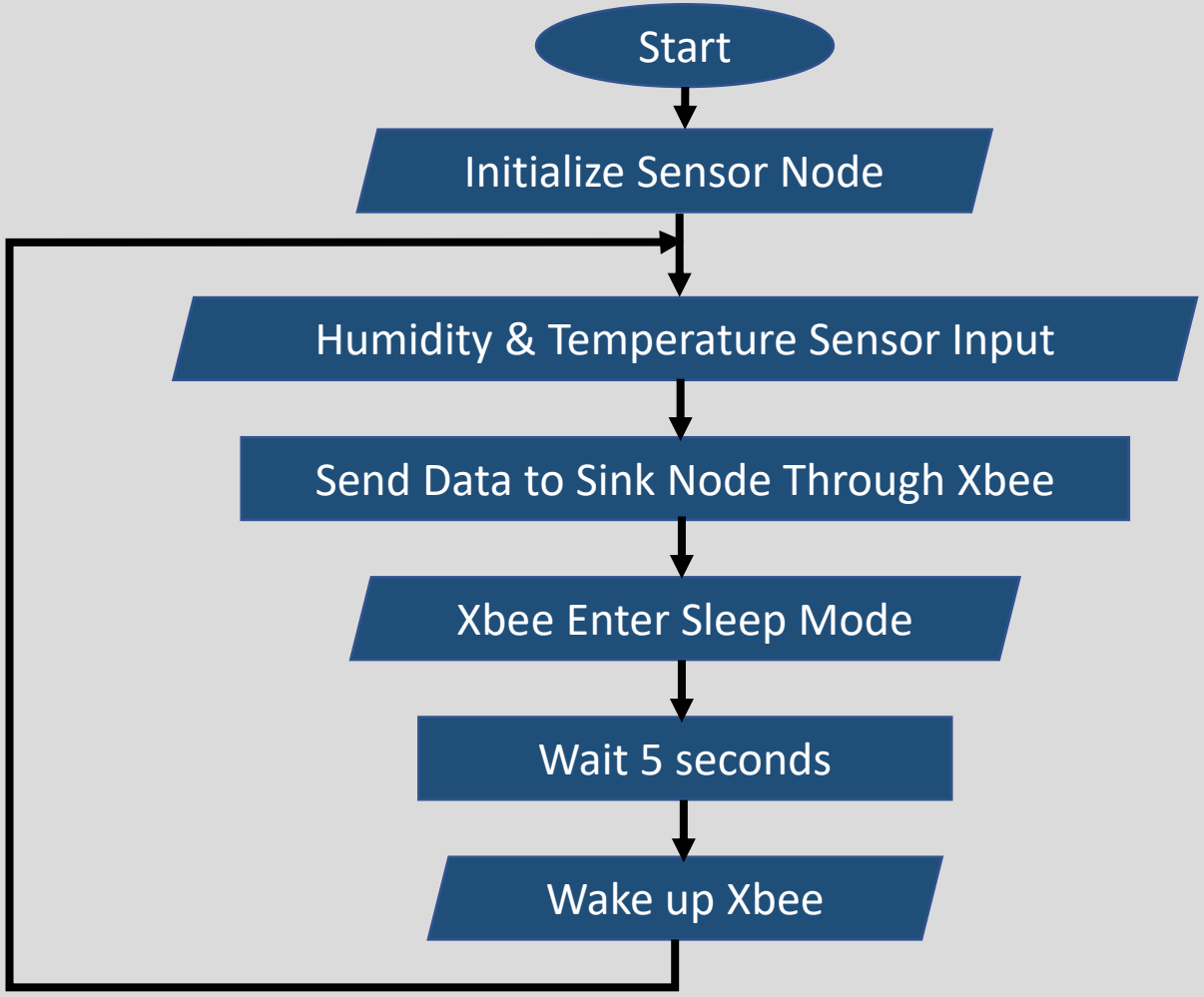
Sink Node

Xbee Pro
Series 1

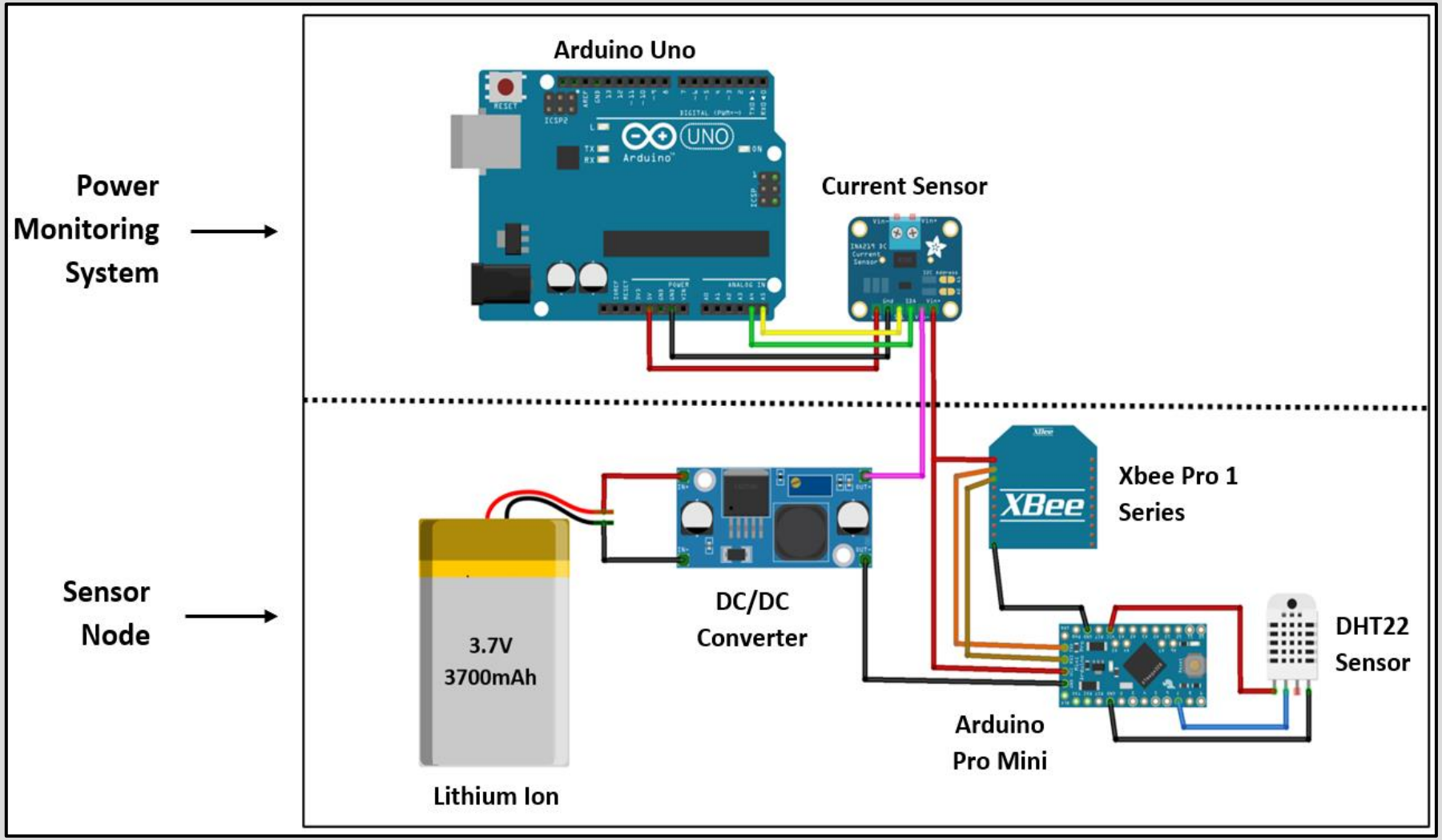
Raspberry Pi
3 Model B

Energising
Futures

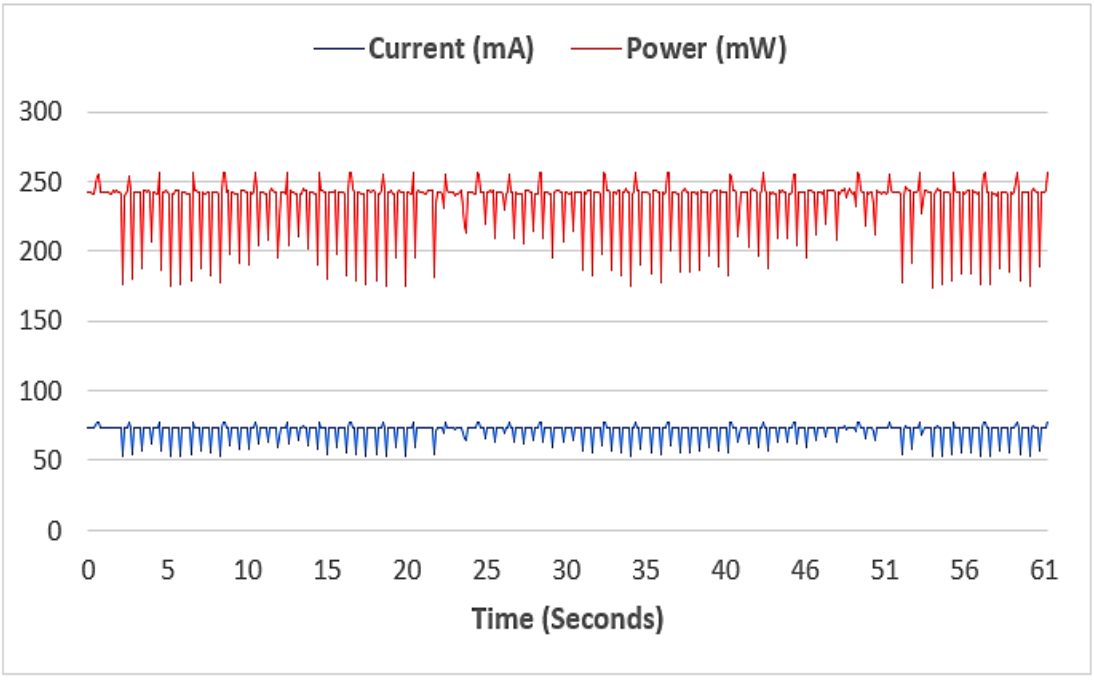
Sensor Node Flowchart

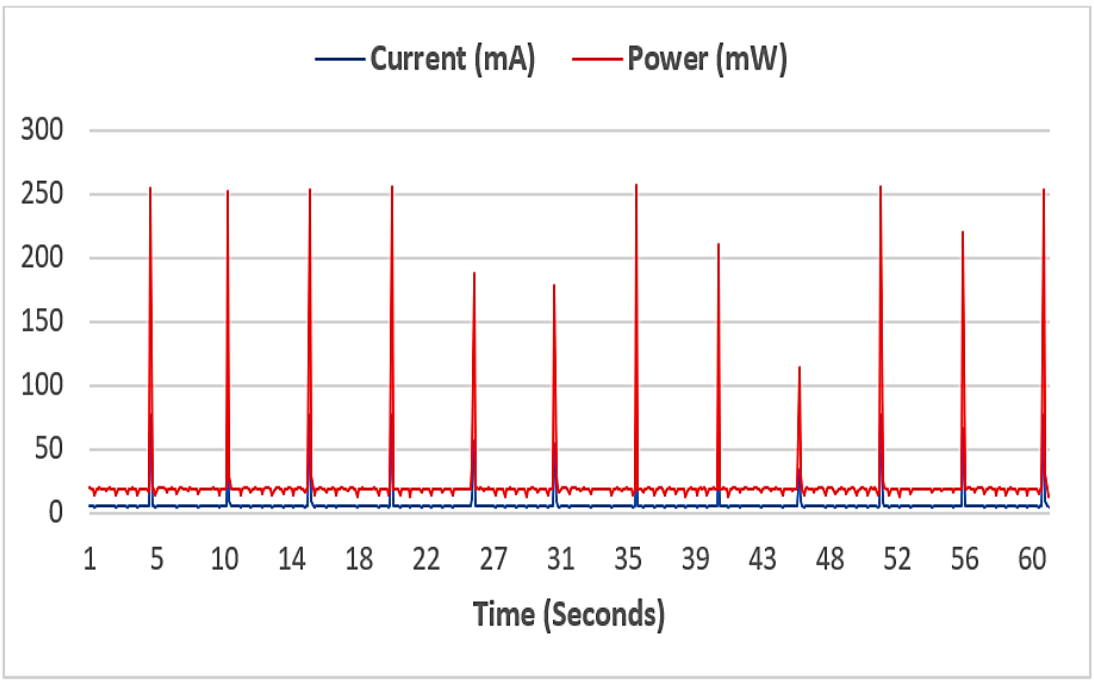


Sensor Node Power Consumption



Sensor Node Power Consumption





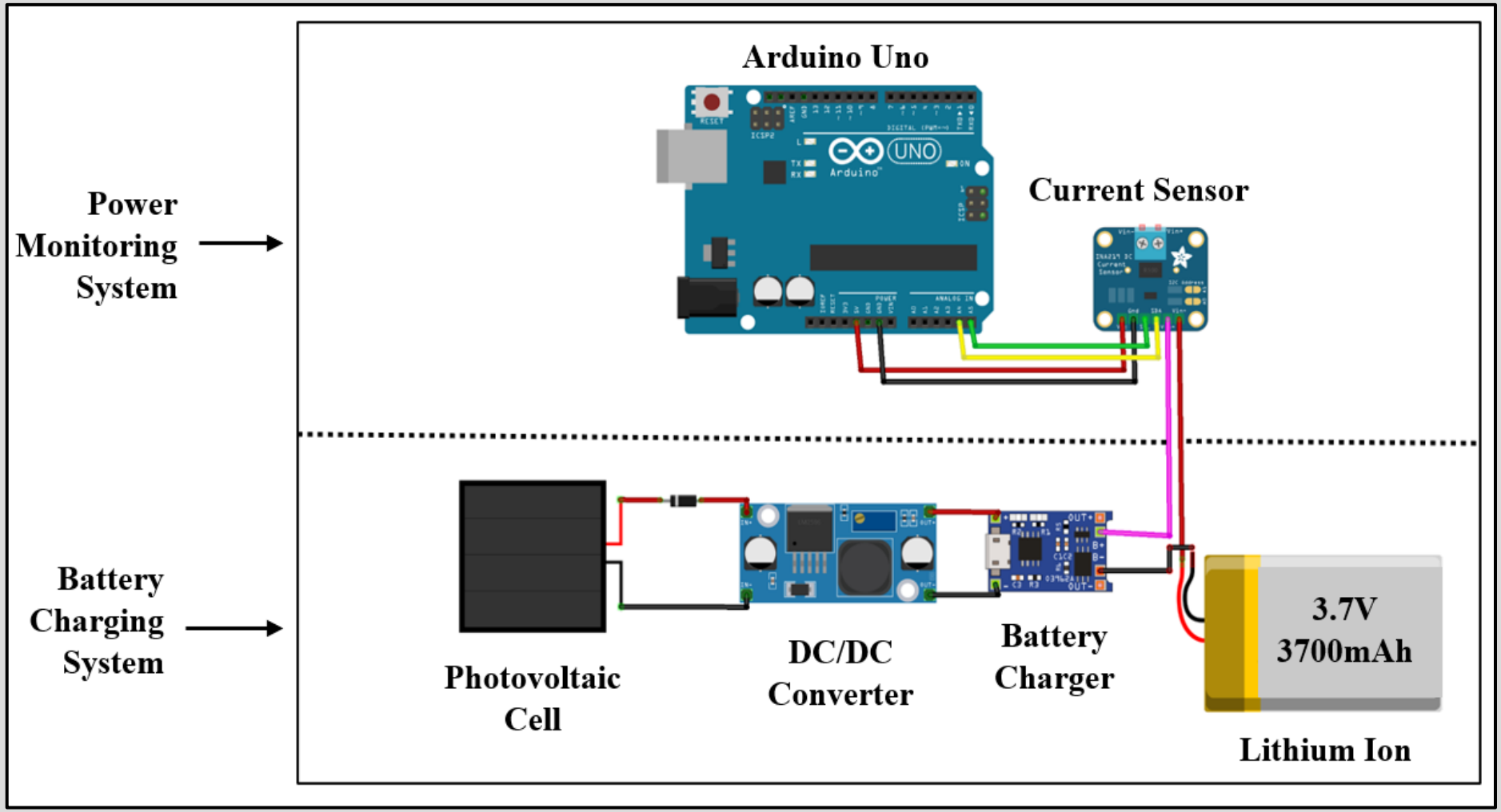
Without Sleep Mode

Power = 235.31mW

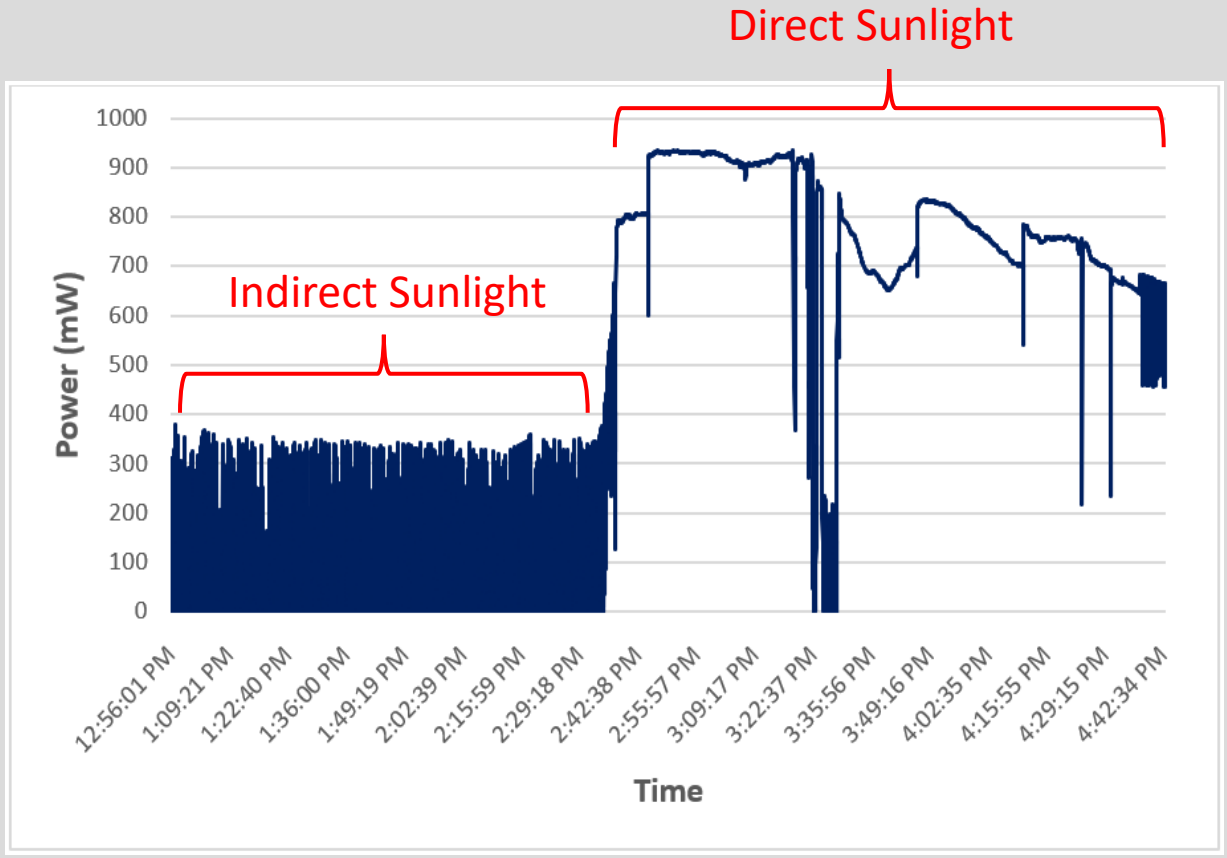
With Sleep Mode

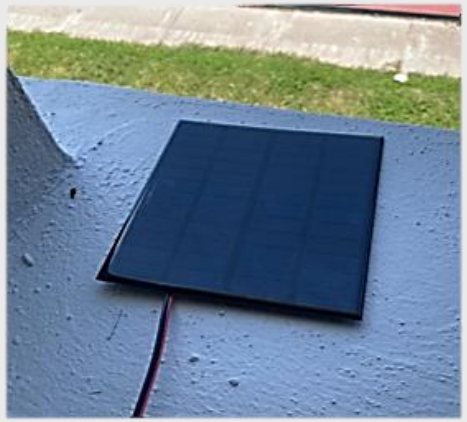
Power = 22.76mW

Light Energy Harvesting Output



Light Energy Harvesting Output





Date: 5th March 2022

Location: UTP

Time: 1PM – 5PM

Results

1	Date	Timer	Voltage	Current	Power	Changes in Time	Energy
6811	4:42:52 PM	13611	3.72	177.9	661.79	2.00	1.32358
6812	4:42:54 PM	13613	3.72	122.6	456.07	2.00	0.91214
6813	4:42:56 PM	13615	3.72	178.8	665.14	1.99	1.32363
6814	4:42:58 PM	13617	3.72	177.4	659.93	2.01	1.32646
6815	4:43:00 PM	13619	3.72	174.7	649.88	2.00	1.29976
6816	4:43:02 PM	13621	3.72	178.3	663.28	2.00	1.32656
6817	4:43:04 PM	13623	3.72	174.7	649.88	2.00	1.29976
6818	4:43:06 PM	13625	3.72	174.8	650.26	1.99	1.29402
6819	4:43:09 PM	13628	3.72	174.8	650.26	2.64	1.71669
6820	4:43:10 PM	13629	3.72	177.6	660.67	1.36	0.89851
6821	Total Energy						6327.78825

Total Energy Generated = 6327.79J

Results

Sensor Node Power = 22.76mW

Sensor Node Energy Consumption per Day

= 22.76mJ x 60 seconds x 60 minutes x 24 hours

= 1966.46 J

Therefore, the energy generated can last for

$$= \frac{6327.79J}{1966.24J} = \underline{\textbf{3.22 days}}$$

Conclusion

The sensor node uses a Photovoltaic cell to harvest ambient light energy

4 hours of energy generation is enough to last for more than 3 days

The objective of sustained operation over prolonged time is achieved

Questions & Answers Session

Project Timeline (FYP I)

Activities	Week											
	1	2	3	4	5	6	7	8	9	10	11	12
Title Selection / Proposal												
Research on Related Works												
Research on Light Energy Harvesting And Low Power IoT Devices												
Perform Comparative Study												
Equipment Selection												
Finalize System Design Architecture												
Create Budget List for Material Procurement												
Software Development for Arduino & Sensors												
Material Procurement												

Project Timeline (FYP II)

Activities	Week											
	1	2	3	4	5	6	7	8	9	10	11	12
Design Wiring Diagram for Light Harvester & Sensor Node												
Light Harvester Power Generation Experiment & Tests												
Raspberry Pi Configuration & Setup												
Prototype Assembly												
Sensor Node & Sink Node Communication Configuration												
Integrate Sink Node with Ubidots.com												
Design Web User Interface												
System Testing												
System Rectification & Optimization												

Key Milestones

Research on Related Works

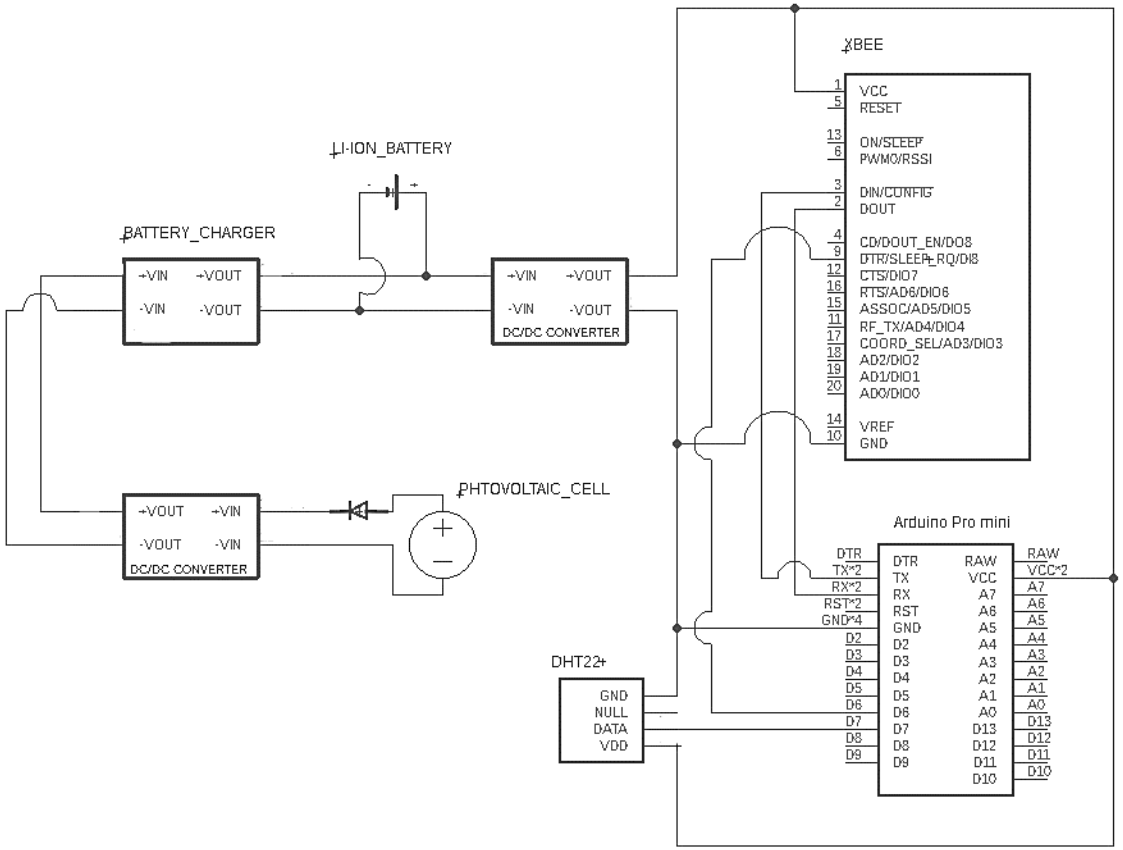
Perform Comparative Study

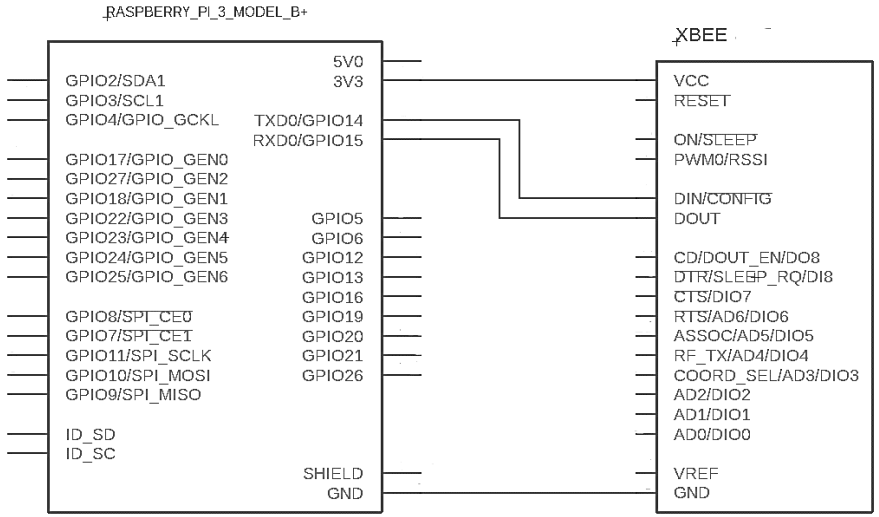
Finalize System Design Architecture

Prototype Assembly

System Testing

Schematics Diagram





Comparison of Controllers

Specification	Arduino Uno	Arduino Nano	Raspberry Pi 3 Model B	Raspberry Pi 4
Processor	ATmega328P	ATMega4809	Broadcom BCM2837	Broadcom BCM2711
Clock Speed	16Mhz	16Mhz	1.2GHz	1.5GHz
Current Consumption	50mA	19mA	500mA	700mA
RAM	32kB	32kB	1GB	2GB
Network	Via external module	Via external module	Wi-Fi	Wi-Fi
Programming Language	Arduino IDE	Arduino IDE	Python	Python
Estimated Cost	RM62	RM51	RM155	RM209

Comparison of Wireless Communication

Specifications	ZigBee	Wi-Fi	Bluetooth	Bluetooth Low Energy
Network Topology	Star, Tree and Mesh	Star	Point-to-Point	Star, Bus
Protocol	IEEE 802.15.4	IEEE 802.11n	IEEE 802.15.1	IEEE 802.15.1
Data Rate	96-250kbps	54 – 600Mbps	700kbps	1Mbps
Frequency	2.4GHz	2.4 – 5GHz	2.4GHz	2.4GHz
Network size	65000	255	7	Unlimited
Transmission Range	10 – 100m	50m	<30m	50m
Latency in Data Transfer	Low	High	High	Low
Power Consumption	Low	High	High	Low
Security	High	Low	Low	Low
Battery Lifespan	Months to Years	Hours	Days	Months to Years