Experiments in Sensing, Networking, and STEM Education at Ohio State

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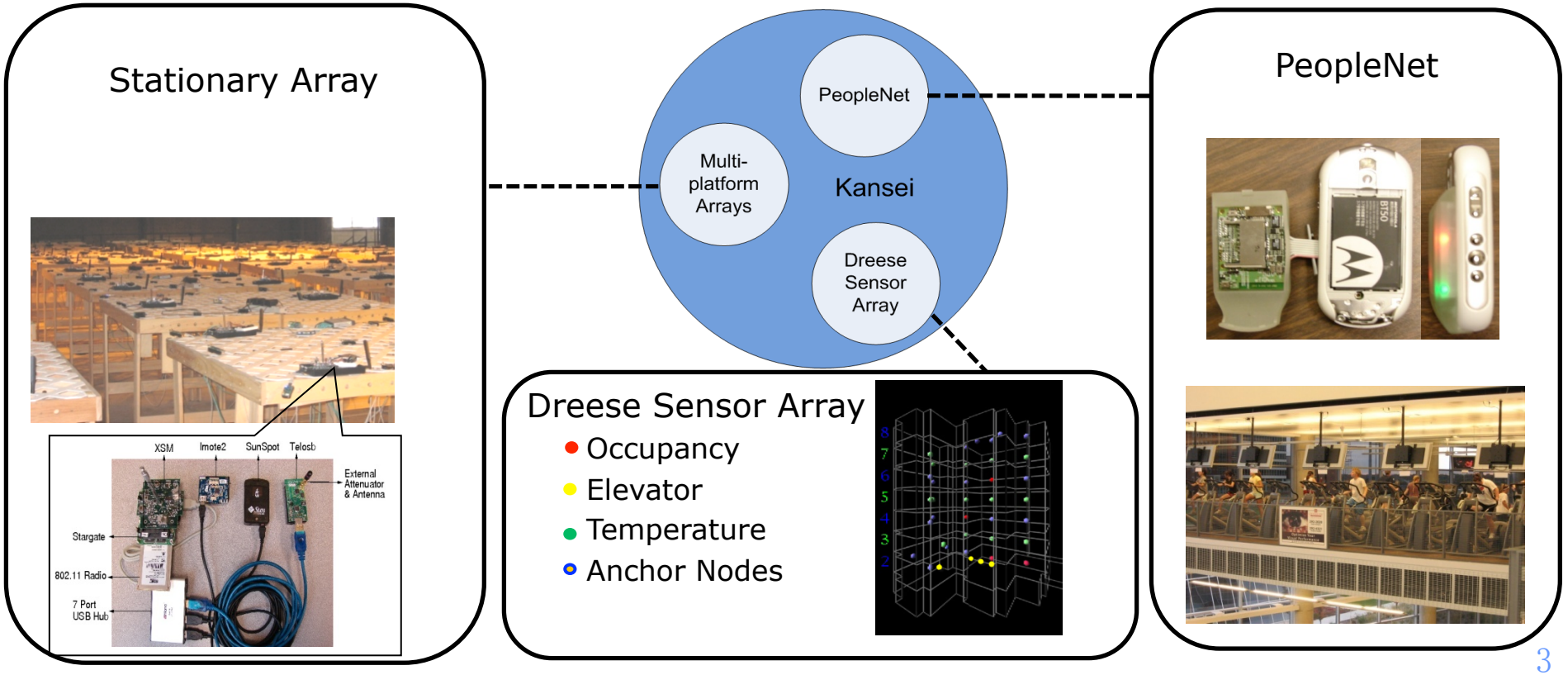
The short story

- Hands-on projects involving networked sensor nodes in our introductory courses in networking and distributed computing since ~2003

- Evolved from graduate to undergraduate (2006) to high school curricula (2010)

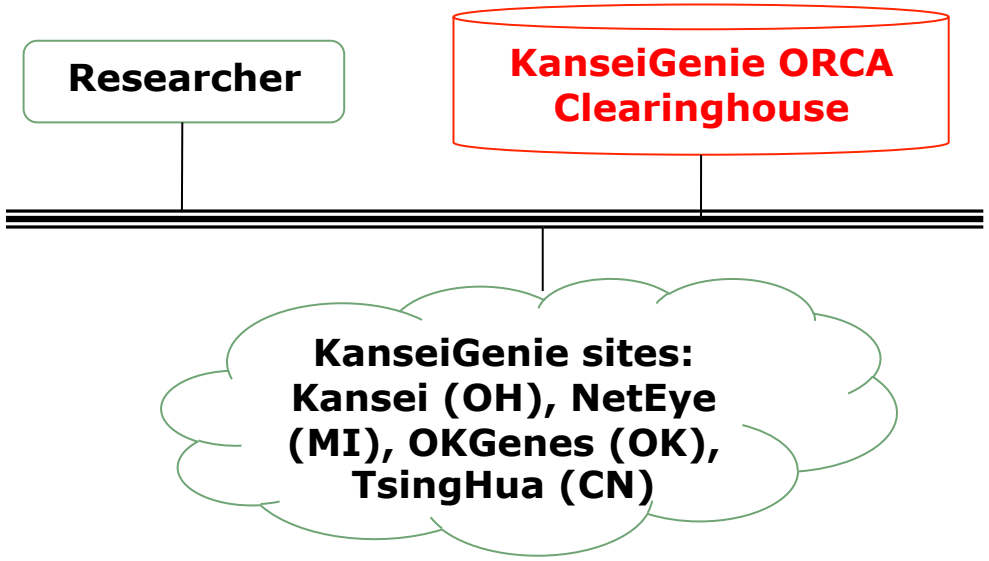
The short story

- Emphasis on experiments with real hardware
  - low power sensor arrays (motes, smartphones)
  - live setting (application-oriented testbeds and projects)

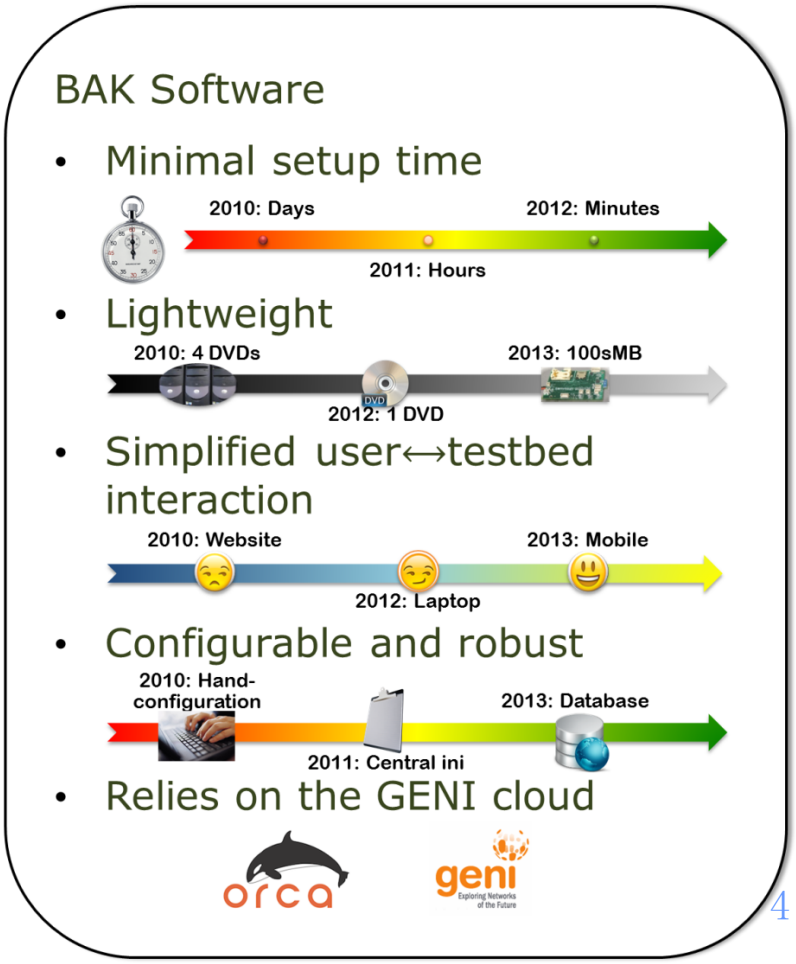


The short story

- Leveraging KanseiGenie and derivative infrastructure, and continued plan for GENI "cloud" resources



Web based portal for experiment control and data in-/ex-filtration



Teaching modus operandi

- Each offering has ~15 custom projects
  - 3 students per project (2, if team includes a grad student)
  - each project has assigned grad expert
- Two hour tutorial on concepts, development environment, and hello-world exercises
  - TinyOS programming (in NesC), Android programming
  - project resources and tutorial compilations shared online
- Pace through regular deliverables
  - demo env. setup (hardware & emulator), design report, …
- Per group exam
  - demo and written report
  - evaluate design and conceptual understanding

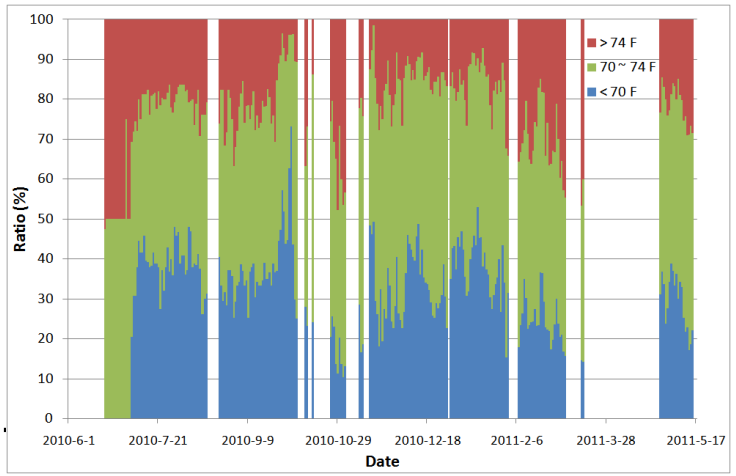
Operational details (Sensor Network projects)

- TinyOS (historically, now shifting to .NET MF)
- Pre-packaged VM, includes simulator, setup
  - VMSphere walled playground available
- WSN motes borrowed when needed
  - <100 used per quarter
- Provide server access for projects

- Kansei arrays accessed via Researcher Portal web (mostly by graduate students for networking research projects)
  - increasingly these are about the physical layer

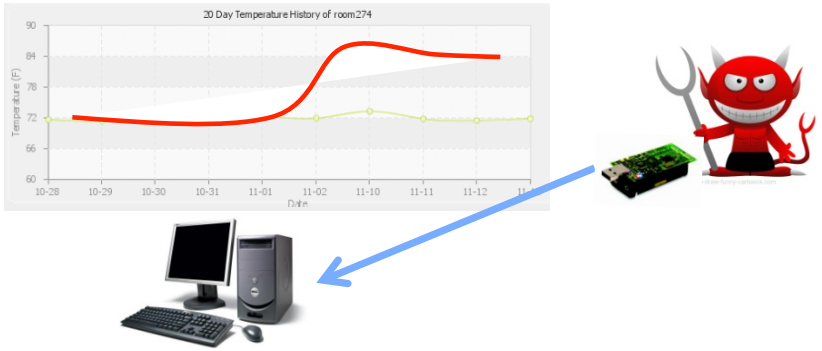
Sample projects: ThermoNet

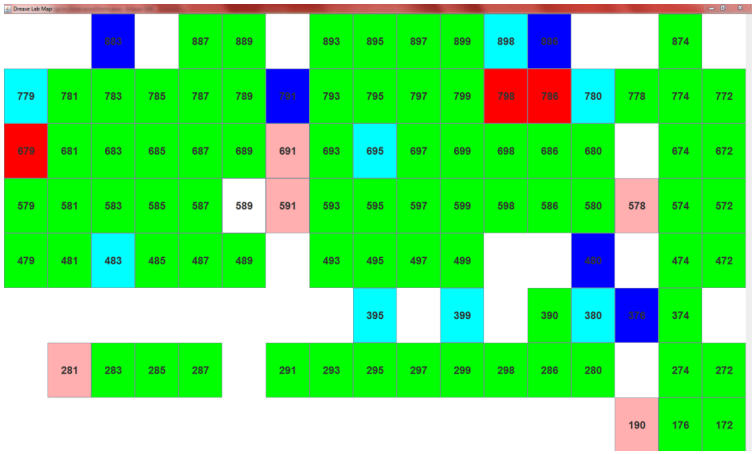
- Fine-grain assessment of building comfort-efficiency
  - on average 47% comfortable area
  - ill-conditioned rooms, alarms



- Localize temperature sensors

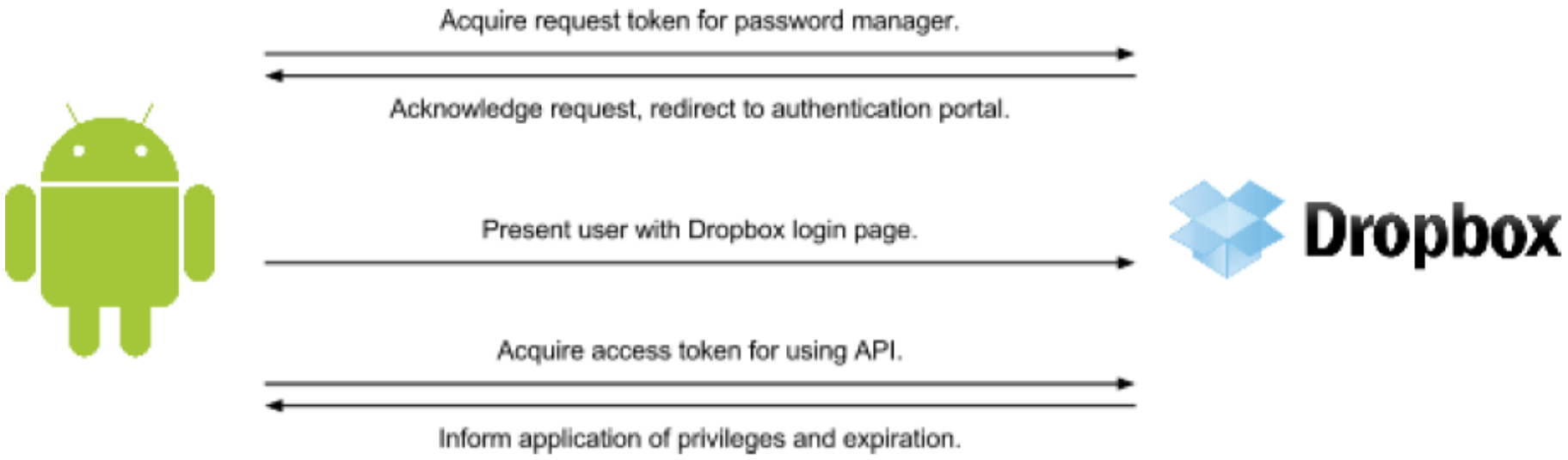
- Spoof sensors to "fool" ThermoNet
  - fake alarm



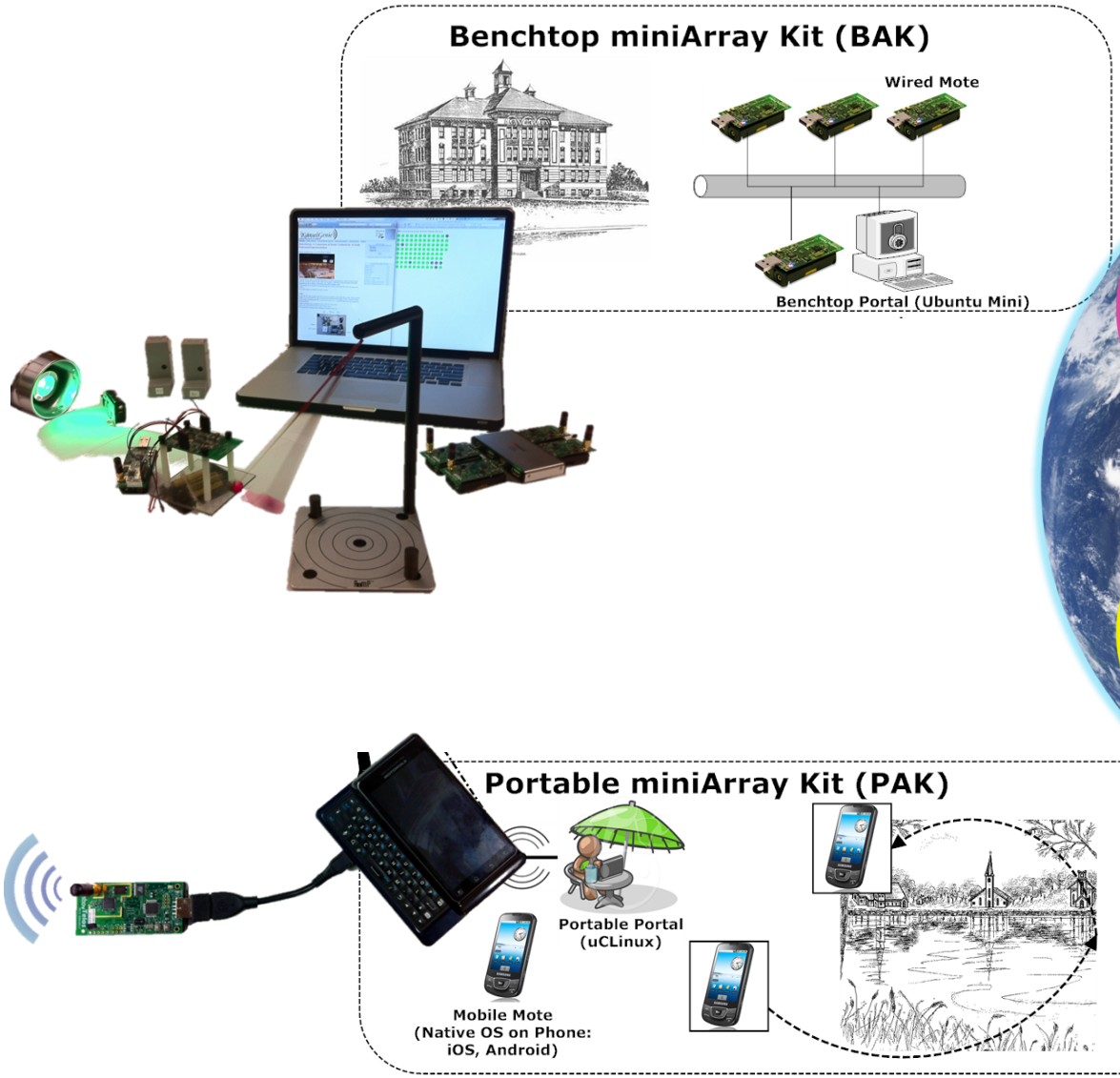


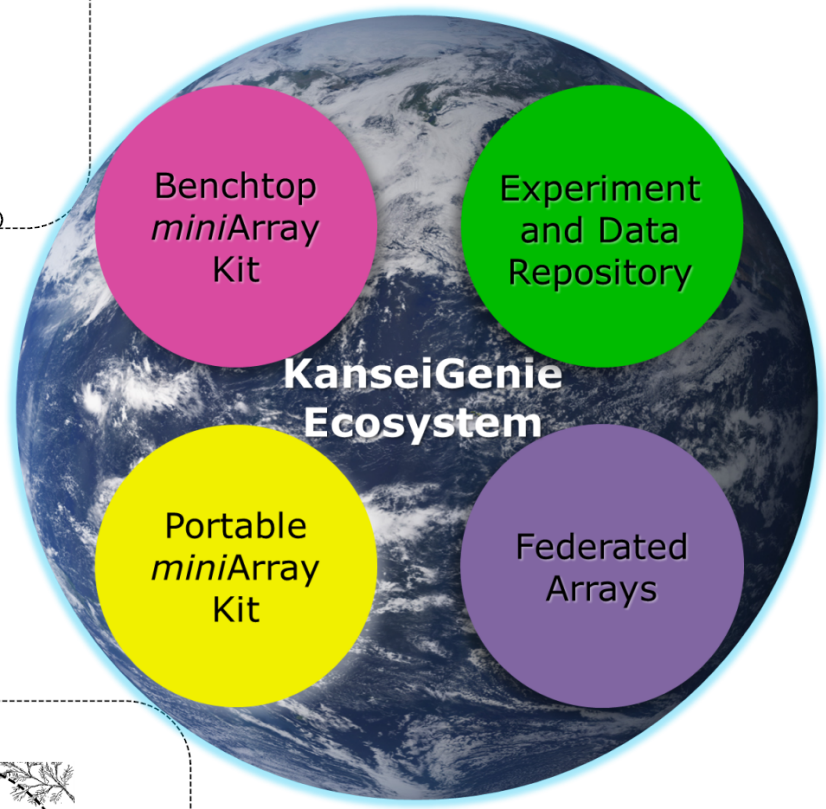
Sample network security project

- Secured password backup manager for Android
  - Centralized management of passwords
  - Backup in the cloud via Dropbox API
  - 3 weeks of development delivers working Android app
    - but really 16 hours of effort



Science experiments for high schoolers





Operational details (STEM experiments @ school)

- Schools provide computer to run KanseiGenie VM image
  - each students gets a sensor node
  - students use web browser to access local VM portal
- Image pre-loaded with apps; more apps available online
  - kit is stand-alone until user is ready for cloud resources
  - kit array can be exposed to cloud as a programmable fabric
- OSU machines
  - to act as “Data Hub” , “App Store” , “STEM Social Network”
  - run ORCA actors to shepherd kit arrays as resources in federated sensor arrays

Lessons Learned

- Undergraduates respond well to playing with device arrays
- KanseiLite / kit infrastructure lowers barrier to experimentation
- Helps to "can" the dev. environment, pace students through initial learning curve with programming system
  - most disasters at this stage
  - sample programs (app notes) helped
- Extra credit and open-ended projects work for motivated students