Redesign of Low-Cost Sensors used in Community-Engaged Air Pollution Monitoring

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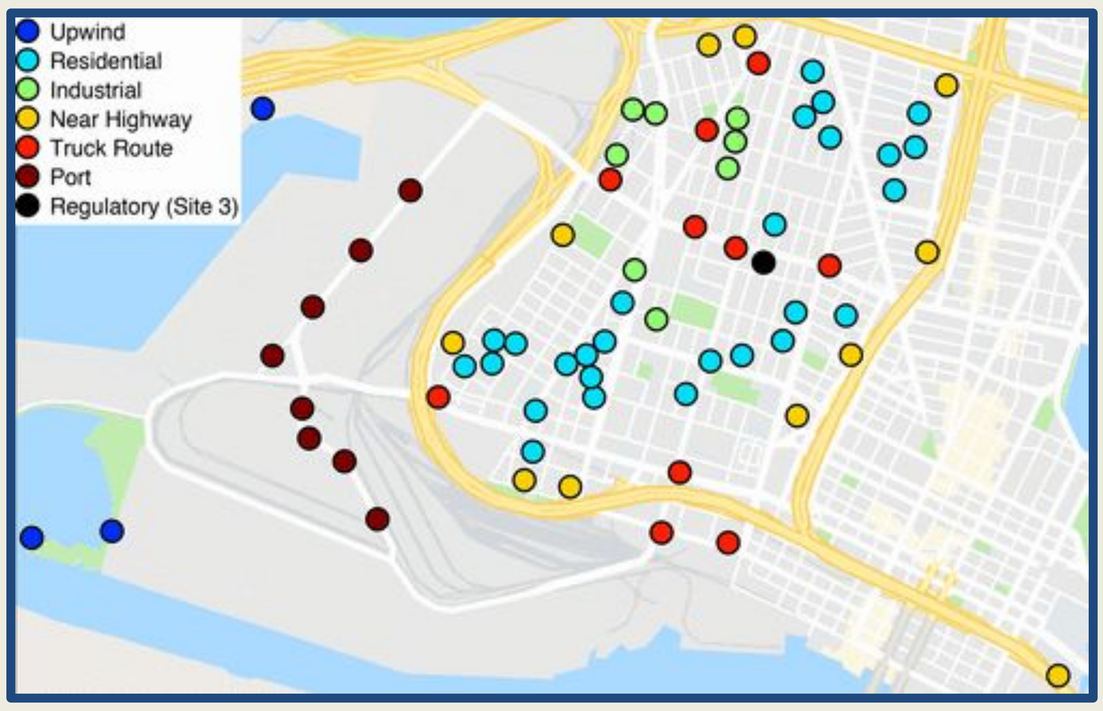
Background

UC Berkeley deployed 100+ Black Carbon sensors (ABCD) across West Oakland, and data revealed high BC levels near highways, railways, and the Port of Oakland.



Why redesign the sensor?

- Previously relied on 2G network, which is now obsolete
- Required manual updates for location data

Problem Statement

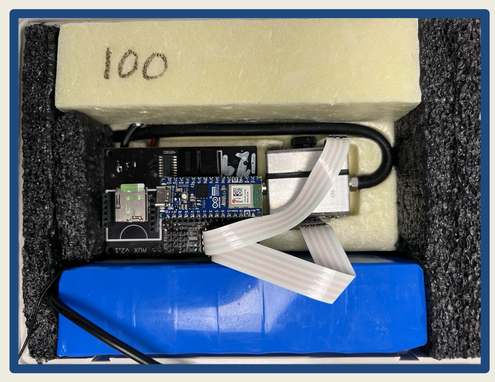
UC Berkeley needs to **redesign** several hardware components of a **black carbon (BC) sensor** to improve ease-of-use, robustness, and keep costs low. The new design needs to incorporate an **improved data communication method** and a **localization method**. The BC sensor package should be designed for long term use, needing minimal maintenance.

Impact

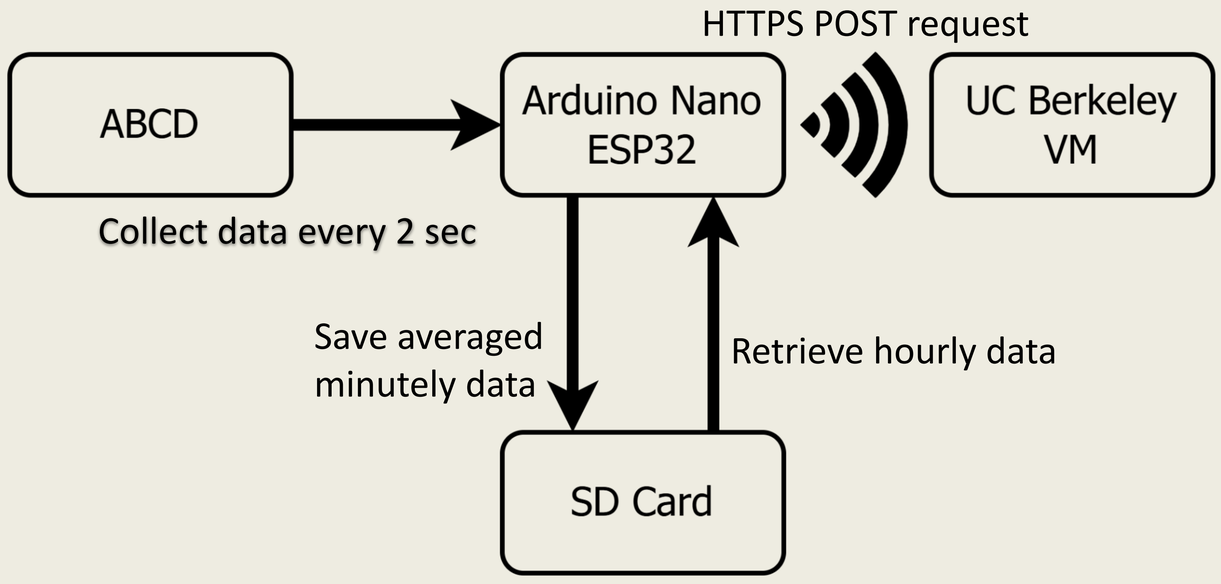
- Commercial BC sensors cost up to $20k each, limiting widespread use.
  - This project develops **affordable** BC sensors enabled with Wi-Fi to improve pollution monitoring in underrepresented communities.
- Sensors designed with encrypted data transmission to the UC Berkeley server via HTTPS.
  - Volunteers from targeted areas will host these sensor with **minimal security or privacy concerns**
- Past study helped pass Assembly bill California AB617 (air pollution reduction law).
  - Data helps local environmental justice groups to advocate for reduced emissions

Design

To enable both Wi-Fi-based data communication and localization, we upgraded the sensor's hardware and software to use the **Arduino Nano ESP32**, which includes a **built-in Wi-Fi module**. This allowed wireless transmission of sensor data to the UC Berkeley VM and enabled location tracking through the **Google Geolocation API**.

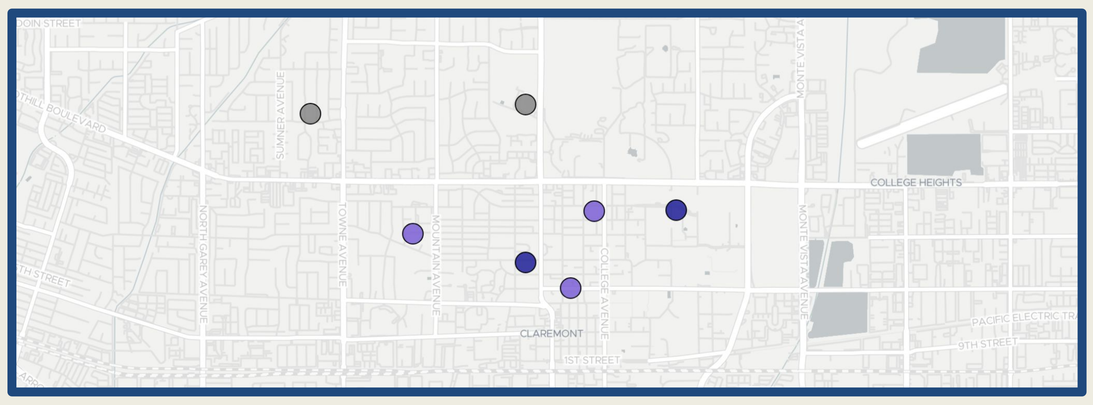


Data Communication

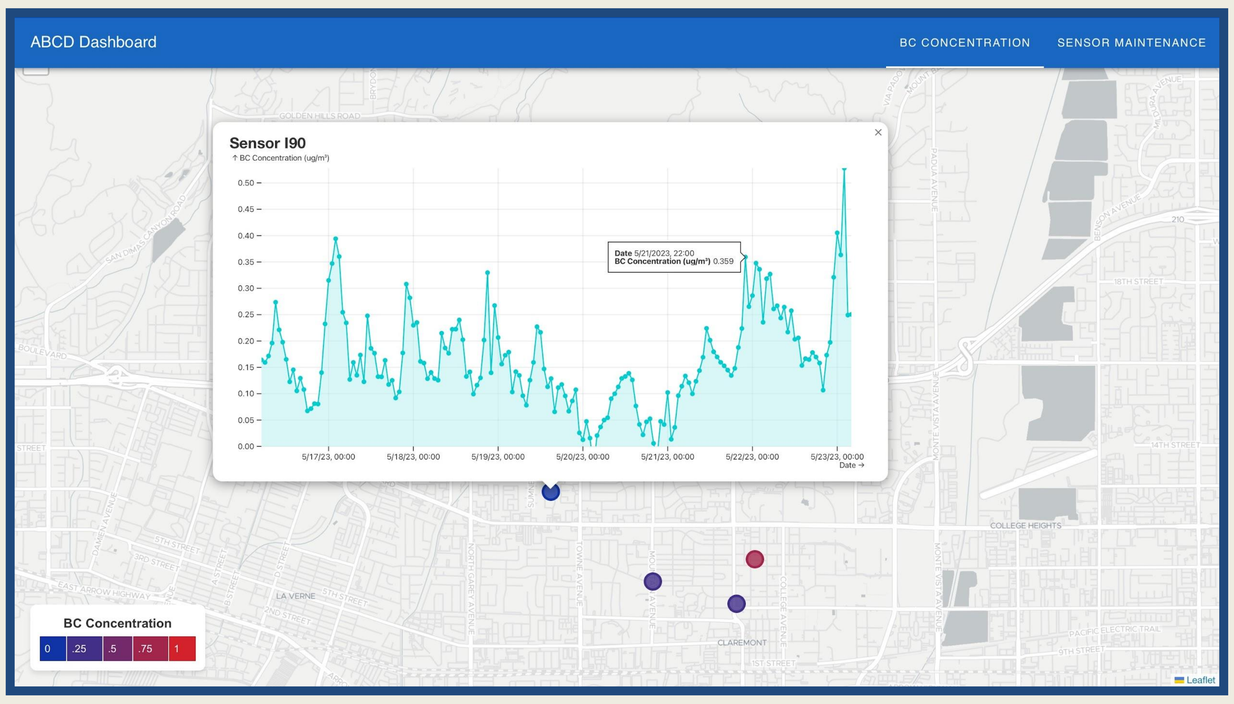


Localization

- Sends MAC addresses and signal strengths of nearby access points to Google's servers
- Uses Google's extensive Wi-Fi database for precise location estimates
- Minimal setup and easy to implement



Conclusion and Sensor Deployment

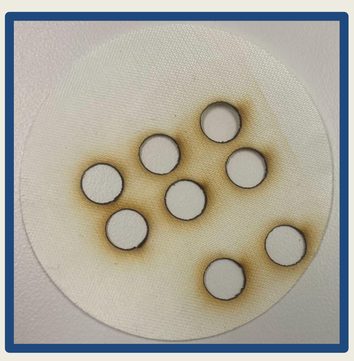


A **fully functional data communication prototype**, with **automatic localization updates**, was implemented with **successful connection to the UC Berkeley Virtual Machine (VM)** developed by the Harvey Mudd Clinic Computer Science team.

The data communication and localization solutions will be **implemented into the fleet of 100+ sensors** to be used in BC air quality studies in Richmond, Stockton, and Fresno. The location and BC data of each sensor will be transmitted via Wi-Fi to the VM every hour and displayed on a public-facing website, shown to the left.

Future Work

- Add 4G communication to improve placement flexibility and ensure reliable data transmission.
- Develop a laser-cutting method for faster and more efficient filter preparation.



Acknowledgements

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