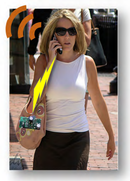
CitiSense – A Participatory Air Quality Sensing System for Real-Time User Feedback

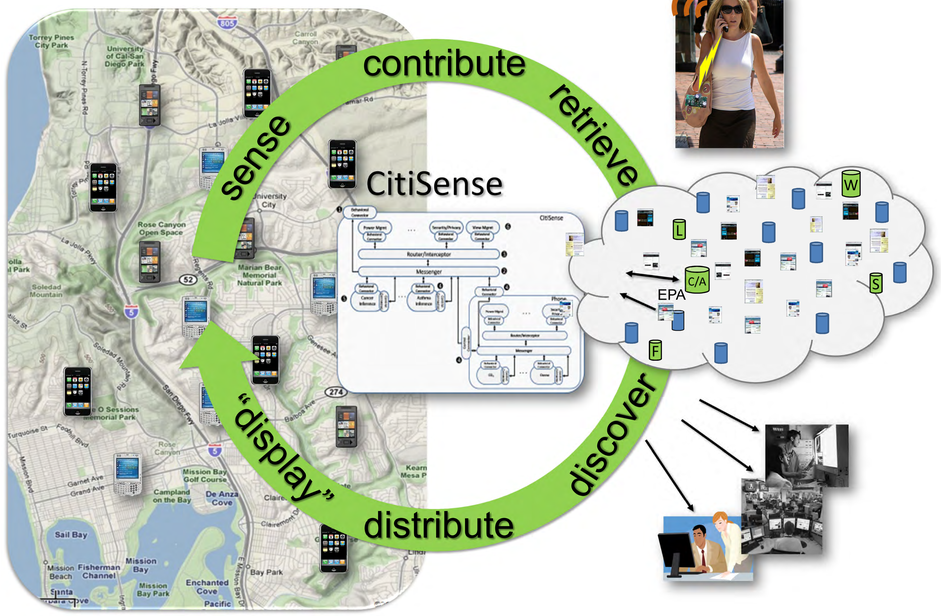
William G. Griswold, Sanjoy Dasgupta, Ingolf Krueger, Kevin Patrick*, Tajana Rosing, Hovav Shacham, Elizabeth Bales, TJ Barbour, Nima Nikzad, Nichole Quick*, Nakul Verma, Piero Zappi, Celal Ziftci

Computer Science and Engineering, UCSD *UCSD School of Medicine and Calit2

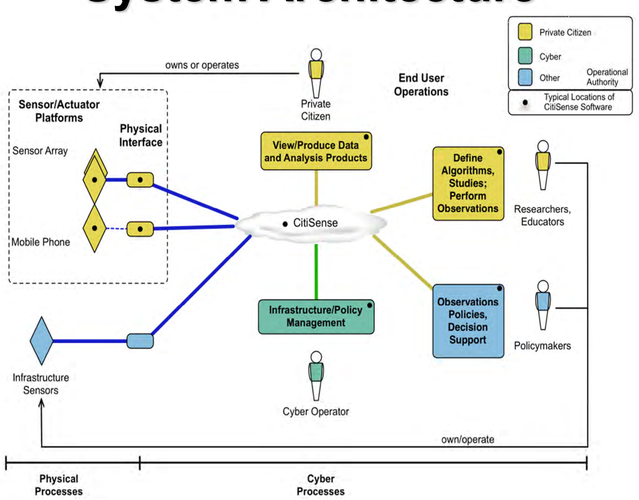
Motivation

- Interplay between environment and health is not fully understood
  - 158 million experience poor air quality, higher cancer rates
  - 30% public schools near highways, where asthma rates ↑ 50%
  - Only 6 EPA monitors in SD Co., 4000 sq. mi., 3M residents
  - Air pollution not uniformly distributed in space or time
- Challenges:
  - Continuously monitor environment with wearable and environmental sensors, aggregate the data for analysis
  - Quickly reflect personalized results back to populace, and support scientific studies of behavior and health



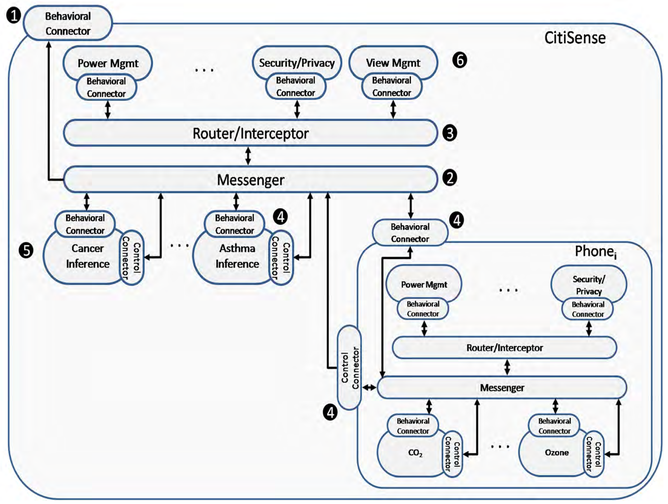


System Architecture



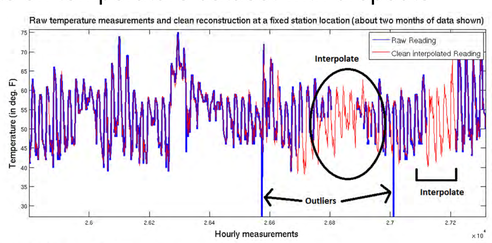
Software Architecture

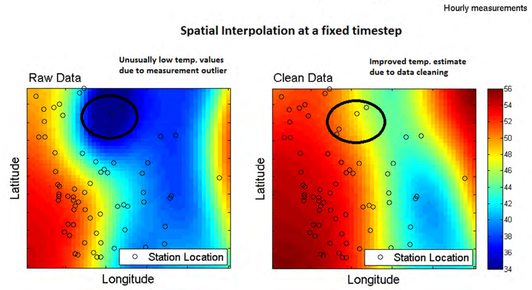
- CitiSense integrates components for:
  - Data collection, inference, and quality assurance
  - Event notification and data distribution
  - Security and privacy
- CitiSense employs the aspect-oriented Rich Services Arch.
  - Decouples the message-based orchestration of services from the enactment of policies
  - Provides separation of concerns, extensibility, and adaptability



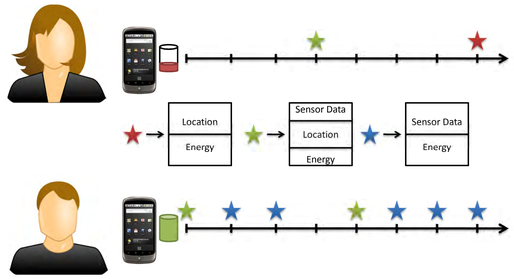
Statistical AI

- Designed kernel-based regression algorithms to overcome sparseness and noise (e.g., sensing and GPS errors)
  - Combines spatial and temporal interpolations
- Early spatial results on temperature dataset with dropouts



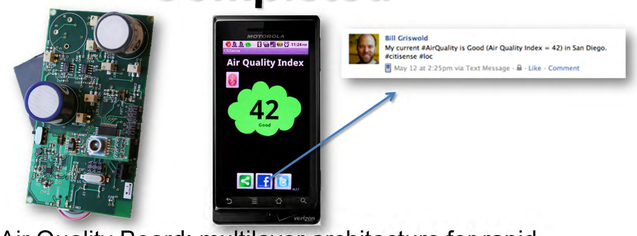


Energy Management



- Load-balances based on location, energy, sensing, and their rate of change
- Power savings up to 34% when stationary, 20% when mobile (simulation)

Completed



- Air Quality Board: multilayer architecture for rapid prototyping and evaluation of low power wireless sensor nodes and applications
  - ATMEGA 1281 8-bit RISC MCU @ 7.3728 MHz
  - 128 KB Flash, 8 KB RAM, 4KB EEPROM
  - Bluegiga WT12 Bluetooth transceiver
  - Sensors for Carbon Monoxide, NO_2, Ozone
- Phone application with social bridge
- Rich Services for server & Android phones
- Pilot field trial with bike commuters
  - NO_2 levels on commutes often above EPA limits
  - Users reported increased awareness & usefulness

In Progress

- Full-scale field trial with variety of commuters
- Implementing holistic power management
- Implementing kernel-based regression algorithms to overcome sparseness and noise
  - Combines spatial and temporal interpolations
  - Allows any smartphone to report est. air quality