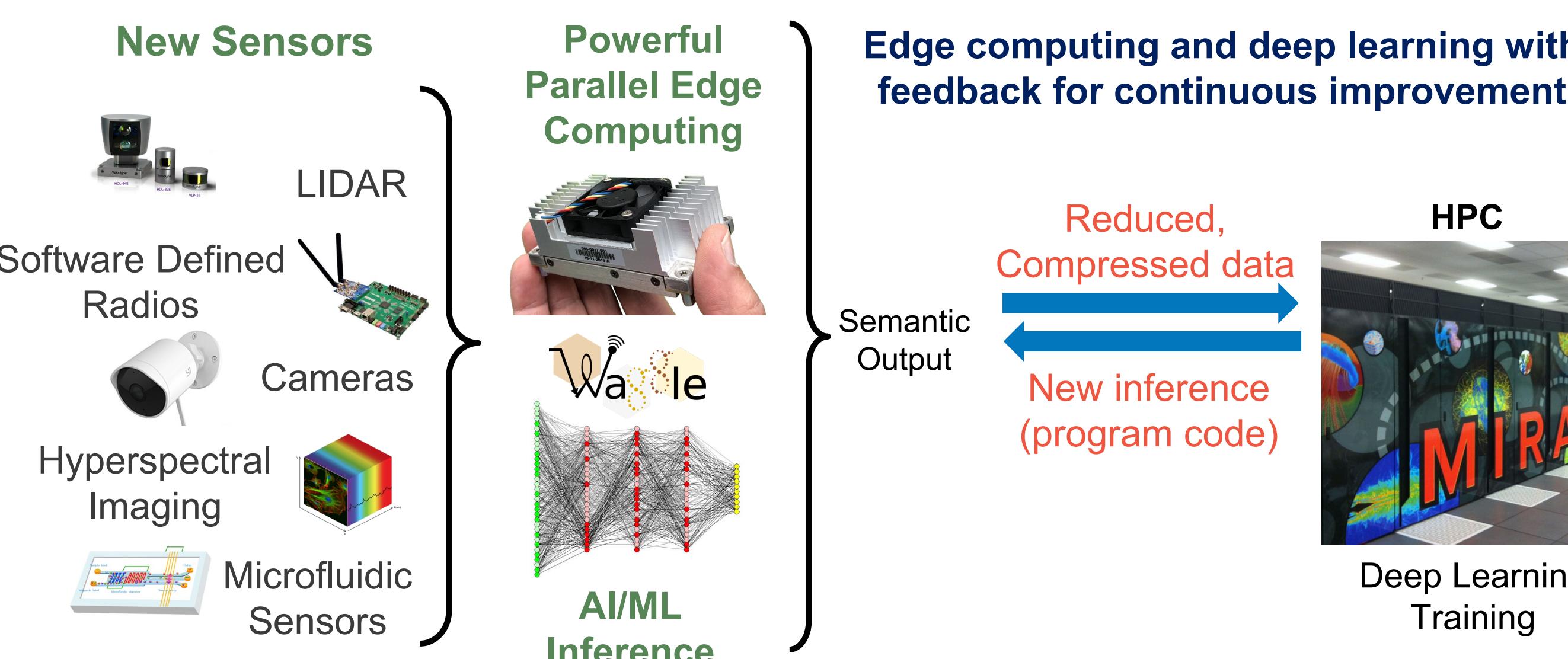


What is Waggle?

The Waggle Platform is a research project to design, develop, and deploy a novel wireless sensor platform with advanced edge computing capabilities to enable a new breed of sensor-driven environmental science and smart city research.

The innovative architecture leverages emerging technology in low-power processors, sensors, and cloud computing to build powerful and reliable sensor nodes that can actively analyze and respond to data. Cloud computing provides elastic resources for storing and computing on data.

Waggle is designed from the ground up with security, privacy, extensibility, and survivability as key design points. All of the software is Open Source and the software is modular, so researchers can add their own sensors, computing pipelines, and data analysis.

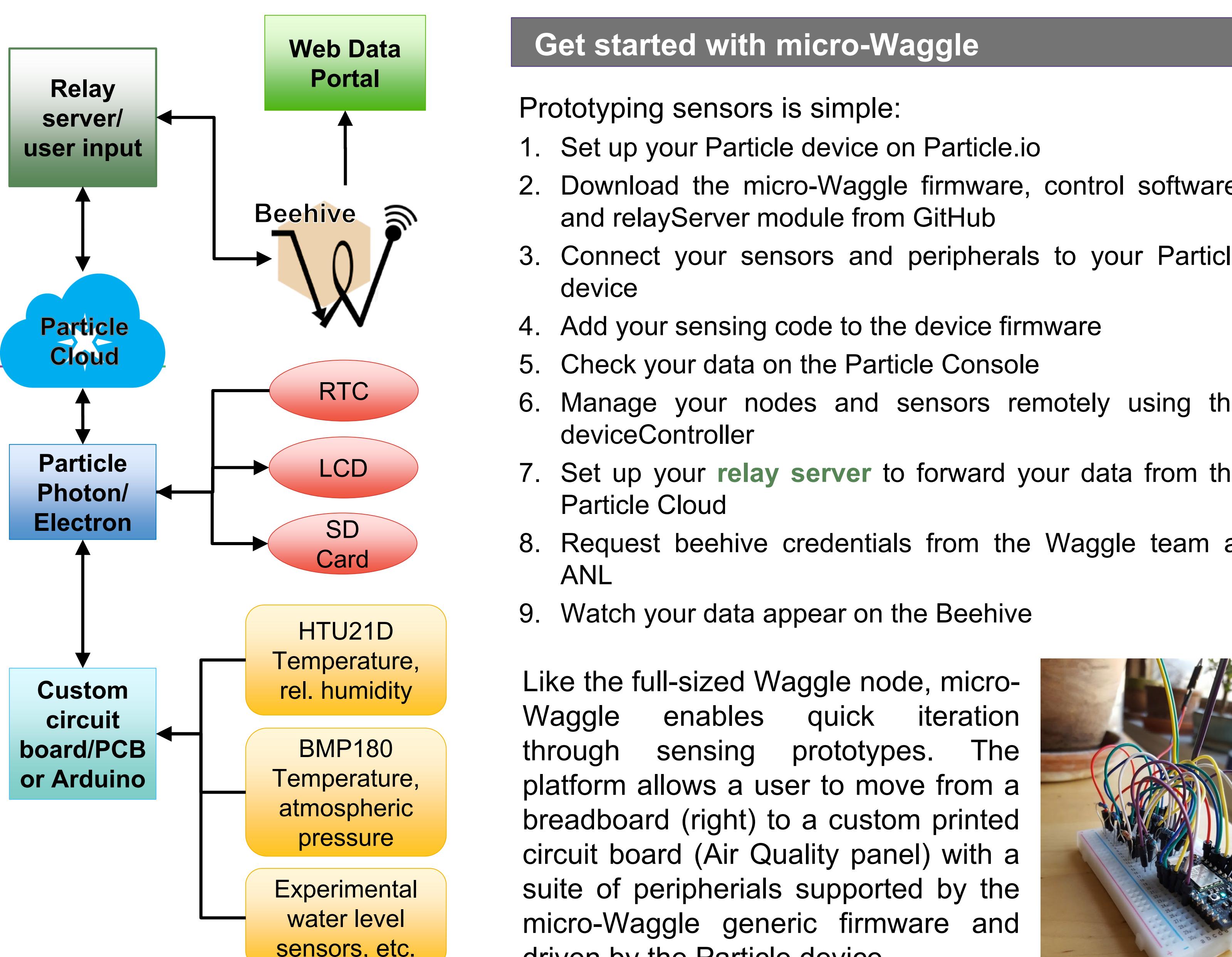
**Waggle consists of:**

1. A field deployed sensor and actuator device with advanced edge computing capabilities for inference, filtering, compression and data reduction (the **nodes**)
2. A cloud software stack (the **Beehive**) for data aggregation, analysis, and dissemination and feedback to the edge-devices



micro-Waggle Implementation

We developed a miniaturized Waggle platform that merges Particle IoT devices and Arduino microcontrollers to form a powerful data logging and transmission platform that can be controlled and configured remotely and adaptively. The micro-Waggle firmware manages data and packages them into small packets called sensograms which are interpretable by the Waggle Beehive.

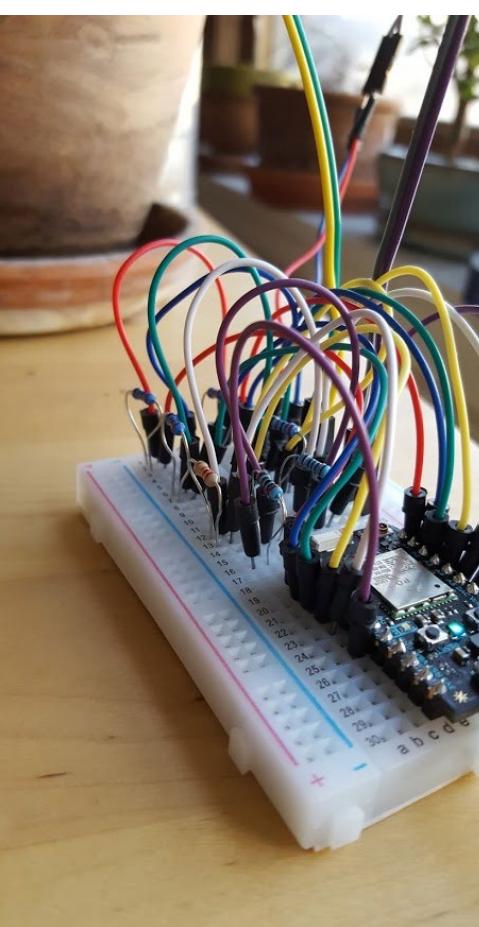


Get started with micro-Waggle

Prototyping sensors is simple:

1. Set up your Particle device on Particle.io
2. Download the micro-Waggle firmware, control software, and relayServer module from GitHub
3. Connect your sensors and peripherals to your Particle device
4. Add your sensing code to the device firmware
5. Check your data on the Particle Console
6. Manage your nodes and sensors remotely using the deviceController
7. Set up your **relay server** to forward your data from the Particle Cloud
8. Request beehive credentials from the Waggle team at ANL
9. Watch your data appear on the Beehive

Like the full-sized Waggle node, micro-Waggle enables quick iteration through sensing prototypes. The platform allows a user to move from a breadboard (right) to a custom printed circuit board (Air Quality panel) with a suite of peripherals supported by the micro-Waggle generic firmware and driven by the Particle device.



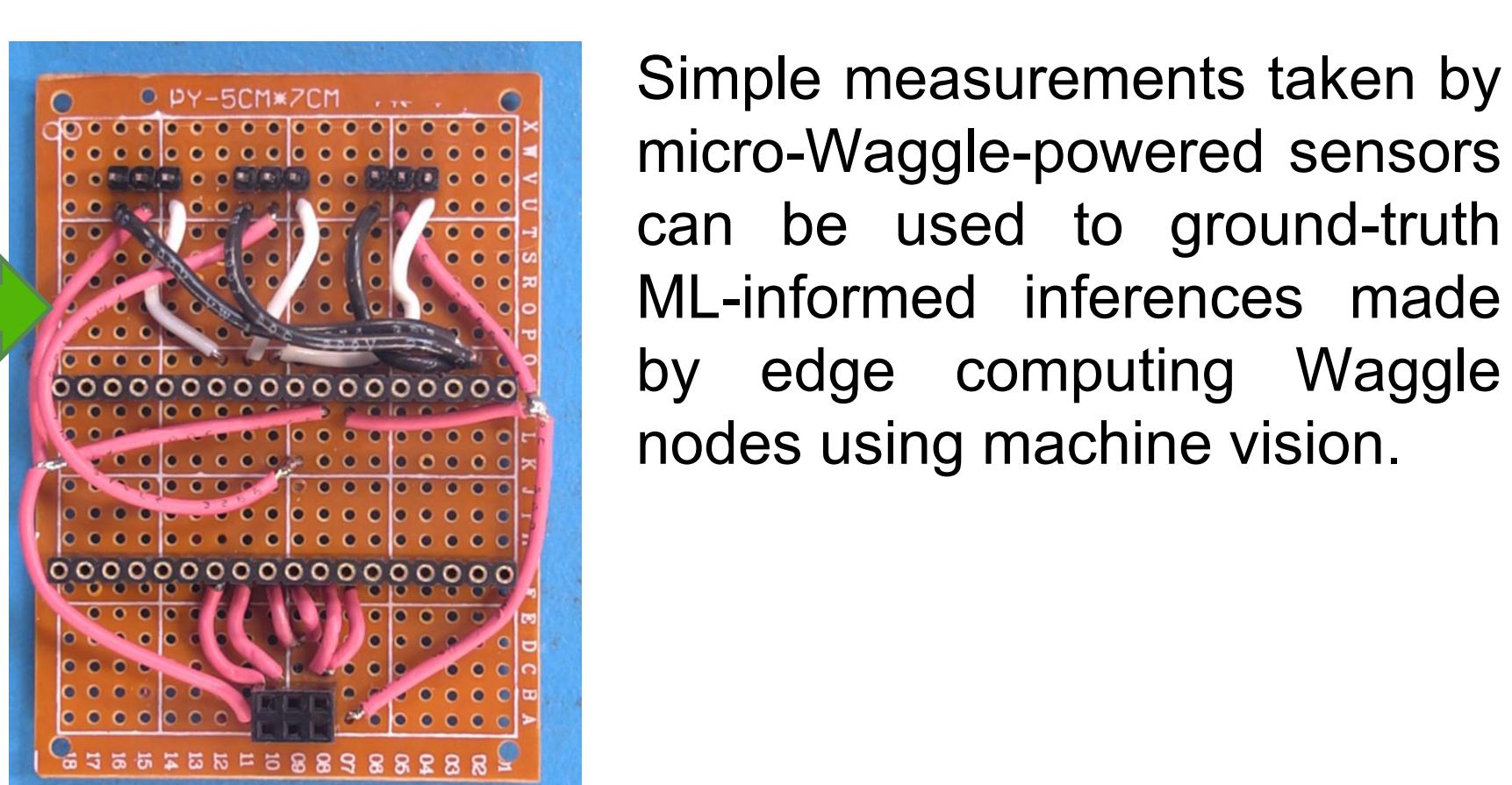
Applications

Residential Flooding in Chicago, IL

We monitor stormwater runoff in Chicago's flood-prone Chatham community area via a mixture of commercial sensors, low-cost micro-Waggle builds monitoring soil moisture and water level, and standard and development-version Waggle nodes which provides real-time data to inform important decisions in response to extreme weather events.



Figure: Ball fields flooded in early spring, Tuley Park, Chatham, Chicago, IL



Simple measurements taken by micro-Waggle-powered sensors can be used to ground-truth ML-informed inferences made by edge computing Waggle nodes using machine vision.

Small custom circuit boards allow swapping of sensors and easy replacement of Particle devices when needed for upgrades or damage repair.

Easily obtainable parts with simple assembly makes rapid deployment for field testing possible for student projects and low-cost pilot experiments.

Visit the NU Center for Water Research:
bit.ly/NUCWR_w88le



Why make it micro?

micro-Waggle is a miniaturized, easily customizable version of the Waggle platform which fits sensing and processing capabilities similar to the full-sized nodes into a small device that can fit in a cupholder. The platform is especially suited for student research projects and bespoke sensor networks requiring unique or dense sensor layouts to capture necessary data.

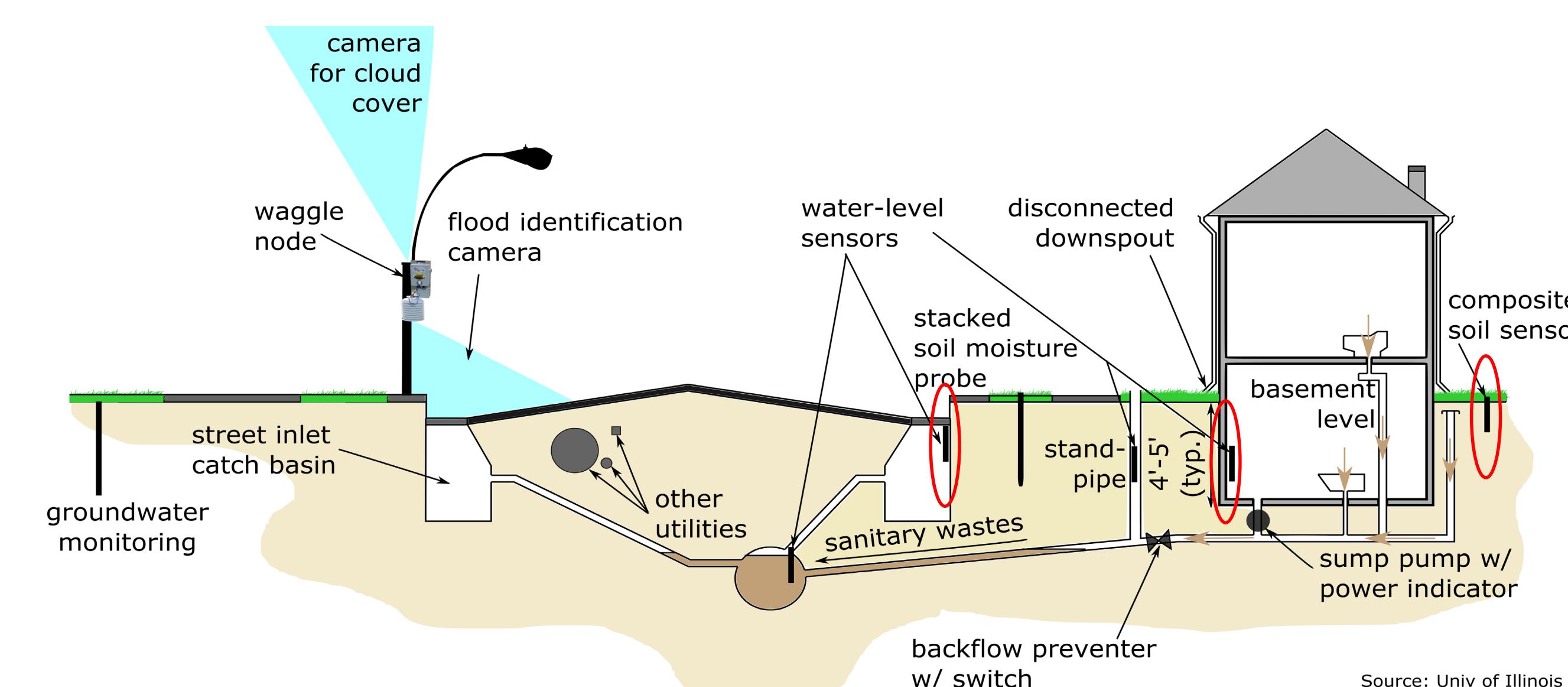


Figure: General plan for instrumentation of an urban site for floodwater monitoring using a blend of full-size and micro-Waggle nodes

Continuing Development

We are working to increase the communication between micro-Waggle and full-size Waggle nodes to enable new sensing programs, in addition to incorporation of external data streams such as local or regional weather forecasts. The edge computing capabilities of the full-sized Waggle node allow for adaptive sampling by micro-Waggle nodes, triggering higher measurement frequencies or toggling on and off sensors to conserve power so that the device is available when needed most.



No precipitation, low measurement frequency, perhaps only sense soil moisture and temperature



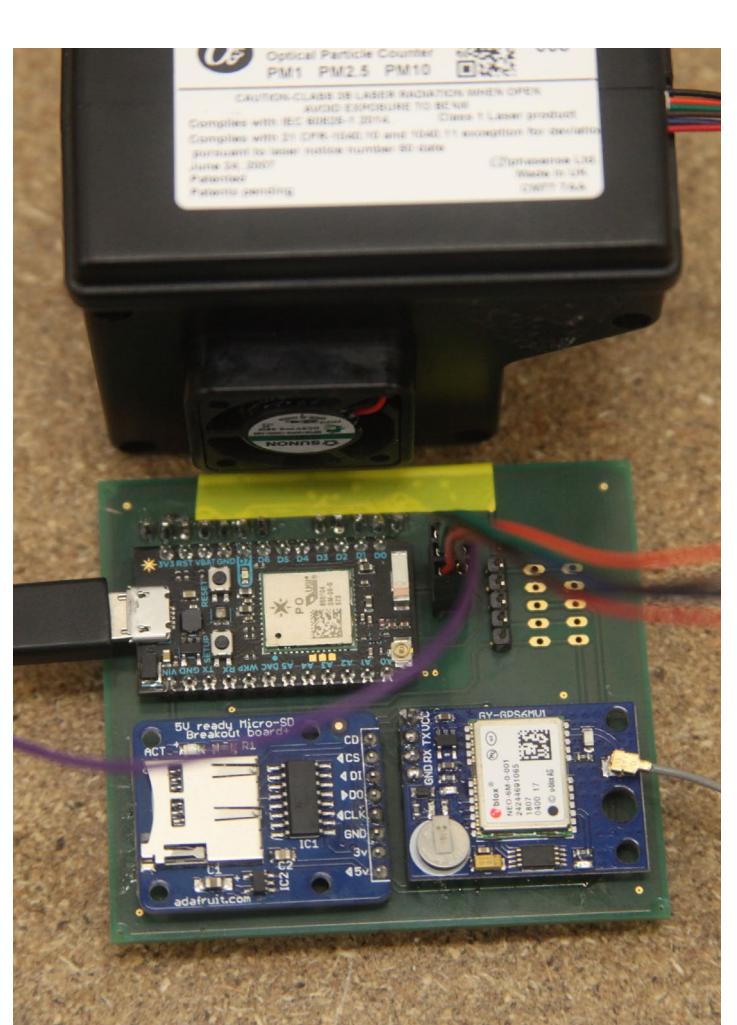
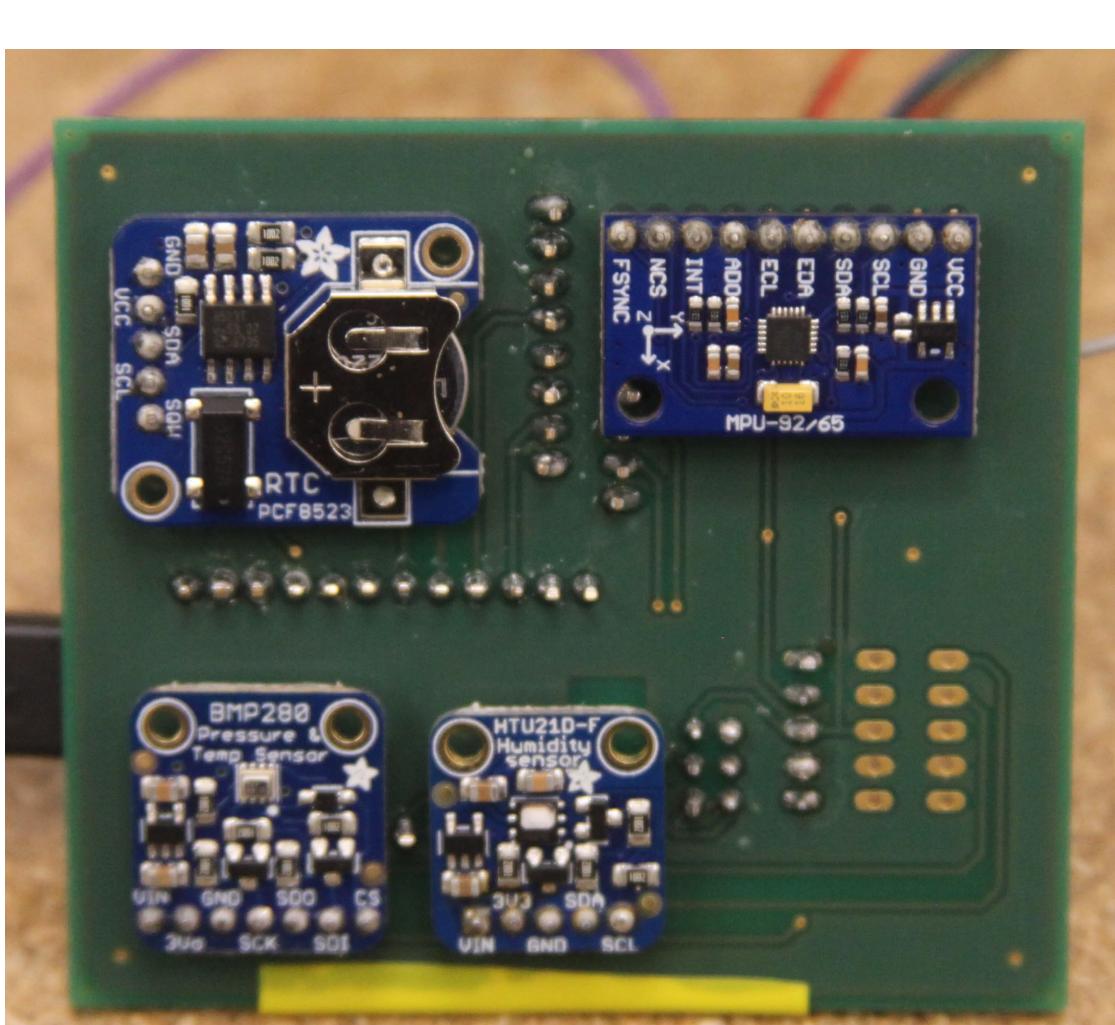
Rain in the forecast, continue sensing of soil moisture but at higher measurement frequency



Rain is observed at the field site by the node, begin sensing water levels and increase frequency significantly

Air Quality in Dallas, TX

micro-Waggle is mobile. Because it can communicate via cellular connection or WiFi, it can be mounted on a moving device or even worn to collect data as a researcher or test subject moves through space.



Researchers develop a custom PCB to host sensor breakout boards, a GPS module, an experimental particulate sensor, and the Particle device. In this version, data is packaged and stored on an SD card until internet is available to transmit to the Particle Cloud.



The build can be mounted on a bicycle and powered by a battery pack to collect data as the wearer travels around a city. This data can be combined with data from Waggle nodes mounted at intersections and data streams from wearables to make inferences about air quality and its potential impacts on health.

Acknowledgments:

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists, Office of Science Graduate Student Research (SCGSR) program. The SCGSR program is administered by the Oak Ridge Institute for Science and Education (ORISE) for the DOE. ORISE is managed by ORAU under contract number DE-SC0014664.

ANL MicroWaggle summer student team: Adam Morrison, Ashwin Saxena, David Dawnkaski, Efe Saatci, Kenan Arica, Timothy Bargo, Vikram Sunderrajan, Nathan Tsegai, Amaan Khan, Cora Pancoast

NSF Convergence: RAISE: Systems Approaches for Vulnerability Evaluation and Urban Resilience (SAVEUR) Award No. 1848683.

Lakitha Wijeratne and David Lary, for work on the BikeWaggle Project at ANL and at UTD



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