Battery Life Estimate

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Power Consumption of Each Node

Node A (Sensing Node)

Component	Voltage (V)	Current (mA)	Power (mW)
ESP32-C3	3.3V	~100mA	330mW
FSR Sensors (x4)	3.3V	~4mA each	13.2mW
Light Sensor (TSL2591)	3.3V	~0.4mA	1.32mW
Total Power for Node A	-	-	**~345mW**

Node B (Display & Output Node)

Component	Voltage (V)	Current (mA)	Power (mW)
ESP32-C3	3.3V	~100mA	330mW
Stepper Motor (X27)	3.3V	~150mA	~500mW
WS2812B LED Strip (1m, 60 LEDs)	**5V (separate power)**	**~1200mA max**	**6000mW max**
Total Power for Node B (excluding LEDs)	-	-	**~830mW**

System Usage Model

- Estimate **4 times per night**
- Each usage lasts **5 minutes**
- **Total daily usage: 20 minutes**

Battery Selection & Capacity Calculation

Nodes A & B (ESP32 + Sensors + Stepper) - Powered by 18650 Battery

Daily Energy Consumption (20 min/day)

Node	Power (mW)	Daily Usage (min)	Daily Energy (mWh)
Node A (ESP32 + sensors)	~345mW	20	**115mWh**
Node B (ESP32 + stepper, excluding LEDs)	~830mW	20	**277mWh**
Total Energy (both nodes)	**-**	**-**	**392mWh/day**

Battery Energy Available (18650 Li-ion 3.7V, 2500mAh)

2500mAh×3.7V=9250mWh

After LDO conversion (~85% efficiency):

9250mWh×0.85=7862.5mWh

Estimated Battery Life

For a **2500mAh 18650 battery**:

Node	Battery Life (2500mAh 18650)
Node A (ESP32 + sensors)	**~68.3 days**
Node B (ESP32 + stepper)	**~28.4 days**

For a **3500mAh 18650 battery**:

Node	Battery Life (3500mAh 18650)
Node A (ESP32 + sensors)	**~95.7 days**
Node B (ESP32 + stepper)	**~39.8 days**

WS2812B LED Strip - Powered by USB Power Bank

- **Max Power Consumption:** 6000mW (full brightness)
- **Estimated Duty Cycle (~30%) → 1800mW average**
- **Daily Usage:** 20 min

1800mW×2060=600mWh/day

For a **10,000mAh USB power bank (5V)**:

10,000mAh×5V=50,000mWh

Estimated LED Strip Runtime

50,000mWh600mWh≈83 days

Final Battery Life Estimates

System	Power Source	Estimated Runtime Before Recharge
Node A (ESP32 + sensors)	18650 (3.7V, 2500mAh)	**~68.3 days**
Node B (ESP32 + stepper motor)	18650 (3.7V, 2500mAh)	**~28.4 days**
LED Strip (WS2812B, 1m)	USB Power Bank (10,000mAh, 5V)	**~83 days**

Reflection

How did you determine your "days of use" metric?

The **"days of use"** metric is calculated based on the estimated **power consumption** of each component, the **battery capacity**, and the **expected daily usage**.

- **Power consumption** for each node is determined by summing up the power of all components.
- **Daily energy consumption** is computed using the estimated **duty cycle** (4 activations per day, 5 minutes each, totaling **20 minutes/day**).
- **Battery life is estimated** by dividing the available energy of the battery (considering efficiency loss) by the daily energy consumption.

For the **LEDs**, I estimate their average power consumption at **30% brightness** rather than maximum usage to reflect real-world conditions.

What do you think is the optimum size for the battery in your device?

- **For Node A (ESP32 + sensors):** A **2500mAh 18650 battery** can last **~68.3 days**, while a **3500mAh battery** extends this to **~95.7 days**. Since the sensing node consumes relatively low power, a **2500mAh battery is sufficient** for at least **2 months** of operation.
- **For Node B (ESP32 + stepper motor):** A **2500mAh battery** provides **~28.4 days** of operation, which may require recharging **monthly**. Upgrading to a **3500mAh battery** extends this to **~39.8 days**, making it a more practical choice.
- **For WS2812B LED Strip:** A **10,000mAh USB power bank** offers **~83 days** of operation. A **5,000mAh power bank** would still last **~41 days**, making it a good tradeoff between cost and battery life.

Thus, my battery setup would be:
- **Node A:** 2500mAh (or 3500mAh for longer duration)
- **Node B:** 3500mAh (to reduce frequent recharges)
- **LEDs:** 5,000mAh or 10,000mAh USB power bank

What hardware/software/cost/effort tradeoffs could you make to improve the user experience?

Tradeoff Type	Improvement	Pros	Cons
Hardware - LED Power	Lower LED brightness (adaptive control)	Extends USB power bank life	Might reduce visibility

Software - Sleep Mode	Enable **deep sleep** for ESP32 when idle	Reduces power consumption significantly	Requires additional wake-up logic
Software - Sensor Optimization	Lower FSR & light sensor polling frequency	Less frequent wake-ups save power	Might slightly delay response time