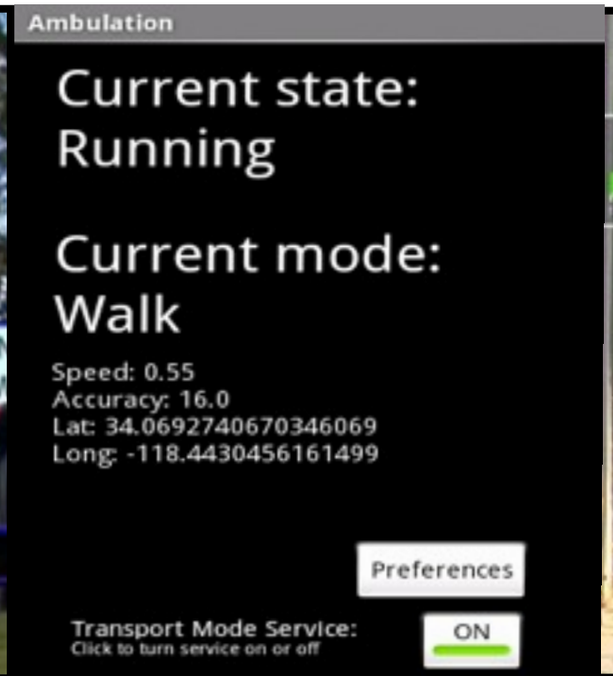
Participatory Sensing: from ecosystems to human systems

Deborah Estrin
UCLA, Center for Embedded Sensing System

Enabled by >3 x 10^9 mobile phone users, increasingly with gps, imagers, UI

Motivated by 6 x 10^9 people on planet earth and their concerns...



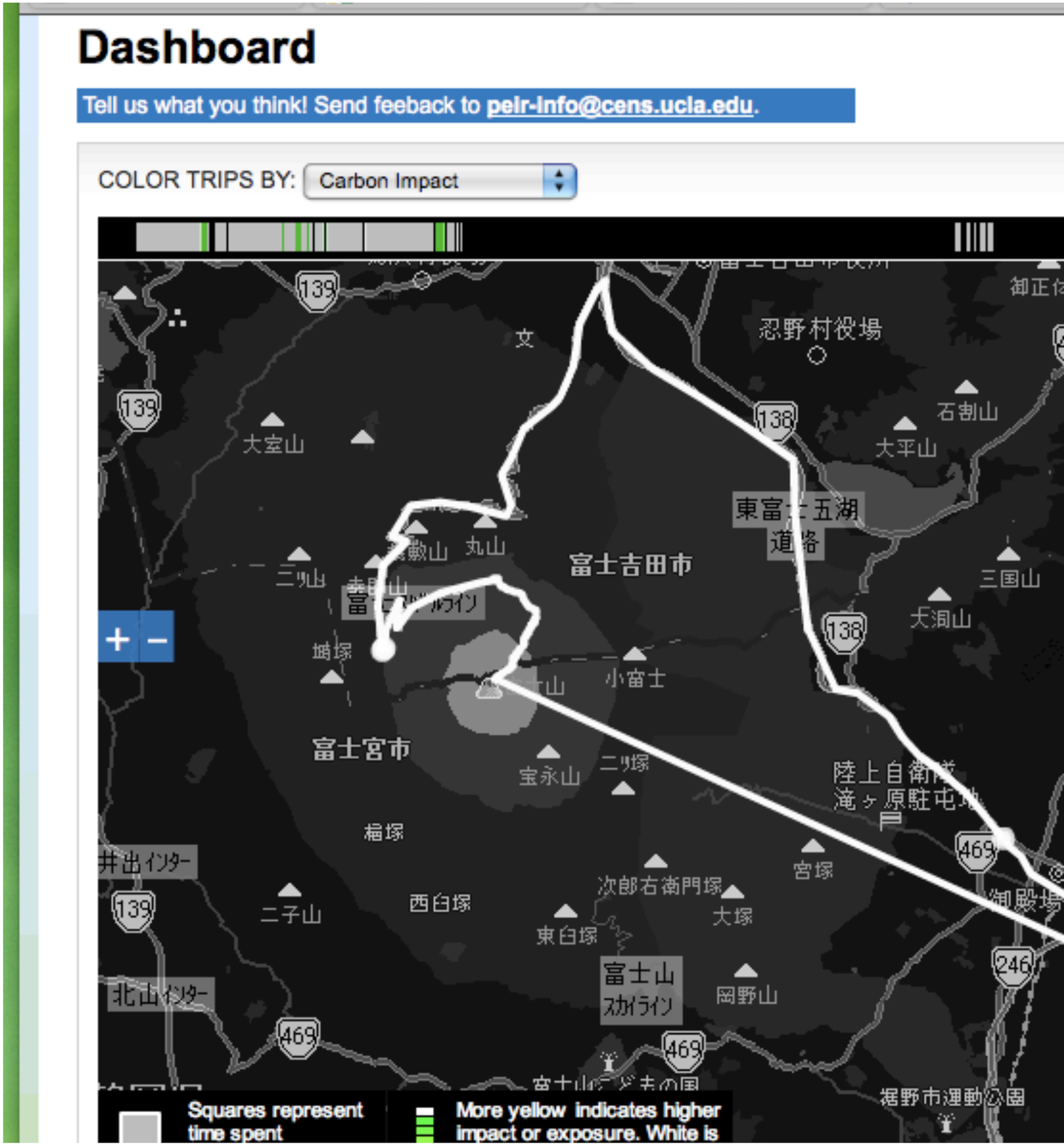
Mobile smartphones + web/cloud services + social networking

real time
(*always on*)

real place
(*always carried*)

real context
(*historical, environmental, spatial, social*)

engage data in the context of applications:
civic data campaigns
transportation patterns
health



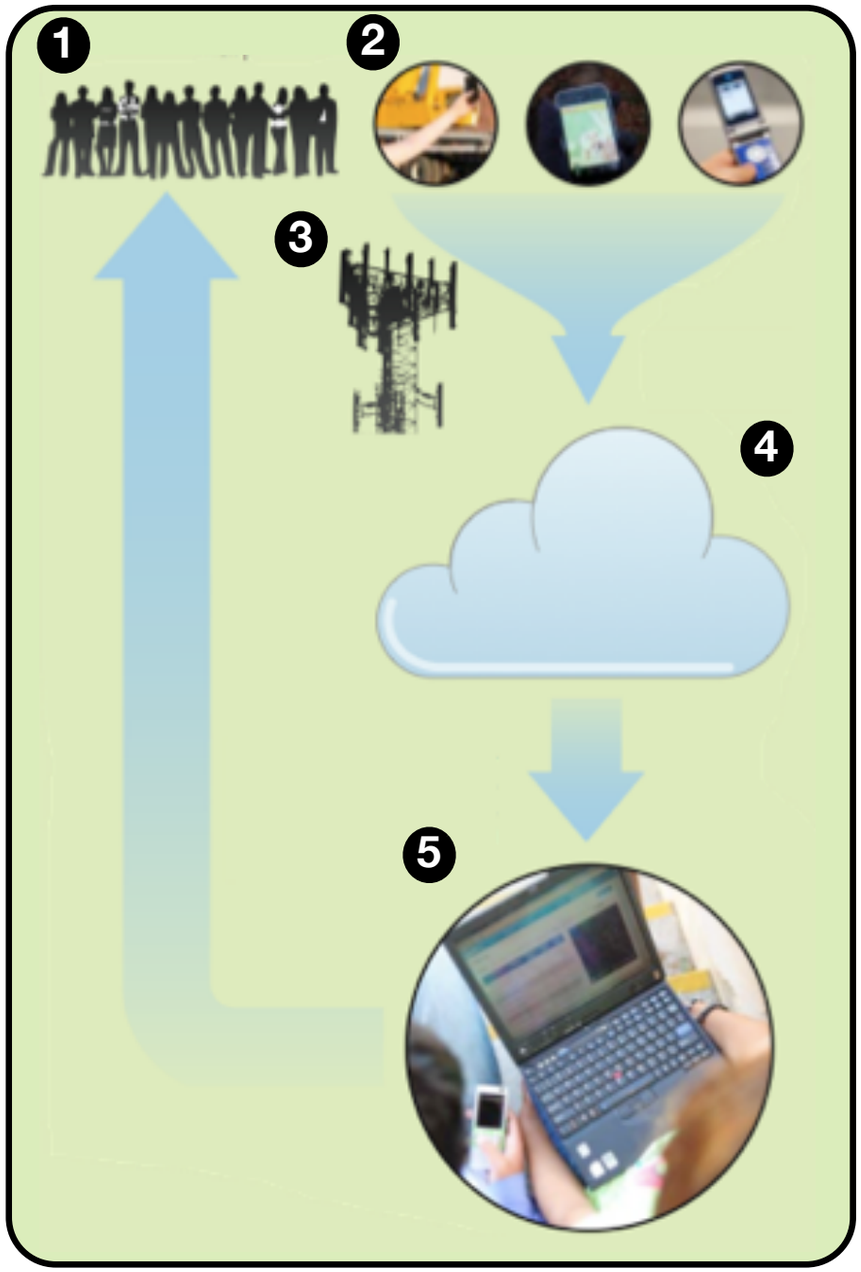
Center for Embedded Networked Sensing

Civic and Citizen Data Campaigns

coordinated, real-time, geo-coded, tagged, images and prompted entries

GarbageWatch

Recycling Practices on Campus



What's Bloomin

Blooming Flora on Campus

Invasive Plants Campaign - “What’s Invasive!”

w/National Park Service, Santa Monica Mountains

Harding grass

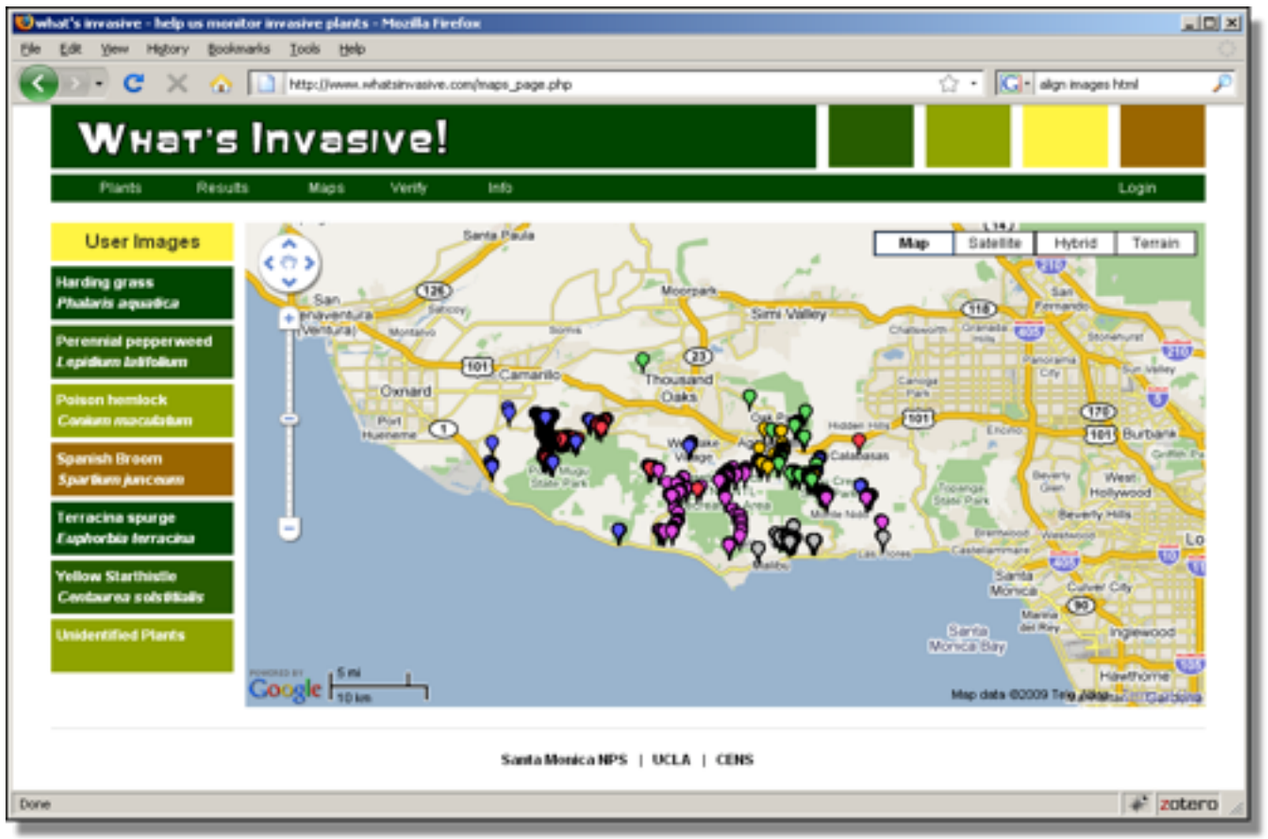
Perennial pepperwood

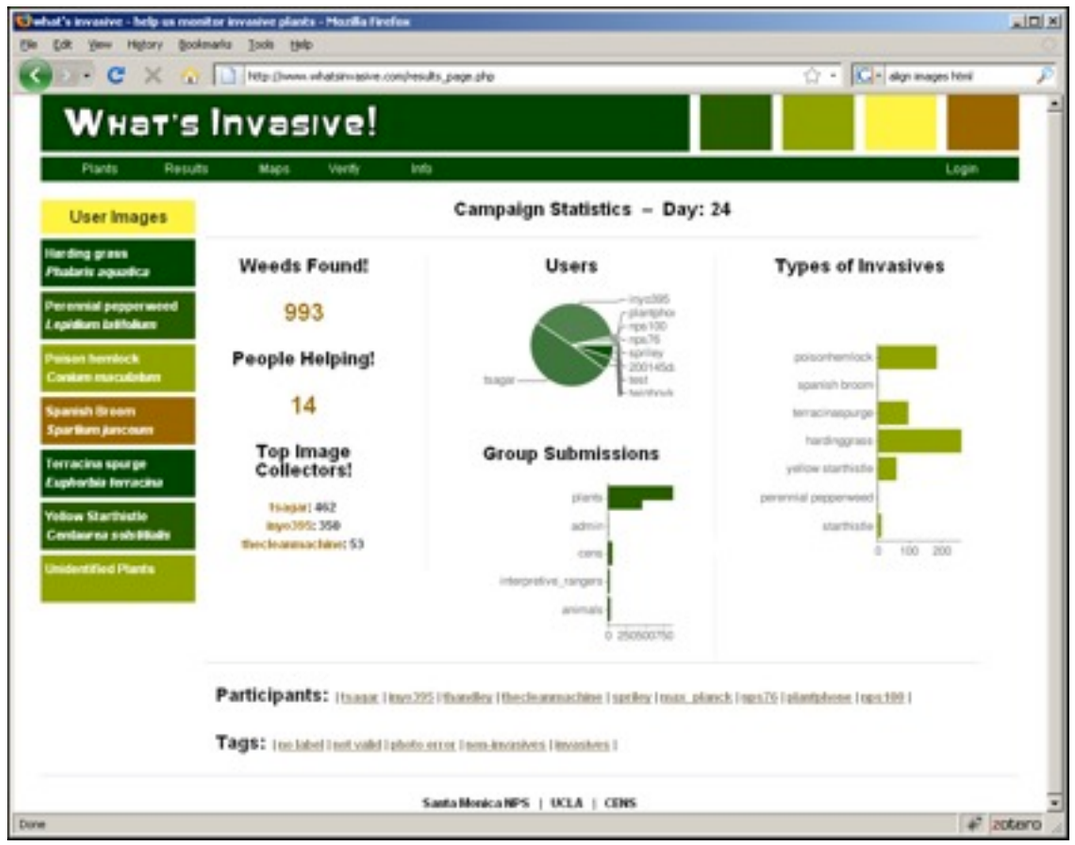
Poison hemlock

Spanish broom

Terracina spurge

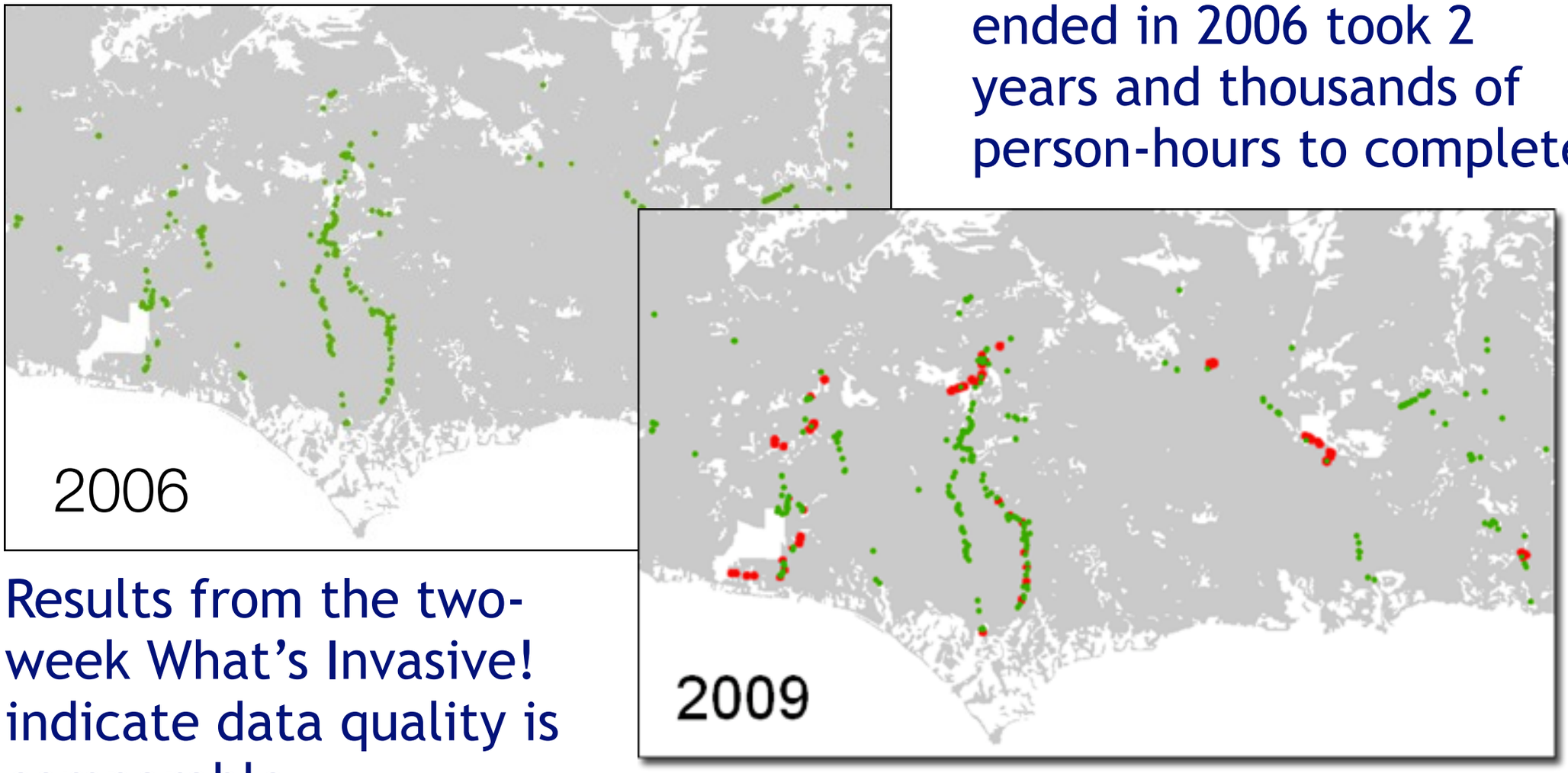
Yellow starthistle





Invasive Plants Campaign - “What’s Invasive!”

The weed survey that ended in 2006 took 2 years and thousands of person-hours to complete.



Results from the two-week What’s Invasive! indicate data quality is comparable.

New distributions and significant advancement of some invasive species have occurred within that last 3 years since the original survey.

Conservation specialists at the NPS, armed with this new data, can focus attention on managing areas that are newly invaded.

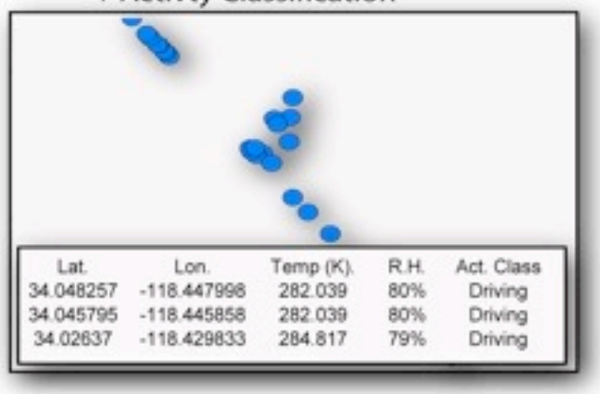
Hansen, Graham, Reddy, ...

Personal and community sustainability tool: PEIR: Personal Environmental Impact Report

http://peir.cens.ucla.edu

Location Trace Processing

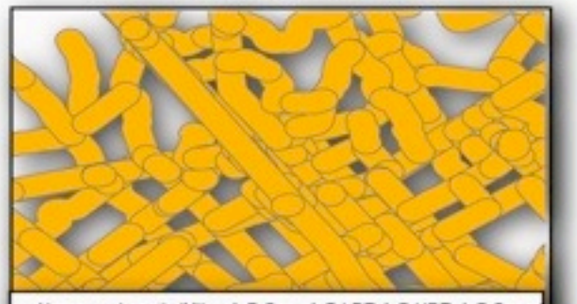
Location Trace + Weather + Activty Classification



Lat.	Lon.	Temp (K).	R.H.	Act. Class
34.048257	-118.447998	282.039	80%	Driving
34.045795	-118.445858	282.039	80%	Driving
34.02637	-118.429833	284.817	79%	Driving

+

Road Buffers

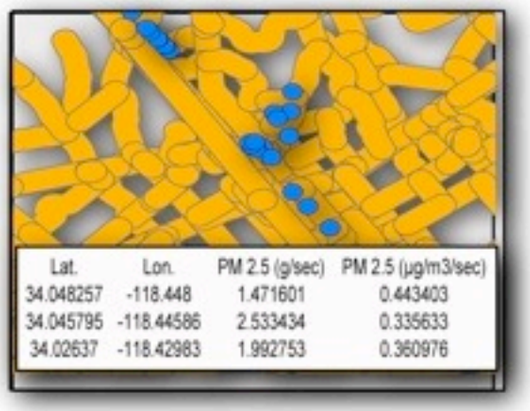


Name	Length (Mi)	A-B Car	A-B LDT	A-B HDT	A-B Speed
Westwood	0.38	2550	13	7	20
Westwood	0.36	3776	22	20	19
Wilshire	0.5	5095	36	25	23

+

EMFAC

Trip Aggregation



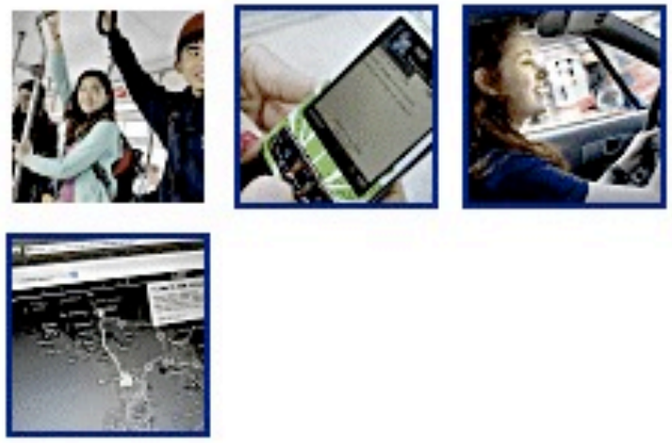
Lat.	Lon.	PM 2.5 (g/sec)	PM 2.5 (µg/m3/sec)
34.048257	-118.448	1.471601	0.443403
34.045795	-118.44586	2.533434	0.335633
34.02637	-118.42983	1.992753	0.360976

Trip Summary

Trip	Avg. PM 2.5 Exposure	time spent over 0.112716 (hours)
2432	0.470002	0.15
2423	0.235333	0.27
2410	0.210576	0.04

PEIR UI

Center for Embedded Networked Sensing



« PREVIOUS NEXT »

Program helps kids find their carbon impact

Catalina Gutierrez (center) and twin brother Trevor are learning to make better carbon-based transit decisions. (Brant Ward / The Chronicle)

Brant Ward / The Chronicle

GoGreen Foundation

YOUR GO GREEN RANKINGS

Your rankings are displayed below for each group you're in:
(shorter bars are better)

ASDF?! **rank 3 of 3**

My Impact	0.00 lbs CO2 0% of 112 hrs	score: 0
Group Average	9.85 lbs CO2 49% of 112 hrs	score: 4447567

GoGreen Testing Group **rank 3 of 3**

My Impact	0.00 lbs CO2 0% of 112 hrs	score: 0
Group Average	239.64 lbs CO2 49% of 112 hrs	score: 180432

participation capped at 16 hrs/day (112 hrs/week)
statistics calculated over the last 7 days
last updated at 12:45:03 PM, 03/12/2009

Example: Biketastic:

bicycle commuters document, plan, share route data
...to promote safe cycle commuting

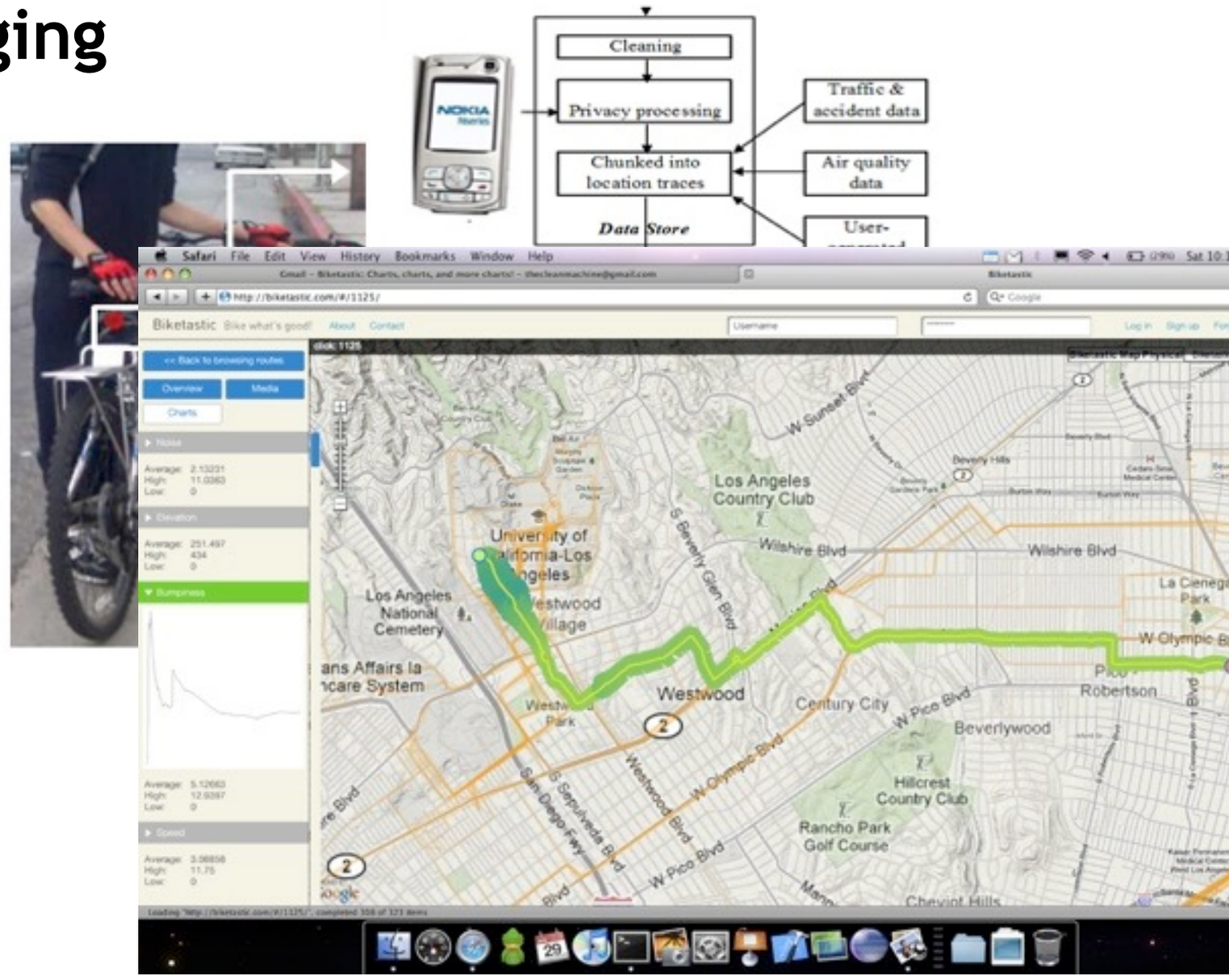
location+motion trace augmented with images and tagging

Capture & share route features

Collects: **location, duration, stops/ starts, roughness,** prompted images/tags

Web interface compares route qualities

Mash up routes with air quality, traffic conditions, accidents

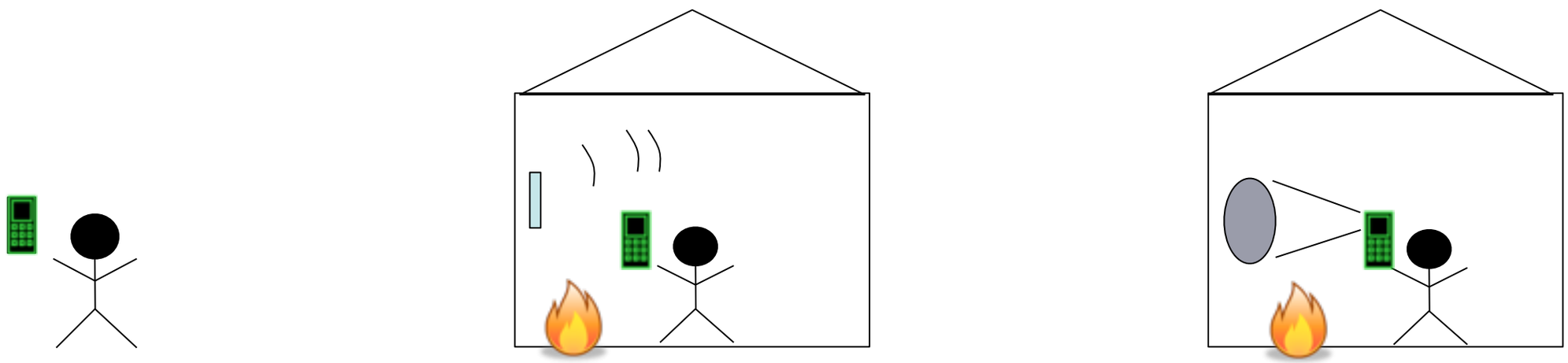


http://biketastic.com

project surya
Fighting Climate Change Now

Monitoring exposure to cookstove pollution in rural India:

profile daily activities, exposure to indoor air pollution, at unprecedented detail (Ramanathan et al)



GPS, accelerometer traces

Bluetooth temperature sensor beacons

Images of a special filter

Outdoor activities

Cooking duration

Pollution levels

Exposure Model

Participatory Sensing for health and wellness

what can we learn,
what impact can we have,
with access to

...the other 167 hours of the week...
...the other 1439 minutes of the day...

Ambulation: monitor chronic disease progression and response

Mobile Sensing Client

GPS Traces

Transportation Modes

Data Storage Service

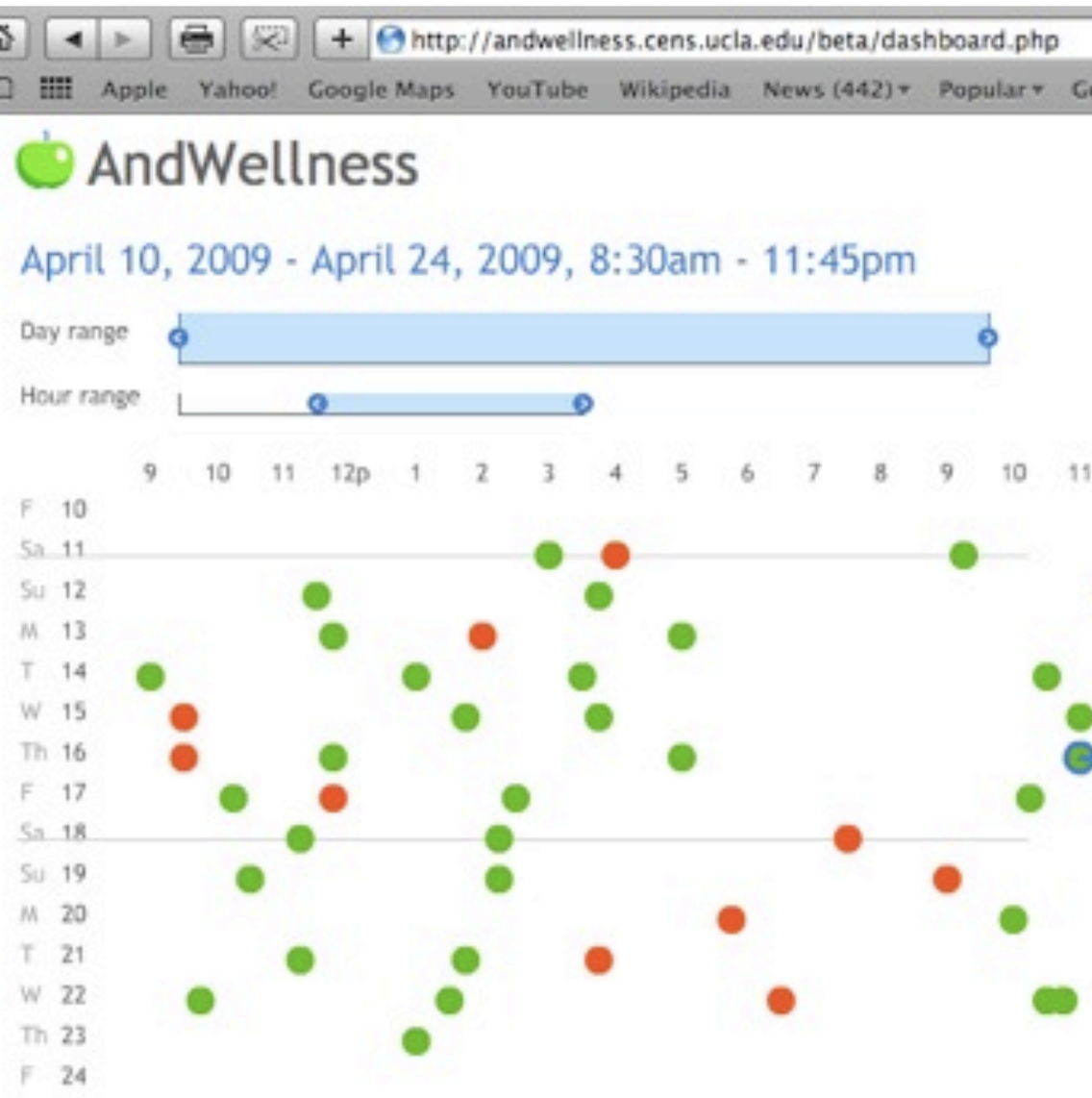
Processing Module

Aggregation

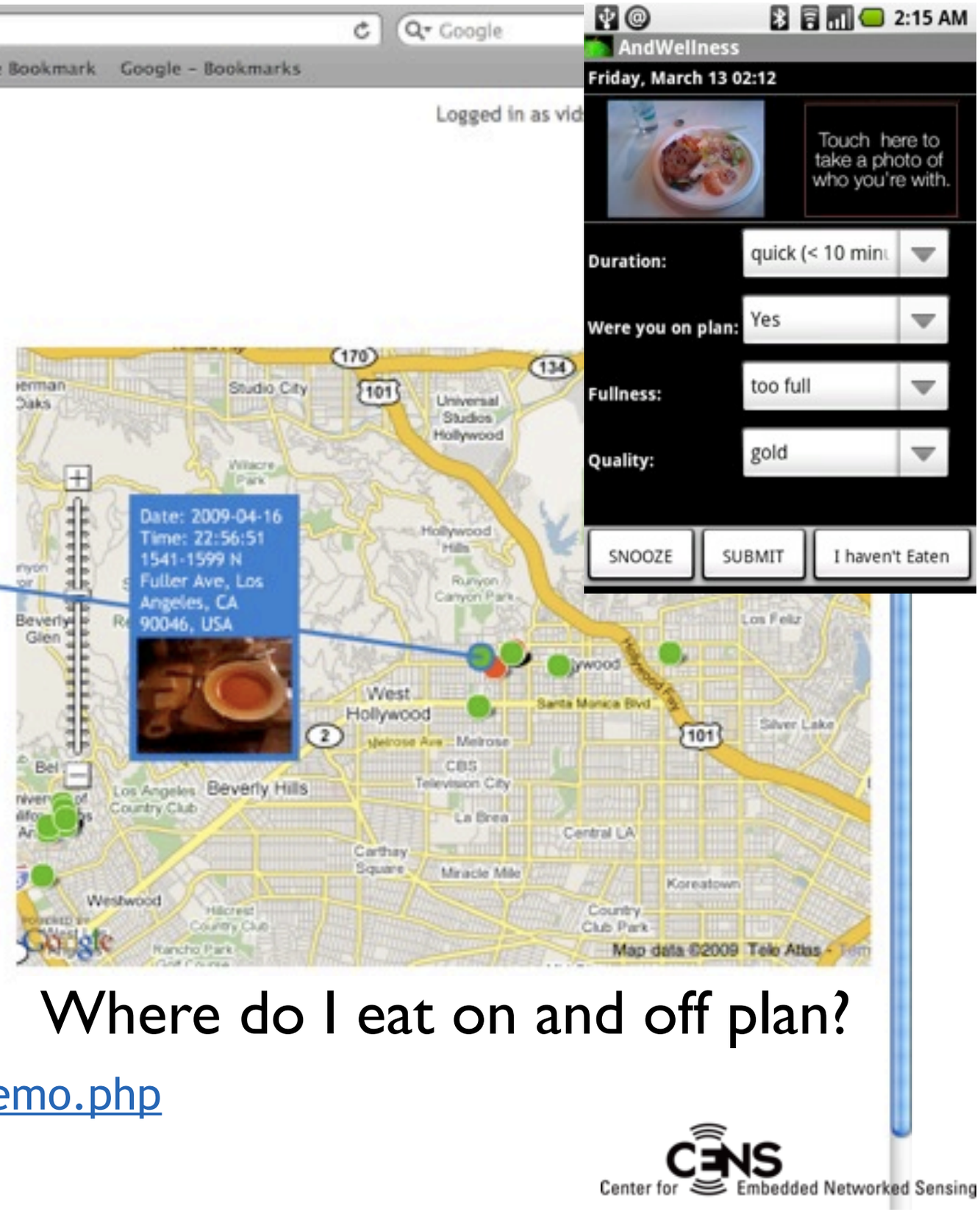
Event detect

Visualization Platform

Geocoded imagery:
health behavior data through self monitoring



When do I eat on and off plan?

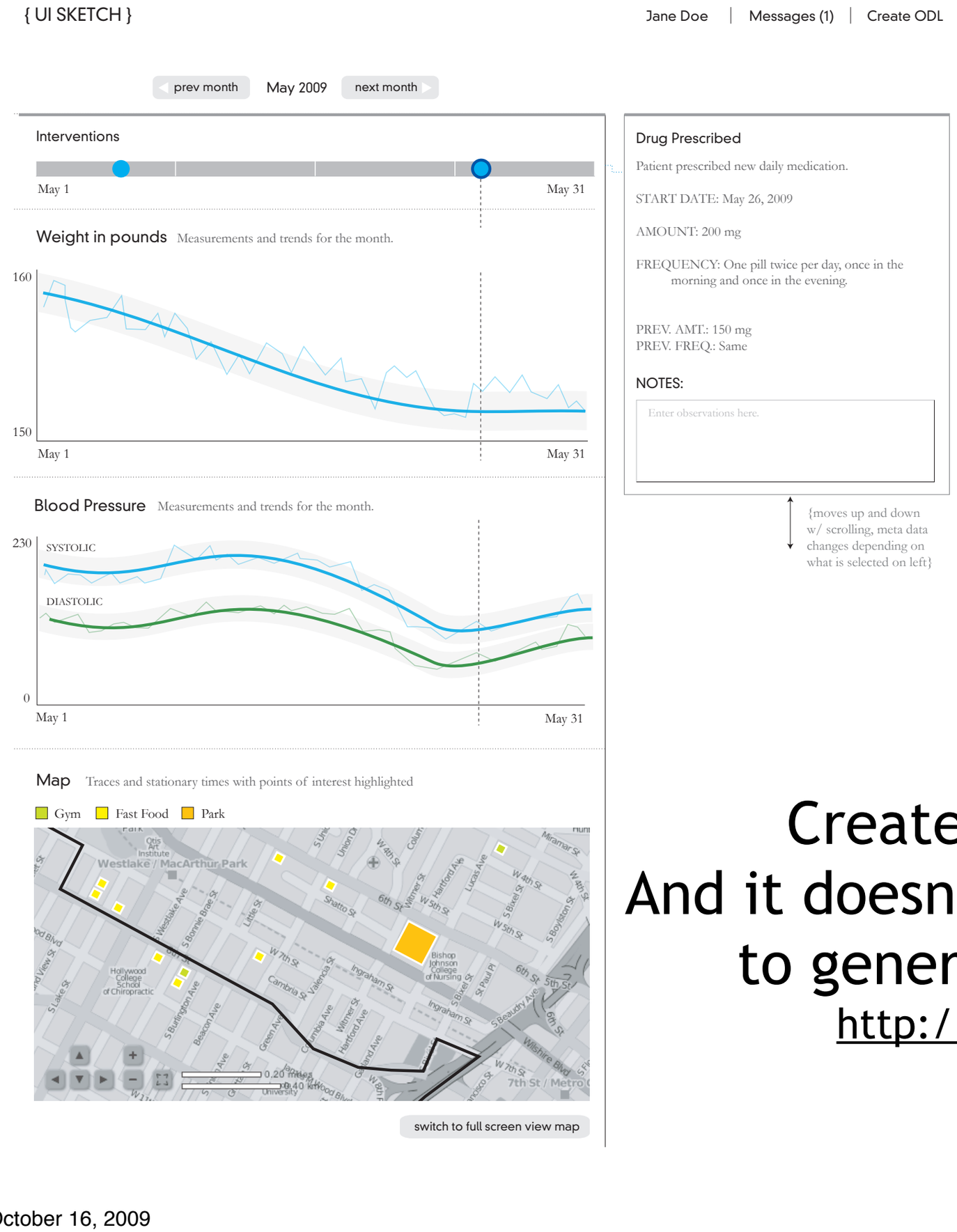


Where do I eat on and off plan?

http://andwellness.cens.ucla.edu/beta/demo.php

Center for Embedded Networked Sensing

Putting it together: Your *Living* record



Automatically prompted, geocoded, uploaded:

Physiological (BP, glucose...)

Patient reporting (medication, symptoms, stress factors)

Location traces

Contextual/Environmental factors

Creates a ***living record***...
And it doesn't require a smartphone to generate telling traces...
http://your.flowingdata.com

Center for Embedded Networked Sensing

Capture your life in **data**. One **tweet** at a time.

Get Started Now »

Step 1. Follow @yfd on Twitter

Step 2. Sign in to *your*.flowingdata with Twitter

Step 3. Start recording data (via direct messages) following a few simple guidelines

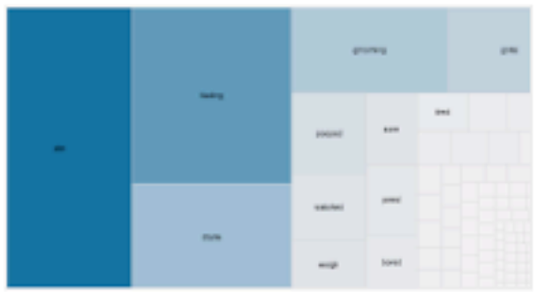
Making Choices

We make tiny choices every day. Those choices become habits, and those habits develop into behaviors. *your*.flowingdata helps you record these choices.

READ MORE

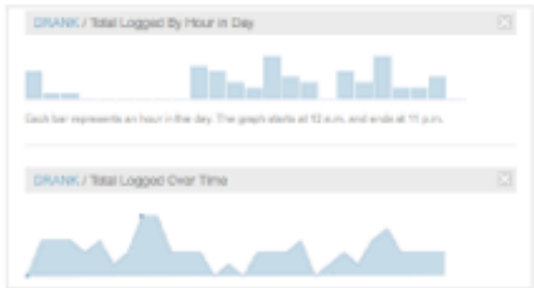
Collect data anywhere.

The ubiquity of Twitter allows you to record data from just about anywhere. If you can tweet, you can record data.



Interact with your data.

Data is meant to be played with. Use interactive data visualization and explore your data.

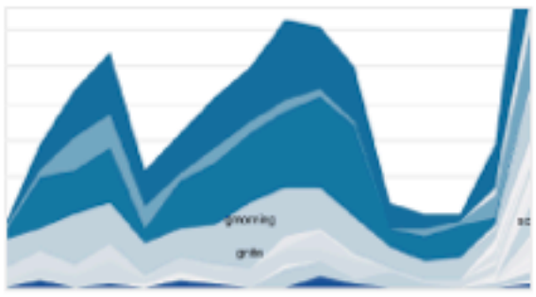


Customize views to your data.

All data is not created equally. Create custom visualization pages for what you're most interested in.

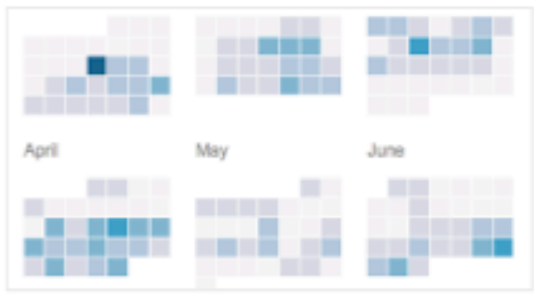
Share your findings.

Some data is meant to be private, but some is worth sharing. You decide what others can and can't see.



Understand yourself.

In the same way you can see growth from reading old entries in a diary, monitor your growth and progress through data.



Explore your data easily.

your.flowingdata was designed by a statistician, but you don't have to be one to play with your data.

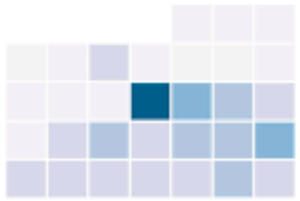
Yau, Hansen

Follow @yfd on Twitter and Get Started Now

Previous Year | 2009 | Next Year // **This Year**

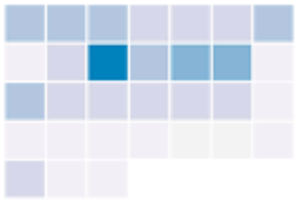
Actions Calendar /

January



February

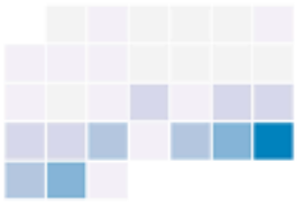
March



April

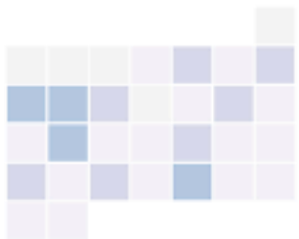
May

June



July

August



September

October

November

December

Saturday, July 18

drank water 10:46 p.m.
ate grapefruit sorbet 9:13 p.m.
ate pho 9:02 p.m.
watched I love you, man 7:00 p.m.
drank water 6:59 p.m.
drank diet squirt 5:31 p.m.
ate hot tamales 5:30 p.m.
ate peach cake 4:47 p.m.
watched garden state 2:31 p.m.
ate hot dog 1:47 p.m.
ate cherries 1:47 p.m.
drank diet coke 12:44 a.m.
played nba2k8 12:44 a.m.
drank water 10:27 a.m.
exercised jump rope 10:05 a.m.
drank water 9:19 a.m.
gmorning self 9:00 a.m.
gnite 1:23 a.m.
feeling tired 1:09 a.m.

Total Recorded

1,345

Actions (17)

ate	429
feeling	293
drank	185
gmorning	154
gnite	121
watched	62
chores	33
played	21
exercised	15
cooked	8
listened	7
napped	4
smoked	4
read	3
headache	3

SHOW ALL

Recent Actions

gnite 3 days ago
listened This American Life 4 days ago
ate turkey artichoke panini 4 days ago
feeling annoyed 4 days ago
gnite 1 week ago
drank water 1 week ago
gnite 1 week ago
drank diet dr pepper 1 week ago
feeling hopeful 1 week ago
drank diet coke 1 week ago

Yau, Hansen

Example application scenarios

- **Chronic disease management**---medication titration/stabilization (Activity traces + prompted entry of physiological measure + prompted entry of side effects--activity features analyzed as an indicator of functional health)

- **Acute health-behavior change**---post cardiac surgery support implementation of radical change in nutrition, exercise, stress, smoking (Activity traces + Prompted entry surveys/entries on targeted behaviors--food/smoking/phys activity)

- **Cancer survivor checkups**--3 day living record along with lab tests (Activity traces + prompted entry about mood, stress, and physical exercise)

- **Youth preventative health app (obesity/asthma)**---tie in activity and prompted input to social media and games

- **Clinical trial antidepressants**--interesting features extracted from activity traces such as trends about work and weekend time; as well as prompted inputs about mood, avoidance activities, medication and sleep...

- **Research study for stroke rehab protocols**--Activity traces to determine ability to cross the street, and achieved acceleration, in the persons natural environment; important indicator or functional mobility

- **Promotora/CHW support** --data gathering, patient management including prescribing SMS based EMAs for the patient). A tie in to personal health records and participatory health where these data become topics for discussion and problem solving by patient and providers

- **Elder Caregivers** -- across the collection of caregivers, ability to measure basic health status and track, alert, over time---the things that don't get on the chart but that are relevant to patient health status, interaction, alerts, etc...

General mobile to web architecture

General flow

APPLICATIONS
web, researchers/
health providers/community

PROCESSING
mobile device and
web Services

DATA CAPTURE
mobile device
and individual

Potential Examples

Chronic disease monitoring/mngmt	Health behavior change/adherence
Activity, mobility trends	Health behavior diaries
Location traces	Geo-coded mobile EMA

CENS Center for Embedded Networked Sensing

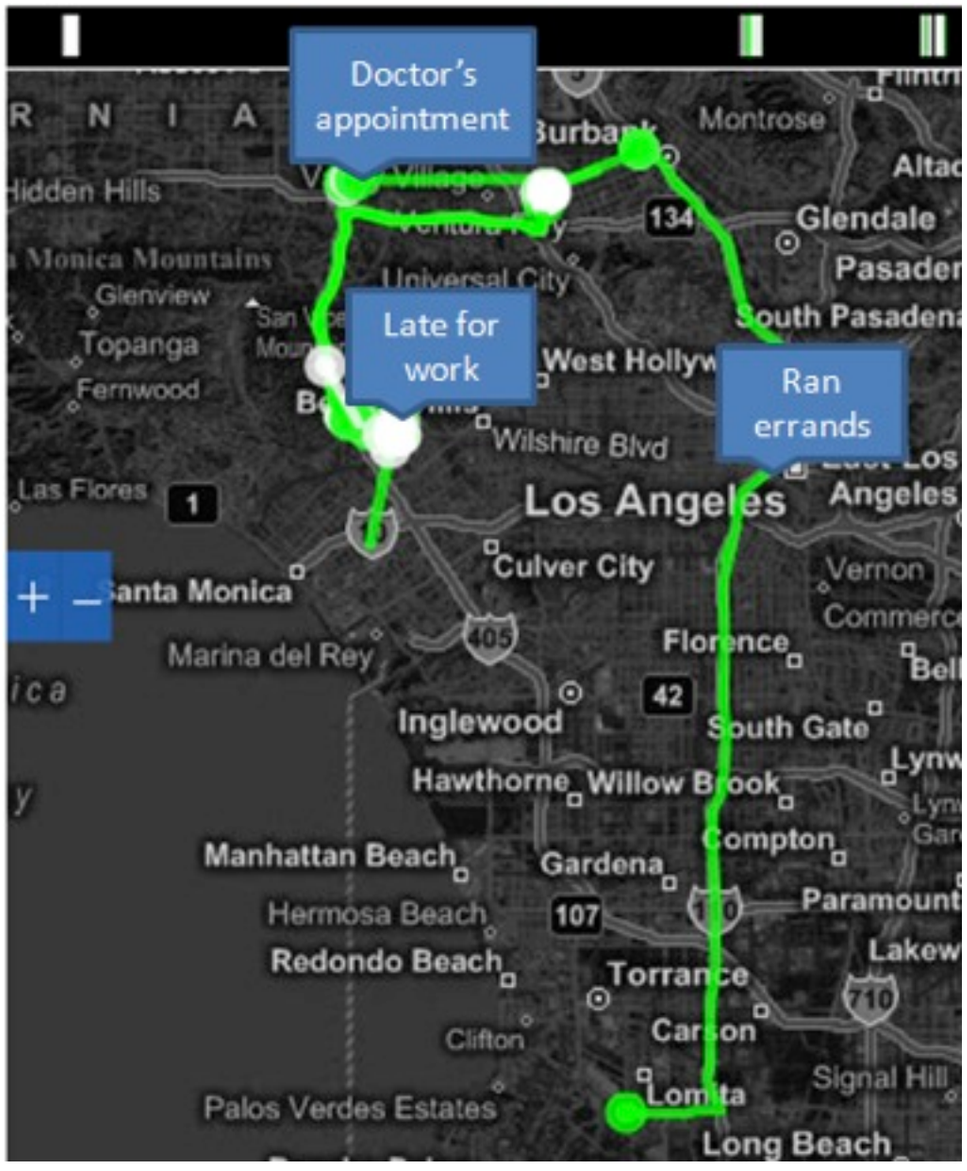
Privacy concerns: Granular Personal Data

Sensitive data

- Quantify habits, routines, associations
- Increasingly easy to share, mine
- Anonymizing location traces/geocoded time series is often infeasible
- Available to government, insurance, employers, creditors, ...

Diverse usage

- Collected by individuals
- Using apps authored by ... anyone?
- Shared with nobody, everybody, or some set in between



Knowledge@Wharton

Human Resources

search | Special Sections | Podcasts | Sponsors | News Room

From Incentives to Penalties: How Far Should Employers Go to Reduce Workplace Obesity?

Published: January 09, 2008 in Knowledge@Wharton

DOWNLOAD AUDIO PLAY AUDIO

This month, more than half of Americans probably made health-related New Year's resolutions, judging from past data, but few are likely to stick to them. Employees at CFI Westgate Resorts, an Orlando, Fla.-based vacation properties company, might consider themselves lucky: They have an incentive to get healthy. If they join in the company-wide weight-loss contest this month and succeed in reaching their goals, they could win cash prizes or a luxury vacation.

Inspiration for the contest, now in its second year, came from CEO David Siegel, who himself recently lost more than 20 pounds. "He put it on the radar," says Mark Waltrip, chief operating officer at Westgate, adding that in the contest's first year, some employees lost up to 60 pounds.

Print
Get as a PDF
Send a comment

PROTOTYPE

Predicting Where You'll Go and What You'll Like

Suzanne DeChillo/The New York Times

Gregory Skibiski, left, and Tony Jebara of Sense Networks, a company that uses location data to make recommendations for businesses and consumers.

By MICHAEL FITZGERALD
Published: June 22, 2008

SIGN IN TO E-MAIL OR SAVE THIS

'TRACK' MAN IS SACKED

GPS NAILS ED. GUY

By DAVID SEIFMAN City Hall Bureau Chief

August 31, 2007

Schools Chancellor Joel Klein yesterday fired a veteran worker whose movements were tracked for five months through the GPS device in his cellphone, leading to charges that he was repeatedly cutting out early.

"This individual was getting paid for not working," said schools spokeswoman Margie Feinberg, explaining Klein's decision to accept an administrative law judge's recommendation to ax John Halpin, a longtime supervisor of carpenters.

Halpin had worked in the school system for 21 years and was conscientious enough to show up as much as two hours early for his 8 a.m.-to-3:30 p.m. shift.

Tim Wamsley

JOHN HALPIN
Cellphone's his undoing.

Sponsored Links

BNET BUSINESS NETWORK: BNET | TECHREPUBLIC | ZDNET

b BNET

The go-to place for management | Find Articles | in free and premium articles

Today | Management | Strategy | Work Life | Insight | Industries

Find Articles in: All | Business | Reference | Technology | News | Lifestyle

Business Publications

Topic: RSS Feed

AIG Auto Insurance Launches GPS Based Teen Driver Pilot Program

Business Wire , April 9, 2007

EMAIL PRINT

NEW YORK -- AIG Auto Insurance today announced the AIG Teen GPS Program for auto insurance policyholders with teen drivers. According to the National Highway Safety Administration (www.nhtsa.gov), auto accidents are the leading cause of death for 16 to 20 year-olds, with roughly 6,000 young lives lost annually. The program will initially be piloted in Arizona, Illinois, New Jersey, Pennsylvania, South Carolina and Washington, and uses GPS technology to allow parents of teen drivers to monitor the location of the teen's car and driving.

After installing a small GPS unit, which is easily set up in

Calls for new best practices

Different concerns than data held by mobile carriers/credit card companies/ etc: regulated usage

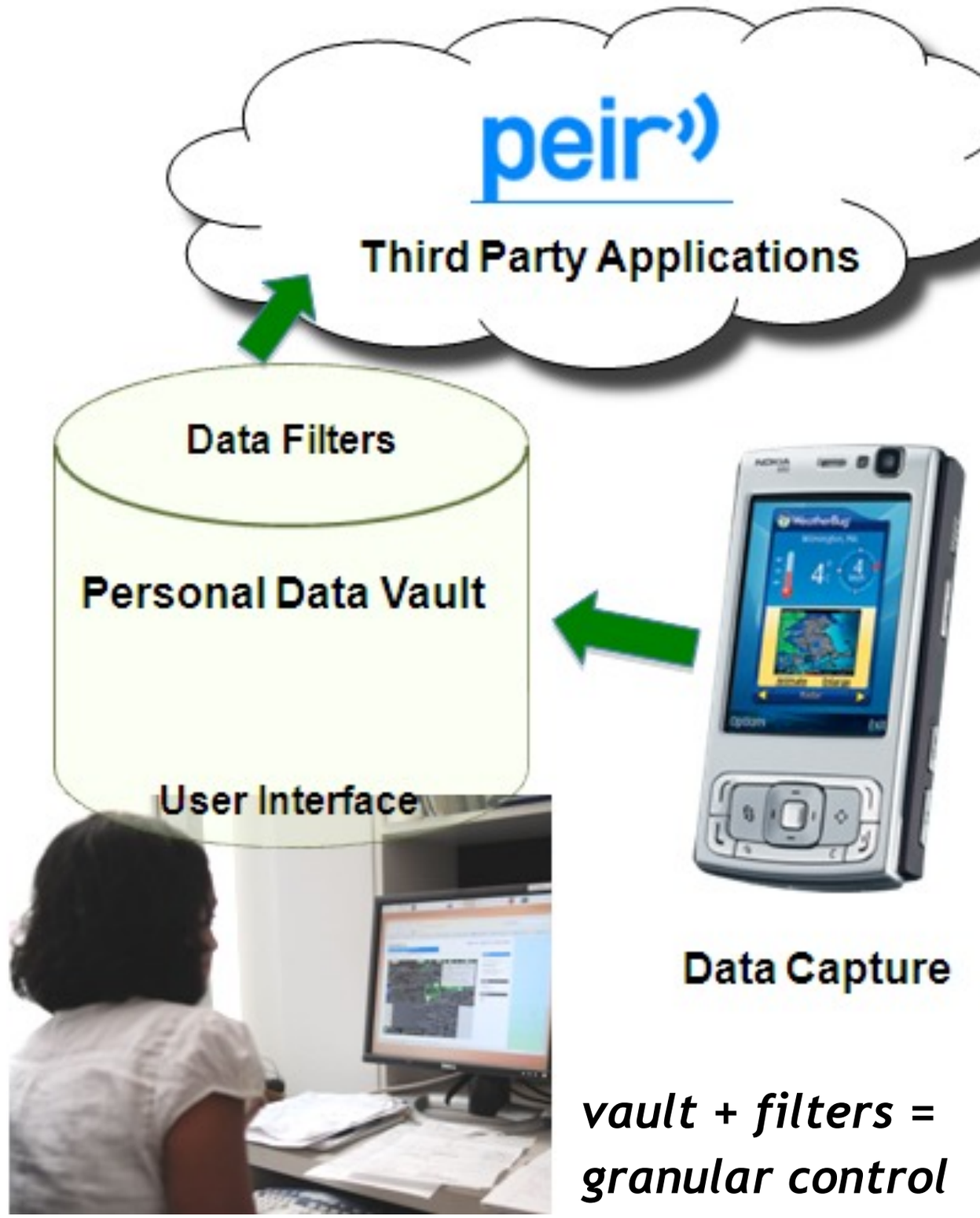
Individual captures and shares data:

- lure of *free* apps, *free* services
- *"Everything is free except for the data we collect about you"*

(adapted/paraphrased from Ondi Timoner, We live in public)

Explore legal and technical mechanisms to protect our ***telling traces***.

- difficult to anonymize location traces
- Personal Data Vault (PDV)



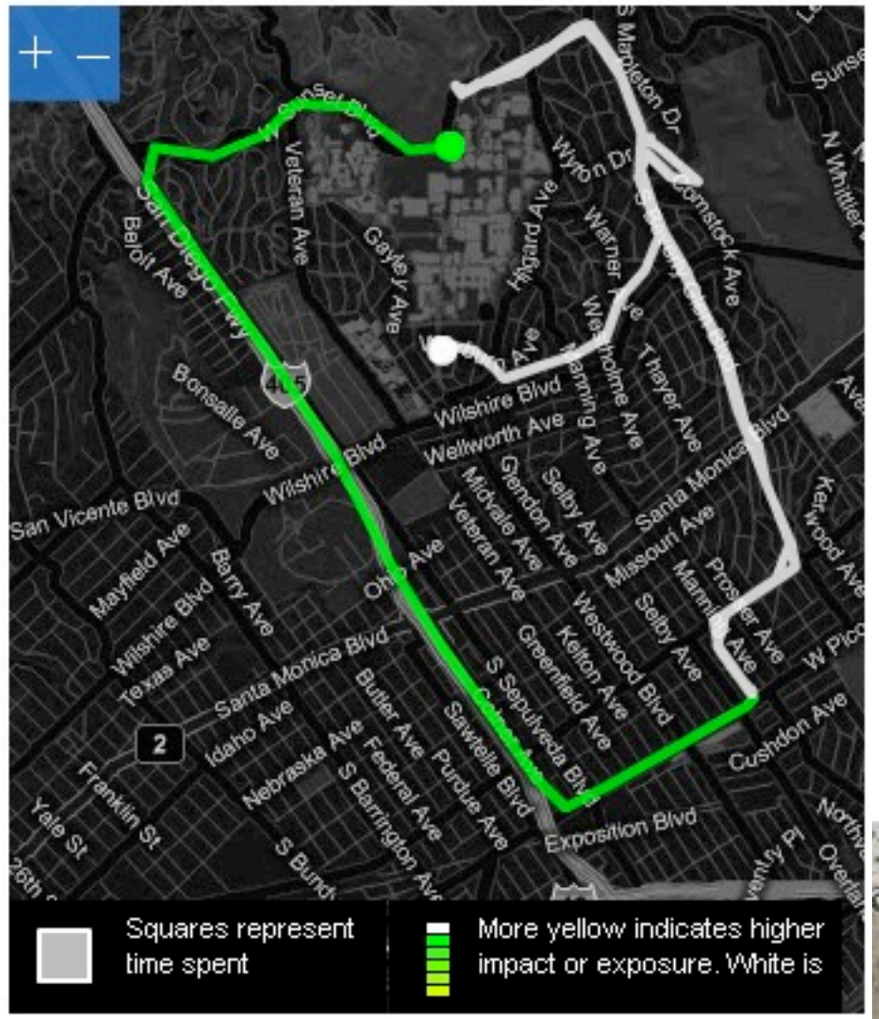
vault + filters = granular control

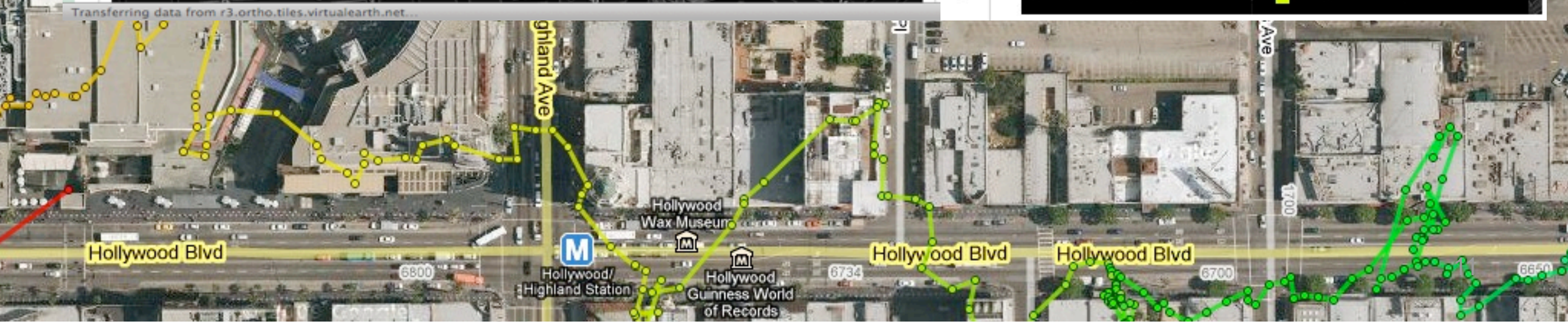
Exploring new best practices

Beyond consent: Personal data vault

Beyond access: Legibility

Beyond redress: Long-term engagement





Personal Data Vault (PDV):
allowing participants to retain control over their raw data

vault + filters = granular, assisted control over what you send to who, what that data says about you, whether you reveal who you are or share anonymously, ...

Data Capture

Personal Data Vault (PDV)

Data Filters

Partitioned applications

User Interface

Third Party Applications

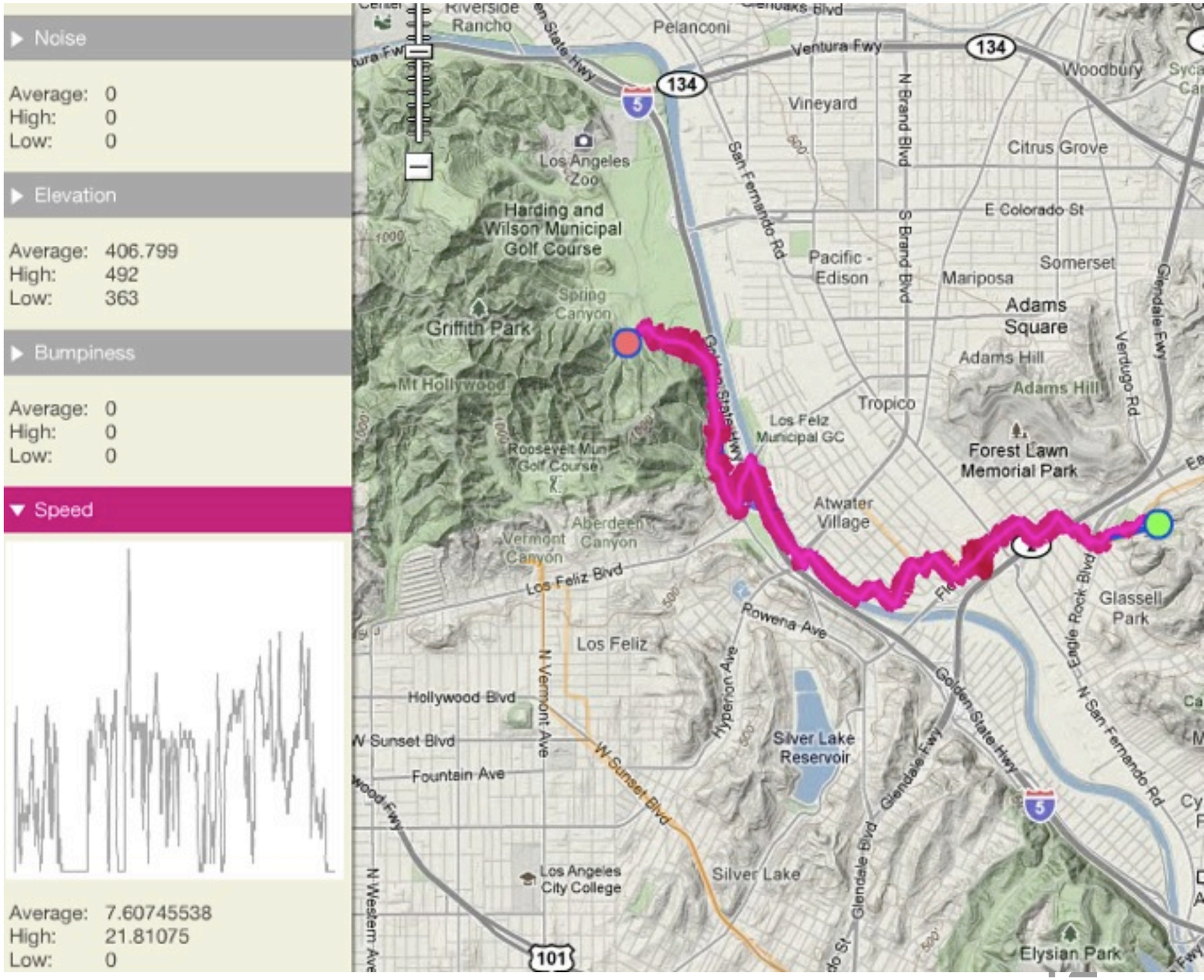
data legally-accessible only to Individual

filtered data shared with specific service providers

Data legibility

Help participants make sense of, decisions about, data

- Legible phone & service interfaces
- Basic visualization in vault
- User engagement in analysis

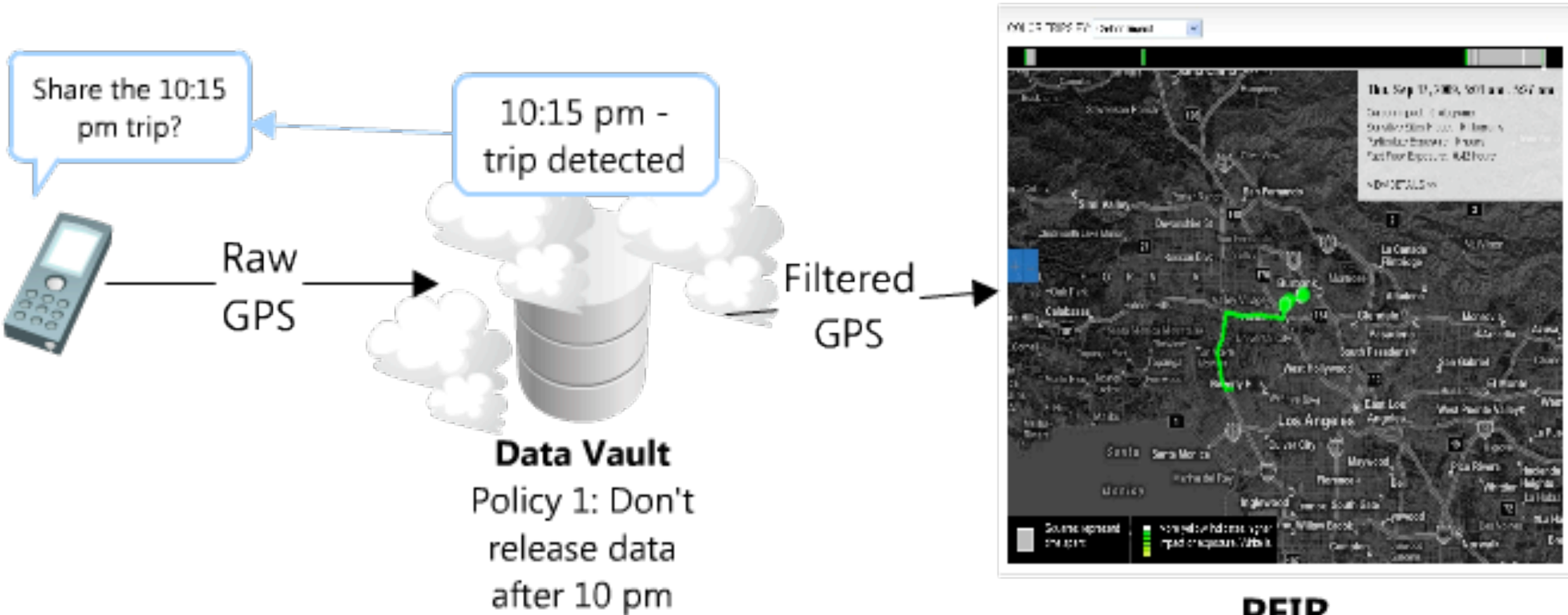


Longitudinal Engagement

Participation from collection through analysis, retention, deletion.

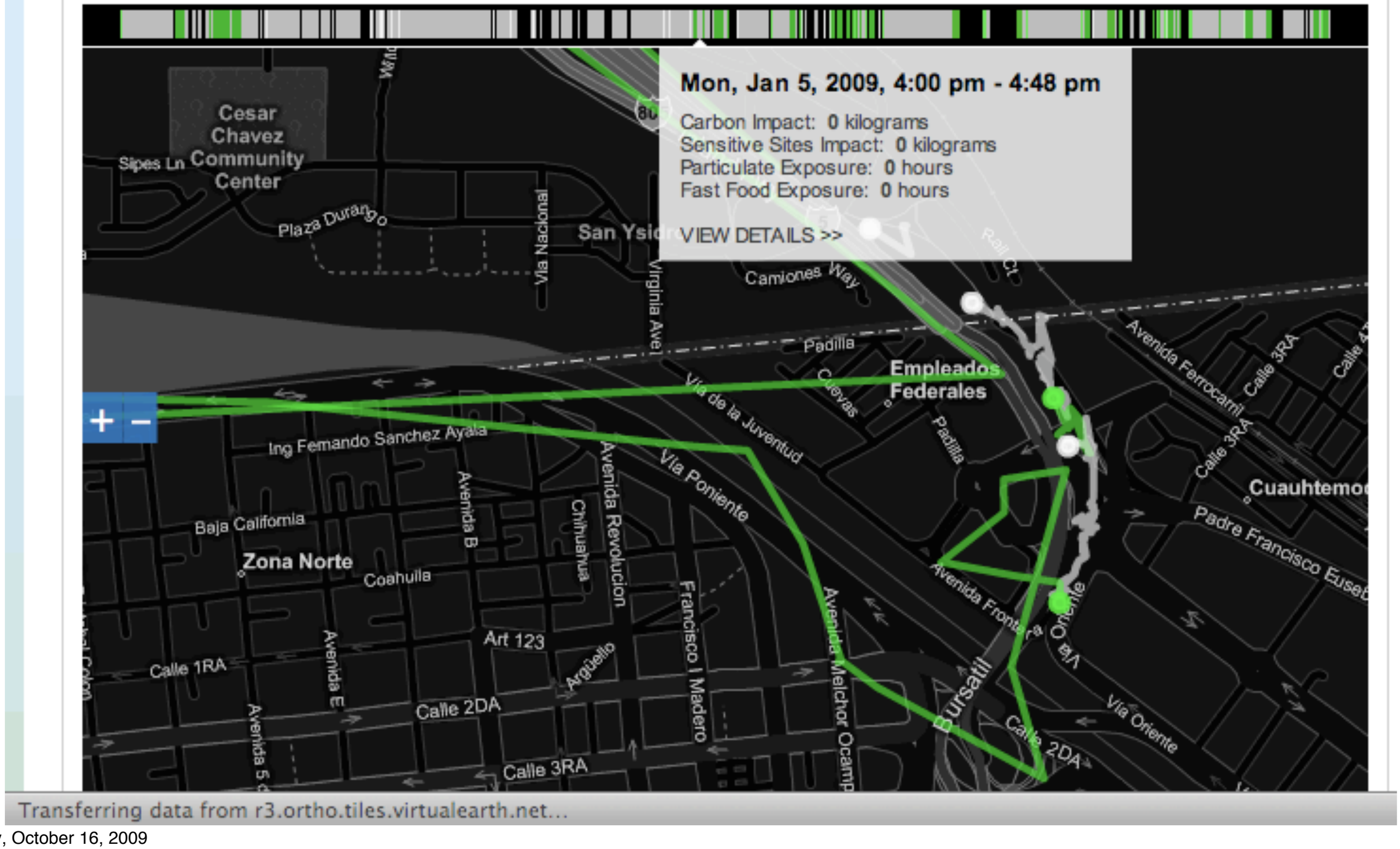
Support ongoing practice of informed-sharing of data streams; not just protection of already-stored data.

Example mechanism: Configurable, Adaptive Filtering

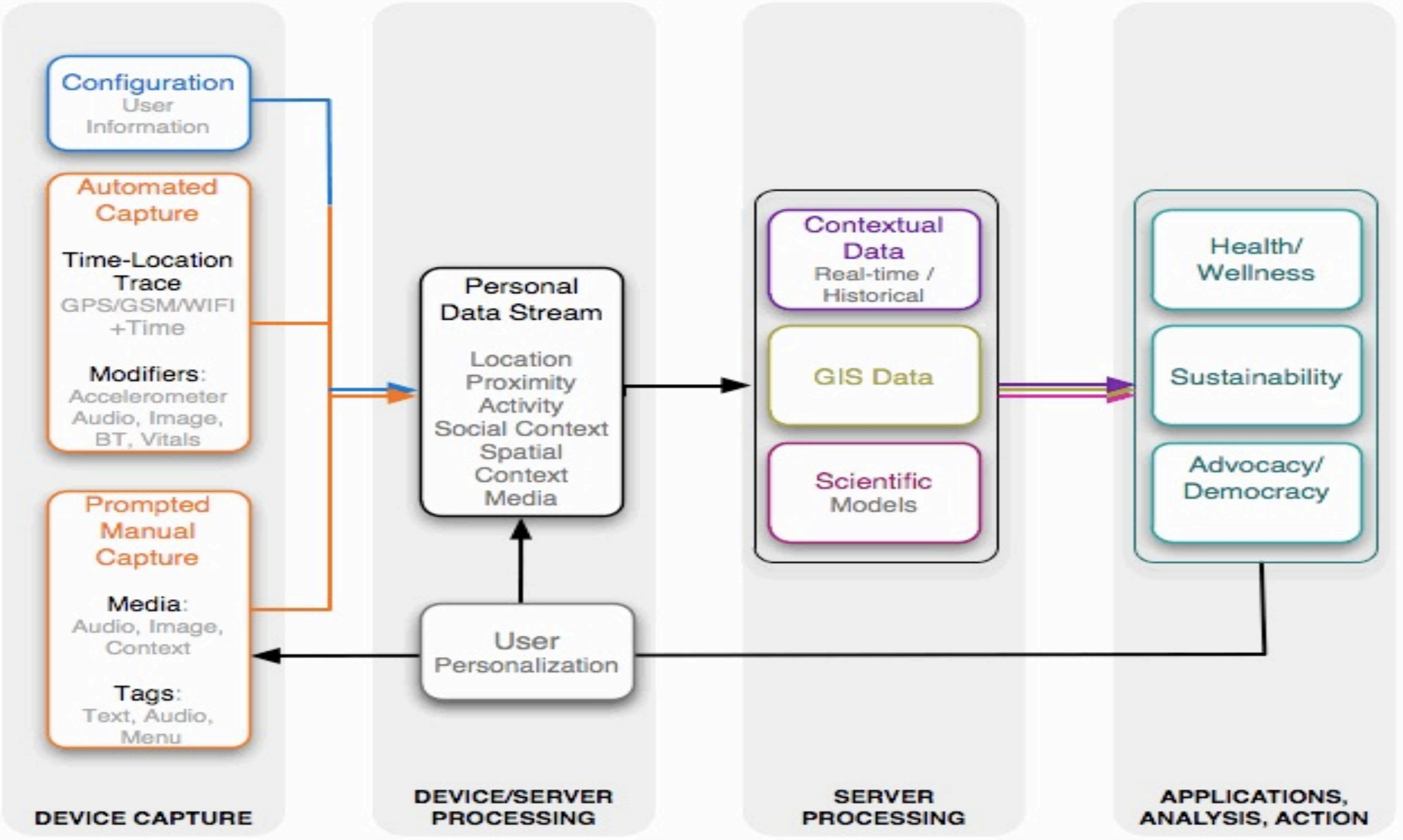


Legal Privilege

Protection of vault data from subpoena, discovery?



Mobile Personal Sensing common workflow and services



Conclusion

If you can’t go to the field with the sensor you want...go with the sensor you have! (Anon)

The power of the Internet, the reach of the phone (Voxiva)

A trace is worth a thousand images (Anon)

Its not too late to establish legal and technical mechanisms to protect our telling traces

Acknowledgments: Collaborators and Sponsors

Collaborators

- Co-PIs:Jeff Burke, Mark Hansen, Jerry Kang, Jeff Goldman, Ramesh Govindan, Eric Graham, Nithya Ramanathan, Mary Jane Rotheram-Borus, Mani Srivastava, Ruth West
- Students/staff: Betta Dawson, Hossein Falaki, Brent Flagstaff, Donnie Kim, Min Mun, Nathan Yau, Sasank Reddy, Vids Samanta, Katie Shilton, Eric Yuen

Sponsors

- Collaborations: CENS, REMAP, Global center for families and children
- Federal funding: NSF: NETS-FIND Program, OIA
- Corporate funding: Cisco, Google, Intel, MSR, Nokia, Sun, T-Mobile
- Foundation/NGO: Woodrow Wilson Center, Conservation International