Building a blimp using nano-drones for BLE mesh

1. Problem and Scope

2. System Design

3. Implementation Plan

4. Engineering and Software

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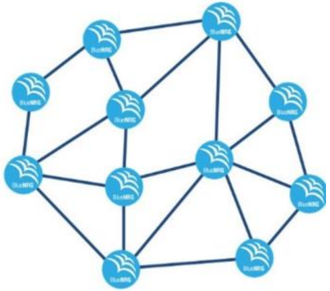
Problem Statement

Objectives:

- Build an indoor blimp using nano drone
- Use it to gather information using BLE
- Coordinate with BLE mesh to:
  - Collect data and communicate with Mesh
  - Link BLE central devices to Mesh

(a) Drone

(b) Blimp Model



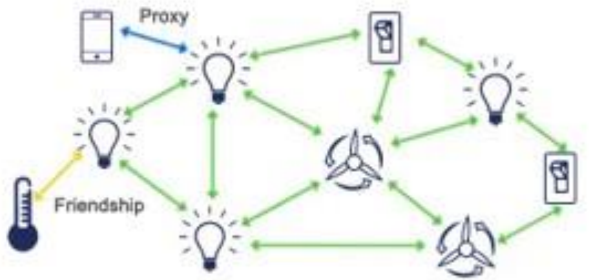
(c) BLE Mesh Example

Challenges:

- Increase on-air time with single charge.
- Coordinating BLE tasks with blimp motion.

Applications and Scope

- Scope
  - Create a BLE Mesh
  - Configure blimp as BLE gateway to Mesh
  - Increase on-air time of blimp
- Applications
  - Inventory Management in warehouses
  - Firmware Over The Air Updates



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System Design

- Mesh network (Application)
  - 3 Nodes (1 Proxy Node + 2 Mesh Nodes)
  - Provisioner: Smart phone
  - Blimp (BLE 4.0 radio nRF51822)

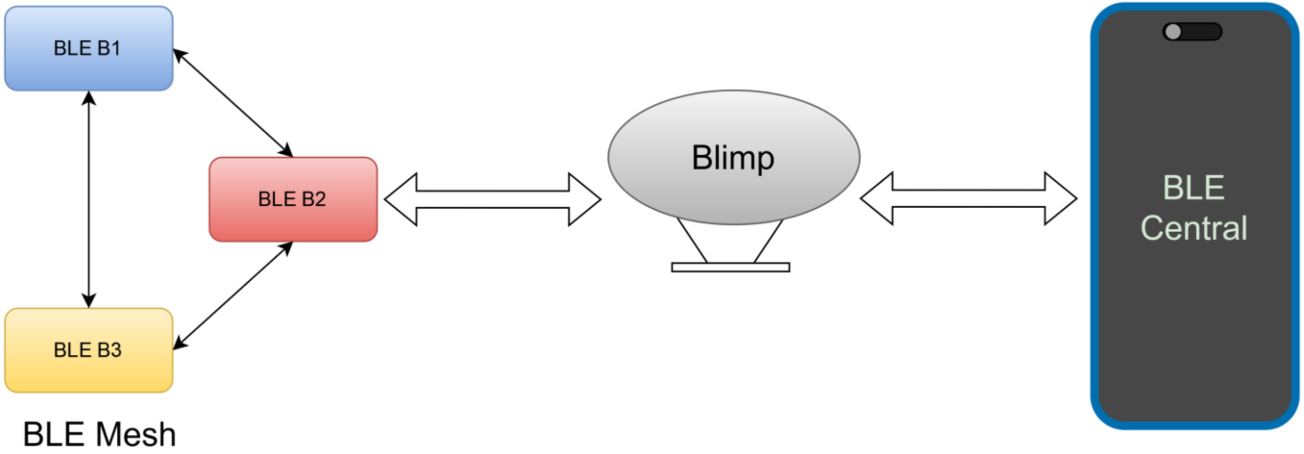

Figure 3: Milestone 1 Application

System Design

Node B1:

- 1 Element with Generic on/off State
- Physical actuation LED

Node B2:

- Proxy node translating MESH messages to classic BLE services and characteristics

Node B3:

- 1 Element with Generic level State
- Physical actuation FAN

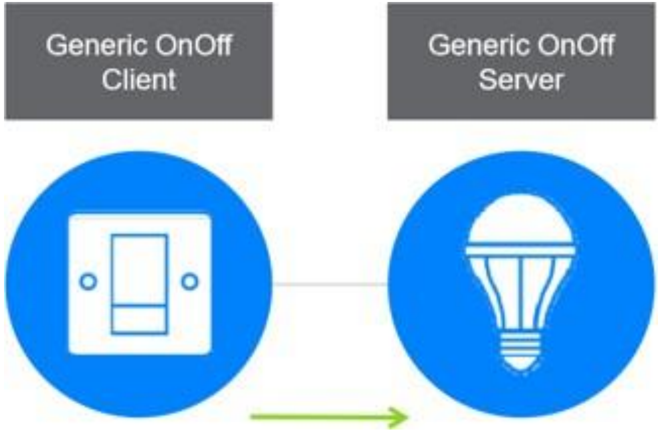

Figure 4: Generic Models

Bluetooth Meshing Challenges

- Crazy Flie 2.1 uses nRF51822
- No support for meshing
- Conventional point-to-point BLE
- Blimp cannot be directly integrated to mesh
- Can communicate with proxy node only
- Alternative - nRF52/ nRF53 family of SoCs

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Mesh Implementation Plan

- Node B1 (nRF52840DK):
  - LED light node
  - Proxy function disabled
  - Powered by Li-ion cell
- Node B2 (nRF52832DK):
  - Proxy node link for BLE central
  - Proxy function enabled
  - Powered by wall socket
- Node B3 (nRF52840DK):
  - Fan node with variable speed
  - Proxy function disabled
  - Powered by Li-ion cell
- Development using VSCode, Zephyr and

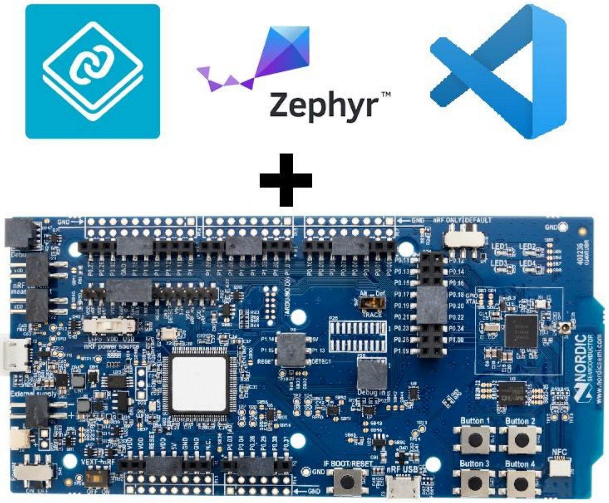

Figure 5: Hardware and Software

Blimp Implementation Plan

- Balloon Materials:
  - Mylar or Melinex (Superior retention)
  - Latex (Higher lift poor retention)
- Buoyant gas:
  - Hydrogen (lift capacity $\approx$ 1.12 gm/litre)
  - Helium (lift capacity $\approx$ 1.02 gm/litre)
  - Helium preferred due to safety concerns
- Nano Drone:
  - Crazy Flie 2.0
  - Total weight 27gm
  - Controller: Android Phone

Progress

- Mesh Implementation
  - 3 Nodes Mesh programming ✓
  - Provisioning the nodes into Mesh ✓
  - Communication to mesh using Proxy ✓
  - Implement actuation circuit for nodes
  - Use nRF51822 to send mesh messages
- Blimp Implementation
  - Balloon Material and filler gas ✓
  - Test motor orientation and control
  - Modify BLE radio firmware for mesh

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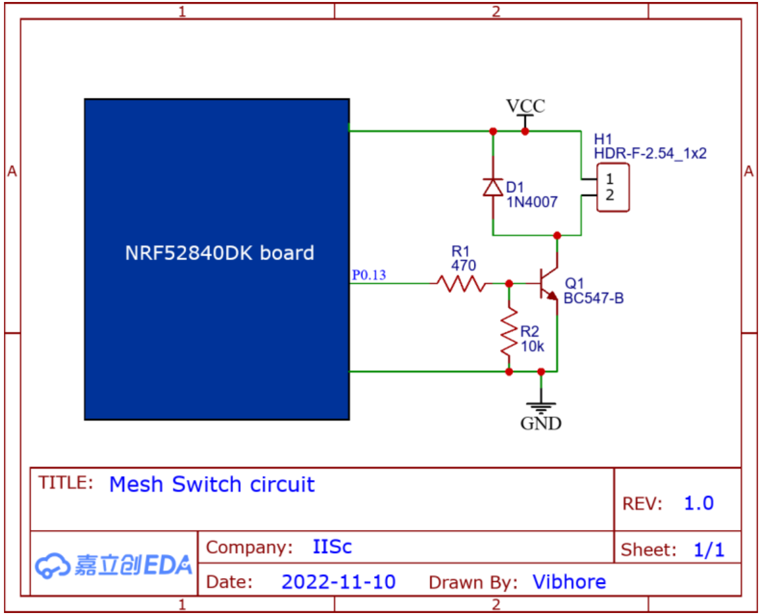
Hardware: Mesh Node

- Fan and Light Control
- Max Current 200 mA
- Diode : 1N4007 fly-back
- GPIO : Port 0 Pin 13



TITLE: Mesh Switch circuit

REV: 1.0

Company: IISc

Sheet: 1/1

Date: 2022-11-10 Drawn By: Vibhore

Figure 6: Switch circuit for high current loads

Hardware : Drone-I

- Controller : Arduino Nano BLE 33
  - Based on nRF52840
  - Only Accelero & Gyro sensors present
- Motor : Coreless 720 motors with 55mm propeller
- MOSFET : AO3400 N-channel MOSFET
- Diode : 1N4007 fly-back
- ToF sensor : VL53L0X
- LDO : TLV71333 3.3V
- Battery : 150 mAh Li-Po 1S

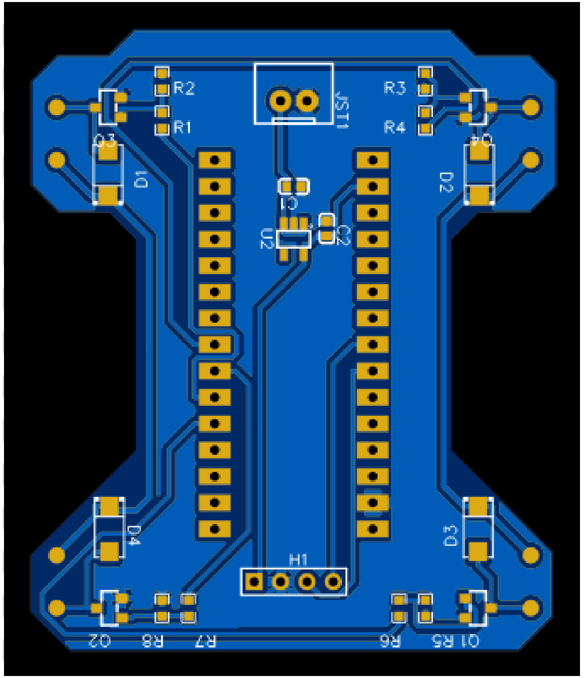


Figure 7: PCB design for drone (Top View)

Hardware : Drone-II

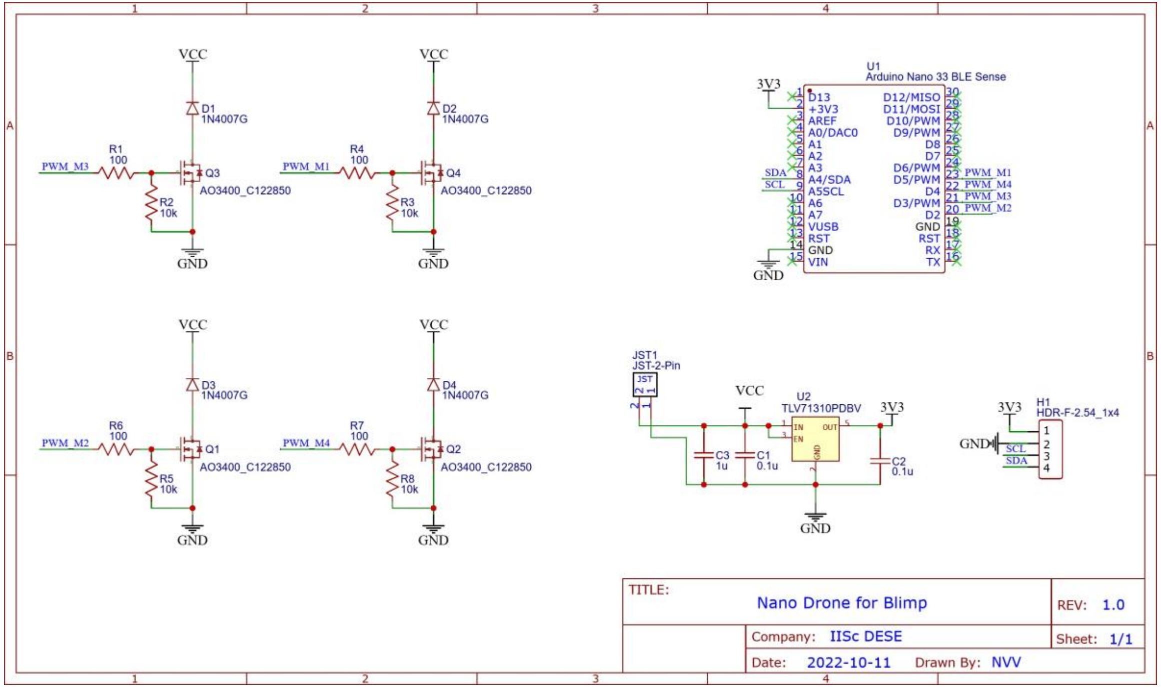


Figure 8: Schematic of Nano Drone Controller

Hardware : Drone-III

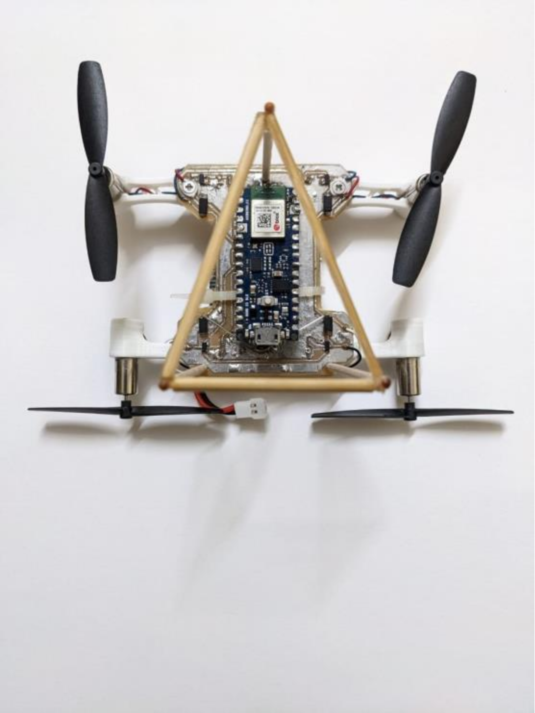


Figure 9: Design for drone (Top View)

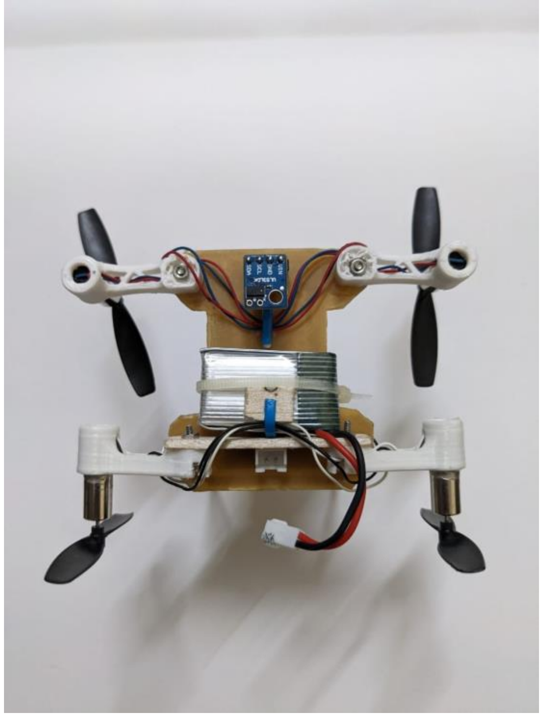


Figure 10: Design for drone (Bottom View)

Software: Mesh

- Boards : nRF52840DK & nRF52832DK
- IDE : VS Code
- Toolchain : nRF connect SDK V2.1.0
- Provisioner : nRF Mesh App

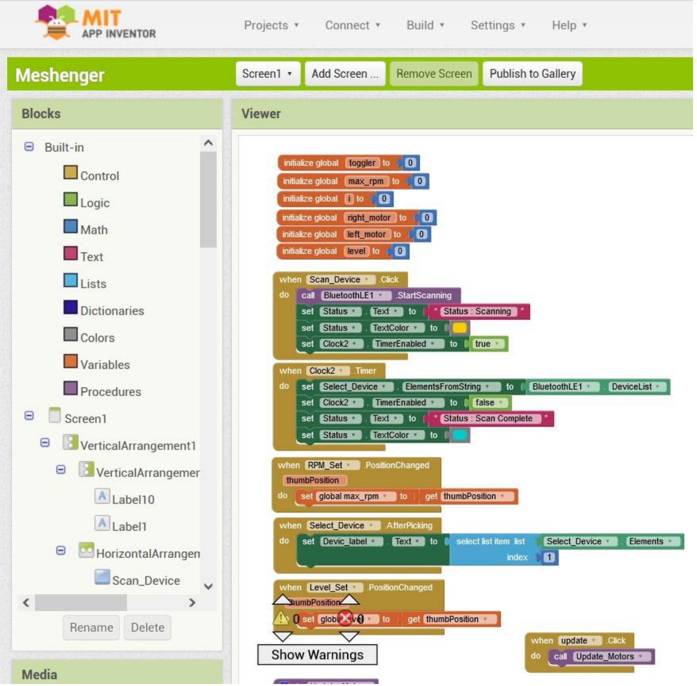
Software: Blimp firmware

- Board : Arduino Nano BLE 33
- IDE : Arduino IDE
- Libraries: Scheduler and Adafruit ToF
- BLE role: Central and Peripheral

Software: Blimp Control App-I

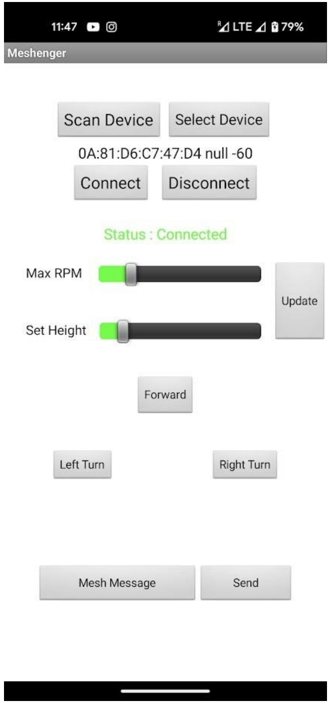
- Android App for Blimp navigation
- Development platform : MIT App Inventor 2
  - BLE connection for Blimp control
  - Mesh message communication

Software: Blimp Control App-II



```
initialize global toggler to 0
initialize global max_rpm to 0
initialize global i to 0
initialize global right_motor to 0
initialize global left_motor to 0
initialize global level to 0

when Scan_Device .Click
do  call BluetoothLE1 .StartScanning
    set Status . Text to " Status : Scanning "
    set Status . TextColor to
    set Clock2 . TimerEnabled to true

when Clock2 .Timer
do  set Select_Device . ElementsFromString to BluetoothLE1 . DeviceList
    set Clock2 . TimerEnabled to false
    set Status . Text to " Status : Scan Complete "
    set Status . TextColor to

when RPM_Set .PositionChanged
  thumbPosition
do  set global max_rpm to get thumbPosition

when Select_Device .AfterPicking
do  set Devic_label . Text to select list item list Select_Device . Elements
                                            index 1

when Level_Set .PositionChanged
  thumbPosition
do  set global level to get thumbPosition

when update .Click
do  call Update_Motors
```

Figure 11: Mit App Inventor



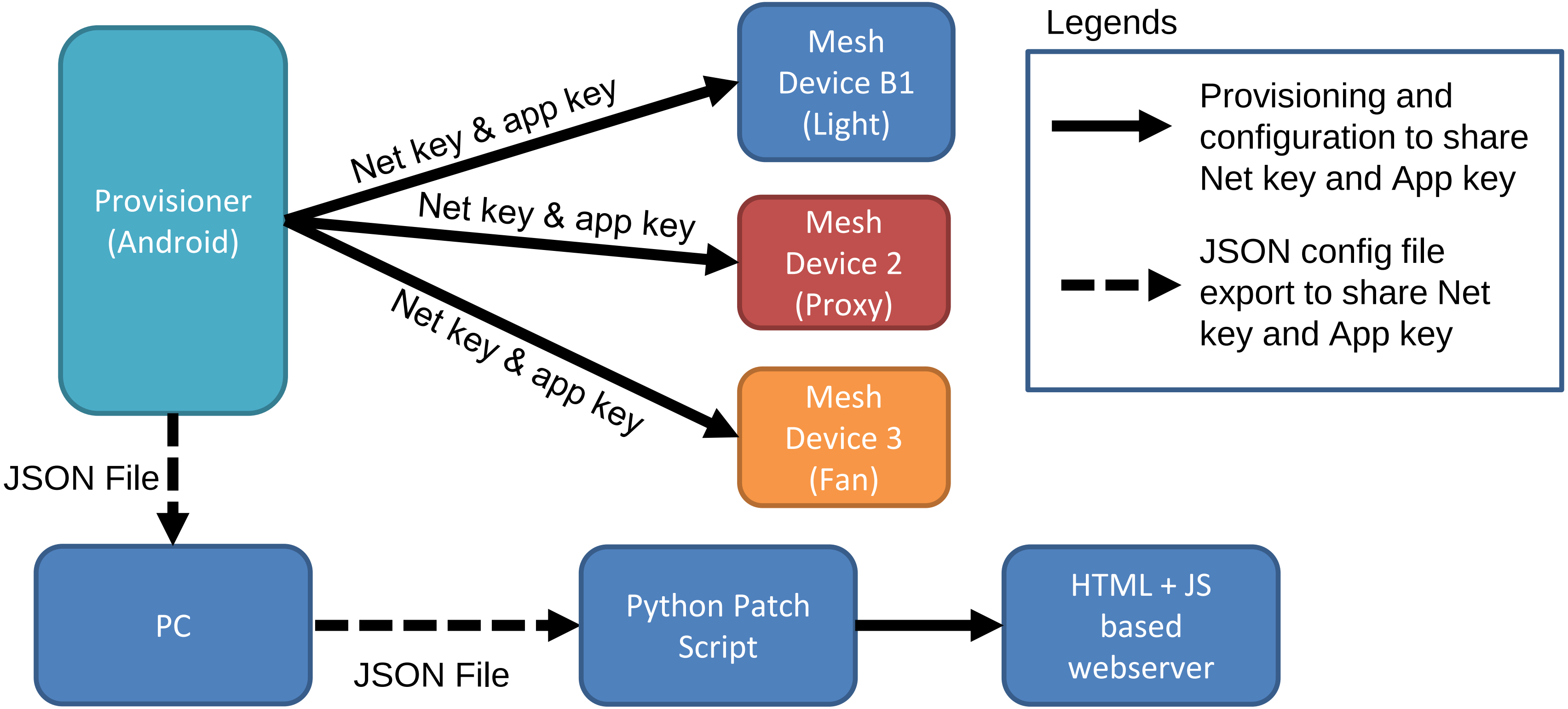
0A:81:D6:C7:47:D4 null -60

Status : Connected

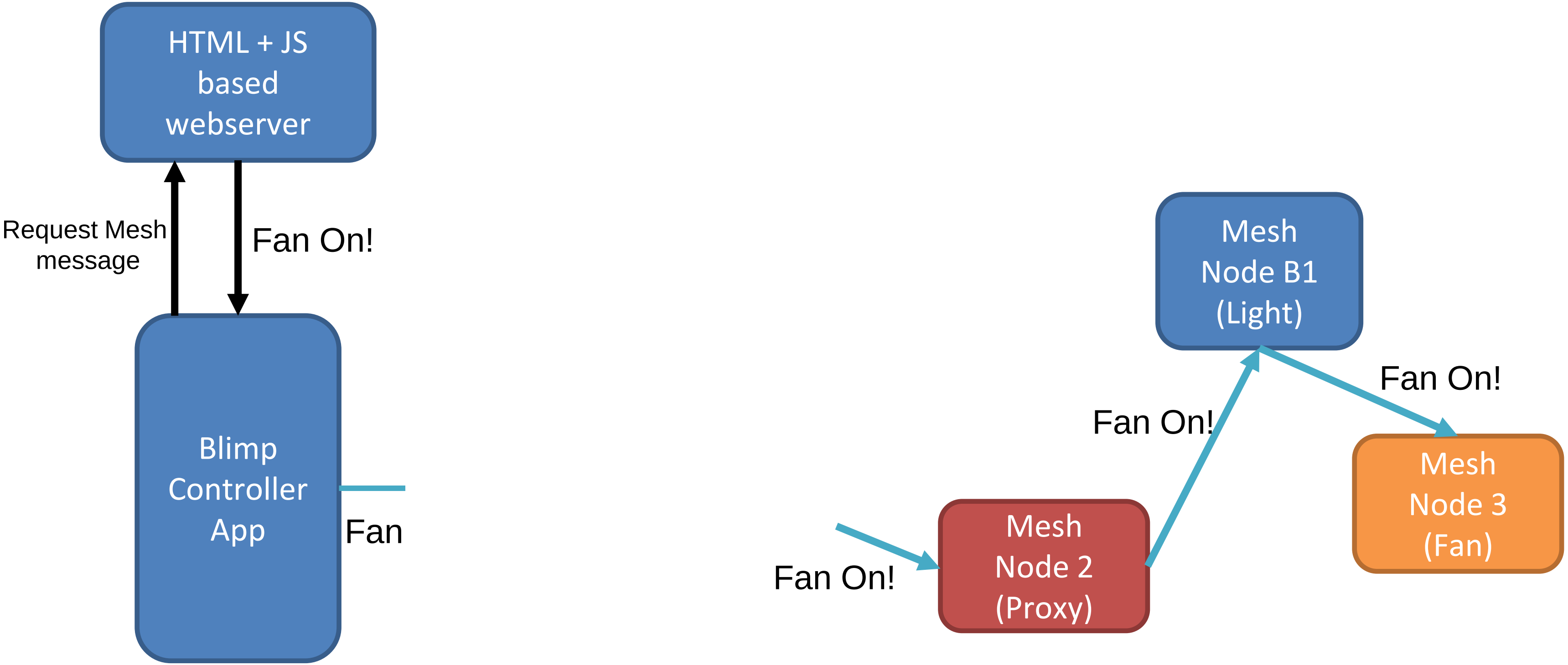
Figure 12: Blimp App

Pre-Demo Activities

Mesh Configuration



Mesh Message Transport



HTML + JS based webserver

Request Mesh message

Fan On!

Blimp Controller App

Fan

Fan On!

Mesh Node 2 (Proxy)

Fan On!

Mesh Node B1 (Light)

Fan On!

Mesh Node 3 (Fan)

Why BLE on a drone?

- We essentially have a BLE post man
- Capabilities inherited from Mesh
- Advantage:
  - Mobility and increased range compared to stationary BLE
  - Maintains low power compared to traditional drones
  - Suitable to “divide and conquer” large meshes
- Why not WiFi/Zigbee?
  - WiFi overheads very large for simple IoT applications
  - Zigbee mesh at best supports 100 devices

Numbers!

Parameter	Value	Unit
Weight	45	gm
Range (LoS)	19	meters
Flight Time*	>10	minutes

*Subject to throttle and blimp buoyancy

Some Application Areas

- Warehouse Inventory Management
  - Dedicated mesh network for each Rack
  - Prevents battery drain due to unnecessary flooding
- Building Automation
  - Configuring BLE meshes in hotels
  - Health Monitoring of nodes
- Mobile Beacon for advertisement
  - Advertising to smartphones in malls

References

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- https://www.bluetooth.com/blog/bluetooth-mesh-developer-study-guide-v2-0/

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Behind the Scenes