Parallel Computing at the Edge: Deploying Parallel Computers and Sensors on Chicago Street Poles

Pete Beckman, Charlie Catlett, Rajesh Sankaran, Nicola Ferrier, Rob Jacob, Mike Papka, and more....
Argonne National Laboratory

- $675M /yr budget
- 3,200 employees
- 1,450 scientists/eng
- 750 Ph.D.s
Argonne’s Next Big Supercomputer: Aurora
Big Sensor Science

Big, Expensive, Precise, Sparse
Little Sensor Science

Small, Cheap, Imprecise, Dense
(almost no on-board processing)
Waggle: An Open Platform for *Intelligent* Sensors
Exploiting Disruptive Technology, *Edge Computing*, Resilient Design

- **Machine Learning**
  - Computer Vision

- **Novel Sensors**
  - Nano / MEMS

- **Low Power CPUs**
  - GPU / Smartphones
Powerful, Resilient & Hackable

Multiple boot media (µSD / eMMC)

4-core ARM

Node Control & Communications

4 + 4-core ARM

In-Situ / Edge Processing

8-core GPU

Real time clock & Internal sensors

Relays

Current Sensors

Heartbeat Monitors

Reset pins

“Deep Space Probe” Design

Linux Development Environment

4-core ARM

Control Processor
Edge Computing: Analysis and Feature Recognition

- Parallel Computing
- Open Platform
- Deep Learning
Waggle Machine Learning & Edge Computing

- We are exploring Caffe & OpenCV
  - Convolutional Neural Networks
- Training will be done on systems at Argonne
- Classification on Waggle

https://waggle.sensor.slack.com/files/noaholsman/F243LQL66/output.jpg
Waggle / AoT
Robust Testing
The Data
Deploying Waggle
Waggle: A Platform for Research

• **Open Source / Open Platform**
  – Reusable, extensible software communities

• **Machine Learning: Computer Vision**
  – Data must be reduced in-situ

• **Novel Sensors**: Nano / MEMS / μfluidics
  – Explosion of nano/MEMS & imaging tech

• **Low-Power CPUs**: GPU / Smartphones
  – Powerful, low-power, smartphone CPUs

**Opportunity**: Big Data + Predictive Models

Smart Sensors + Supercomputers/Cloud Computing = predictions and analysis
The Array of Things
Why Focus on Cities?

- 70% GHG
- 70% Energy
- 80% GDP
Why measure cities?
A collaborative project: Argonne National Laboratory, the University of Chicago, and the City of Chicago

Supported by collaborating institutions and the U.S. National Science Foundation.
Industry In-Kind partners: AT&T, Cisco, Intel, Microsoft, Motorola Solutions, Schneider Electric, Zebra
Damen & Ashland

PM 2.5 Alert

Power Outage
Developing a pilot project strategy aimed at empowering partner universities and national laboratories to work with their local cities.
Why HPC Geeks Should Care

• New sensors are *programmable parallel computers*
  – Multicore + GPUs & OpenCL or OpenMP
  – New algorithms for in-situ data analysis, feature detection, compression, deep learning
  – Need new progmod for “stackable” in-situ analysis (for sensors and HPC)
  – Need advanced OS/R resilience, cybersecurity, networking, over-the-air programming

• 1000s of nodes make a *distributed computing “instrument”*
  – New streaming programming model needed
  – New techniques for machine learning for scientific data required
    • Both for within a “node” and collectively across time series

• How will **HPC streaming analytics and simulation** be connected to live data?
  – Can we trigger HPC simulations after first approximations? (weather, energy, transportation)
  – Unstructured database with provenance and metadata for QA/collaboration

• Use novel HPC hardware to solve power issue?
  – Can we use neuromorphic or FPGAs to reduce power for in-situ analysis & compression?

• We are trading precision & cost for greater spatial resolution: What is possible?
Questions?

http://www.wa8.gl

http://arrayofthings.github.io