SAGE

A Software-Defined Sensor Network

Cyberinfrastructure for AI at the Edge

sagecontinuum.org

Cyberinfrastructure for AI@Edge

Sharing scientific data via OSN

Wolfgang Gerlach

OSN webinar Research Drivers and Software 2020

Pete Beckman, Rajesh Sankaran, Nicola Ferrier, Scott Collis, Charlie Catlett, Eugene Kelly, Valerie Taylor, Mike Papka, Ilkay Altintas, Jim Olds, Kate Keahey, Frank Vernon, Dan Reed, and many more….

Argonne NATIONAL LABORATORY

Example: Hyperspectral SPECIM Camera:
PFD VNIR with 768 bands
(2734 x 1312) x 768 x 2bytes = **5.1GB image**

1 sample every 5 min
Twilight to twilight on June 21 = **1TB**

We need a parallel computer with each sensor!

AI @ Edge

Sensors

LIDAR

Software Defined Radios

Hyperspectral Imaging

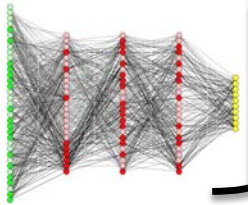
Facilities

Actuators

Servos

Dynamic adaptation

Powerful
Parallel Edge Computing



Artificial Intelligence
Deep Learning Inference
Lightweight Training

Edge computing and deep learning with feedback for continuous improvement

5G

ESnet

Reduced, Compressed data

New inference (model)
Adaptive steering

HPC

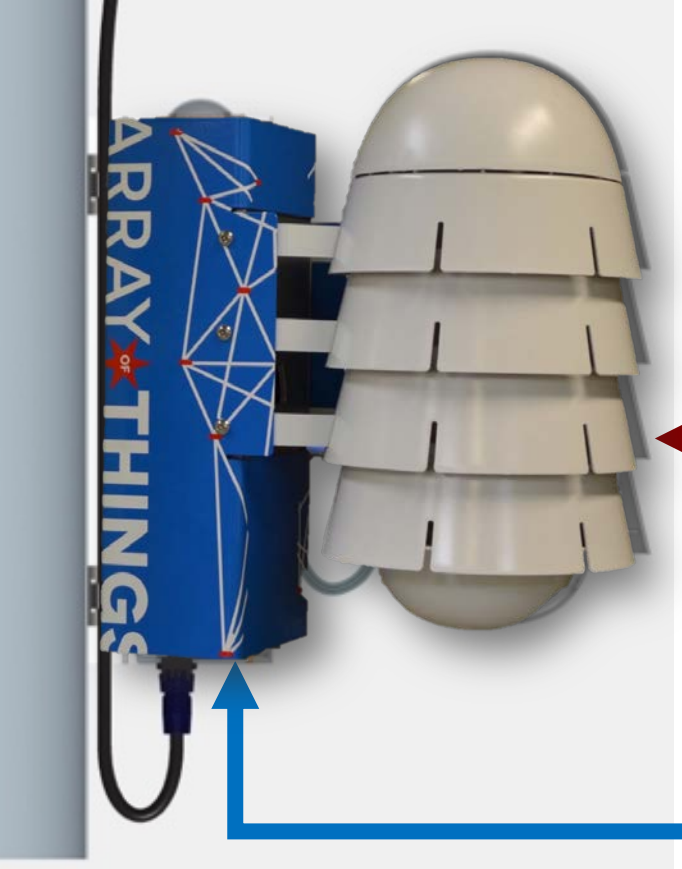
Deep Learning Training
Simulation / Forecast

Why Live on the Edge?

- **More data than bandwidth**
  - Spallation neutron source, light source, SW defined radios, HD Cameras, LIDAR, radar, hyperspectral imaging, grid micro-synchrophasors, etc.
- **Latency is important**
  - Quick local decision & actuation; adaptive sensing & control systems
- **Privacy/Security requires short-lived data: process and discard**
  - Compromised devices have no sensitive data to be revealed
- **Resilience requires distributed processing, analysis, and control**
  - Predictable service degradation, autonomy requires local (resilient) decision
- **Quiet observation and energy efficiency**
  - Vigilant sensors, transmit only essential observations, not big data streams

Array of Things

(First units built and deployed in 2016)



Environment

- Ambient, UV, IR light
- Visibility
- Magnetic Field
- Vibration
- Sound pressure
- Temperature
- Relative humidity
- Barometric pressure

Air Quality

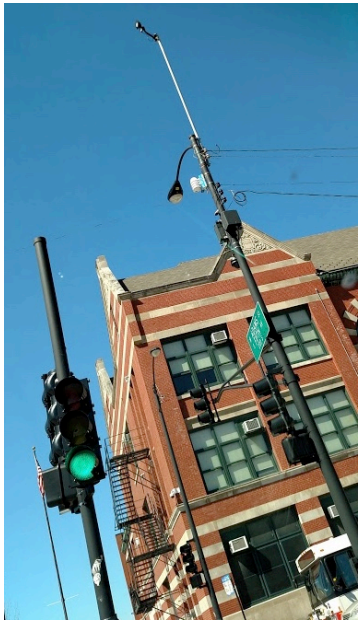
- PM 1, 2.5, 10
- Carbon monoxide
- Ozone
- Sulfur dioxide
- Nitrogen dioxide
- Hydrogen sulfide
- Total reducing gases
- Total oxidizing gases

Edge Computing or "AI at the Edge" Research:

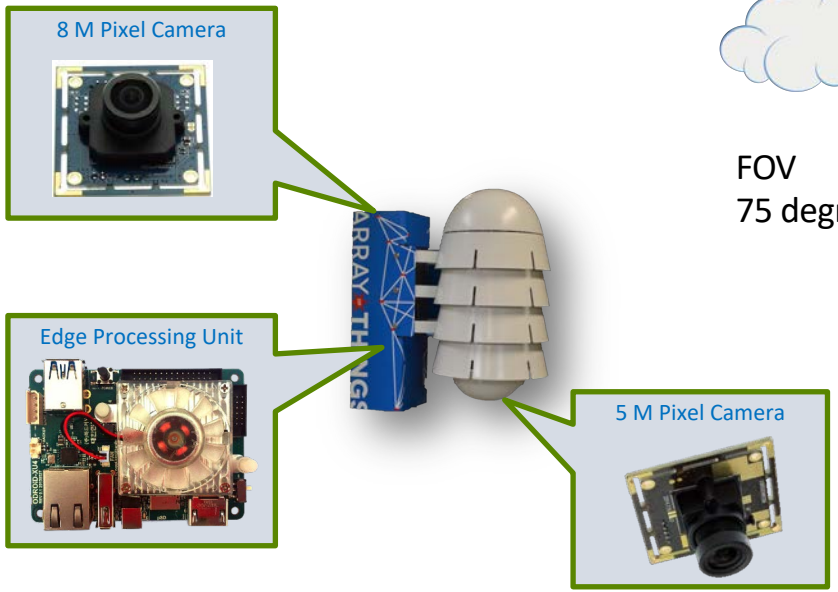
Computer Vision: Flooding, traffic flow, safety (bike helmet use, pedestrian patterns…), use patterns of public spaces, cloud cover

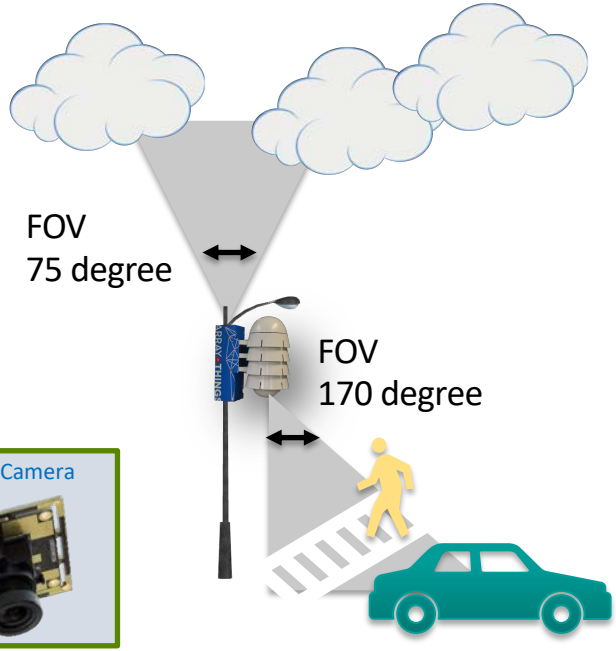
Computer Audio: Noise components, sound events

The "Array of Things" (AoT) was an NSF-funded Major Research Instrumentation project in partnership with the City of Chicago, led by the University of Chicago and Argonne National Laboratory. The underlying hardware and software used is Argonne's Open WAGGLE platform. (wa8.gl)

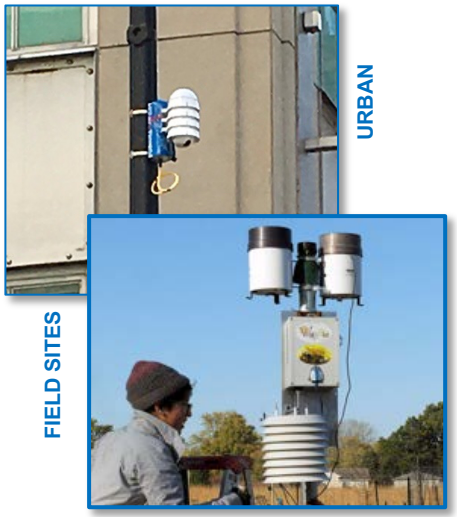


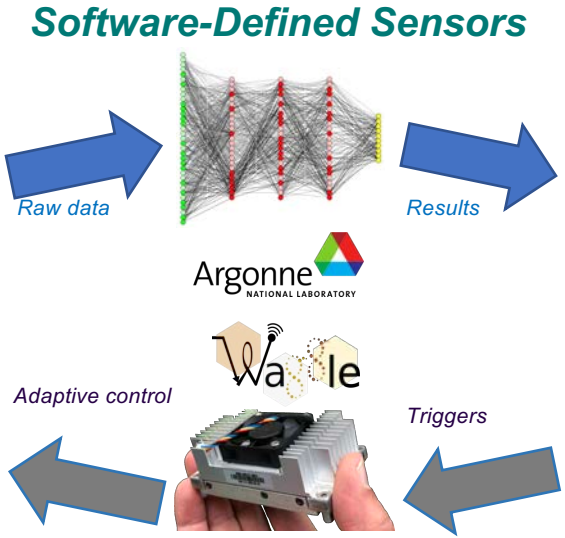
Edge Vision
Cameras on Array of Things Nodes

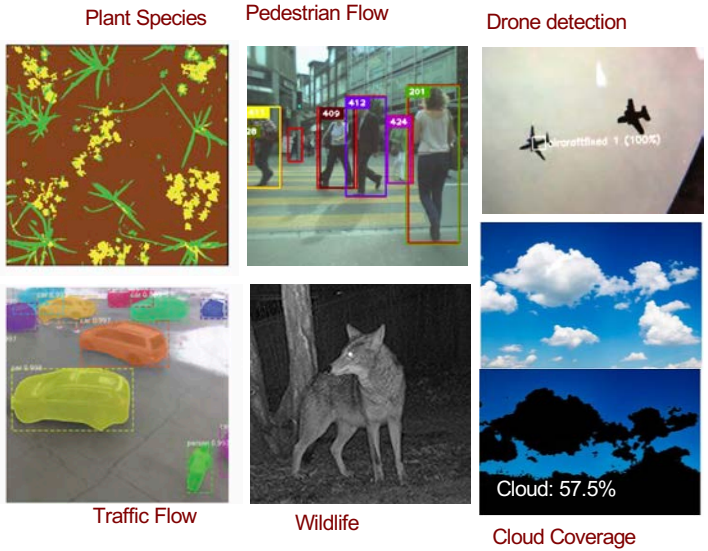




WHAT DOES “AI-AT-THE-EDGE” ENABLE?



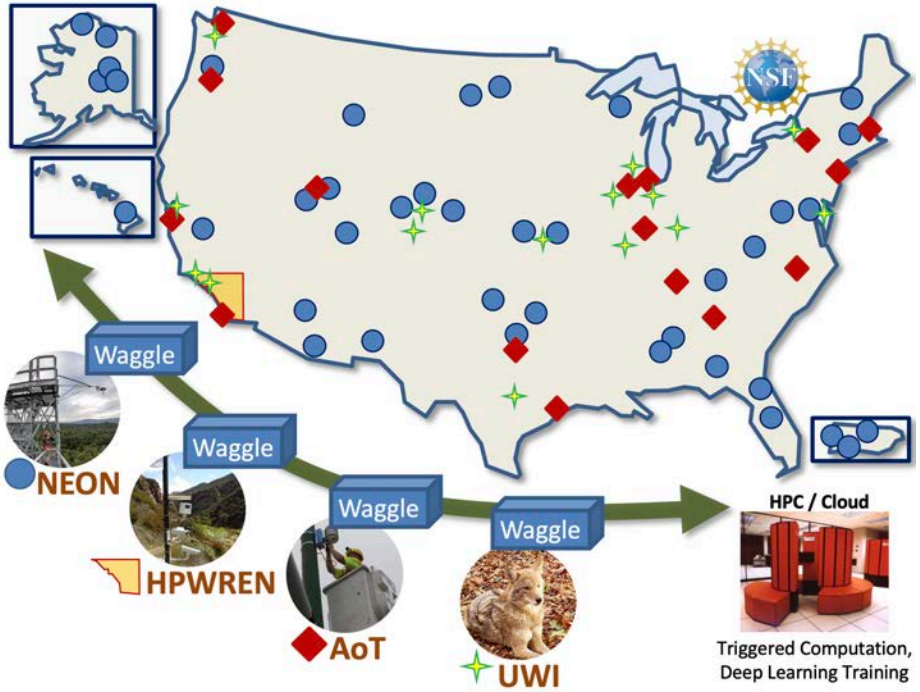




Autonomous Adaptive Sensing

SAGE

Cyberinfrastructure for
AI at the Edge
sagecontinuum.org



Education & Training




Leadership Team


Pete Beckman
(NU; Director)


Nicola Ferrier
(NU; Deputy Dir.


Ilkay Altintas
(SDSC; Data)


Charlie Catlett
(UIllinois; AoT)


Scott Collis
(NU; ARM)


Valerie Taylor
UChicago; Broader Impacts)


Jim Olds
(GMU; Life Sci, Risk)


Dan Reed
(Utah; Architecture)

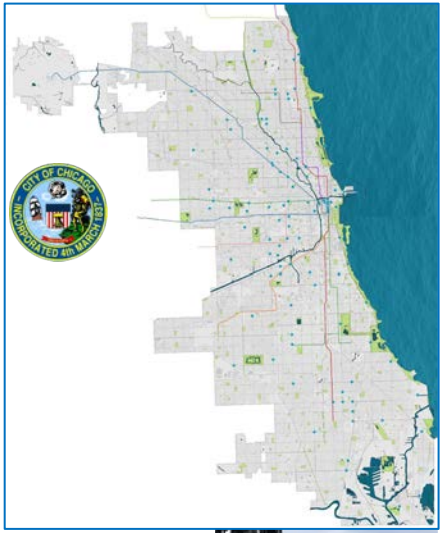

Eugene Kelly
(CSU; NEON)


Irene Qualters
(LANL; Advisory Committee Chair)

VERSITY OF CAGO

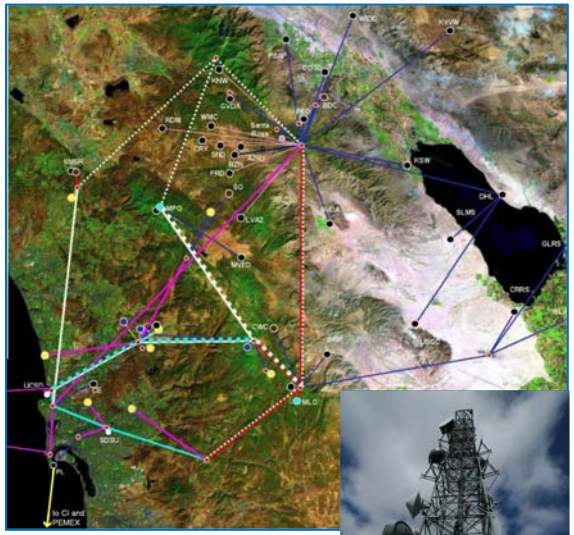
Argonne NATIONAL LABORATORY

SAGE Partner Instruments



ARRAY THINGS

AoT: ***Neighborhood*** scale urban environment and activity.



HPWREN/WIFIRE: ***Regional*** Environmental Conditions and Events.

HPWREN
SDSC
SAN DIEGO SUPERCOMPUTER CENTER

NEON: ***Continental*** scale ecology and environment.

neon
National Ecological Observatory Network

Ecology: NSF NEON & Sage

AI@HPC + AI@Edge = Intelligent Forecast & Sensing

NEON: National Ecological Observatory Network. Multi-decade project to understand changing ecosystem

81 field sites, 100K data samples each year.

Sage will deploy AI@Edge to link with AI@HPC and detect interesting phenomenon and notify scientists in real time

From bats to migrating animals to clouds…

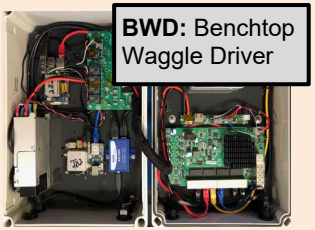
The Edge

AI@Edge

WES: Waggle Edge Stack

Sage Nodes

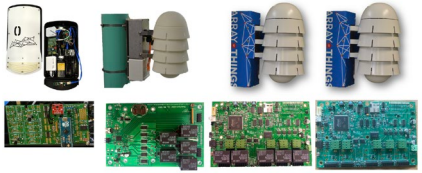
VW: Virtual Waggle

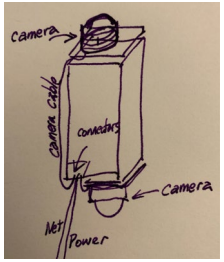


BWD: Benchtop Waggle Driver

1) Sage Blade

2) Wild Sage

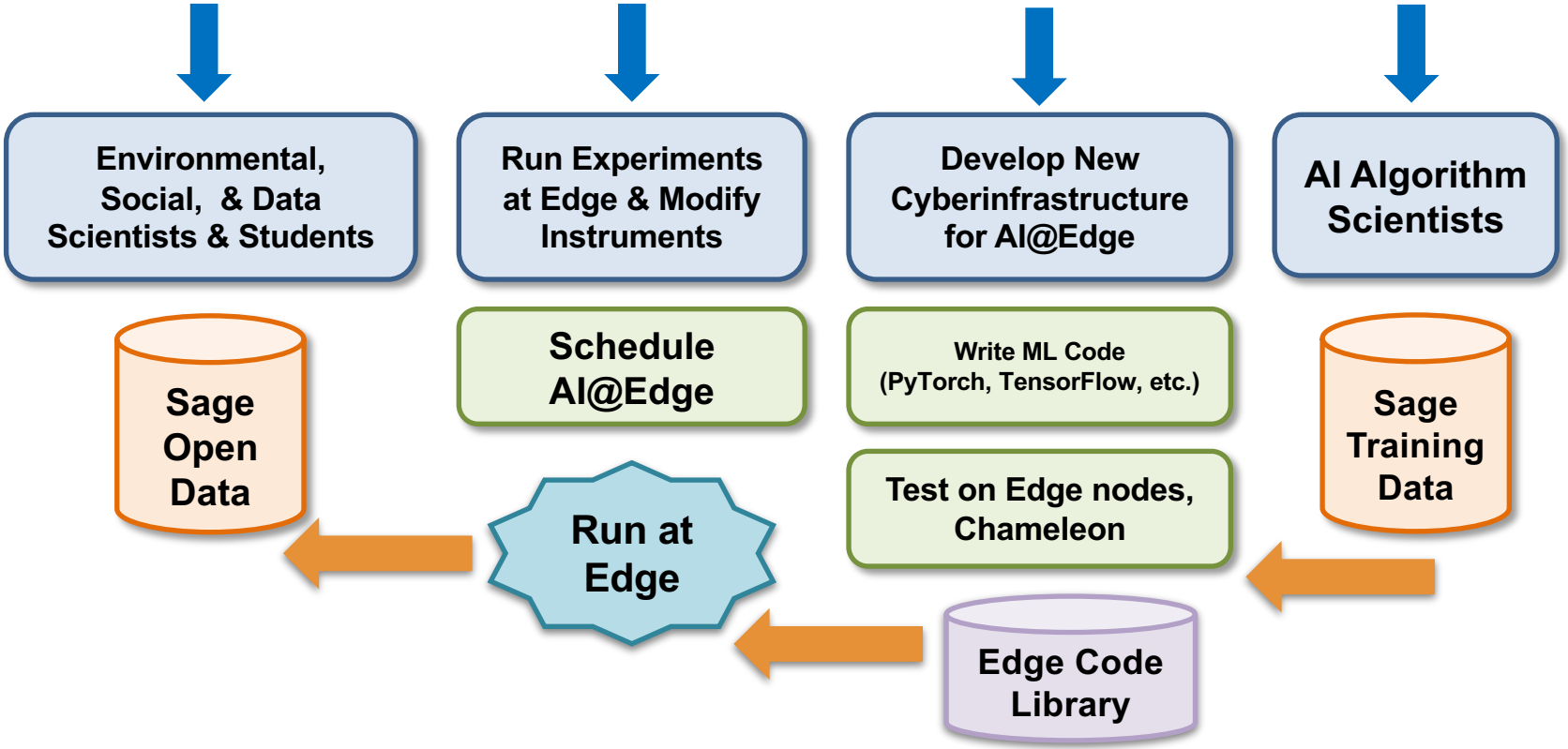




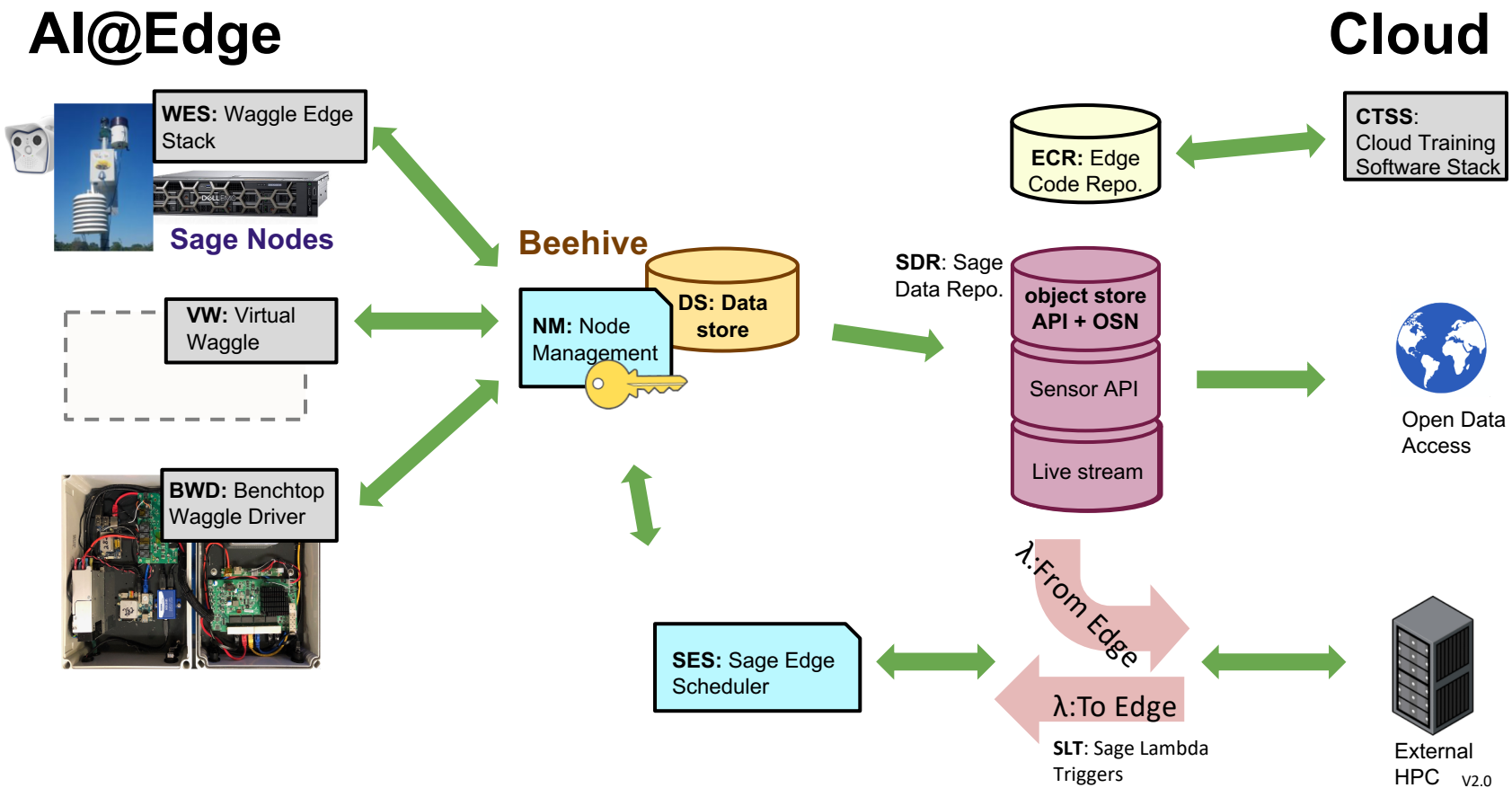
Testbed for latest AI@Edge Hardware

What does AI@Edge Cyberinfrastructure need?

A User-Driven, Science Architecture:



SAGE Technical Architecture

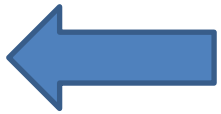


SDR: SAGE Data Repository

Currently: Sensor data in csv files:

Data access in SAGE (work in-progress)

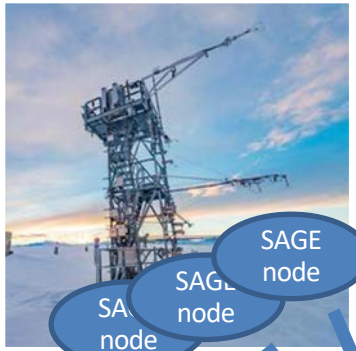
- Sensor data in database
  - API for sophisticated search queries
  - CKAN data portal for UI
- Live stream of sensor data
- Object store for large files



SAGE object store

- Training data from SAGE nodes (and users)
  - Images
  - Videos
  - Sound files
  - LIDAR data
  - Multispectral images
  - …
- Machine learning models created by SAGE users

SAGE object store – API server



SAGE beehive

Training data

SAGE storage API server

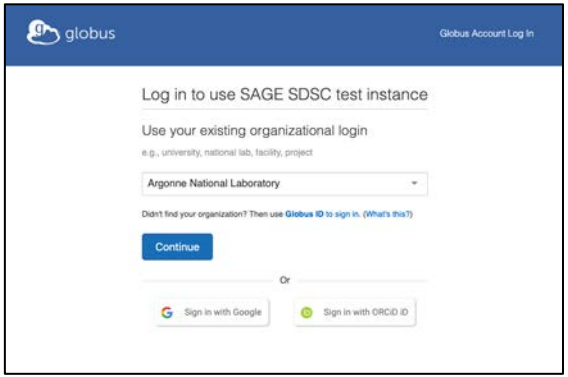
OSN S3
Ceph object storage

SAGE object store – API server

- Supported storage backend: S3-style API
- RESTful API (similar to S3 path-style addressing model)
- “virtual” buckets:
  - UUID names to prevent namespace conflicts
  - One file (or dataset) per bucket
    - (A dataset consists of files sharing the same metadata)
  - Metadata
  - Ownership & Permission control

- Access:
  - JSON REST API
  - python client library
  - command line client
  - SAGE website (not yet)

SAGE object store – API server

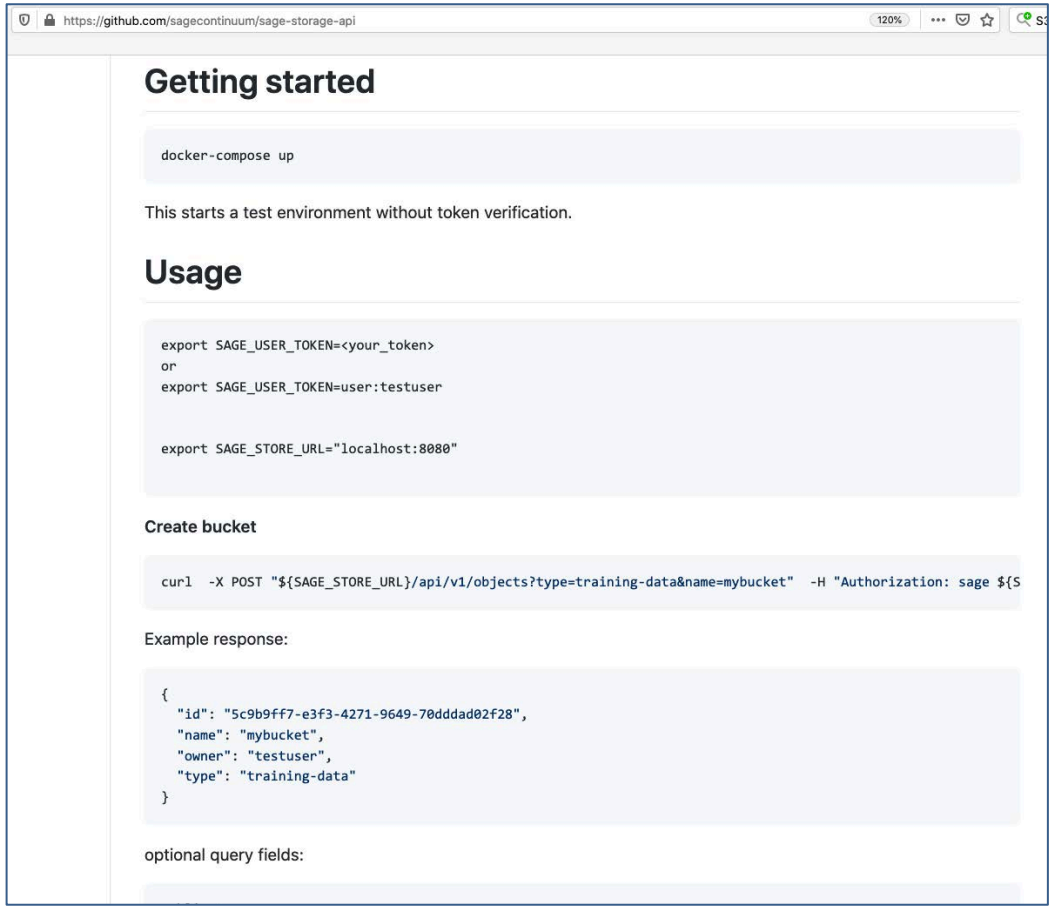


- Sage users authorize via OAuth2 access tokens
- Access management: **FULL_CONTROL, WRITE, READ, WRITE_ACP, READ_ACP**
- Open source, Golang
- implementation & documentation: https://github.com/sagecontinuum/sage-storage-api

SAGE object store – API server

For those interested…

https://github.com/sagecontinuum/sage-storage-api



Questions?

SAGE

A Software-Defined Sensor Network

Cyberinfrastructure for **AI at the Edge**

sagecontinuum.org