Activity, Health, Behavior

CS 347
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Announcements

You should have received Section assignments on Friday

- Discussant for week 2 also assigned, discussants for future weeks assigned in section
- Ad hoc switching sections is strongly discouraged — if needed you must get permission from both section TAs by Monday of the week you need to switch

Only one reading for Wednesday

First quiz is in class on Wednesday

- right after lecture — bring a pencil
- Covers material in lectures and readings through today

Email cs347@cs.stanford.edu with questions or requests

Last time

Ubiquitous computing input and output

- The typical ubicomp sensing and recognition pipeline
- Custom display technologies, augmented reality, virtual reality

HCI interdisciplinarity

Today

Ubicomp envisioning technology in support of our long-term goals

- via commodity sensing
- via infrastructure-mediated sensing

Commodity sensing: activity tracking and behavior change

To discuss why these applications are seeking to break new ground, we need to start by discussing why the current paradigm leads us astray.

HCI 101: tasks and usability

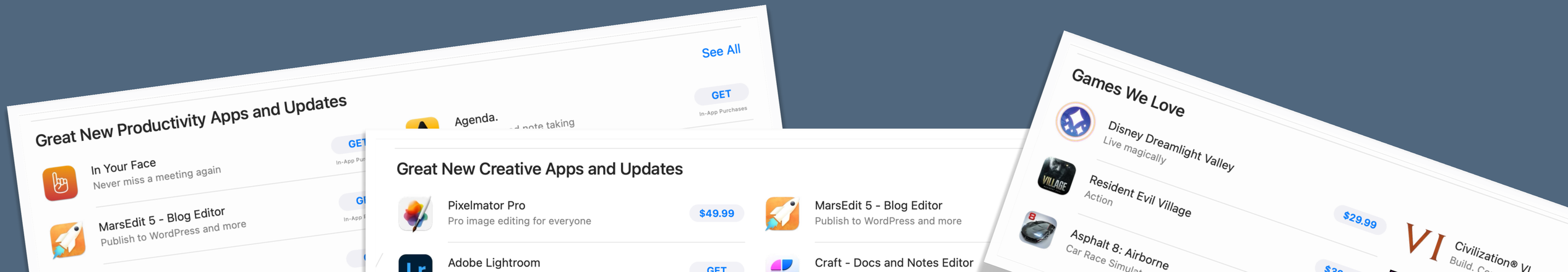
The traditional frame of human-centered design has focused on improving **usability** for well-defined **tasks**, especially tasks of short duration and focused attention

Result: HCI, UI design, usability are now commonplace in industry and academia

HCI 101: tasks and usability

But, this success has come **at a cost**: a focus on interaction design and usability that is not backgrounded as per ubiquitous computing, but **apps at the forefront** of our attention

This is a **legitimacy trap**: what we used to argue for the importance and legitimacy of HCI—task-based usability—is now holding us back [Dourish 2019]



Ubiquitous computing's response: "Hell, no"

This reductive view of HCI as app-ification is limiting

As technology diffuses into all aspects of our lives, its biggest impact may be not on short-lived tasks on screens, but in **issues of much greater societal importance**—education, health, sustainability—and **issues facing a wider cross-section of the population**

This position entails a lens on what a design might encompass—what is, and isn't in scope—far beyond typical app bounds

Behavior change and HCI

Many of the goals in today's lecture fit under the heading of **behavior change:** designs that shape what we do and when

Change in behavior usually requires new interface design:

> "If I only knew how much I was doing, I'd stop."
>
> "If only I got a reminder at the right time…"
>
> "If only I could know if my elderly grandmother were at risk…"

Duolingo

Typical recipe: unobtrusive and commodity

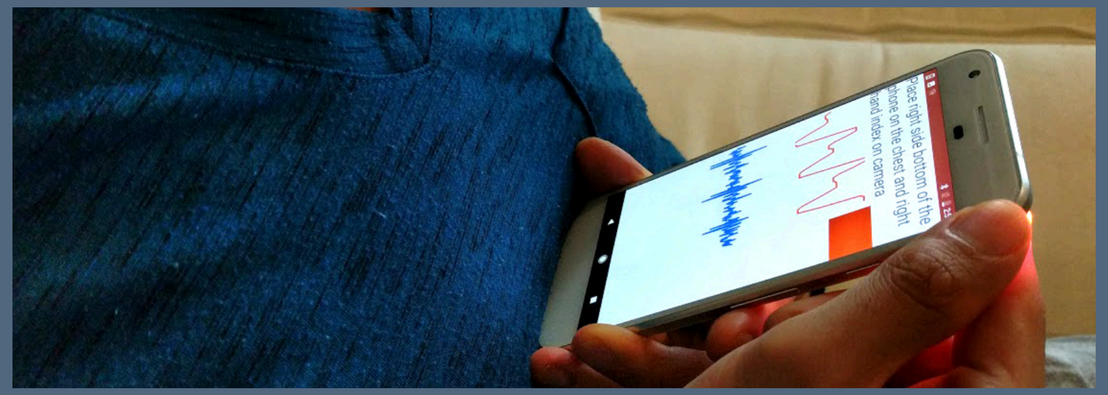
"Can we **unobtrusively detect** _____ using **commodity smartphones**?"

Unobtrusive: without much active user participation
Commodity: widely available and mass produced

Using a similar recognition pipeline as the previous input lecture

…and potentially using novel sensors that could feasibly be integrated into a smartphone or smartwatch in the future

Physical health



Can we monitor blood pressure using commodity smartphones? [Wang et al. 2018a]

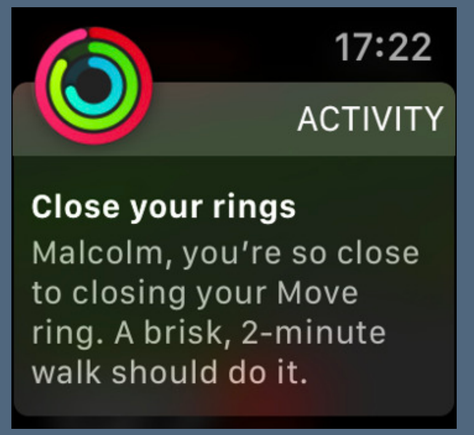
> Yes: measure the time between the heart pumping (via phone accelerometer) and the blood moving in an artery in your finger (via phone camera with flashlight on)

Can we detect opiod overdose — breathing cessation — with commodity smartphones? [Nandakumar, Goldakota, Sunshine 2019]

> Yes: emit an inaudible frequency sweep (FMCW). It bounces off the person and returns to the phone's mic. The chest moving in and out modulates the time to return, from which we derive a breathing rate

Physical health

Ubifit [Consolvo et al. 2008]: the first system to show that exercise interventions could work with commodity sensors and readily-available glanceable interfaces over long periods



Apple Watch
[via AppleInsider]

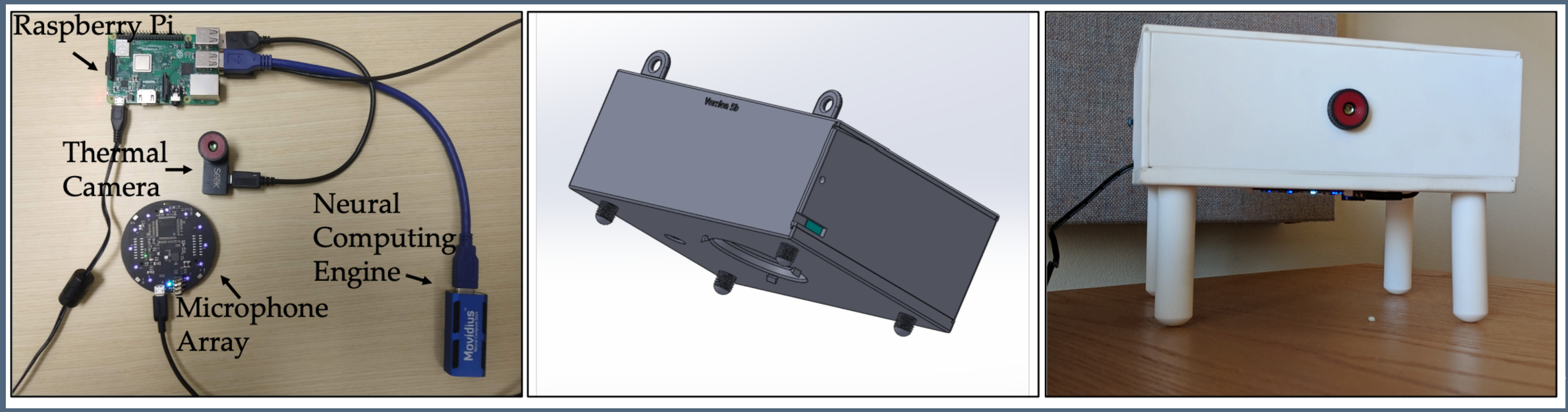
Not yet deployed in industry, but frontiers:

- Detect when someone is eating, using inertial measurements on a smartwatch [Thomaz, Essa, Abowd 2015]
- Data-driven answers to: Do I gain weight when I have busy days? Do I walk more when I work in the city? Do I sleep better on nights after I work out? [Bentley et al. 2013]

Public health (flu sensing)

Can ubiquitous computing technologies help us track group or population-level health?

e.g., deploy a passive sensing box in clinic waiting areas
[Al Hossain et al. 2020]



Mental health

Stress: can we detect stress levels by listening to your voice [Lu et al. 2012], or by how tightly you're gripping the mouse+keyboard at a computer [Hernandez et al. 2014] or your steering wheel in your car? [Paredes et al. 2018]

Depression: Can we detect depression symptoms using commodity smartphones? [Wang et al. 2018b, Xu et al. 2019] Loneliness and social isolation? [Doryab et al. 2019]

Mental changes: Can we detect mental health changes such as psychotic relapse before they're typically diagnosed? [Ben-Zeev 2017; Wang et al. 2016]

The answer to all of these questions is now a (qualified) yes.

Are these tools ethical to deploy?

By whom?

With or without consent?

Tradeoff: privacy and autonomy, vs. lack of access to mental health services

Elder care

How might we design technologies to support successful aging in place? [Kidd et al. 1999]

Can we detect…

Falls, without smartwatches? [Palipana et al. 2018]

Levels of movement and activity in the home?

Neurodiversity

Record and track care for people conditions such as autism

Interventions might include:

- Reducing the effort for capturing data about children with autism [Kientz et al. 2007]
- Creating interactive tools to aid communication with caretakers [Hayes et al. 2010]
- Tools for practicing social skills [Escobedo et al. 2012]

Infrastructure-mediated sensing and societal goals

Where to focus?

Identify a long-lived activity or resilient societal challenge

Ask whether computing can help produce the data or intervention necessary to move the needle in a meaningful way

The answer may be "no"!

But sometimes it's

Typical recipe, part deux

"Can we **unobtrusively detect** _____ using **a single point of sensing**?"

Goal: avoid needing to instrument people in any way (unobtrusive)

Again using a machine learning classification pipeline

Typically, we achieve this by leveraging infrastructure already available in the environment. This is referred to as **infrastructure-mediated sensing** [Patel et al. 2008]

Sustainability

One major challenge is knowing where my energy and power is going: **which appliances and activities are driving most of my consumption?**

If we knew that, we could identify ways to reduce our energy or water use.

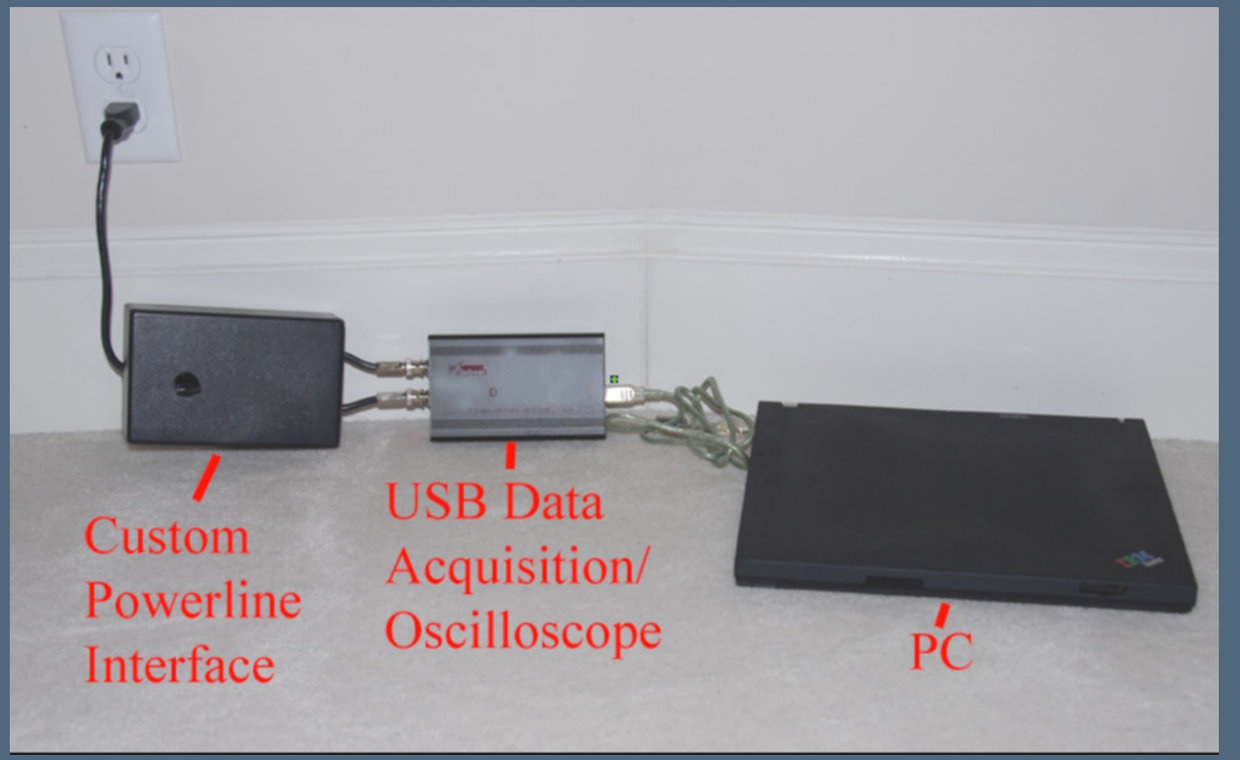
But we can't go around fitting every socket with a sensor…

Disaggregating electrical use

[Patel et al. 2007]

Can we track appliance usage without complex installation or many invasive sensors?

Plug a sensor into a single plug in your home and listen to electrical noise on the power line when switched or in operation

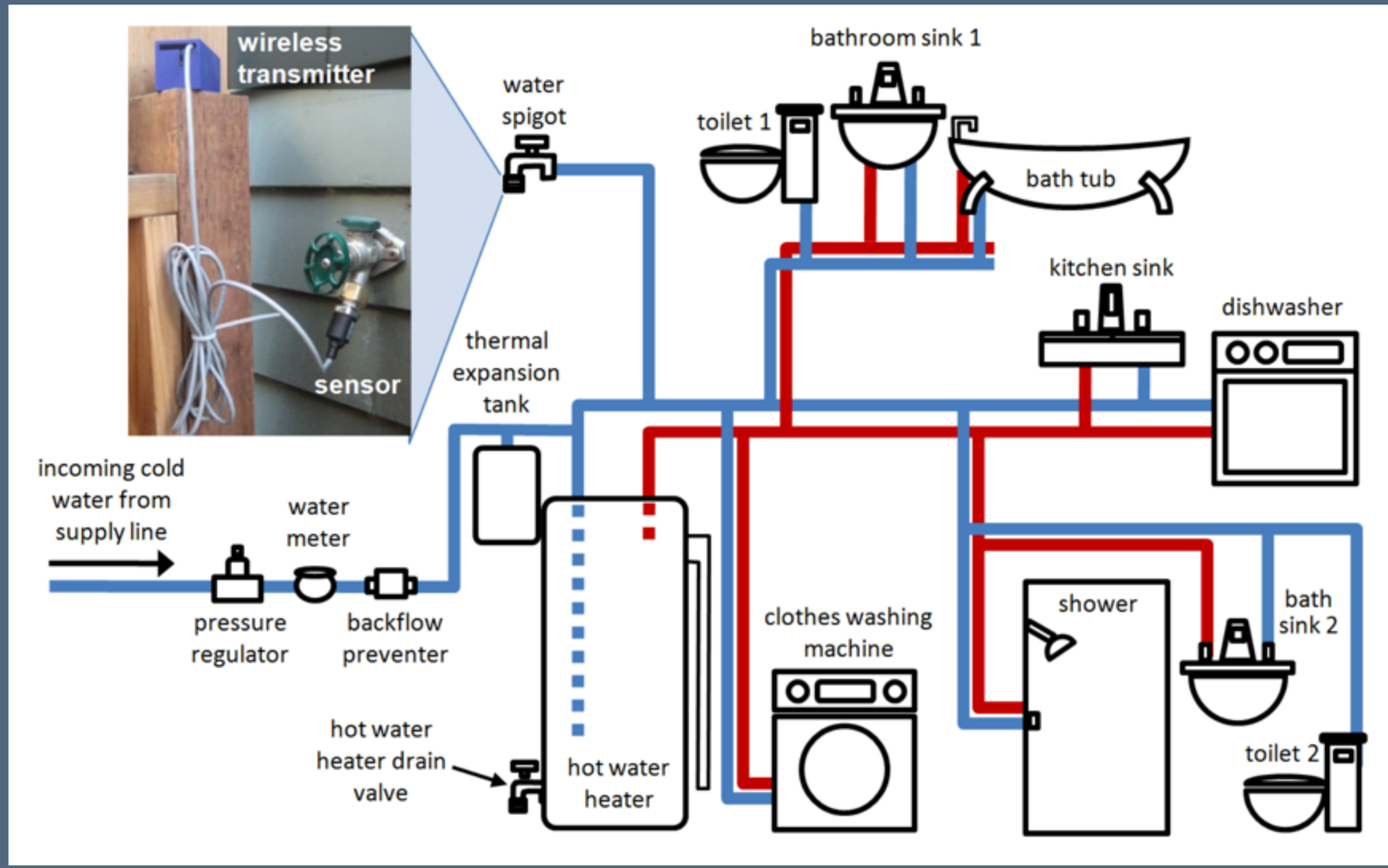


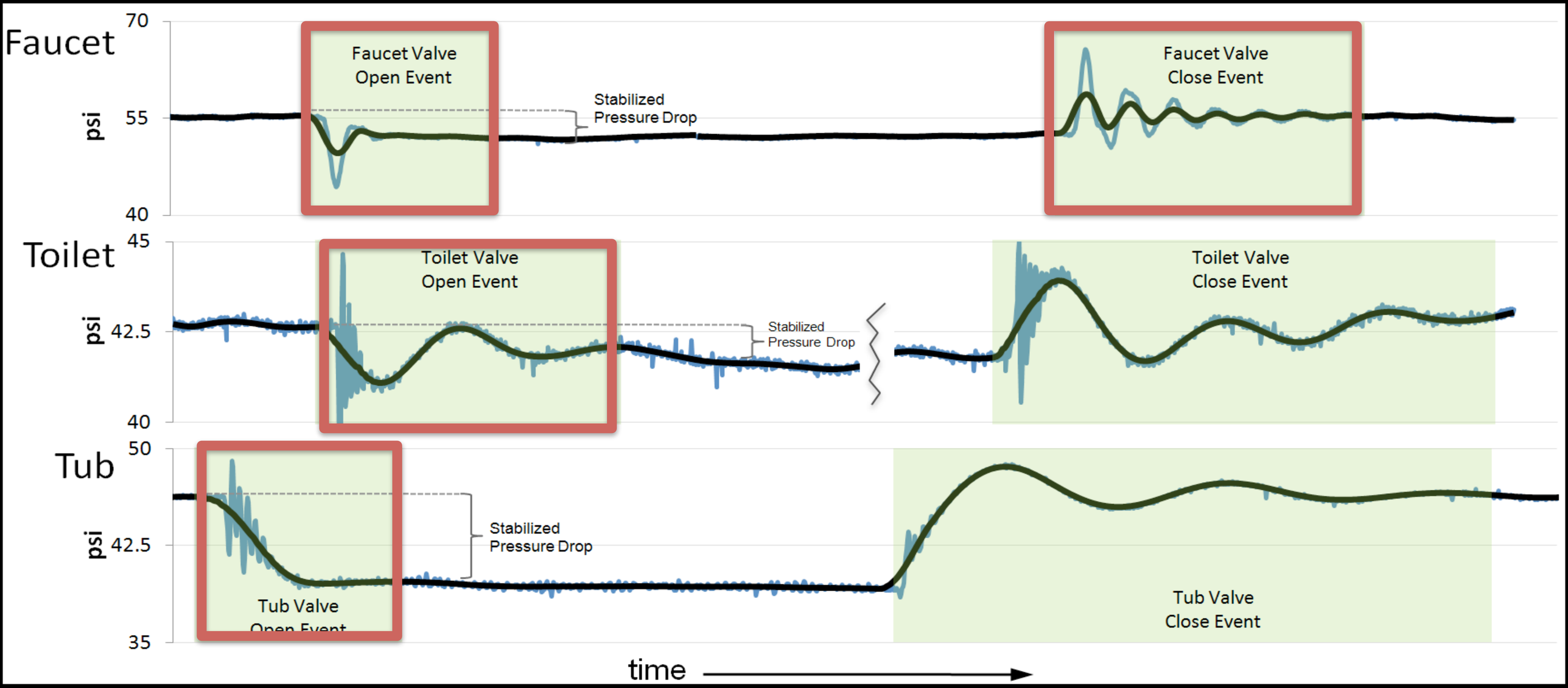
Disaggregating water use

[Froehlich et al. 2009]

A single pressure sensor attached to a hose outdoor faucet

Since your water pipes are typically all connected, that one sensor can see a lot…

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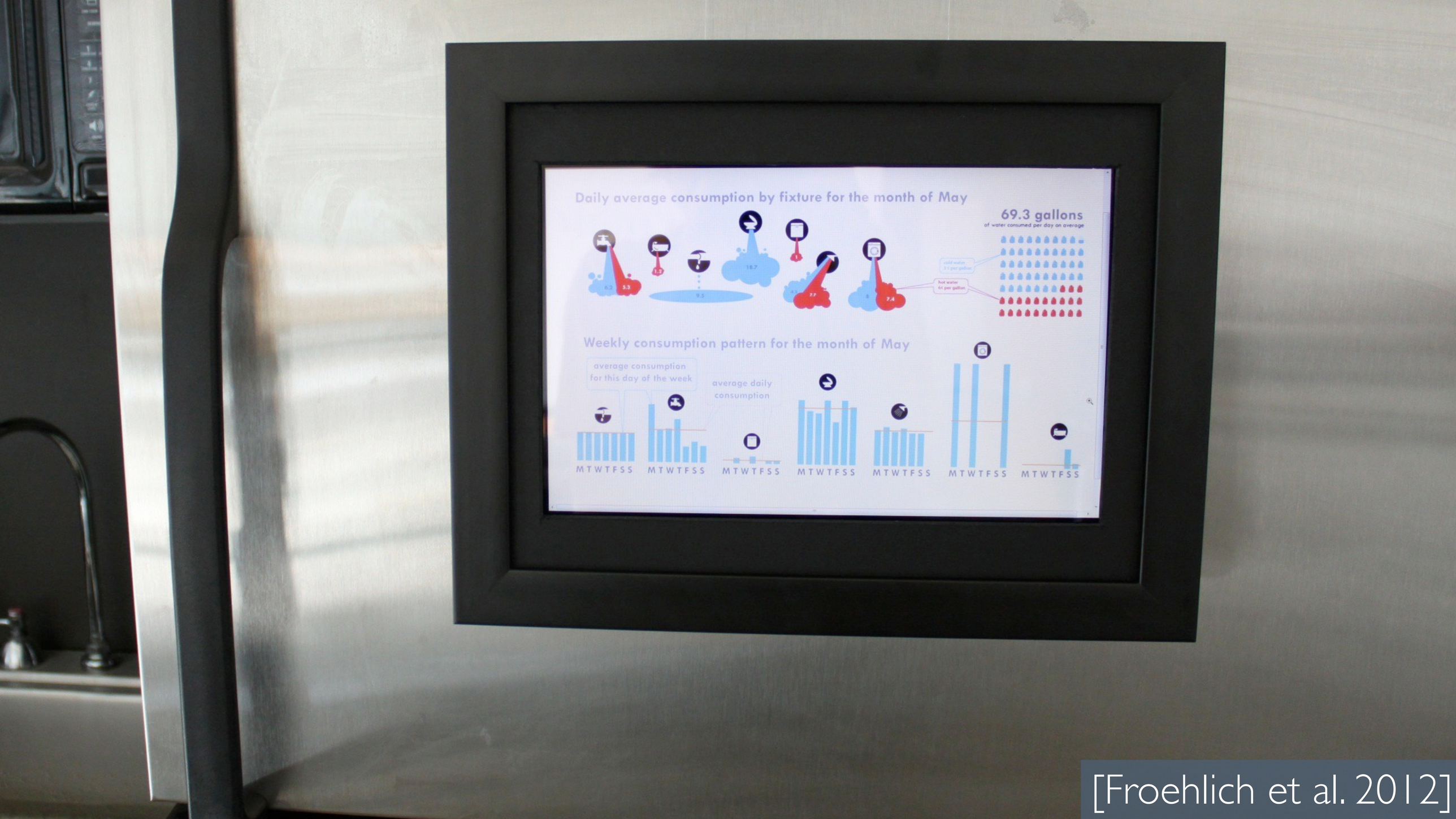
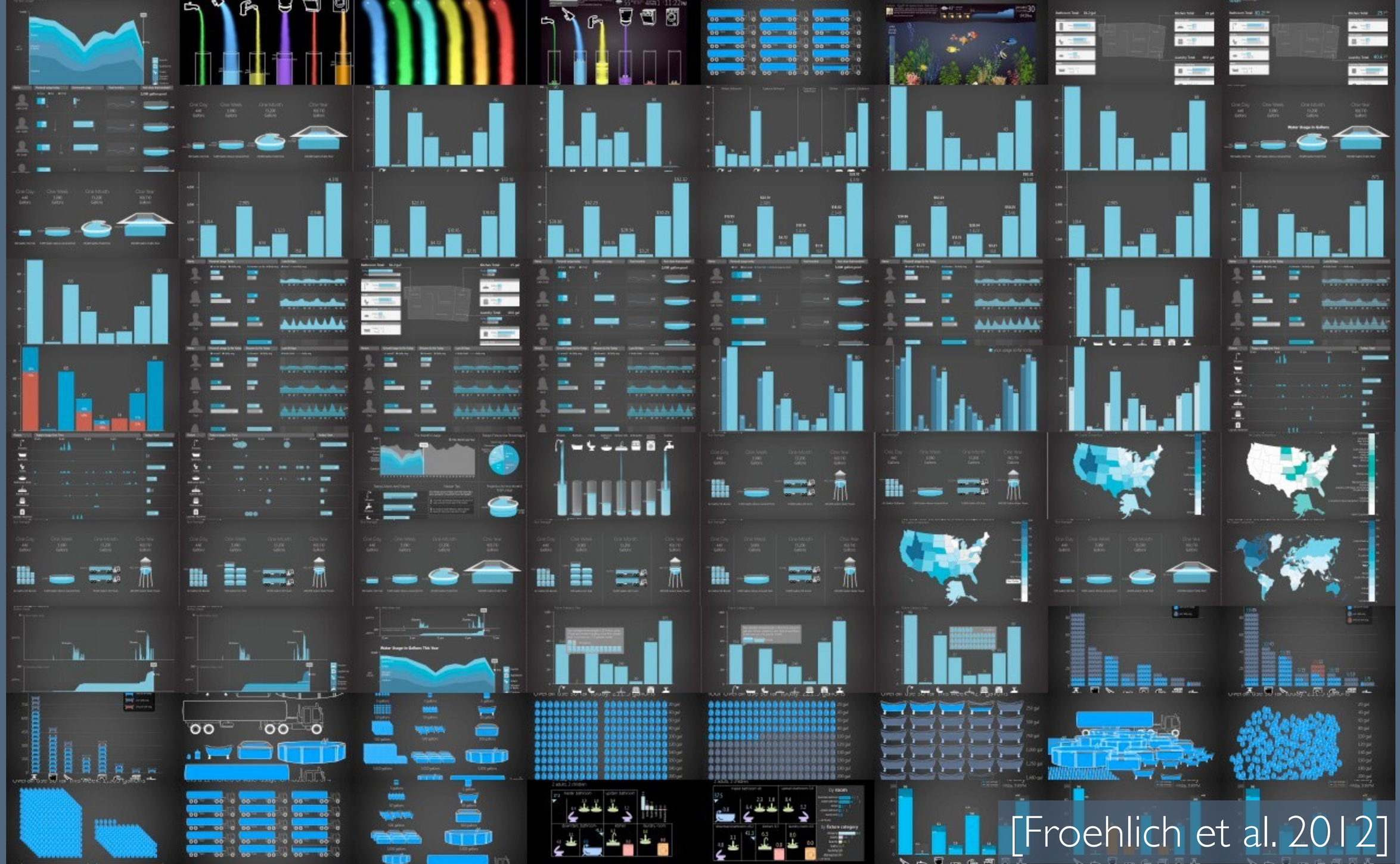


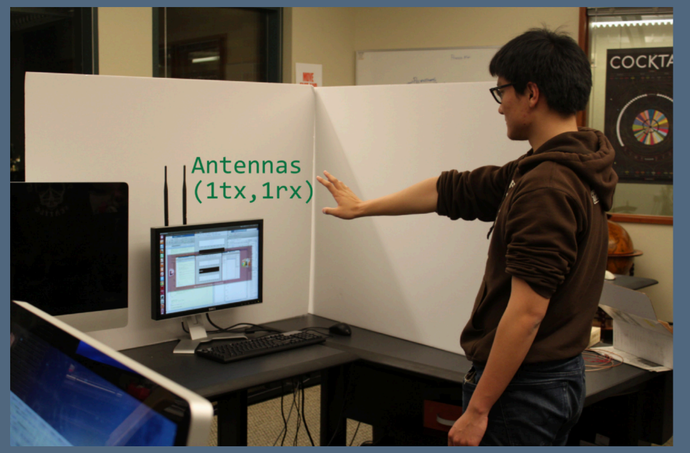
[Froehlich et al. 2012]



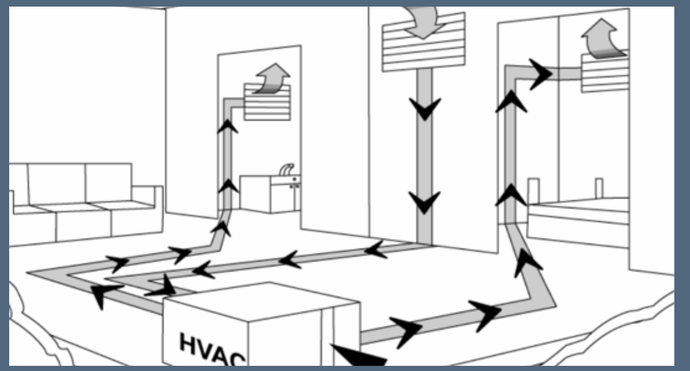
[Froehlich et al. 2012]

Infrastructure-mediated sensing for input as well

Your house is already blanketed in wifi: we can detect minute Doppler shifts and multi-path distortions in wifi reflectance as you move [Pu et al. 2013]



As you walk through doorways in your house, you cause momentary pressure changes in your HVAC system, enabling a recognition of where you likely are [Patel, Reynolds, and About 2008]



#@*$%: the parts that we mess up

Privacy

Ubiquitous computing naturally raises many questions of how much privacy we are giving up in exchange for its benefits

Behavioral work has documented an empirical **privacy paradox** in which people profess to care strongly about privacy but then willingly give it up in their technology use in practice [Acquisti 2015]

Providing transparency and control are simply not enough

Furthermore, rules and controls governing privacy will fall over: we navigate privacy in fluid ways in the real world [Palen and Dourish 2003]

Context [Dourish 2004]

Ubicomp typically reduces context to "things we can measure"

- Finding restaurants or conference rooms near your current location
- Highlighting information that you might find useful for the current task
- Silencing your phone automatically when you're in class

But, context is only a proxy for intent [Dey 2018], and context is emergent and evolving—not stable [Dourish 2004]

- Sitting in a classroom is relevant, but temperature is not, because it is just ordinary

This makes the design challenge more fraught

Confusing “measurable” for “meaningful” [Harrison and Dourish 2006]

Space is the structure of the world: the 3D environment, relative position and direction. It’s what the sensors detect.

Place is the understood reality, invested with understanding and meaning

Ex: hotel ballroom: are we at a wedding or an academic conference?

Same space, different place

Confusing space for place leads to embarrassing inference errors

Ethics

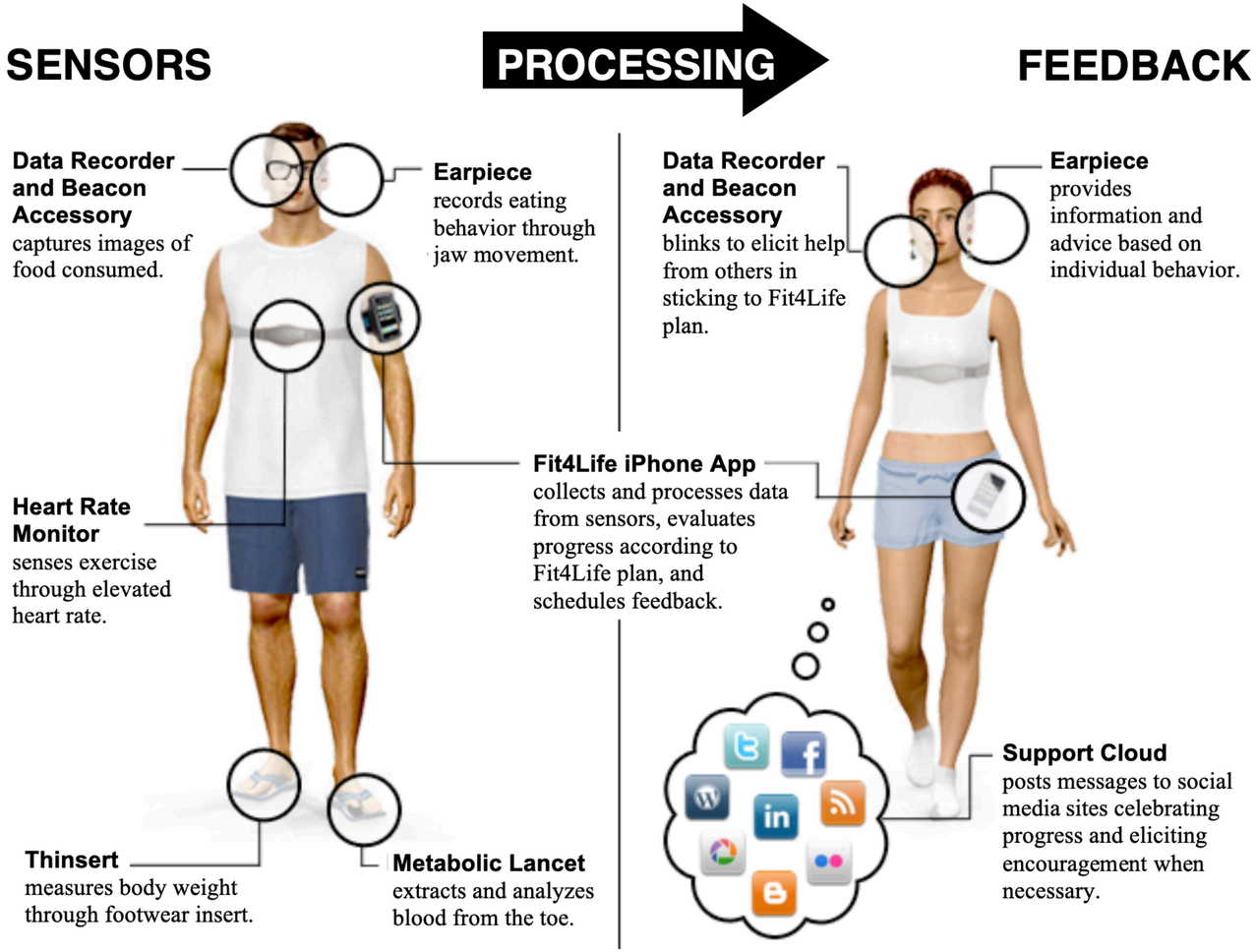


Figure 1. The Fit4Life system in use. All components of the system are shown including sensors, the processing unit, and feedback mechanisms. Certain system components such as The Fit4Life Data Recorder and Beacon Accessory are available in multiple forms (shown here as prescription glasses and fashion earrings) and perform both sensing and feedback functionality.

Fit4Life [Purpura 2011] is a weight loss technology consisting of **sensors** monitoring fitness and **feedback** from Fit4Life evaluators and social media peers

Ethics [Purpura 2011]

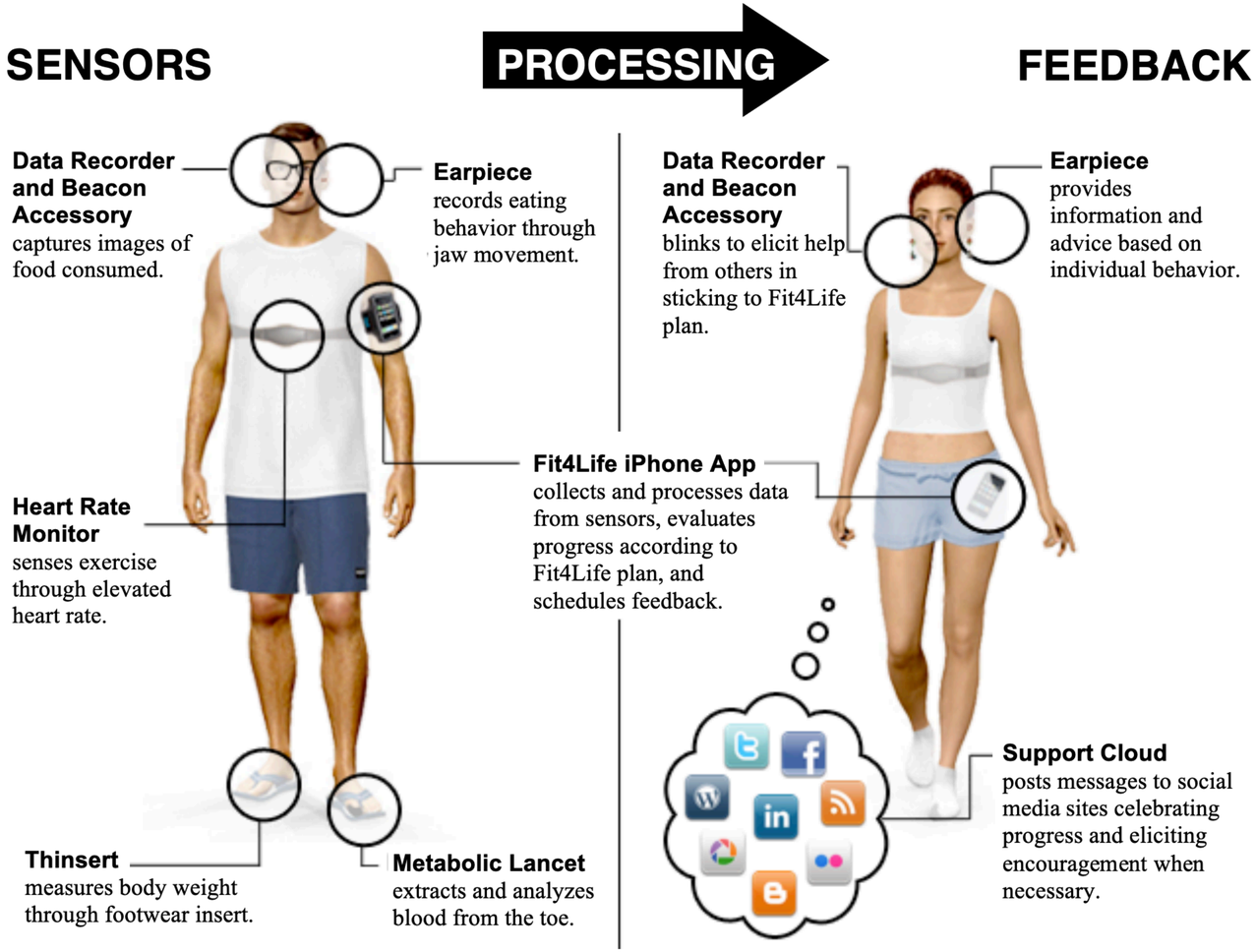


Figure 1. The Fit4Life system in use. All components of the system are shown including sensors, the processing unit, and feedback mechanisms. Certain system components such as The Fit4Life Data Recorder and Beacon Accessory are available in multiple forms (shown here as prescription glasses and fashion earrings) and perform both sensing and feedback functionality.

Are these feedback strategies **persuasion or coercion**?

Whose idea of fitness/diet is being enacted, system designer or user?

Does connecting to social media peers **support** users or **shame** users?

Summary

Ubicomp seeks to embed itself in long-lived activities and goals.

- It does this across a number of domains, including: physical health, mental health and wellbeing, aging, and designing for neurodivergent populations

To achieve these goals, it often seeks to sense information about the user and their surroundings in noninvasive ways

- Commodity sensing: hardware we have or might have soon, typically kept by a single user
- Infrastructure-mediated sensing: single-point sensors that connect to existing infrastructure rather than held by the user

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