

Open-source Handheld pH Sensor with Mobile App

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Popularizing pH Measurement for Marine Protection

Traditional methods of measuring ocean pH levels are hindered by expensive, complex equipment that limits widespread monitoring and participation in ocean acidity. Our project introduces an innovative, open-source handheld pH sensor paired with a user-friendly mobile app, designed to make accurate ocean pH monitoring accessible and straightforward.

Key Features:

- Open-Source Design
- Cost-effective
- Handheld and User-Friendly
- Mobile App Integration
- Cloud Connectivity



Figure 1: The expected pH sensor [1]

Hardware Breakdown

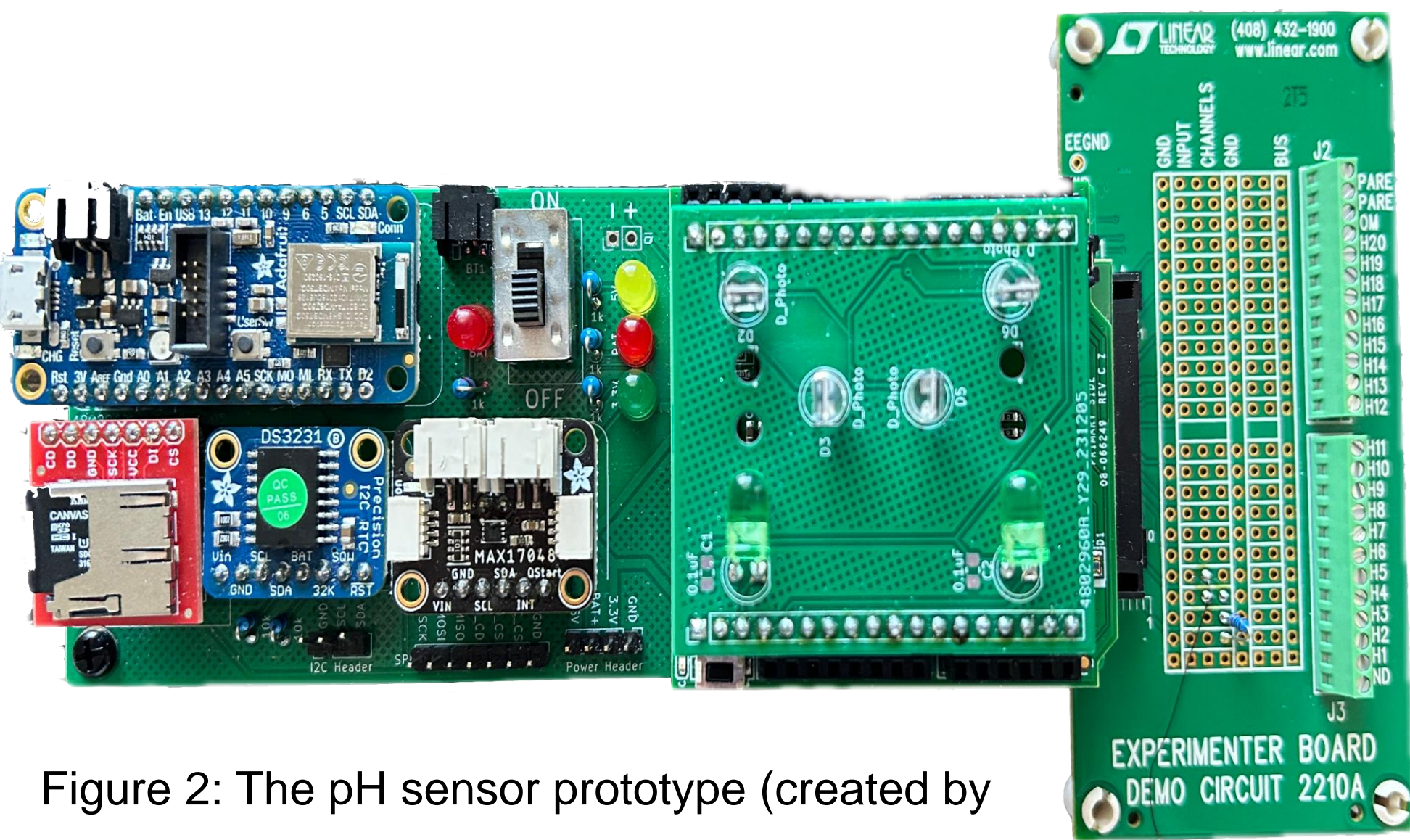


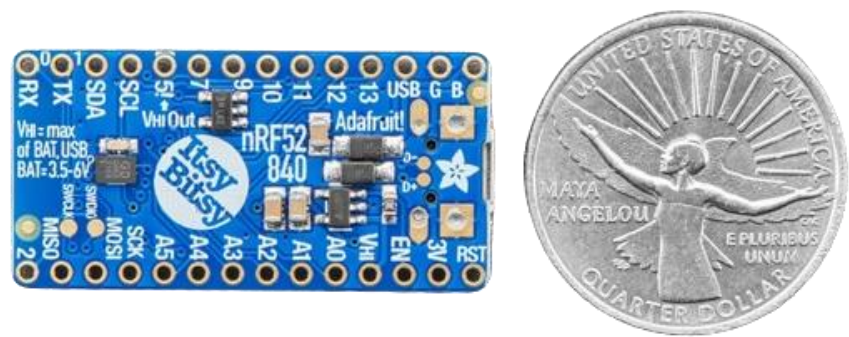
Figure 2: The pH sensor prototype (created by Jonathan Pfeifer and WHOI).

RTC (Real-Time Clock) Module

- Ensures precise time-stamping of each measurement for accurate record-keeping.

Battery System

- Provides a reliable power source and battery management.



ItsyBitsy nRF52840 Express

- Acts as the central processing unit of the sensor system.
- Coordinates the function of all other hardware components.
- Processes sensor data and implements spectrophotometric pH algorithms.
- Acts as Bluetooth LE central to interact with the mobile app.

SD Card Storage

- Stores all measurement data securely for future access and analysis.

ADPD4101 light sensor

- Captures light data crucial for pH measurement.
- I2C protocol

LTC2984 temp sensor

- Measures temperature to ensure accurate pH readings.
- SPI protocol

Website & Cloud

Serves as a nexus for data management and fosters a collaborative community for advancing oceanic carbonate chemistry research.

- Data storage
- Data sharing
- Statistics
- Data visualization

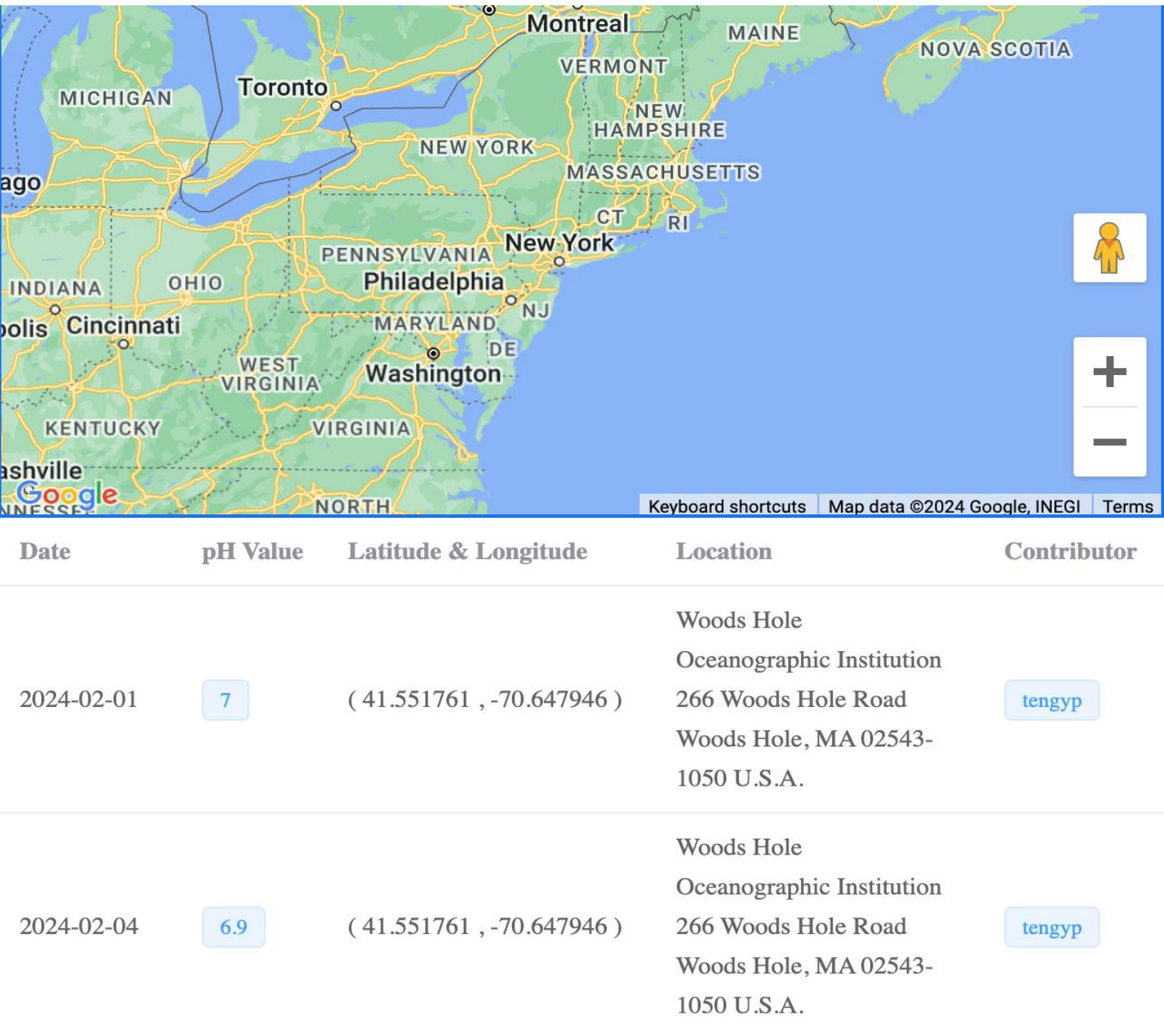


Figure 3: The pH sensor website

Android App

Serves as the user-facing level, syncing seamlessly with the microcontroller and cloud services.

- Bluetooth device discovery and connection
- Direct sensor control
- Geographical location acquisition
- Data reception and visualization
- Cloud uploads

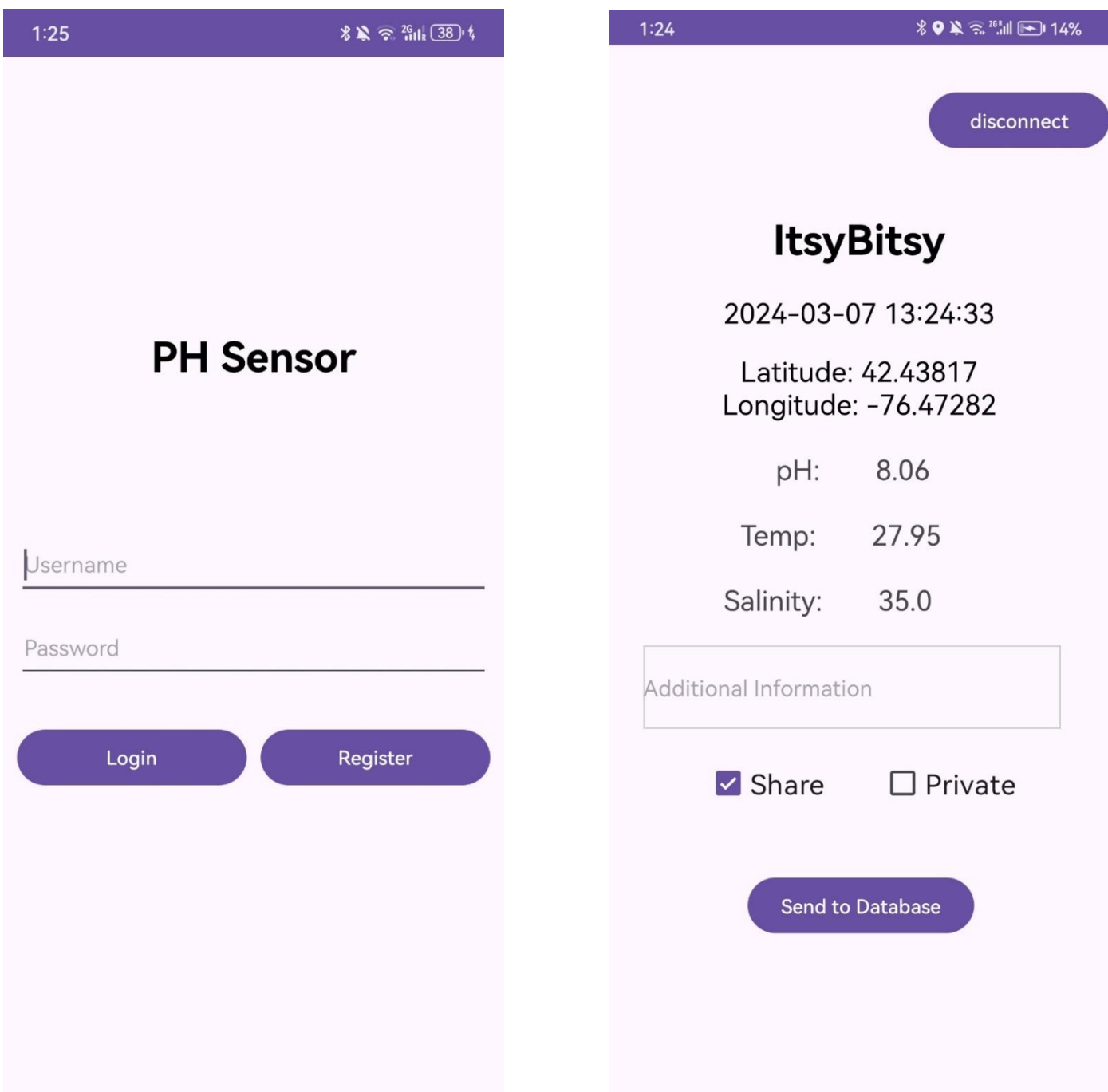


Figure 4: The pH sensor android app

Software Design

Our system's software is structured across three hierarchical levels, each with dedicated sub-modules:

Microcontroller Level: The foundation where data from various modules is captured and processed.

- Low-level code for each module
- pH algorithm
- Robust data handling interfaces (BLE, SPI, I2C)
- Results Storage and battery system management

Android Application: This user-friendly interface allows users to easily interact with the pH device regarding the control and data transmit. All information is securely uploaded to the cloud for storage.

Web & Cloud: The top-tier where data is securely stored and analyzed. It provides a platform for long-term data trends, sharing, and integrates with mapping services for spatial analysis.

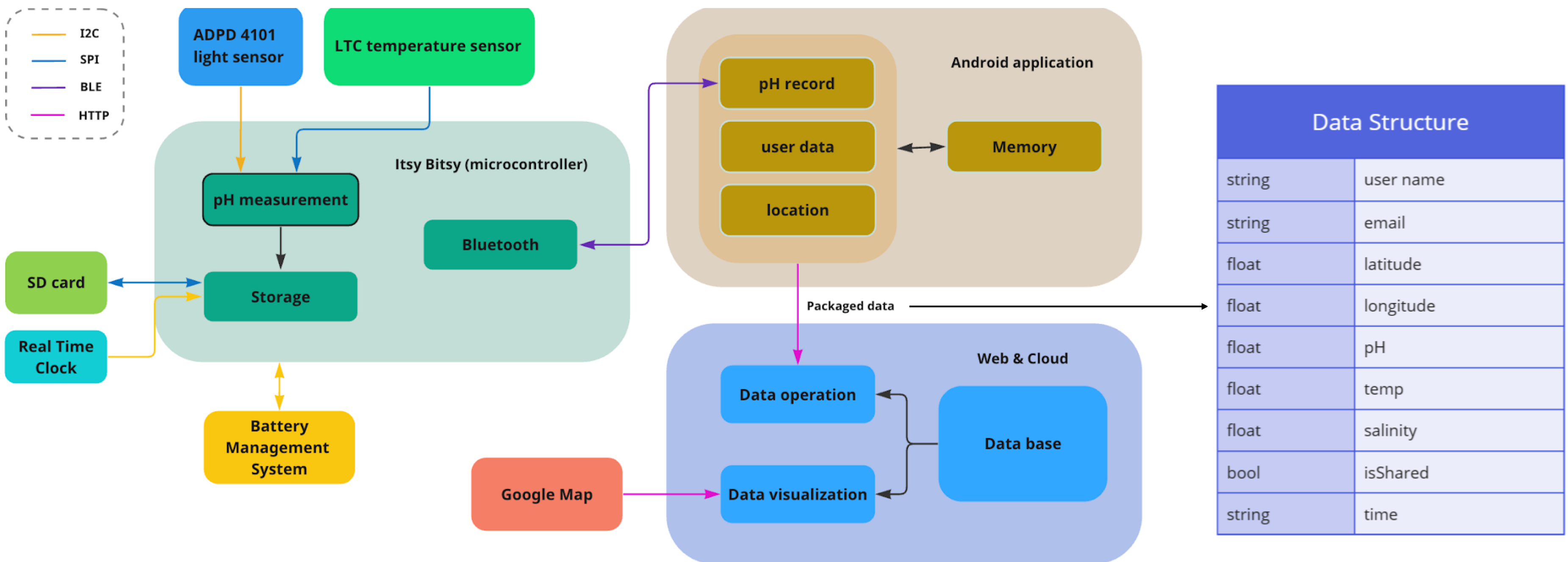


Figure 5: The software architecture and data structure

Results

- Developed a low-cost, portable pH-sensor prototype to measure seawater pH value efficiently.
- Developed low-level drivers and comprehensive test suites.
- Developed Android app with basic functions to control device and transmit data between cloud and device.
- Developed a cloud platform for storing, reviewing and sharing pH data.
- The end-to-end data flow has been thoroughly validated.
- Please see our [website](#) for more information.

Acknowledgements

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References

[1] Pardis W, Grabb KC, DeGrandpre MD, Spaulding R, Beck J, Pfeifer JA, Long DM. Measuring Protons with Photons: A Hand-Held, Spectrophotometric pH Analyzer for Ocean Acidification Research, Community Science and Education. Sensors (Basel). 2022 Oct 18;22(20):7924. doi: 10.3390/s22207924. PMID: 36298277; PMCID: PMC9609735.

