NEXT GENERATION ASSET TRACKING SYSTEM

UW Medicine

Objective & Requirements

UW Medical Center manages over 10,000 pieces of equipment with roughly 8,000 devices that move around the facility. UWMC needs to be able to track and locate these medical devices for maintenance and inventory purposes.

Requirements:

Create a new tracking device to be attached onto medical equipment with the following functionality:

- Blinking LED (battery indicator, preventative maintenance recall)
- Wi-Fi agnostic (previous system was BLE reliant)
- Power-efficient (> 1 year battery)

As well as develop:

- Firmware to handle Wi-Fi transmission, battery monitoring, deep sleep management, location sensing data, and command processing
- Local **server** and **database** to handle asset tracker information and communication
- User-end **webpage** to view and recall trackers

Technical Design - Firmware

Firmware role:
Bridges hardware and server via the ESP32-C6

MQTT Communication topics:
1) Location:
   - Sends 3 strongest APs
   - Includes altitude and battery level (in mV)
2) Recall
   - Server instructs device to turn recall LED on/off
3) Sleep
   - Server sets deep sleep duration

Power Management:
Uses deep sleep cycles to conserve battery between Wi-Fi connections

Flowchart of this cycle with communications can be seen in Figure 1

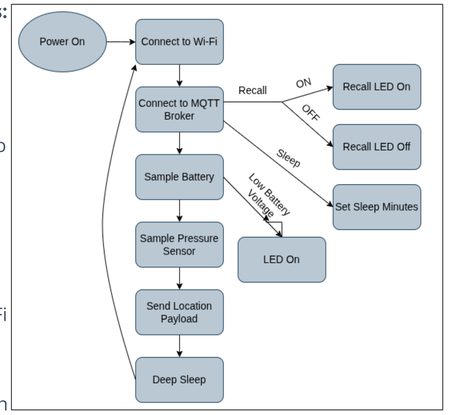


Figure 1. Firmware workflow chart

Technical Design - Hardware

Hardware Goals:

- Compact packaging of all circuit components
- Enable LED blinking even when ESP32-C6 is powered off
- Battery life of 18 months

Circuit Elements:
- ESP32
- LDO Regulator
- Latching Circuit
- Blinking Circuit

Circuit Design:

- **Latching Circuit:** Turns on/off based on ESP32-C6 signals and stays on until toggled
- **Blinking Circuit:** Uses BJTs and capacitors to blink LED when latched on

TX Current (mA)	RX Current (mA)	Deep Sleep (mA)	BMP390 (mA)	LED Current (mA)
354	82	0.007	0.0032	1

Blink Circuit	Latch Circuit (mA)	Over On (mA)	Over Off (mA)
0.34	0.005	50	0.01

Time TX (s)	Time RX (s)	Pings Per Day	Desired Life (Days)
0.5	2	48	555

Min Required mAh	Min Current (mA)	Max Current (mA)
3717.1495	0.0202	405.0082

LED Turn On (%)	LED On For (h)	Time Till Dead (Days)
10	12	35.43249886

Figure 2. Battery life calculator

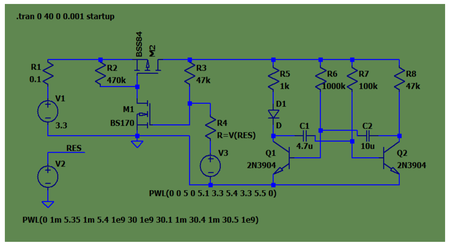


Figure 3. Schematic of the LED circuit

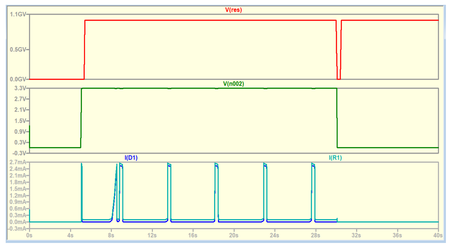
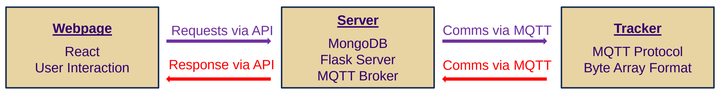


Figure 4. Simulation result of the LED circuit

Technical Design - Software

- **System Stack:** Built with MongoDB, MQTT, Flask & React
- **Data Flow:** MQTT payloads from trackers are parsed and stored as JSON in MongoDB
- **Backend:** Flask API provides data access and updates.
- **Frontend:** React displays real-time map and table for monitoring and control.



Future Work

Power Optimization:
- Try lower-power microcontrollers
- Test different batteries and measure lifespan
- Simplify LED blink circuit
- Send location updates **only when moved**
- Scan **fewer access points** to reduce load

Security & Usability
- Add **encryption** and **authentication**
- Allow manual entry of AP MACs and coordinates in the web interface

Results

Hardware

- **PCB:**
  - Implemented status LED that works independently of SoC power using custom latch circuit
  - Chose smaller components to save space
- **Enclosure:**
  - 3-D printed, **3" x 2" x 1"**
  - Corrosion-resistant to common hospital cleaners

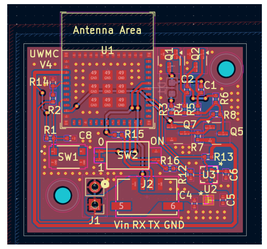


Figure 5. PCB design

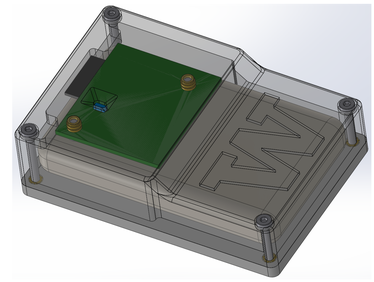
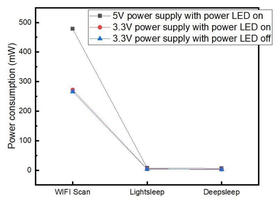


Figure 6. Transparent view of the case

Firmware

- **Power Efficiency:**
  - Successfully utilizes **deep sleep mode** to reduce Wi-Fi use
  - See Figure 7 for differences in power saving
- **Altitude Sensing:**
  - Achieved altitude computation with **~20cm accuracy**
- **Battery Monitoring**
  - Sends low-battery alert to server



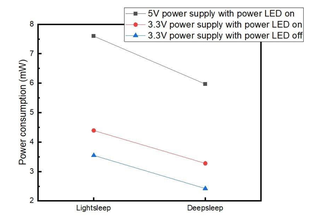


Figure 7.Power usage during Wi-Fi scan, light/deep sleep, under different voltages and LED states

Software

- **Server**
  - Successfully calculates tracker location **within 10 ft**
  - Able to accurately process and store data for **multiple** trackers
- **Webpage**
  - LED recall trigger
  - Map of access points and trackers
  - Adjustable sleep timers
  - Filter specific trackers

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