

Wearable Dynamic Management of Distributed Domestic Utilities



Prof. Joe Paradiso

Responsive Environments Group, MIT Media Lab



<http://www.media.mit.edu/resenv>

*Semiahmoo
July-09*



Topics

- Wearable management of HVAC control
- Accretion of sensing capability onto consumer devices
- Living with ubiquitous sensing and responsive media
- Dynamic privacy management
- Tools for the ubicomp utility worker

Public Misinformation...

Japan: Producing Electricity from Train Station Ticket Gates

by Michael Graham Richard, Gatineau, Canada on 08. 4.06
SCIENCE & TECHNOLOGY (alternative energy)

EMAIL THIS



2141 diggs

digg it



MIT duo sees people-powered "Crowd Farm"

Plan would harvest energy of human movement

July 25, 2007

Two graduate students at MIT's School of Architecture and Planning want to harvest the energy of human movement in urban settings, like commuters in a train station or fans at a concert.



Little treadmills everywhere: Floors that harvest the energy in every step

By Jennifer Cutraro The Boston Globe

Published: July 31, 2007

*“Human” Energy harvesting will do little for sustainability
It will only be valuable in extending/eliminating batteries in
portable devices, wearable sensors, etc.*



Sensor networks for energy conservation

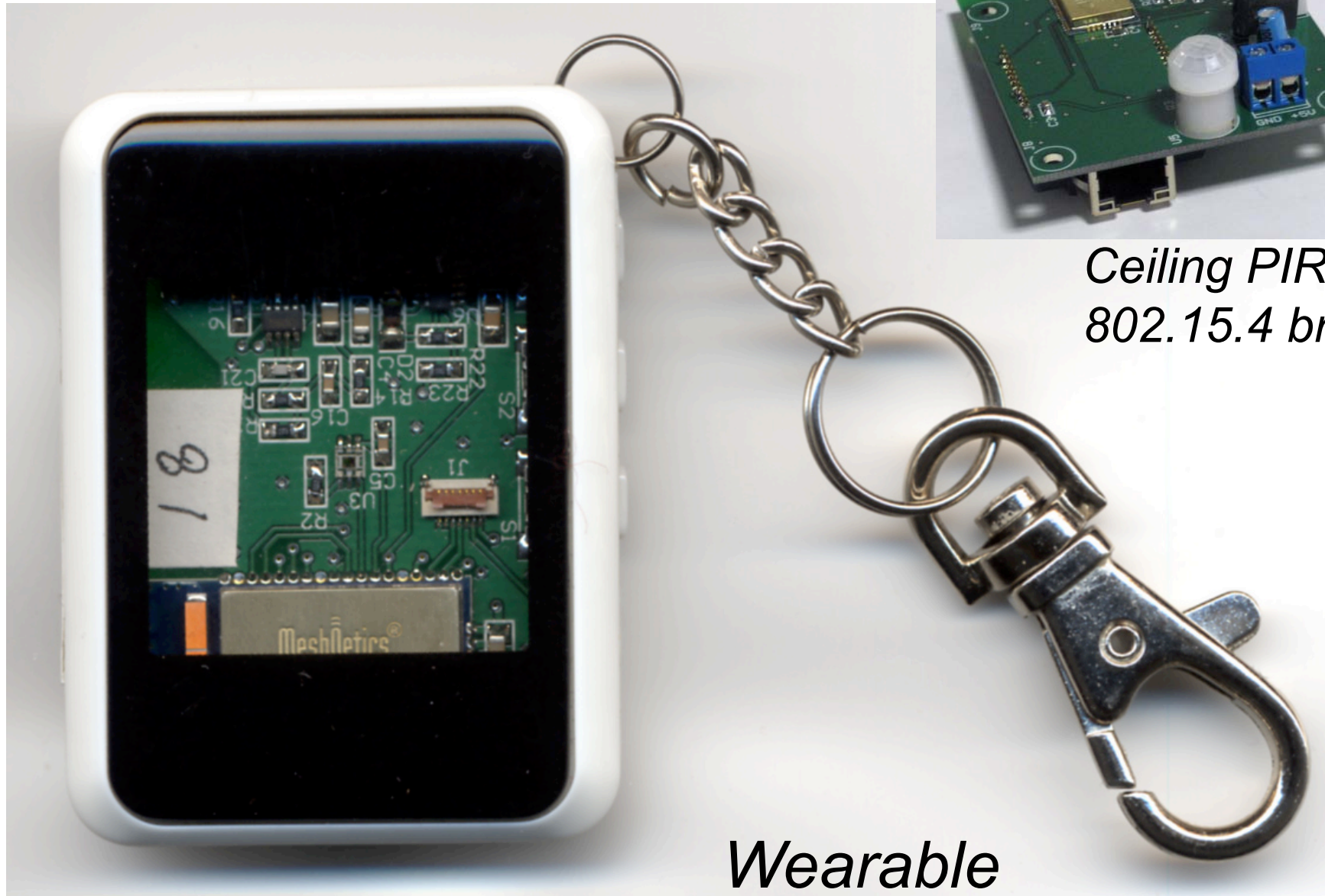


- Leveraging dense sensor networks for optimal energy management
 - 40% of US energy is spent in buildings
 - Pervasive sensor/actuator network can reduce this
 - Optimize heating, AC, lighting for *Person* not room
 - Anticipating behavior & build usage models over time

Wireless Monitor



*Ceiling PIR
802.15.4 bridge*

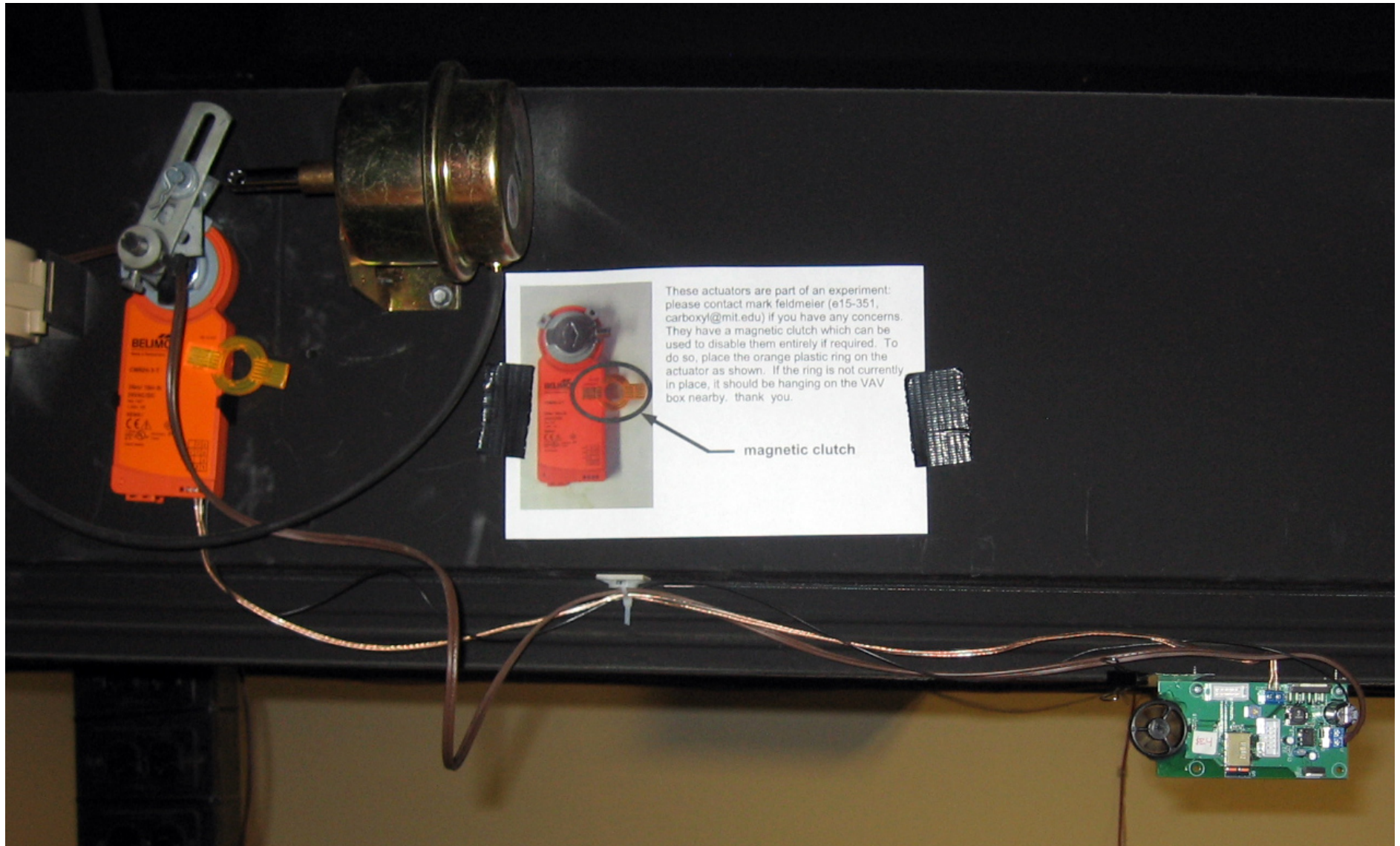


Wearable

Mark Feldmeier

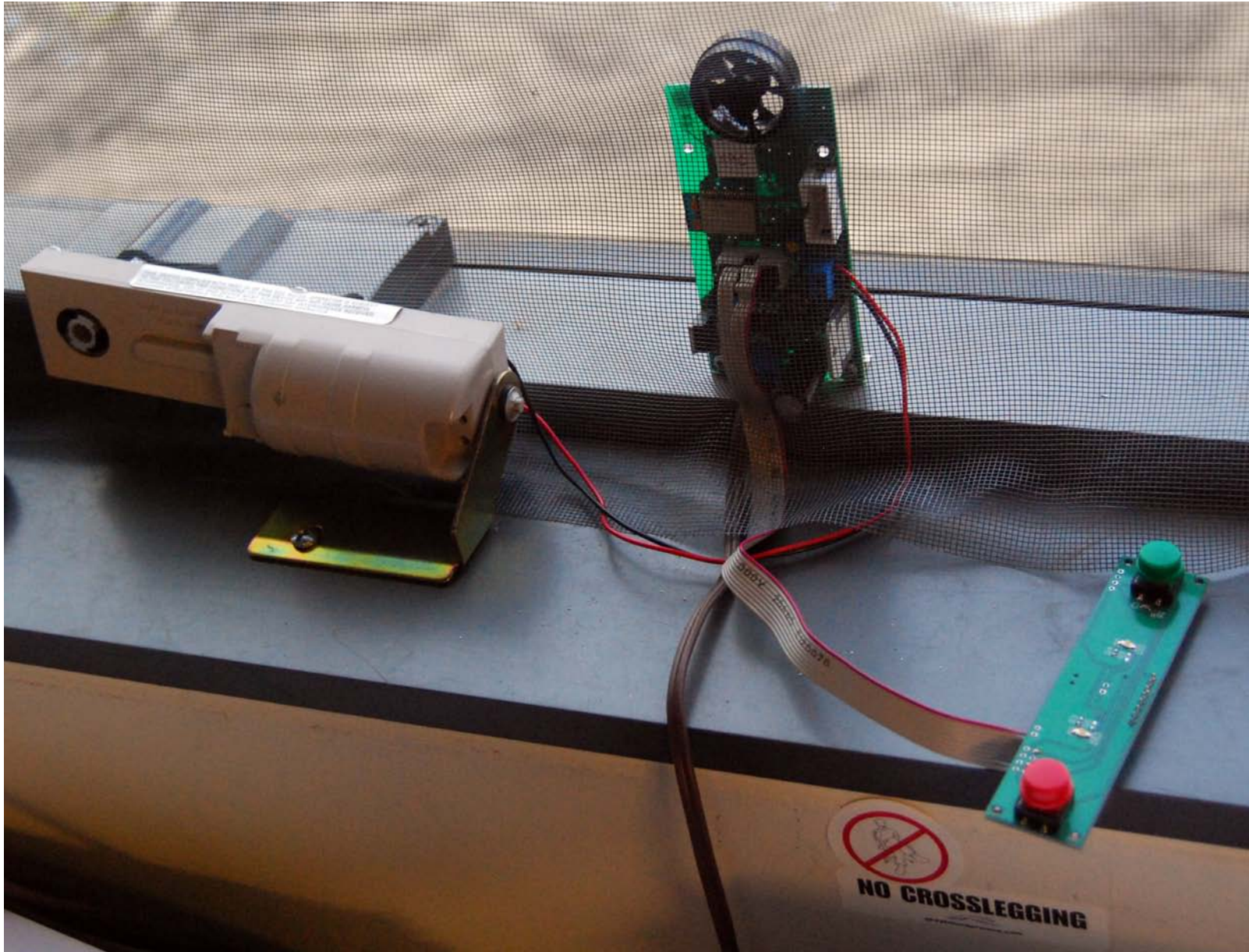
Integrated vibration, T & H, Light @ μ W

Ceiling HVAC Damper Control

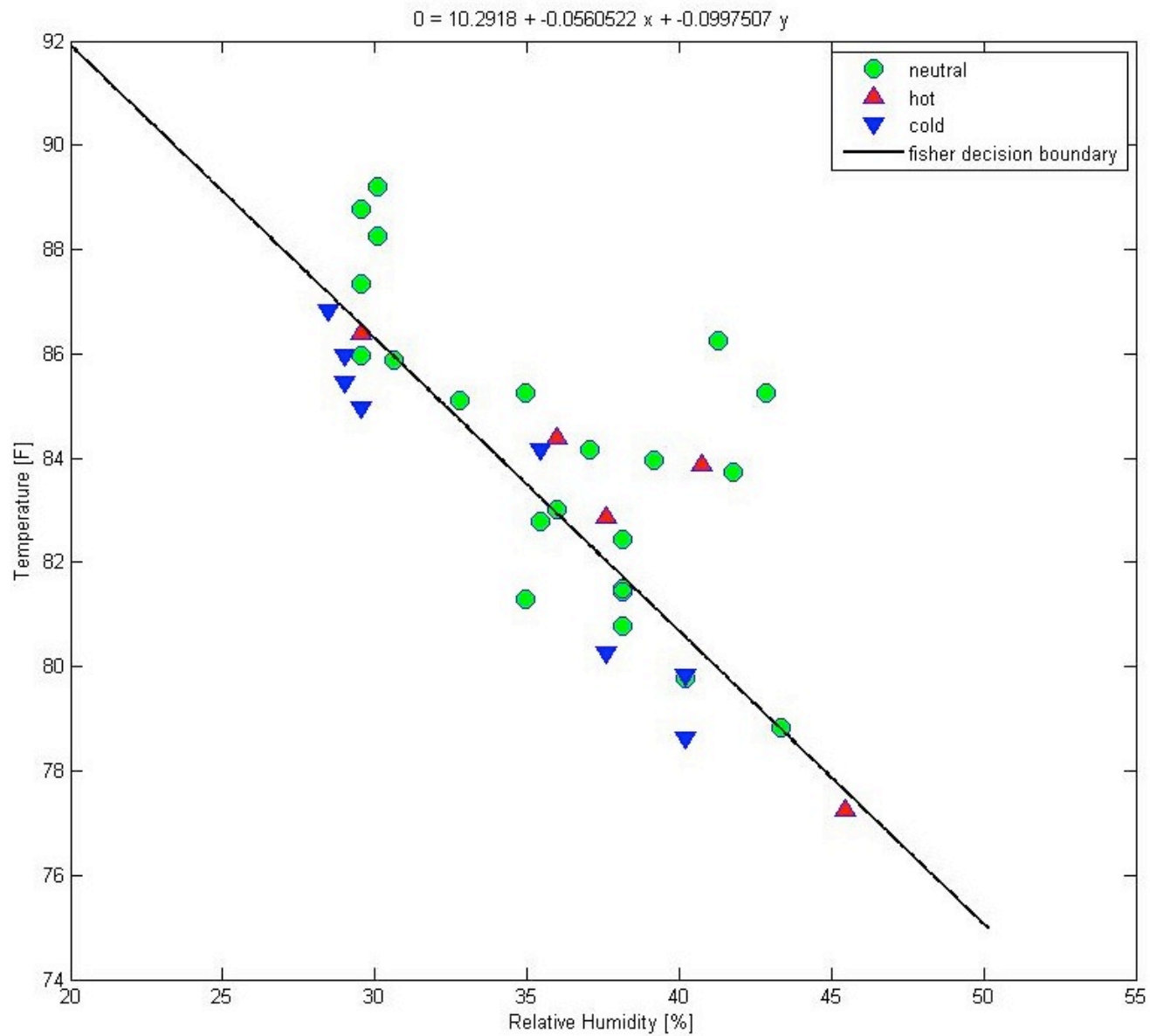


*Measure temperature, humidity, airflow, PIR motion
Continuous Control of Damper*

Open/Close Windows

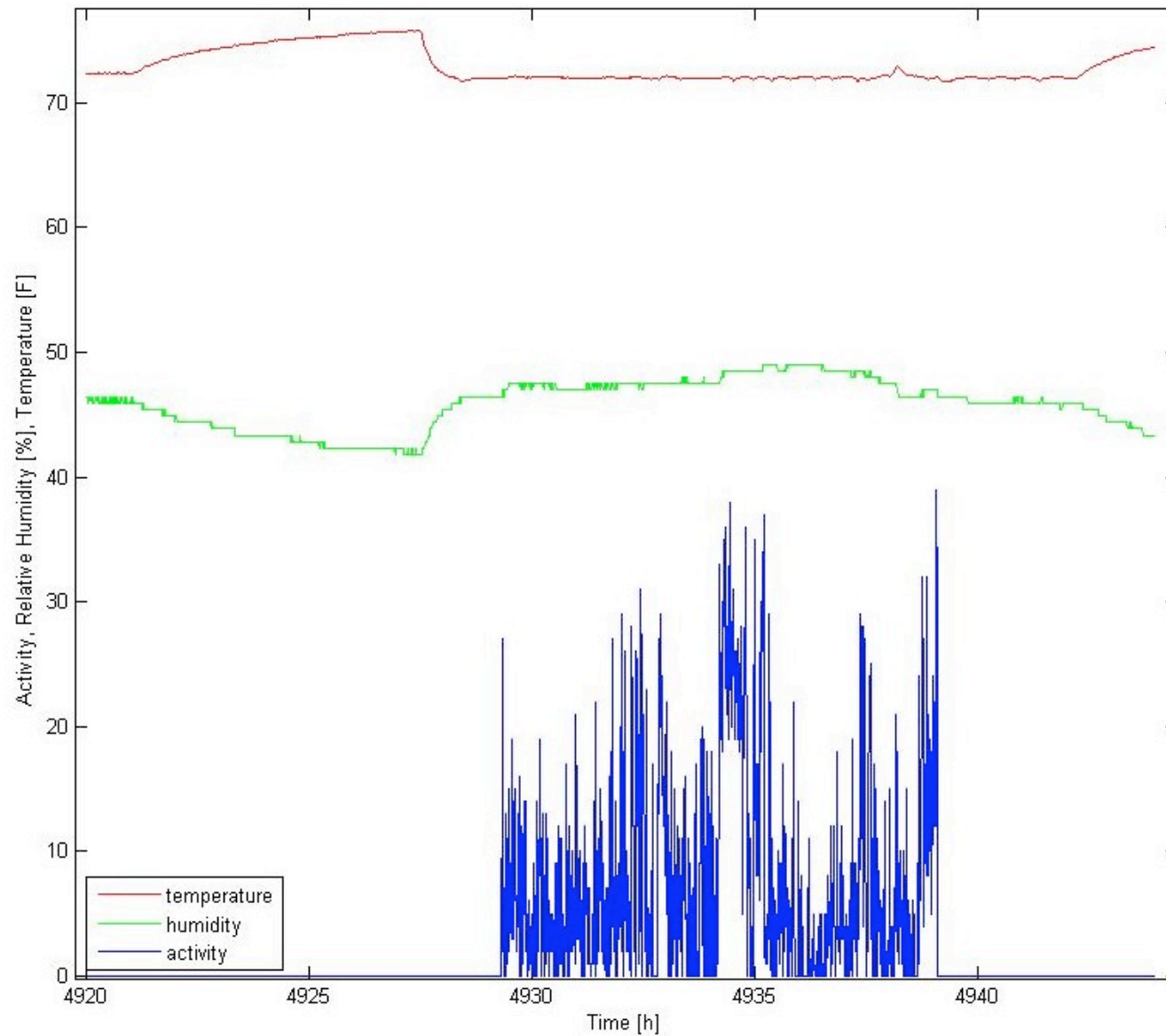


Very Early Data - Comfort





Very Early Data – Learned Setbacks





Bootstrapping a Ubiquitous Sensor Infrastructure



- Sensor networks are the foot soldiers at the front lines of ubiquitous computing
- At this point, few if any customers will buy an ensemble of “UbiComp” sensors
- **They will aggregate from established devices**
 - Home security, appliances, utility devices, entertainment...

Just as the web sprouted from a networked ensemble of personal computers, true “ubicom” will arise from an armada of networked devices installed for other purposes.

Power Strips are Everywhere



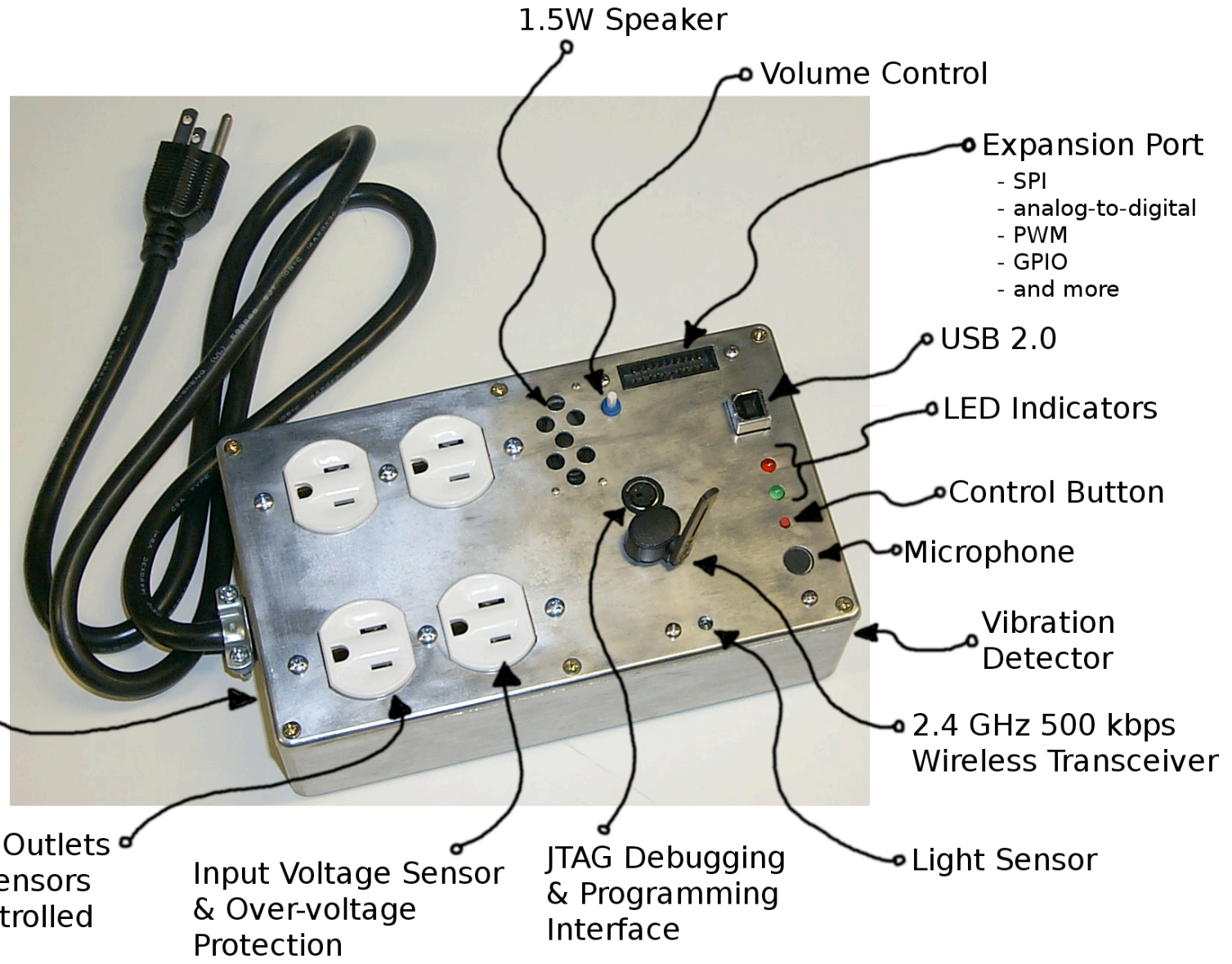
- Needed in Homes, offices, especially the Media Lab!
- Sensors are becoming commodity items
 - Cost of adding sensors to a design is becoming incremental
- Power strips are ideal base platforms for hosting a sensor network
 - Ready access to power
 - Power line can be a network port
 - Can monitor the status of devices that are plugged in

PlugPoint – Power Strips as the backbone of a UbiComp Sensor Infrastructure

J. Lifton, M. Feldmeier, Y. Ono (Ricoh)

Collaboration with Ricoh Research

**Power Line provides
energy & comm**
**Monitor current profiles,
Switch individual sockets**
**Hosts basic sensors (mic,
light, motion)**
Expansion Port for others
**Hub for wireless sensor
network**

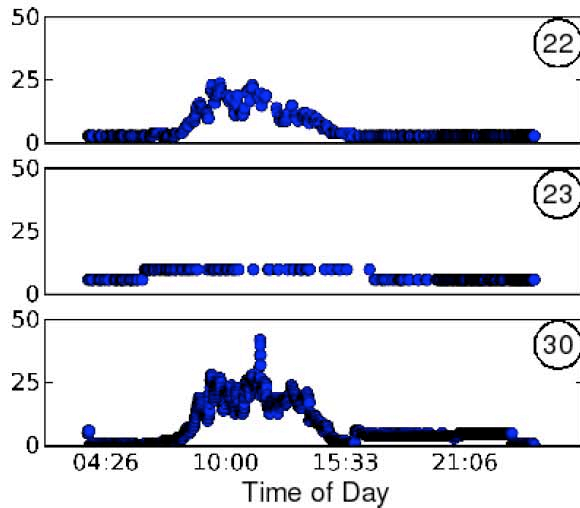


Army of Plugs

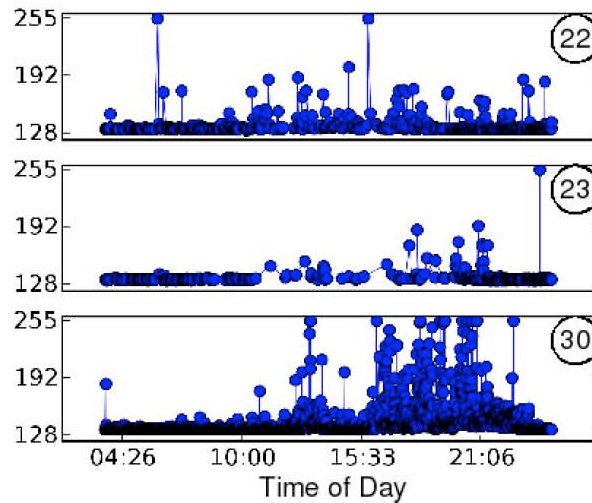


35 ON MEDIA LAB THIRD FLOOR

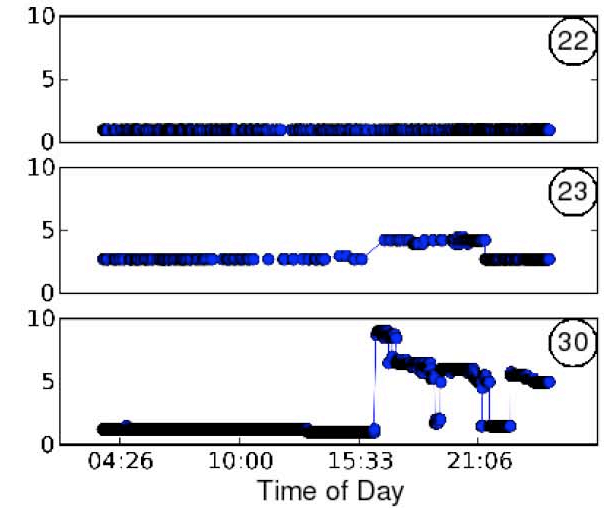
Rhythm of Lab



Incident Light



Sound Volume



Outlet Current

Distributed Acoustic Conversation Shielding

NewScientist

Tech

[Home](#) [News](#) [In-Depth Articles](#) [Blog](#) [Opinion](#) [Video](#) [Galleries](#) [Topics](#)

[SPACE](#)

[TECH](#)

[ENVIRONMENT](#)

[HEALTH](#)

[LIFE](#)

[PHYSICS&M](#)

[Home](#) | [Tech](#) | [Science in Society](#) | [News](#)

'Cone of silence' keeps conversations secret

› 09 May 2009 by [Paul Marks](#)

› Magazine issue [2707](#). [Subscribe](#) and get 4 free issues.

IN *Get Smart*, the 1960s TV spy comedy, secret agents wanting a private conversation would deploy the "cone of silence", a clear plastic contraption lowered over the agents' heads. It never worked - they couldn't hear each other, while eavesdroppers could pick up every word. Now a modern cone of silence that we are assured will work is being patented by engineers Joe Paradiso and Yasuhiro Ono of the Massachusetts Institute of Technology.

Paper in ACM SANET 2007

Yasuhiro Ono

*Ricoh ML
affiliate*

IEEE Pervasive Computing July 09

MIT ML, MIT CMS, Stanford, ETH, University of South Australia, Georgia Tech, Sun, etc.

GUEST EDITORS' INTRODUCTION

Cross-Reality



Environments

The genesis of a ubiquitously networked sensor/actuator infrastructure, leveraged by the increasingly low cost of microelectronics, sensors, and wireless technologies, is endemic to pervasive computing. As the independent application-siloed sensor/actuator networks now being deployed begin to converge through common standards, the world is becoming covered by a seamless electronic “nervous system” that extends across places, things, and people. Concurrently, although 3D virtual environments have been around for decades, their deployment has recently exploded with the advent of massively shared online virtual worlds. Dedicated immersive games such as World of Warcraft and general

purpose worlds like Second Life each now boast over 10 million subscribers. We call the ubiquitous mixed reality environment that comes from the fusion of these two technologies *cross-reality*. Sensor networks can tunnel dense real world information into virtual worlds, where this data is interpreted and displayed to dispersed users. Interaction of virtual participants can incarnate into the physical world through a plenitude of diverse displays and actuators. We can envision a user’s interface into this environment as an extension of human perception and interaction, augmenting our five senses well beyond the canonical “here and now” and redefining the meaning of presence. Although augmented reality applications are no stranger to *Pervasive Computing* readers, we distinguish cross-reality in that the conduits to and from virtuality will be everywhere, not restricted to head-worn or other wearable/mobile

Joseph A. Paradiso
Massachusetts Institute
of Technology Media Lab
James A. Landay
University of Washington

CROSS-REALITY ENVIRONMENTS

Metaphor and Manifestation— Cross Reality with Ubiquitous Sensor/ Actuator Networks

MIT Media Lab’s Responsive Environments Group is exploring ways to bridge networked electronic sensors and human perception through “cross reality” implementations that render and manifest phenomena between real world and virtual environments via densely embedded sensor and actuator networks.

The world is evolving its own electronic nervous system as sensor networks begin to cover the planet, and a rich set of research opportunities and challenges are generated where these cybersenses are projected onto our physical affordances. Much of this will play out where real meets virtual. Real sensed phenomena can freely manifest in virtual realms, where unconstrained by physics, users can adroitly browse and engage them. Similarly, interactions in virtual worlds can incarnate into reality via ubiquitously distributed displays and actuation. Accordingly, we can leverage virtual environments to extend our awareness and participation beyond the clutches of here and now. These environments can serve as a fluid conduit to interface our perception into the fast-evolving electronic realm of ubiquitous sensing and media, leading perhaps toward something of the “digital omniscience” envisioned by some of today’s leading speculative-fiction authors.^{1,2}

Researchers and practitioners have been

working with intermediate blends of the real and virtual for decades (see the sidebar “Related Work with Online Virtual Worlds”). Classically subsumed under the heading of mixed reality,³ common implementations range from installations where entire surfaces of rooms or objects are virtual (such as the partially built houses made complete with projection walls for use in military or situational training exercises) to augmented reality environments, which can be thought of as an “information prosthetic” that overlays normally invisible data onto real objects, often using mobile or head-worn devices. We see cross-reality precipitating when diverse and ubiquitous sensor and actuator networks meet pervasively shared online virtual worlds, where phenomena freely tunnel between real and contrived continua at a multitude of “wormholes” opened by densely deployed networked devices, seamlessly adapting the level of immersion to match a variable ecology of available interfaces and user context or preference. This article overviews several recent and ongoing projects in the MIT Media Laboratory’s Responsive Environments Group that are aimed at interfacing humans with ubiquitous sensor/actuator networks. We describe several ex-

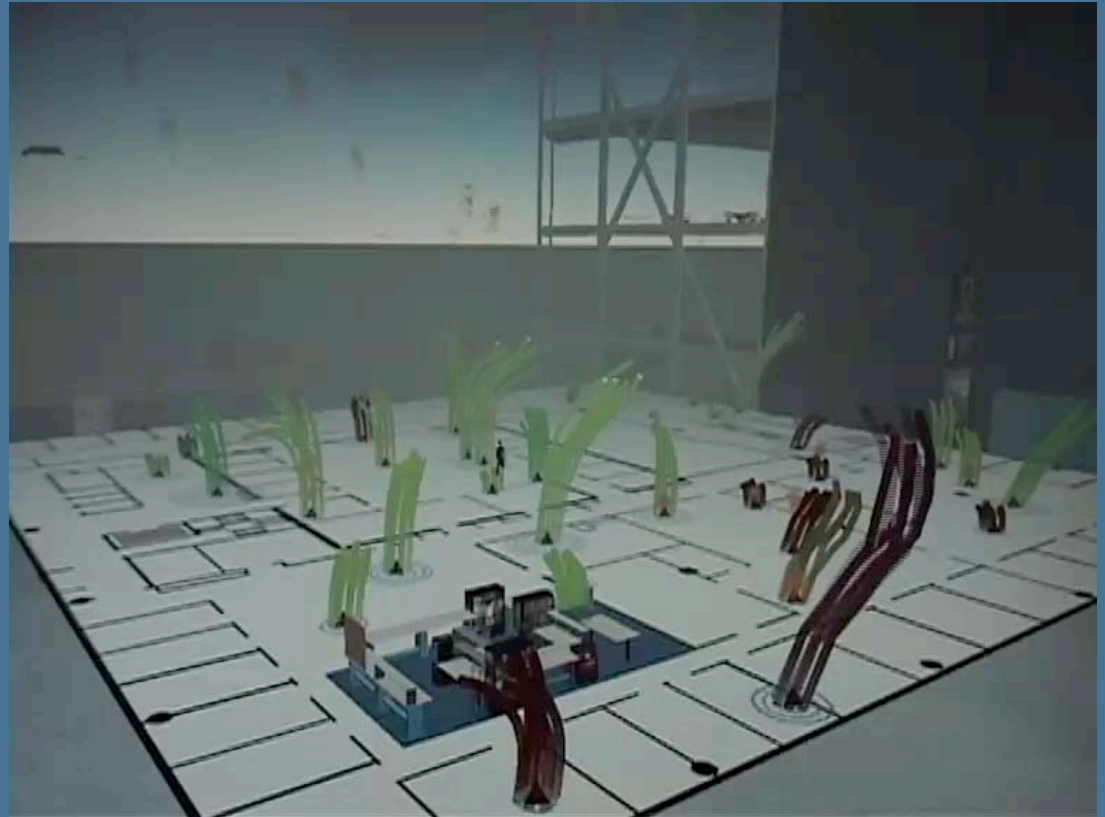
Joshua Lifton, Mathew Laibowitz,
Drew Harry, Nan-Wei Gong,
Manas Mittal,
and Joseph A. Paradiso
MIT Media Laboratory

Shadow Lab - Binding real sensor data to virtual worlds

Third floor of ML built in
Second Life

ResEnv Lab rendered in
detail - other areas currently
derived from map

Sensor data piped in and
interpreted as real-time
graphic phenomena



Simple sensor apparitions to explore basic ideas

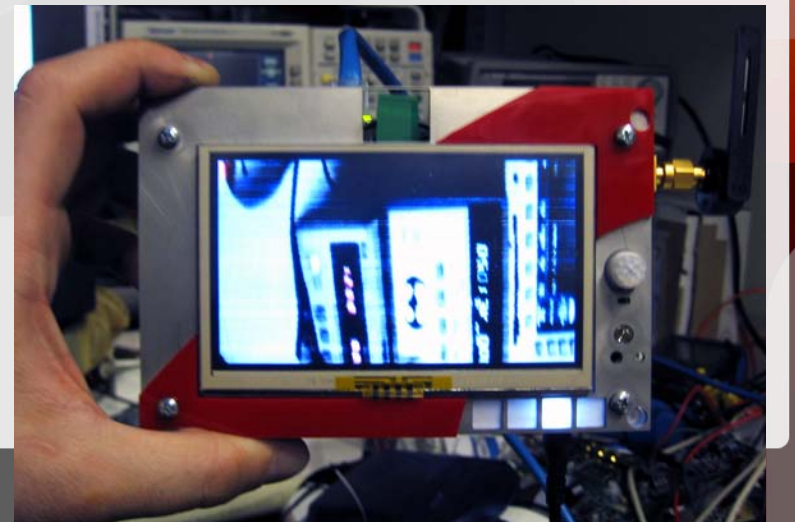
- Energy use → Amount of smoke
- Sound Levels → Ripples
- PIR Motion → Waving Fronds
- Temperature → Frond Color
- Light Levels → Frond Height

Lifton 07



Portal Details – Camera System

Deployed to cover entire building (~50 nodes)
3MP Camera
Motorized Panning and Focus
Dedicated Video DSP/ARM
- (TI DaVinci chip)
Real-time Linux OS
LCD display (Touchscreen)
**Contains Spinner Gateway/
Sensor board (detailed on
next slide)**



Mat Laibowitz

45 distributed across Media Lab since October 08

Device Details – Spinner Gateway

Works with or without camera board

Communicates with wearable/mobile devices in mesh network

Serves as reference beacon for location system

Ethernet or slave to linux board

Audio system with DSP

AVR32

Environmental Sensing

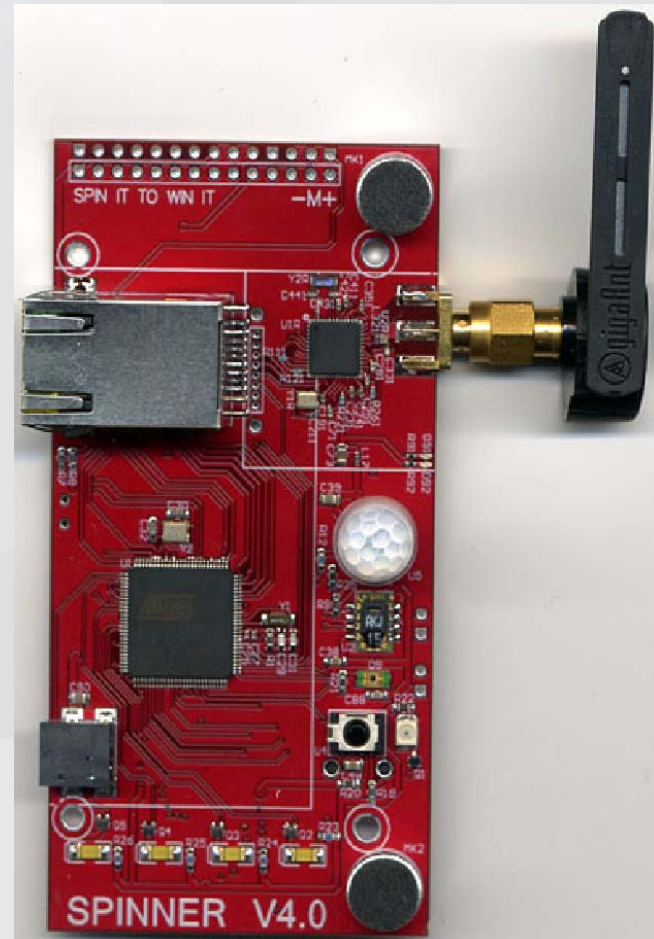
Motion

Humidity and Temperature

Light

Infrared Communication and Detection/Proximity

Talks to badge systems

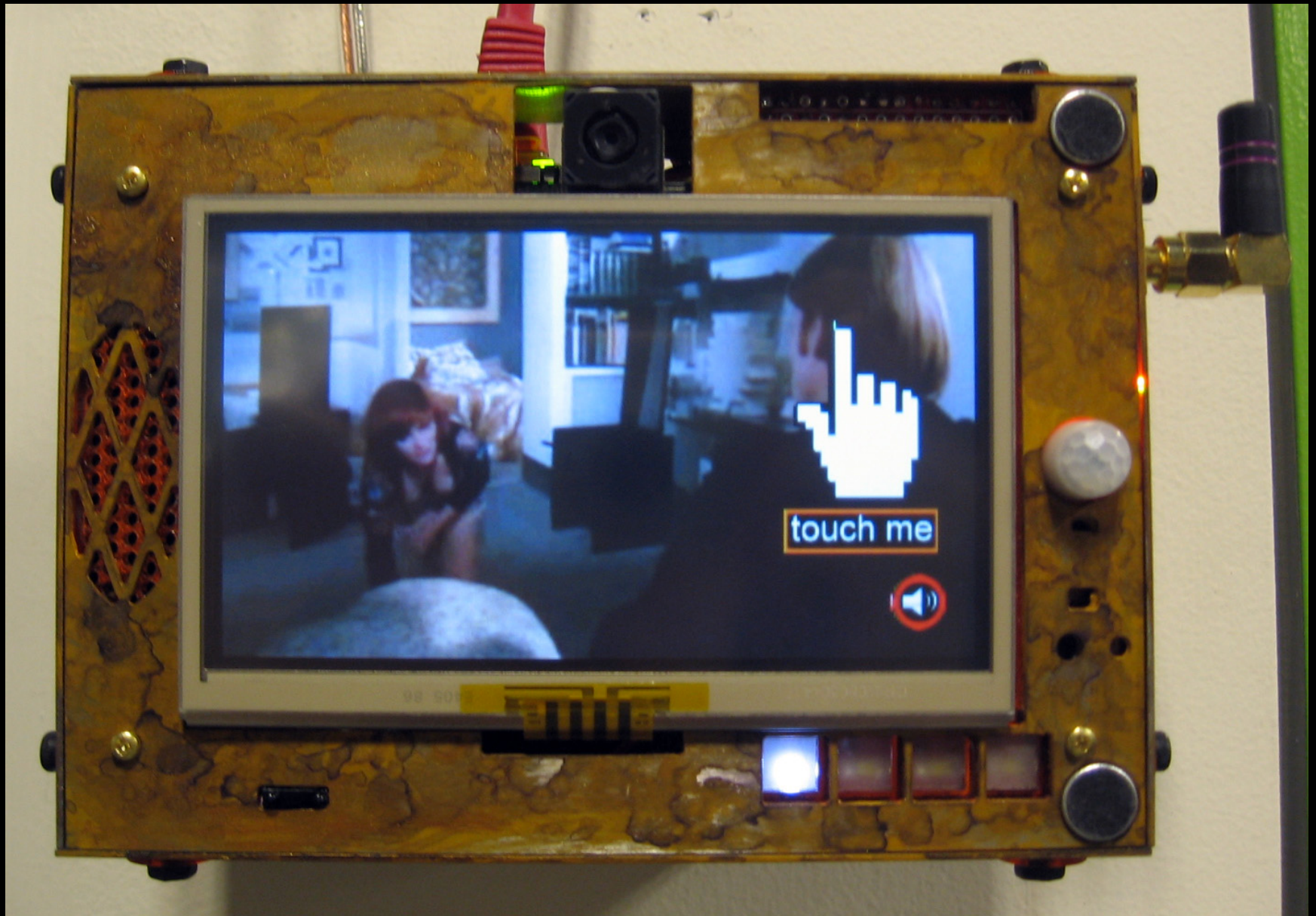


45 all over the Media Lab

*Power
Switch* ❌



Invitation to Interaction

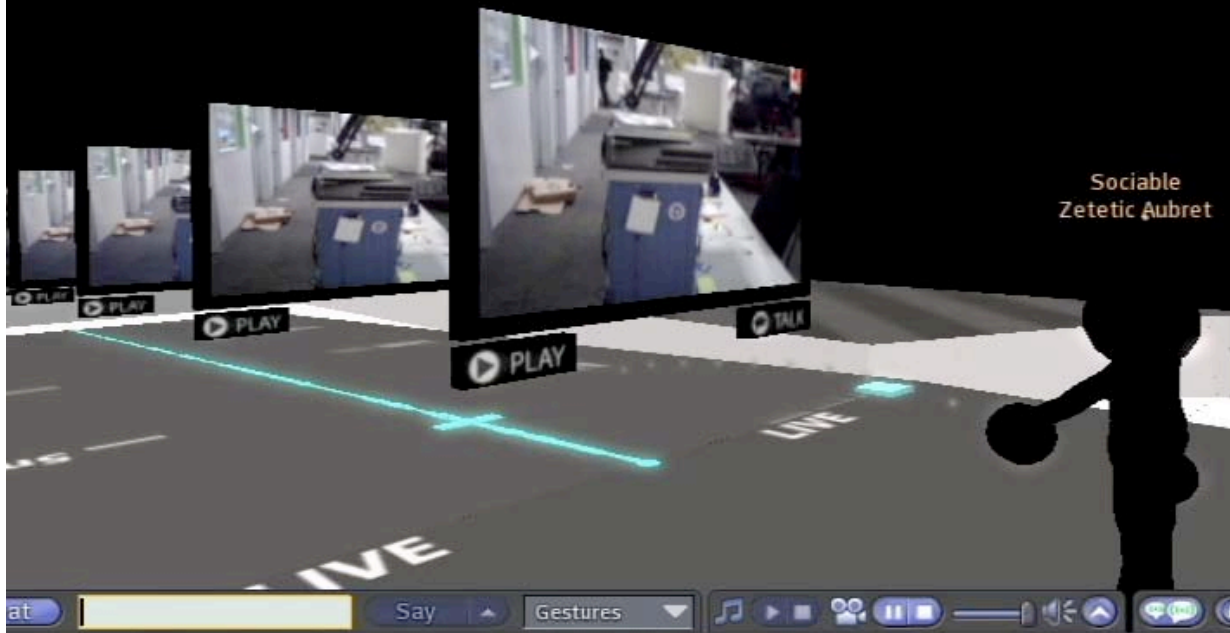


Live Portal-Portal Video Feed

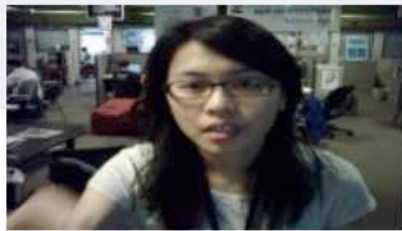


Portals and Cross Reality

Real World



Virtual World



Edit My Profile

Write something about yourself.

Information

Networks:
Boston, MA

Birthday:
July 7, 1983

Friends

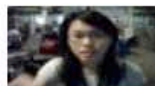
0 friends

Find people you know

Photos

1 album

See All



SPINNER IS EVERYWHERE
Updated 3 minutes ago

Nw Gong

Wall Info Photos +

What's on your mind?

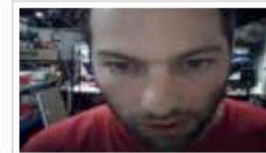
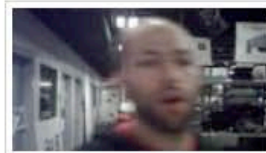
Attach

Share

Options



Nw Gong

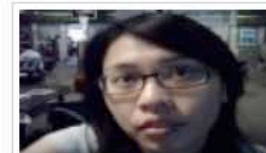
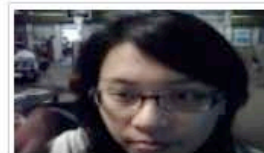
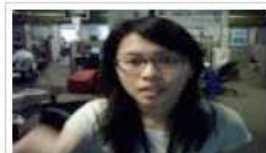


SPINNER IS EVERYWHERE

4 minutes ago · Comment · Like · Share



Nw Gong



SPINNER IS EVERYWHERE

July 16 at 12:33pm · Comment · Like · Share

RECENT ACTIVITY

Nw joined the Boston, MA network.

Nw joined Facebook.

Remove

Will the market demand privacy?

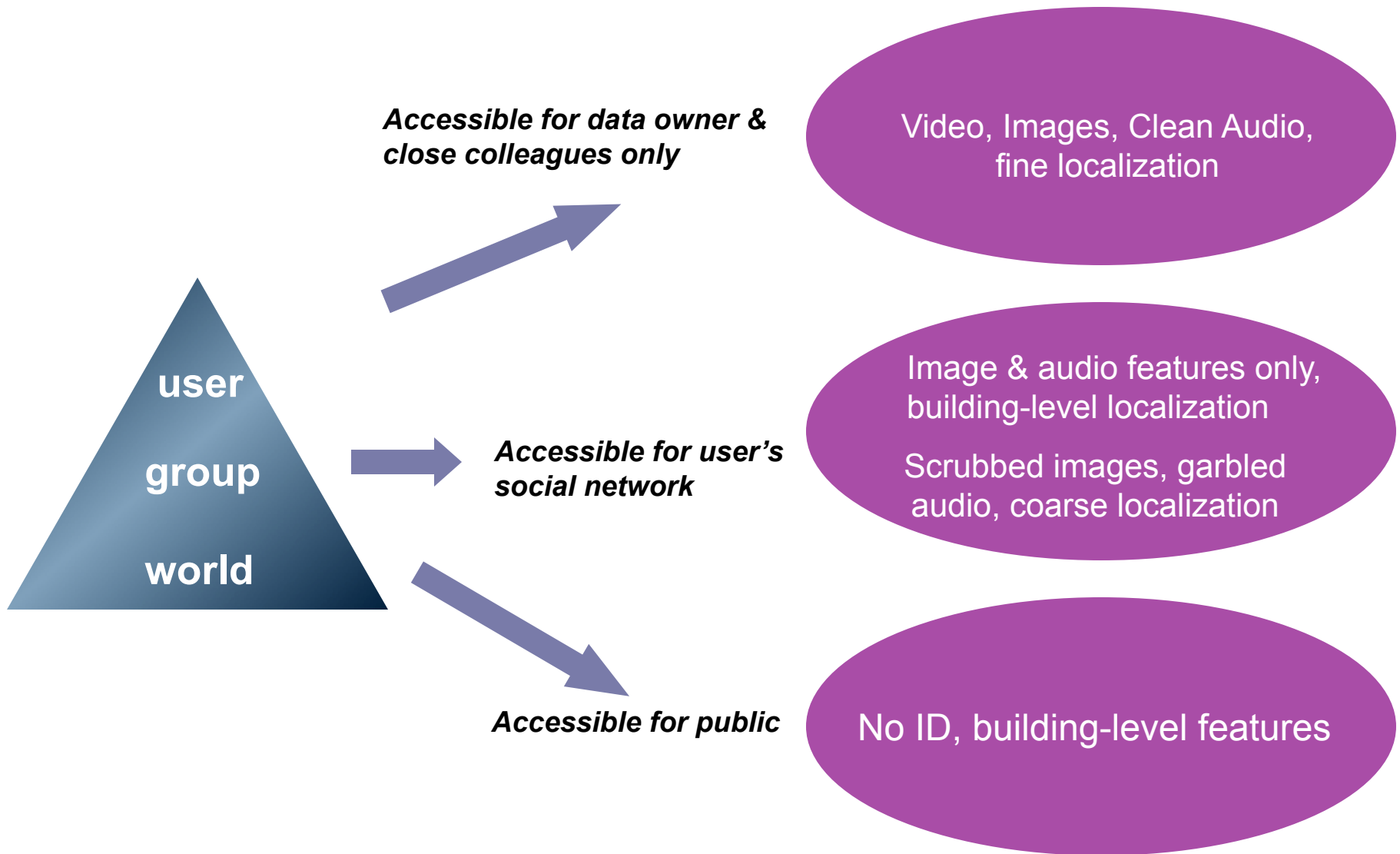
People are bringing these sensors into their homes and lives on the backs of dedicated appliances and devices

If they don't feel in control of them, they won't buy them!

How will they manage their dynamic privacy in a world full of potentially invasive sensors?

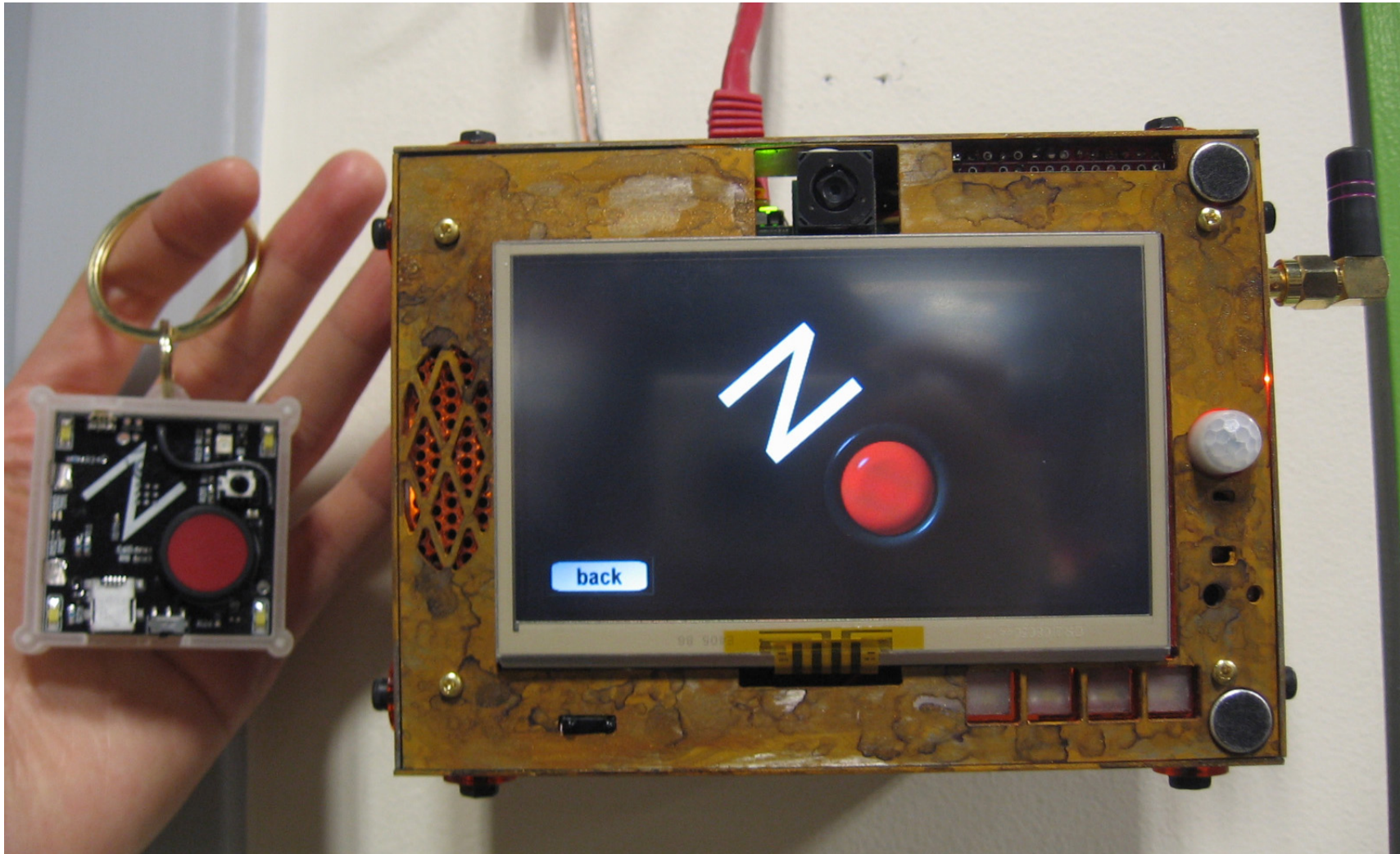
- You can't turn them all off because there are too many, and they are often attached to things that need to stay on or can't be turned off...

User-Configurable Dynamic Privacy Settings



Privacy can depend on physical location, time, and inquiry identity

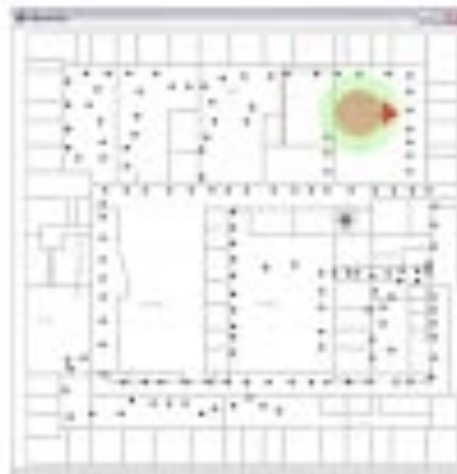
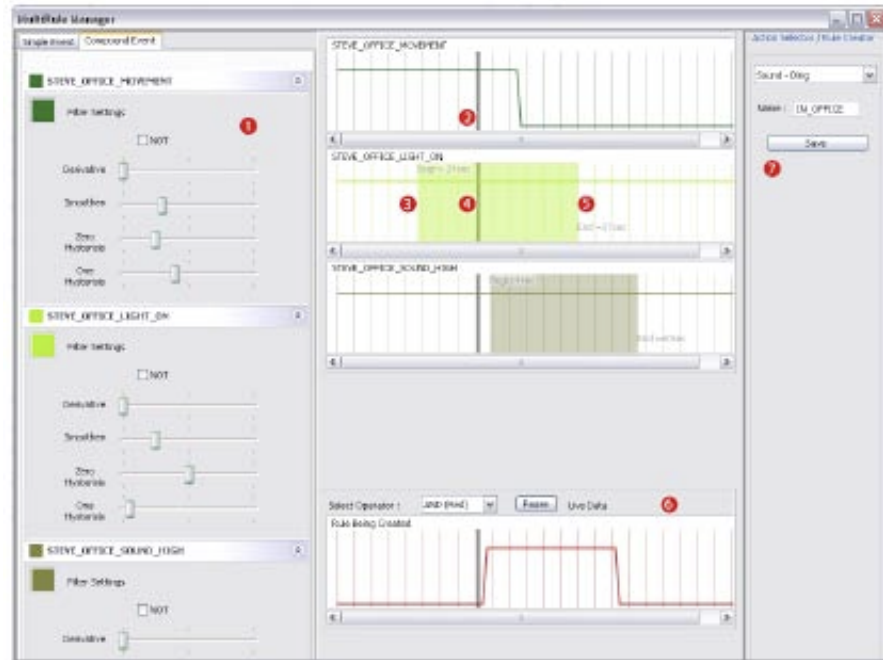
Dynamic Privacy...



Nan-Wei Gong

NoNo Badge for
Dynamic Privacy

The Ubicorder



*Mobile situated
Sensor Net
Browsing
Script-based
rule definition
for detection*

Manas Mittal's MS