Proposal

Household Water Usage Monitoring System

Team 42
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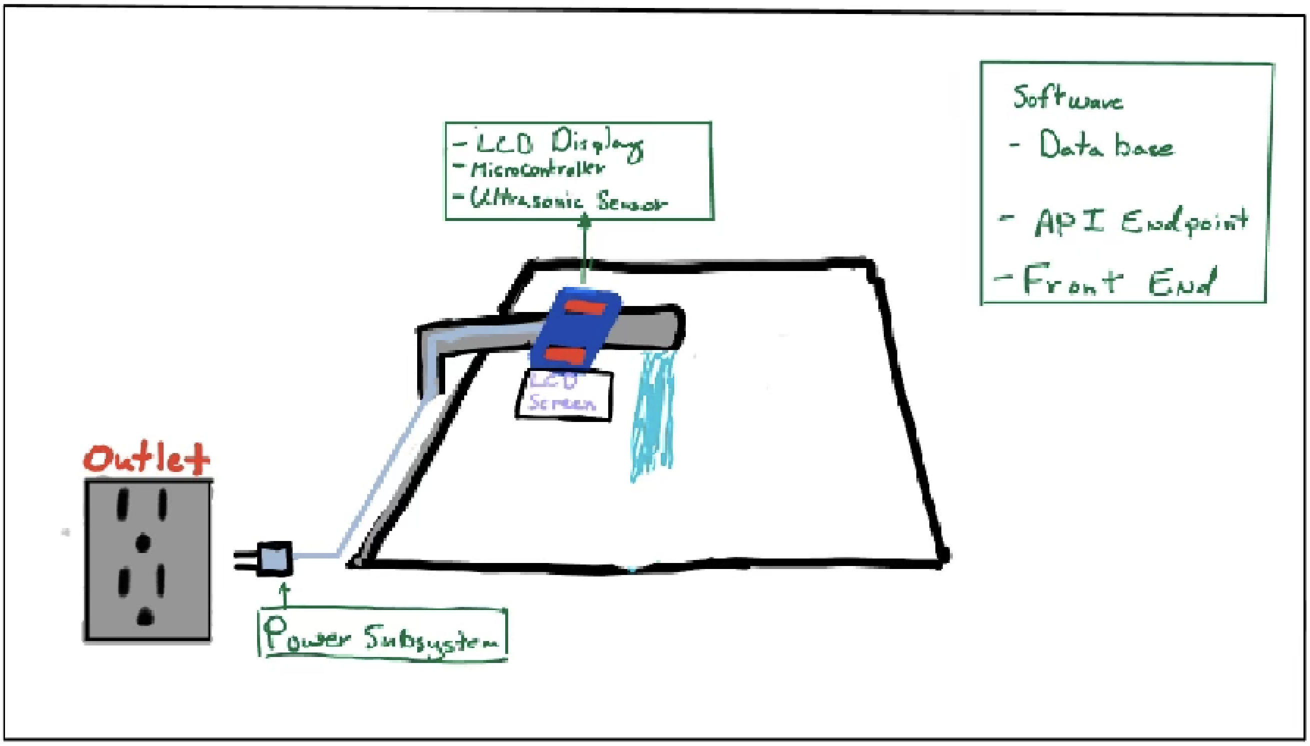
1 Introduction:

- **Problem:** Apartments charge utilities every month. Part of the utilities includes water cost, and in an apartment it is not always clear why the utility bill is high or where all the water is being used. Additionally over use of water is a problem more generally, and saving water conserves natural resources, promotes sustainability and conserves the environment. Our device can pinpoint where the water usage is coming from and how much water is being used.
- **Solution:** Our product is a device designed to attach to the end of faucets around the house and it will monitor the amount of water used by each faucet. Each time the faucet is turned on, the LCD screen will display a count of the measurement of water that had been dispensed since the sink was turned on. Multiple devices can be used in the same house, they will connect to a website dashboard which display stats about each connected device and their specific/aggregated water usage that month. For example, Kitchen sink, 50% of total usage, 100 gallons used.
- **Benefits and Features:**
  - Become more conscious of water usage in general, which increases sustainability.
  - An inexpensive way to monitor water usage, reducing utilities cost.
- **High-level requirements list:**
  - Units will display the amount of water used each time the sink is turned on and display the live count on an LCD screen present on the device
  - Units will be able to connect and send data to a website where the results for the month would be displayed
  - Ultrasonic sensor can accurately take data from the faucet, determine flow rate and report the amount of water used with less than a 5% difference of the real amount of water dispensed

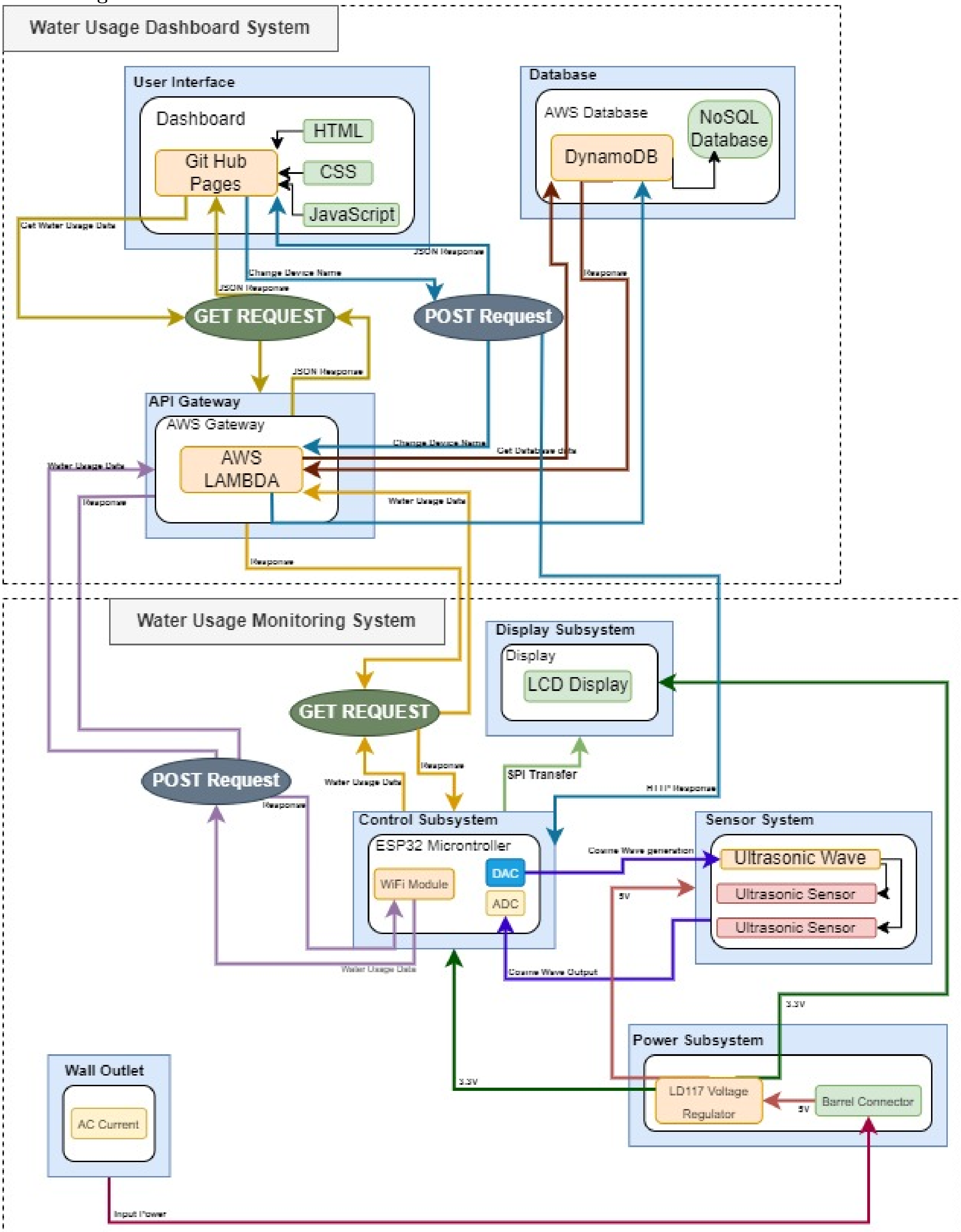
- **Visual Aid:**



- LCD Display
- Microcontroller
- Ultrasonic Sensor
Software
- Data base
- API Endpoint
- Front End
LCD Screen
Outlet
Power Subsystem

2 Design:

- **Block Diagram:**



- **Subsystem Overview:**

  - **Dashboard System - Frontend:** The user will interact with the water usage data on the online dashboard created through Github Pages, HTML, CSS, and JavaScript. The usage data is gathered during communication with the Monitoring System through API calls.
  - **Dashboard System - API Endpoint:** AWS Lamda will be middleman between the frontend, database, and monitoring system. When an API endpoint is hit, AWS Lamda will relay the updated data to the frontend dashboard, database, or monitoring system.
  - **Dashboard System - Database:** Through AWS DynamoDB, this will simply store records of each water monitoring system, including its ID, user given name, and water used. The frontend will request information from the database to update water usage on its dashboard. DynamoDB will send HTTP POST requests to respond to HTTP POST requests from AWS Lamda.
  - **Monitoring System - Microcontroller Subsystem:** All computation of water usage will be done on the ESP32 microcontroller. ESP32 will be connected to the Ultrasonic Sensing System which will transmit and receive its cosine wave forms through its DACs and ADCs for measuring flow rate in the pipe. ESP32 will also be connected to the LCD screen, displaying the device name and water usage through SPI. It has an internal 2.4 GHz WiFi system for communication with AWS Lamda.
  - **Monitoring System - Power Subsystem:** The monitoring system will be powered through a wall outlet, power brick, and USB to 5V barrel connector combination. The 5V supply will be used for amplifying the cosine waves signals through the MCP6001 and LCD screen power. We will use the LD1117-3v3 for voltage down conversion for the ESP32.
  - **Monitoring System - Ultrasonic Sensing Subsystem:** Using two H2KMPYA1000600 transducers, we will take the given cosine amplified waves and transmit the signal. Each will also receive signals from each other and relay them to the ESP32's ADC. The time difference between transmission and reception will help us determine the flow rate in the pipe.

- **Subsystem Requirements:**

  - **Dashboard System - Front-End:** Must be able to initiate data requests through AWS Lamda's AWS API Gateway. Upon receiving a response for this request, it must update its UI with the latest water usage data.
  - **Dashboard System - API Endpoint:** AWS Lamda must be able to send/receive HTTP GET/POST requests to/from the Monitoring Subsystem and Database Subsystem. It then relays this data to the database and frontend subsystems.
  - **Dashboard System - Database:** AWS DynamoDB must be able to send/receive HTTP GET/POST requests and respond with requested data or update the database accordingly.
  - **Monitoring System - Microcontroller Subsystem:** ESP32 must be able to provide and receive 3.3V Amplitude Cosine Waveforms from its DAC and ADC. Must use these signals to calculate ΔT between send/receive, and use this ΔT to calculate the water flow rate in the pipe. 2.4GHz WiFi system must send/receive HTTP GET/POST requests. Must communicate through SPI with the LCD screen.
  - **Monitoring System - Power Subsystem:** Must provide stable 5V and 3.3V Power sources through the barrel connector and LD1117-3v3 linear voltage regulator.
  - **Monitoring System - Ultrasonic Sensing Subsystem:** Must transmit signals from ESP32's DAC to the other Ultrasonic Sensor and vice versa. MCP6001 must amplify the cosine waveforms to/from 3.3V and 5V.

- **Tolerance Analysis:** The main point of the project is to accurately measure water usage. This depends on our calculation of water flow rate, which depends on our measurement of ultrasonic waves from the transducers. Using this difference in time, we use the equation

  $$v = [c^2 * \Delta T]/[2 * L * cos(\theta)].$$

  We can then multiply this by time the faucet is on and the cross sectional area of the pipe to find the total water usage. We will compare this water usage value to measuring it by hand using a container, and aim to be within 5% of the real value.

3 Ethics and Safety:

There are a couple of possible ethics and safety concerns in our project. Our first concern has to do with avoiding harm for the user. Our device is an electric circuit board, with voltage running out of the wall, close to running water. We need to make sure the casing for out PCB and LCD screen and other modules don't let water in then because that could electrocute the user and break the circuit board.

Another possible concern has to do with respecting privacy and confidentiality, these device take data about the water usage of the household they are monitoring and store them on a website. We need to make sure that the data stored on the website does not get out so that the privacy of our users is protected.

References:

ACM Code of Ethics and Professional Conduct. Code of Ethics. (n.d.). https://www.acm.org/code-of-ethics

IEEE - IEEE Code of Ethics. (n.d.). https://www.ieee.org/about/corporate/governance/p7-8.html