Participatory mHealth

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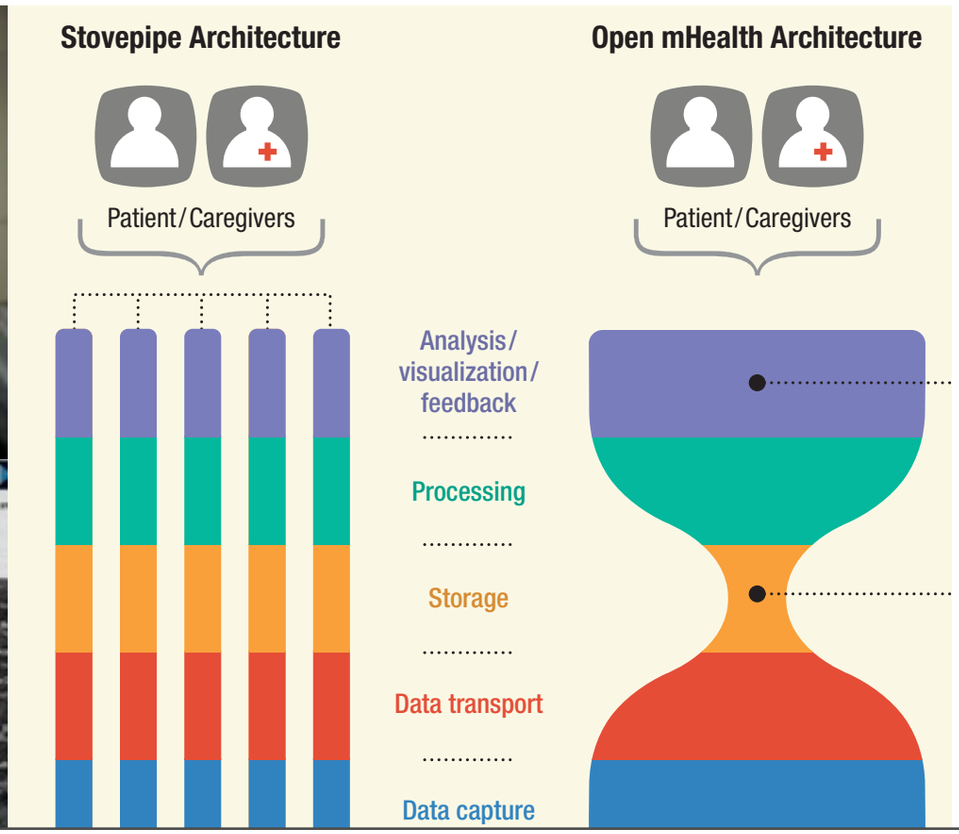
in collaboration with faculty, students, staff at CENS, UCLA, UCSF...

Smartphones are proximate, pervasive, programmable, personal; offer data/interaction in real time, real place, real context



mHealth

Use mobile devices to enhance health and wellness by extending health interventions and research beyond the reach of traditional clinical care.

our actions

Photo: Marshall Astor, WWW

our self report

experience sampling streams

context and activity traces

personal data repository

processing

aggregate measures, trends, patterns

event detection

visualization

Why ***participatory*** mHealth ?

motivation

3 behaviors (diet, exercise, smoking) cause 1/3rd of US deaths

50% Americans have 1 or more chronic diseases

age of onset getting younger

chronic disease prevention/management/research happens in the context of daily life, outside of clinical setting

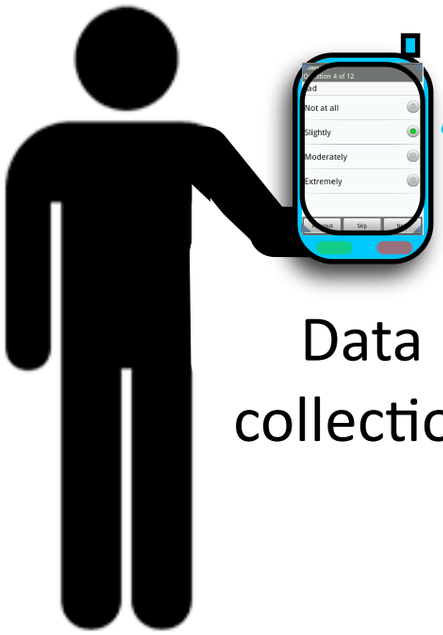
approach

support individuals, communities, clinicians to continuously improve patient-centered, personalized, health and healthcare.

mobile devices offer proximity, pervasiveness, programmability, personalization, affordability.

AndWellness

built to explore ***participatory*** mHealth



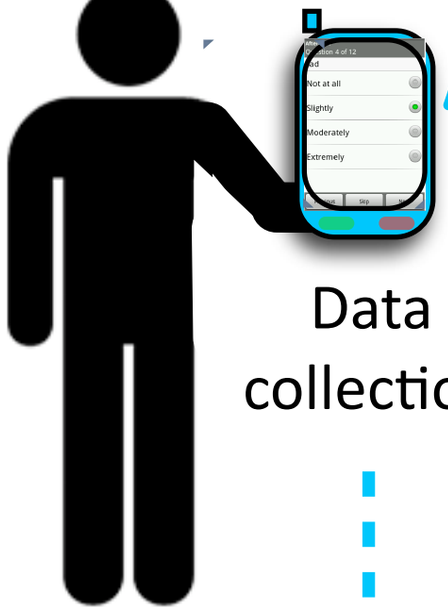
Data collection

Internet

Dashboard access

Data analysis, privacy preserving storage

Ramanathan, Selsky, et al



Data collection

Internet

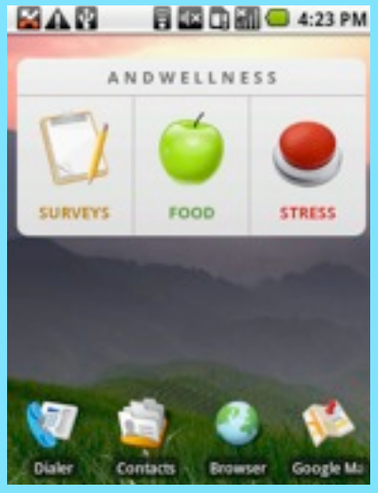
Location and time triggered surveys

Automated capture

GPS ACCELEROMETER

Actigraphy

Phonetop Buttons



Ramanathan, Selsky, et al

Participatory design: functionality shaped by focus groups, interviews

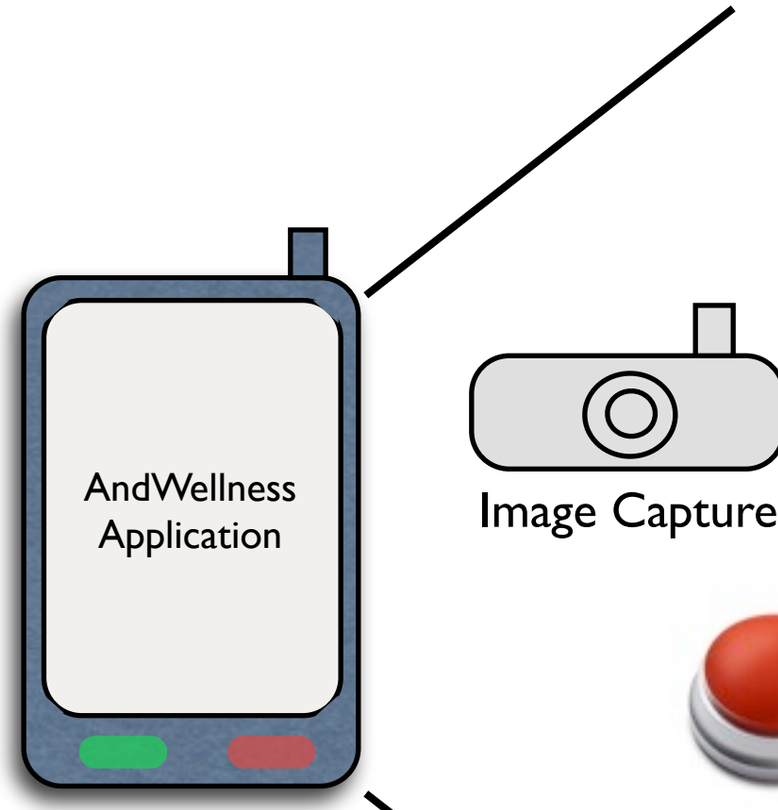
Trigger Authoring

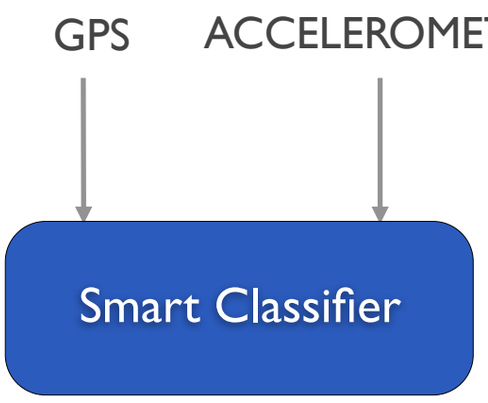
trigger logic as function of location, time, activity, prompt responses

Server

Survey Authoring

```
<survey>
  <title>Alcohol</title>
  <prompt>
  <text>How many drinks did
you have today?</text>
  </prompt>
</survey>
```





Actigraphy

Image Capture

Stress, Eating Buttons

Survey Input

>100 (somewhat) diverse participants: young moms, young men living with HIV, immigrant women, breast cancer survivors, and recruited UCLA student testers

Ramanathan et al

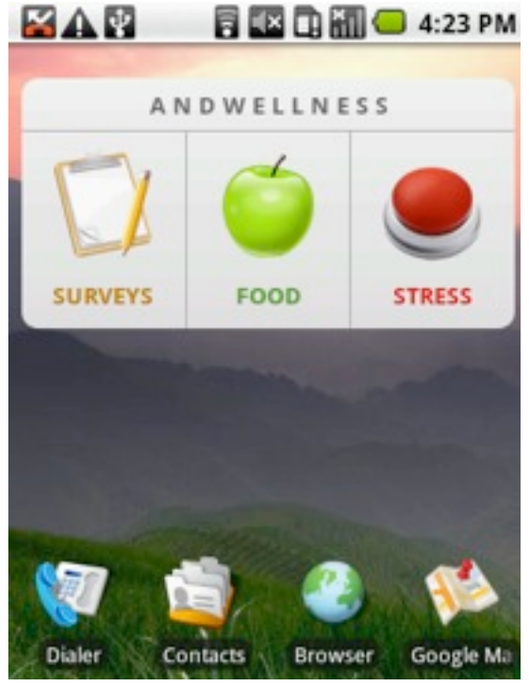
Focus groups summary (n=72)

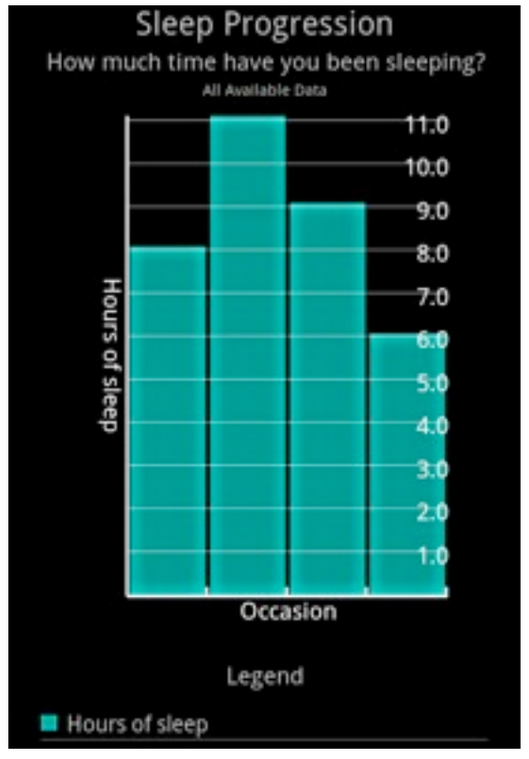
Population	Primary application features discussed
Young Moms n=23	<u>*Engaging participation without increasing user burden*</u> • Customization of reminder times/locations for convenience • Image capture of food to increase accountability • Set, manage, and monitor progress towards a goal • Light-weight data capture • Primary interaction to take place on the phone
Immigrant Women n=20	<u>Mechanisms to help people achieve a goal</u> • Set, manage, and monitor progress towards a goal • Helpful tips and problem solving (suggested by phone)
People Living with HIV n=29	<u>1) Privacy and security of data</u> • Password protection on phone a must • Nondescript text to hide the intent of sensitive questions • Location tracking is controversial, granular control a must • Data anonymization for sharing with counselor, coach, medical provider <u>2) Customizatin of Reminders</u> • Medication adherence reminders, especially using location • Safe sex reminders

Ramanathan, Swendeman, Dawson, Estrin, Rotheram-Borus

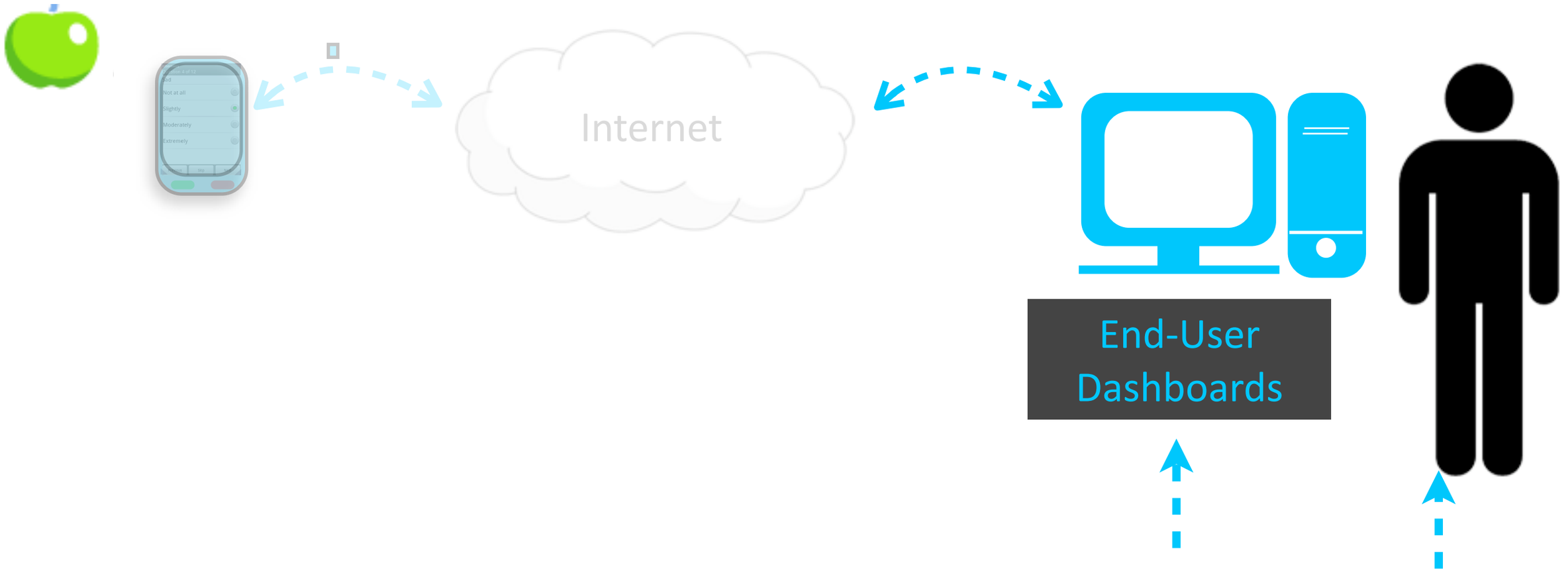
Notable feature requests

- **Images**: Moms LOVED this feature for food, SA women did not.
- **Triggers**: Control of timing important to all--need trigger authoring and personalization
- **Buttons**: Most moms willing to answer at least briefly ‘in the moment’, while SA women almost all wanted to answer only at the end of the day.
- **Feedback**: Very few interested in seeing simple quantifications of their responses. Helpful tips and motivational messaging most popular. SA explicitly preferred *against themselves* vs competitive feedback with group.
- **Server vs Phone**: Very few willing/interested to access server. Most wanted interaction solely on phone.

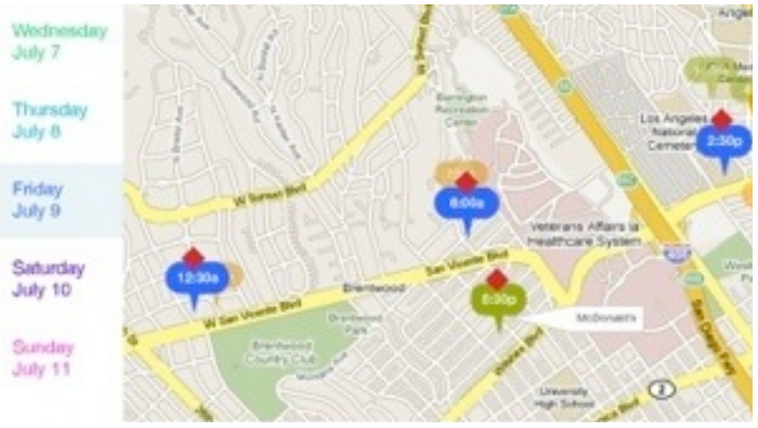




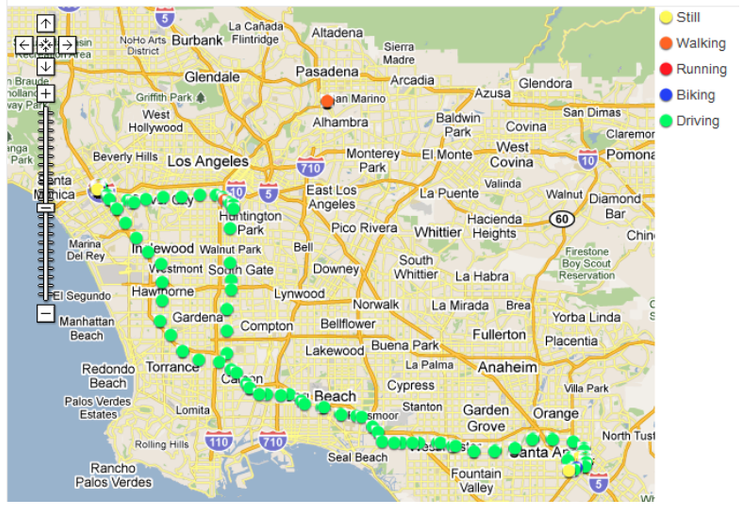
Ramanathan, Swendeman, et al



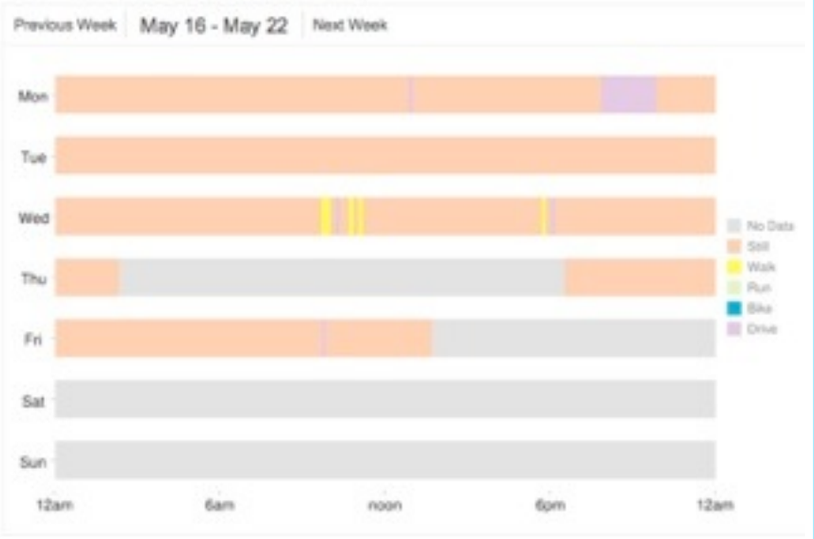
Correlations in time and space



Actigraphy over space

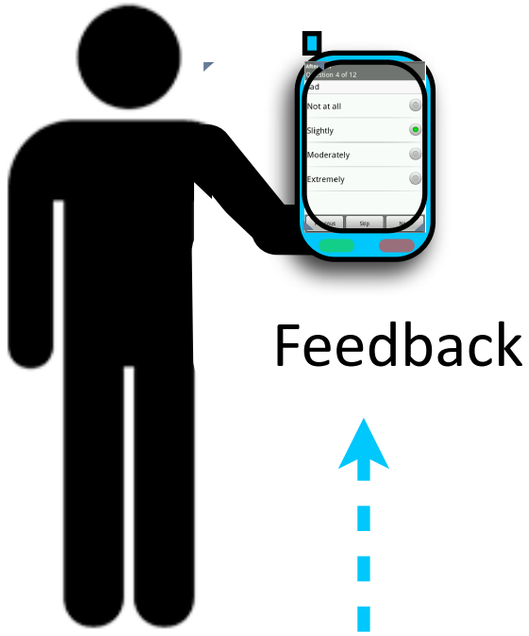


Actigraphy over time



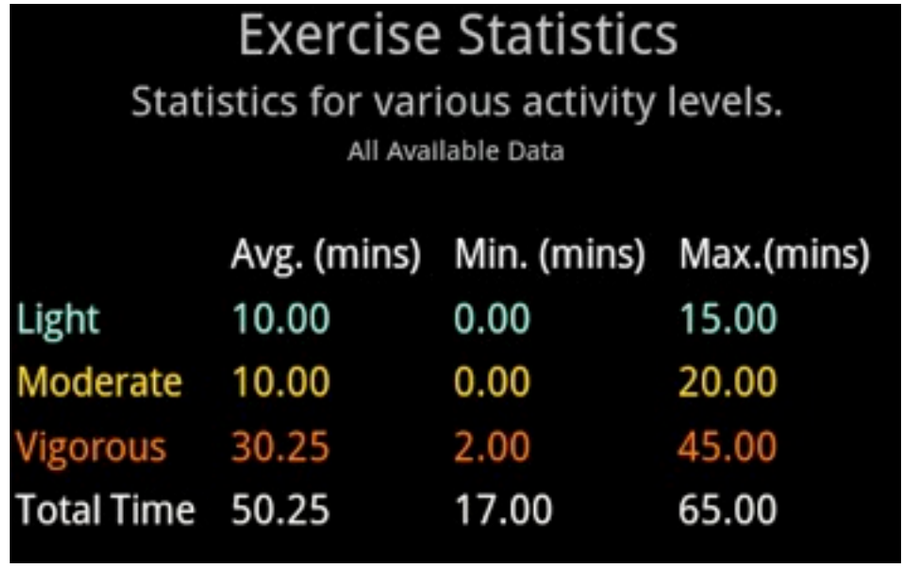
Work in progress for future release: time delayed correlations and correlations across behaviors

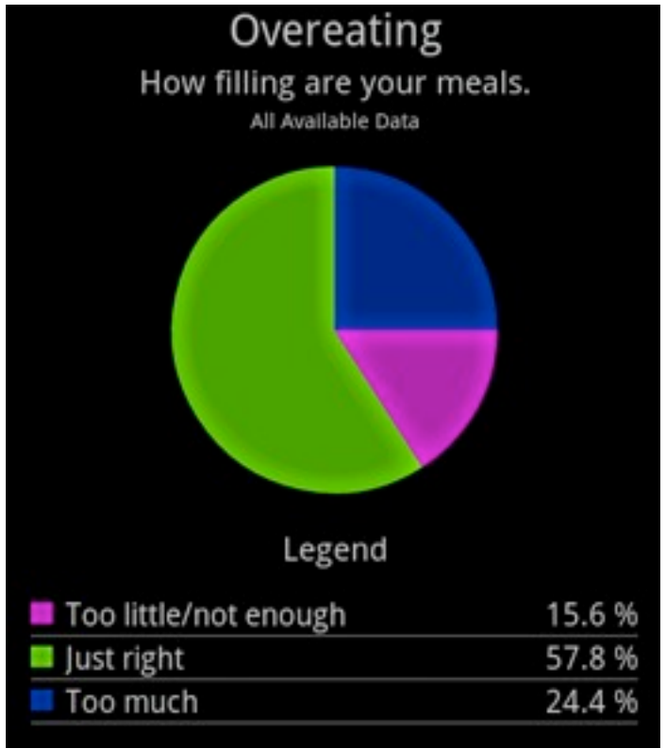
Ramanathan, Selsky, et al

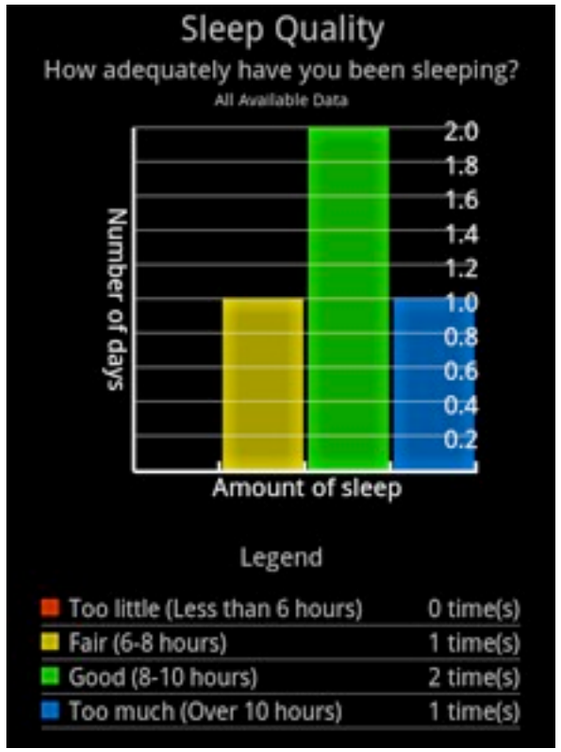


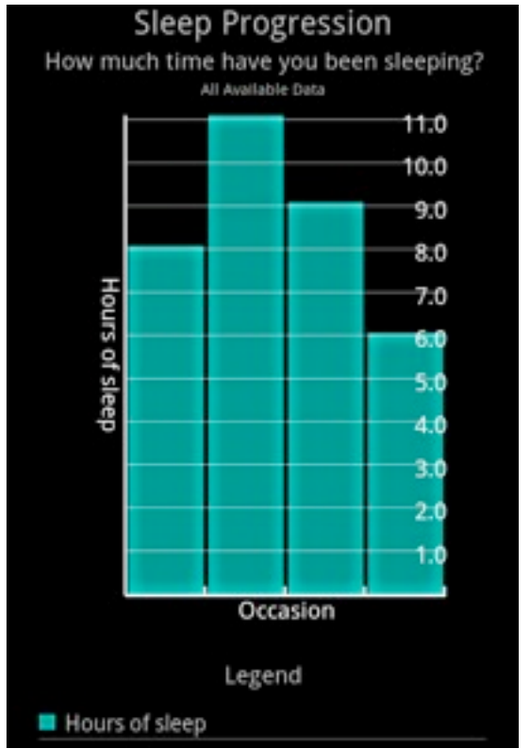
Configure

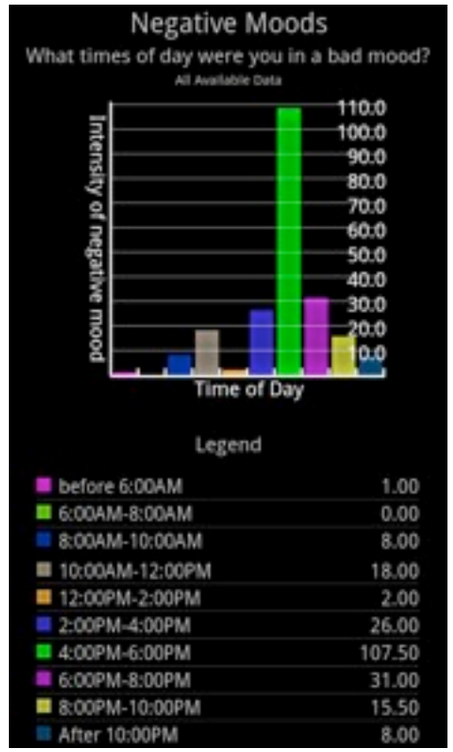
Table Summaries











* To Be Released August, 2011

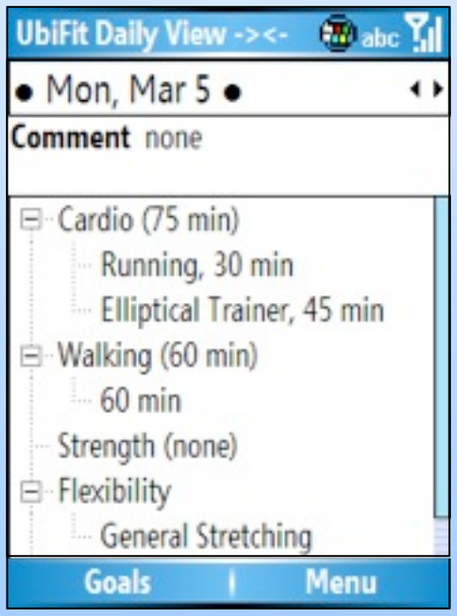
Chart Summaries

Iyer, Ramanathan, et al

Of course…"feedback" should look more like this and be tailored to individual participants-- *Ubifit (UW, Intel)*

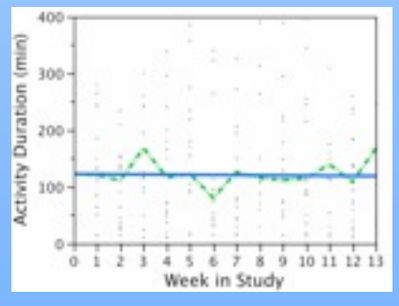
ubifit garden

using on-body sensing, activity inference, and a personal, mobile display to encourage regular and varied physical activity

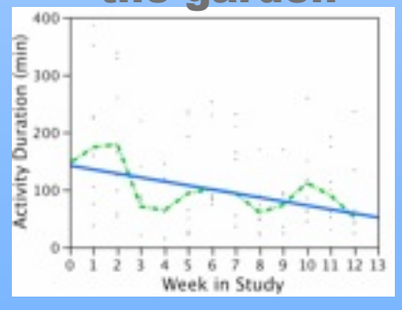


participants who…

had the garden



did NOT have the garden



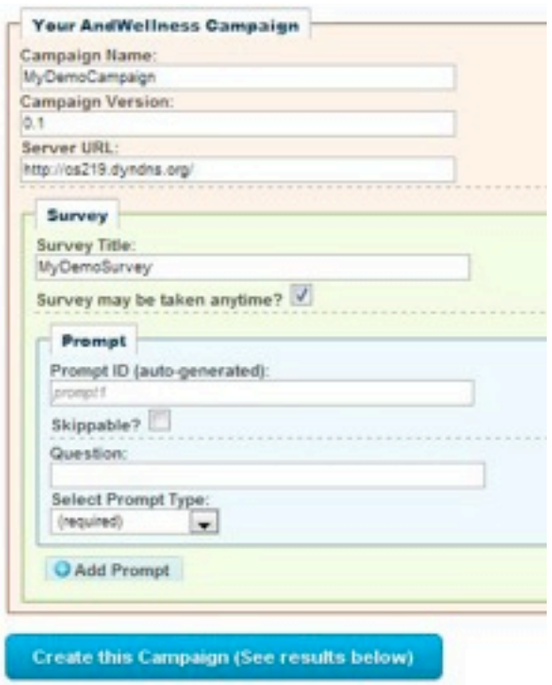
[1] intel research seattle
[2] dub, u of washington

consolvo, mcdonald, landay, chi 09 ❁ consolvo et al, ubicomp 08 ❁ consolvo et al, chi 08 ❁ choudhury et al, ieee pervasive mag '08 ❁ froehlich et al, mobisys '07 ❁ consolvo, paulos, smith, mobile persuasion '07

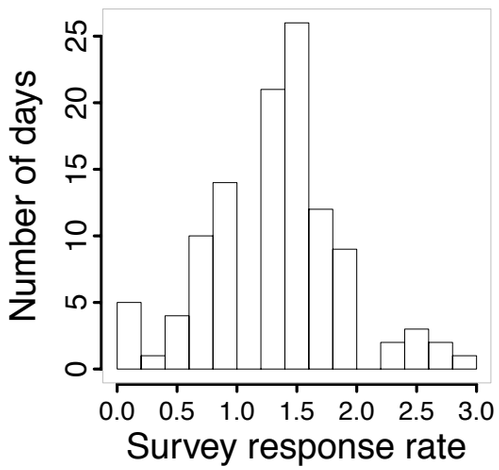
Internet

Researcher Dashboards

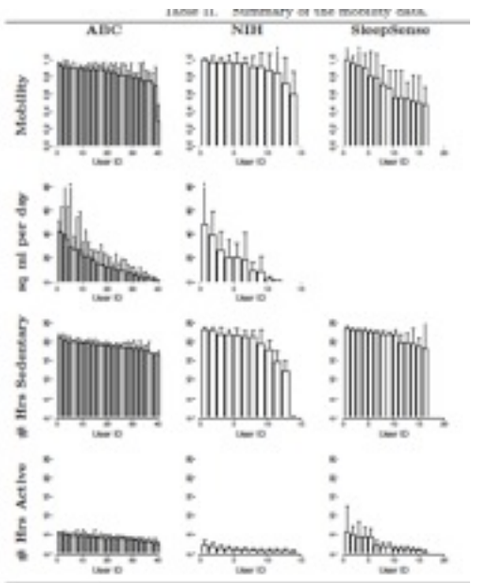
Survey Creation



Participation



Population Statistics

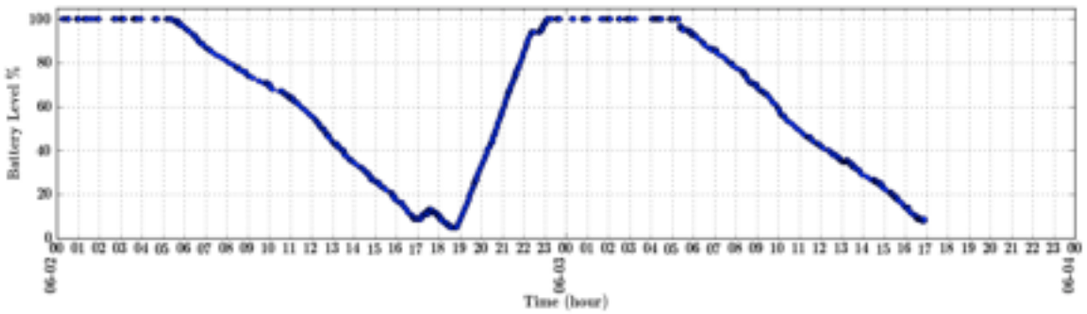


* in progress for release, Dec, 2011

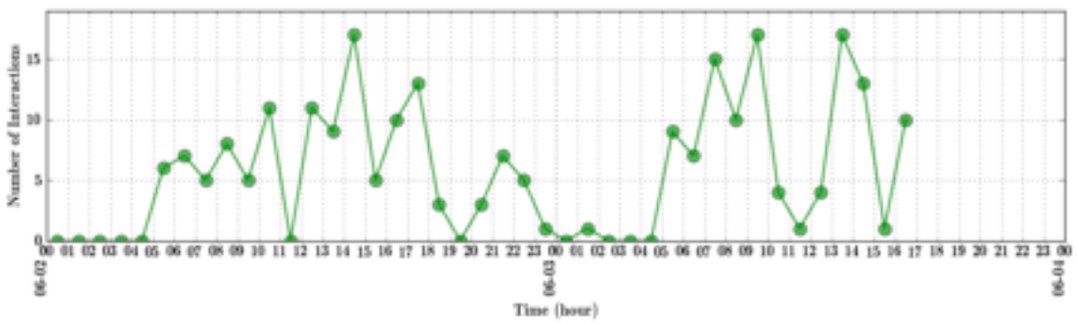
Ramanathan, Selsky, et al

Admin Dashboards

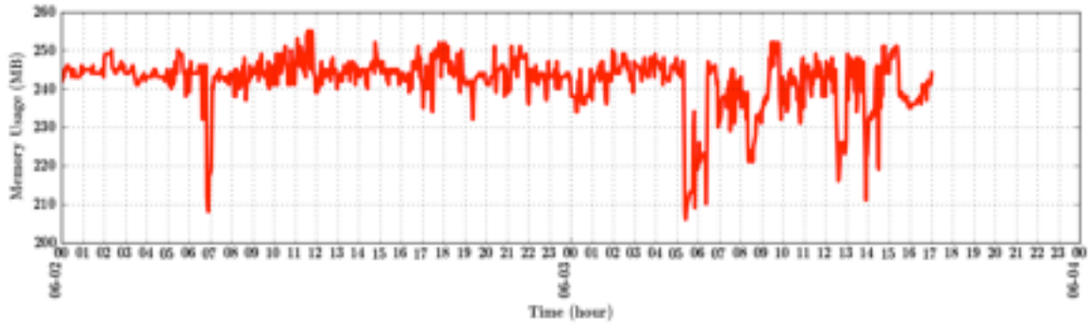
Remaining battery on phone



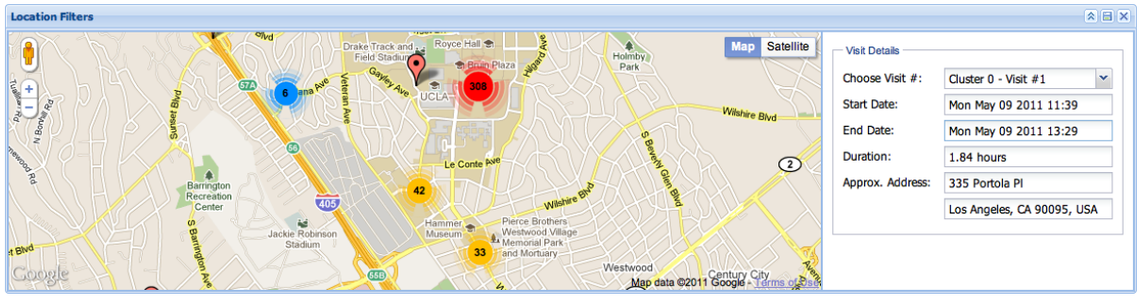
User interaction with phone



Memory usage on phone



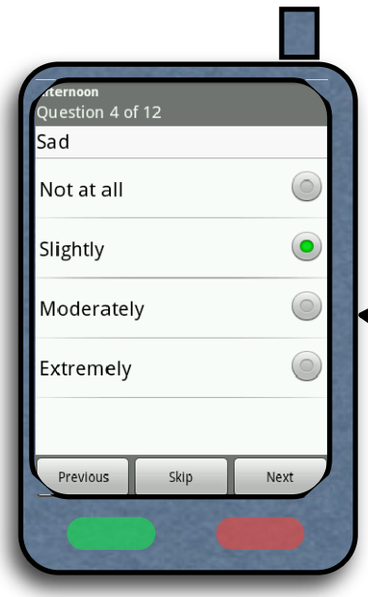
Filter by location, time, user



Wu, Falaki, Estrin, Ramanathan

AndWellness system implementation

Smartphone



Server-side defined by HTTP APIs: GET and POST using JSON, standard HTTP data packaging

JSON/HTTPS

Internet

Server

andwellness.org

Java 6 + Tomcat 7 + MySQL 5.1

RApache for datavis

AndWellness

JSON/HTTPS

Web Browser Clients

What lies behind exposed API calls could be written in any programming language.

Ramanathan, Selsky, et al

Status of AndWellness features to date

(with guesstimate on how far along we are)

- Experience sampling, light-weight data capture (50%)
- Visualization/data presentation for end-user and researcher (15%)

- Smart triggers based on user configurable location, time, activity (25%)
- Background services for actigraphy, location tracing, system analytics (50%)
- Battery-preserving background services (50%)

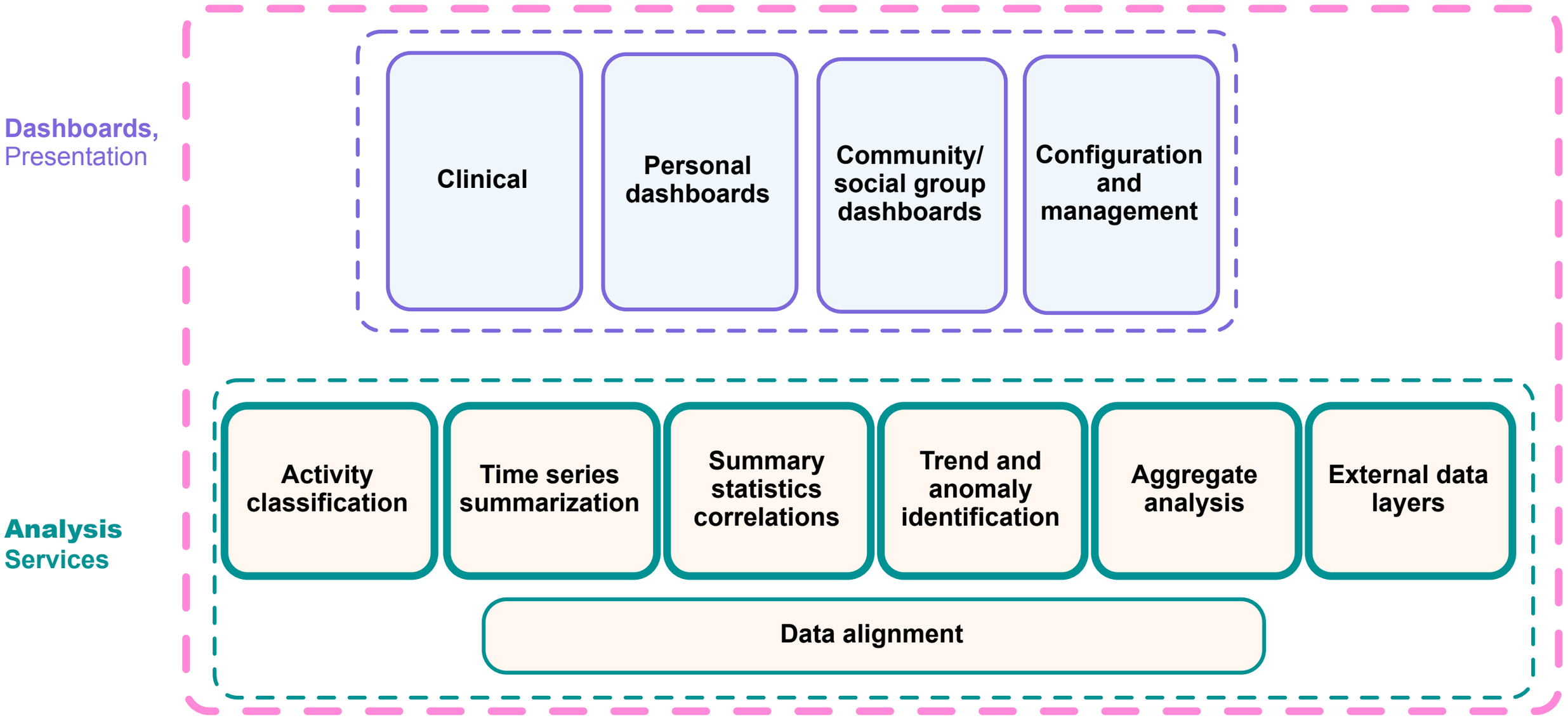
- Open mHealth community building (15%)
- Participatory privacy policies and mechanisms (15%)

Key *research* challenges

- Health sciences community:
  - Establish validity and reliability of mHealth instruments
  - Derive efficacy evidence base from rich usage, system analytics
  - Behavior change: defining, implementing, and adapting interventions that support sustained and beneficial change across populations
- Technical community:
  - Infovis: analysis, presentation, visualization, for self, clinician, researcher
  - Resource management, efficiency (enable full-day phone operation with background activity and data capture)
  - User modeling (eg community models (Choudhury) for activity classification, context, triggers
  - User engagement/experience: motivate sustainable user participation with game mechanics, adaptive interfaces
  - Selective sharing, usable privacy tools
  - Open systems

InfoVis

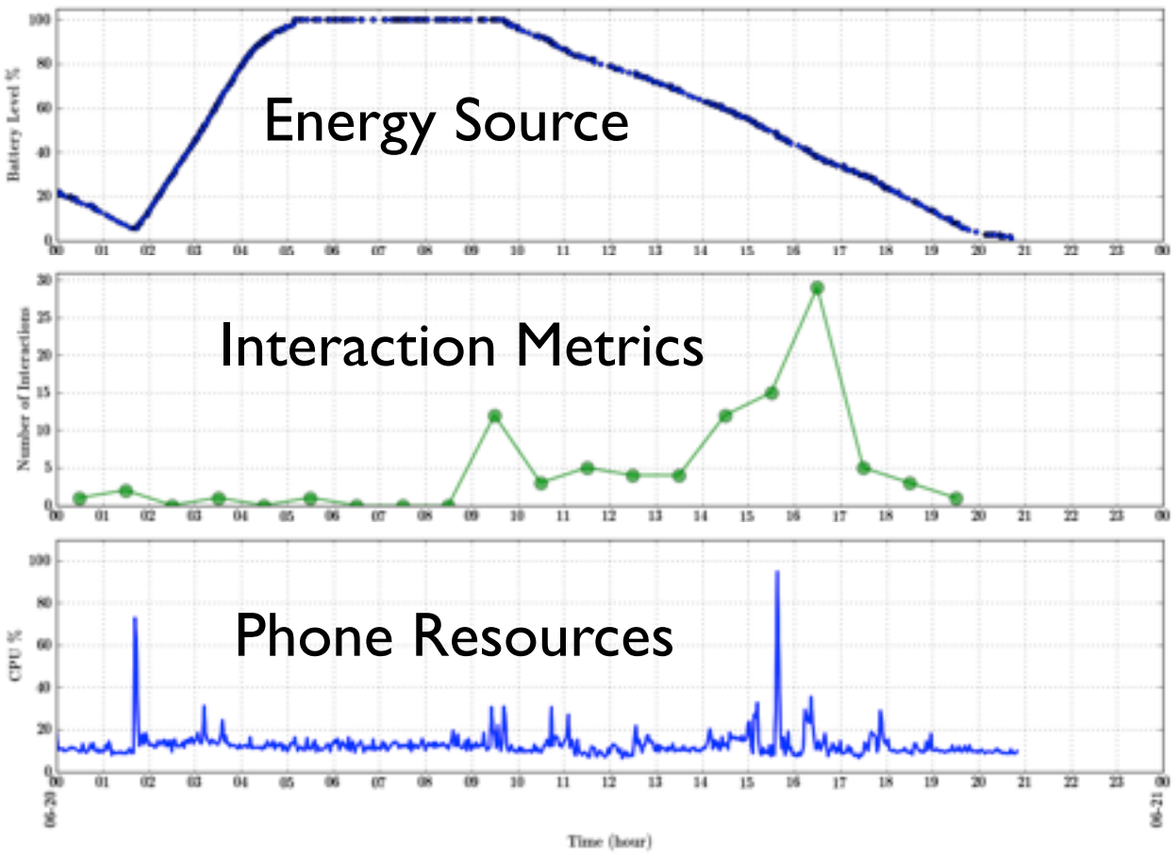
extract and present relevant trends, patterns, anomalies, correlations across diverse data streams and to diverse audiences



Needs: pre-processing, feature extraction, integration with machine learning libraries and statistical analysis tools, incorporation of external datasets, geo-spatial analyses, informative and configurable presentation

Adaptive battery management for background applications

- **Usage** and **context** matter for battery management, e.g., 15% left battery at 10pm is not the same as 15% at 10am.



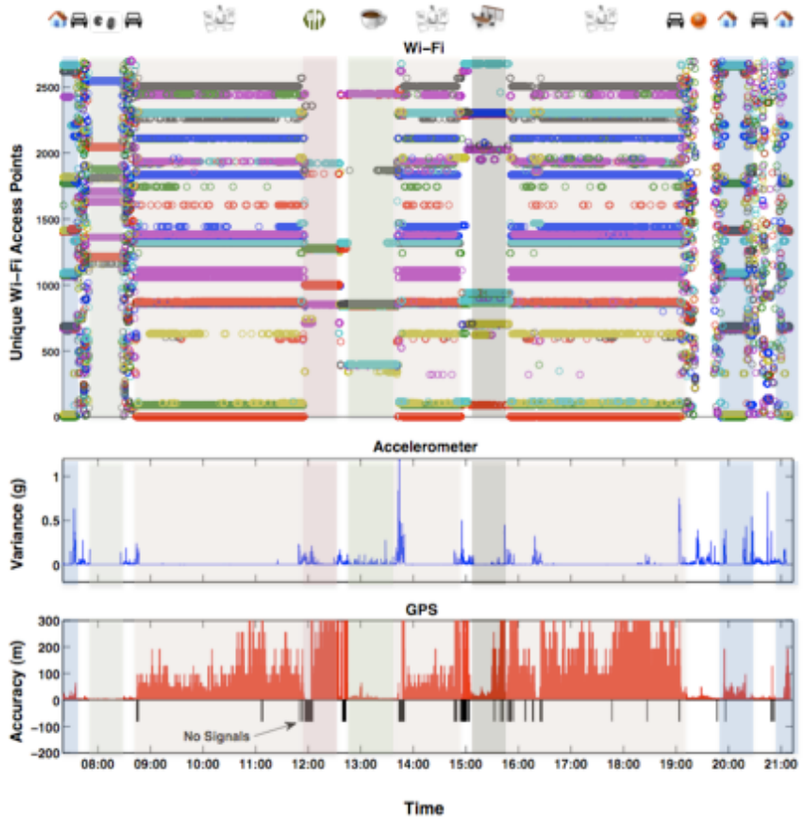
- Battery and resource monitor continuously guides applications to consume enough power to meet the deadline; trading off fidelity/resolution

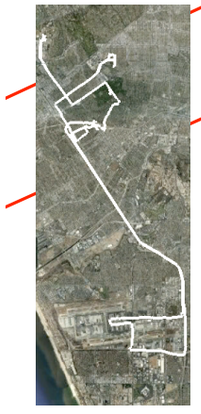
Falaki, et al

Semantic places and path

Objectives
- energy-efficiently sense semantic locations on battery-limited mobile devices
- automatically learn and recognize semantic places and paths closer to user's interpretation of location
- motivate user feedback to bridge between machine-learned and human-defined places

Selectively leverage GPS/Wi-Fi/Accelerometer when each is informative/efficient
- people spend approximately 89% indoors, 5% in a vehicle, and 6% at outdoors on average

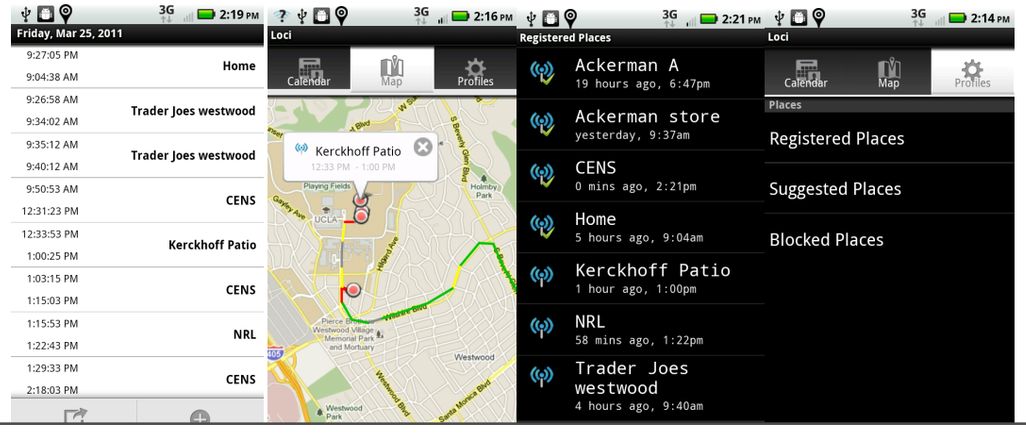




Signal patterns of surrounding RF beacons are noisy but useful for detecting semantic places

Many power saving opportunities exists when the device is immobile

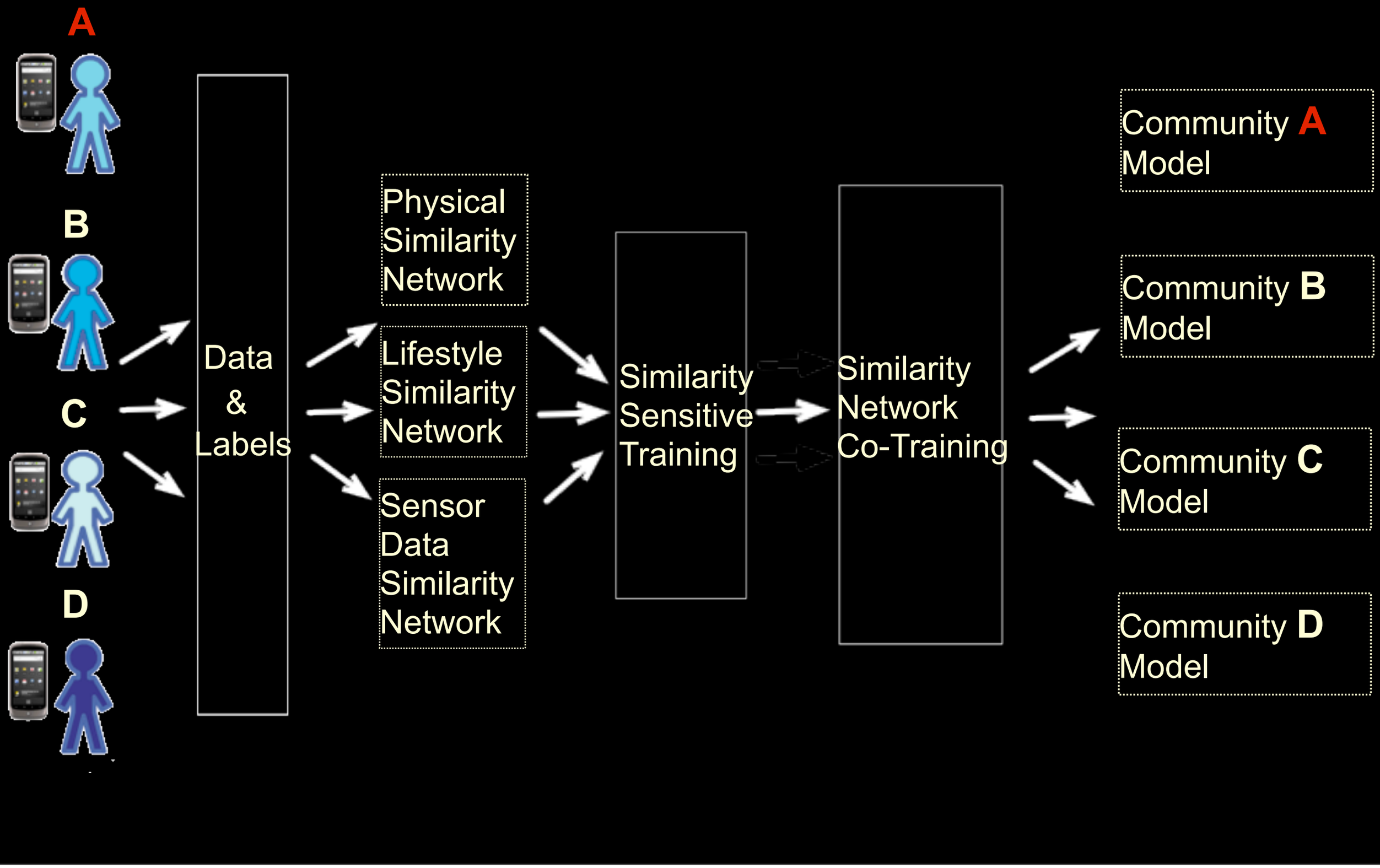
GPS position fixes are inaccurate most of the time but informative when traveling paths connecting places



Sensor traces from a single day following a normal routine

User modeling (sic) Using community similarity networks

to handle population diversity (T. Choudhury, Cornell)



User engagement: informational incentives, feedback, game mechanics

Informational incentives, e.g., analytics about actions, encourage participation initially--See Consolvo, Choudhury, Mynatt

Micro-payments/rewards promoted even (sustained) participation in community data gathering--might also apply for participatory mHealth **Reddy, et al 2009:**

- Micro-payments based on competition worked best for short bursty data collections
- Very low baseline micro-payments discouraged individuals

Future directions: game mechanics, social media tie-ins, goal setting and monitoring tools, adaptive over time for sustainability, configurable

Mobile Ambient Wellbeing Display (T. Choudhury, Cornell)

Personal Data Vault (PDV):

allow participants to retain control over their raw data by decoupling capture and sharing

Mobile App

- Data Capture / Upload (Prompted, Automated)

- Reminders

- Feedback, Incentives

Well defined interfaces allow mobile functions to be mixed, matched, and shared

Personal Data Vault

- User Identity and Authentication

- Long-term Data Management

Patient defined selective sharing with Open mHealth Server function

Third Party Services

- Analytics for Personal Data Streams

- Interface to Clinical Care Plan, Personnel

- Integration with EHR/PHRs

- Cross Patient Aggregation

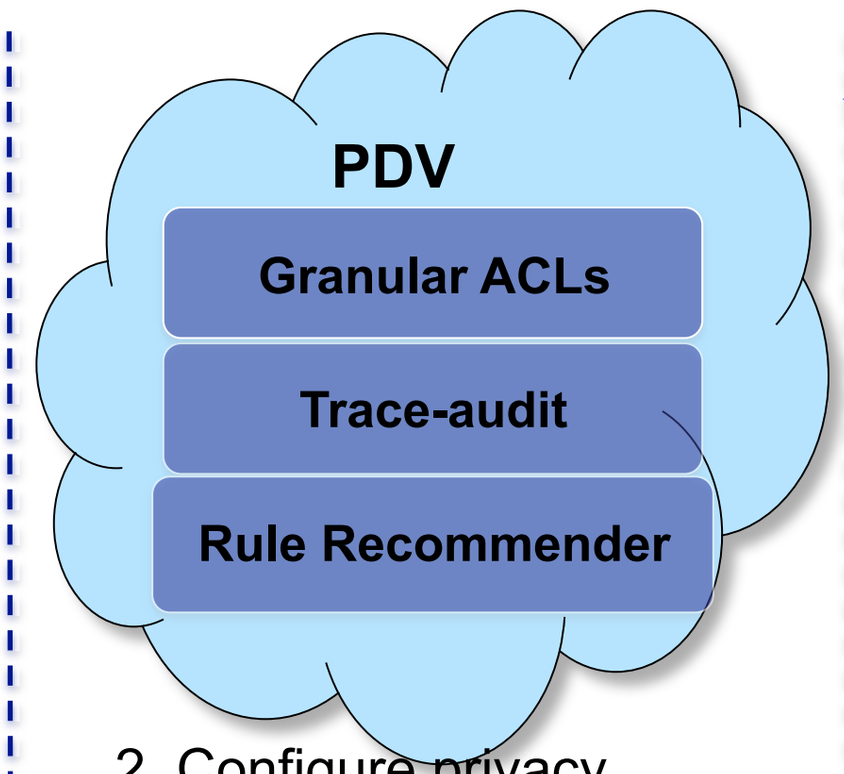
Well defined interfaces allow analytics functions to be mixed, matched, shared, compared

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

M. Mun, et al, CONEXT 2010

But...can we make selective sharing usable?

1. Upload raw data



2. Configure privacy policies/ACLs

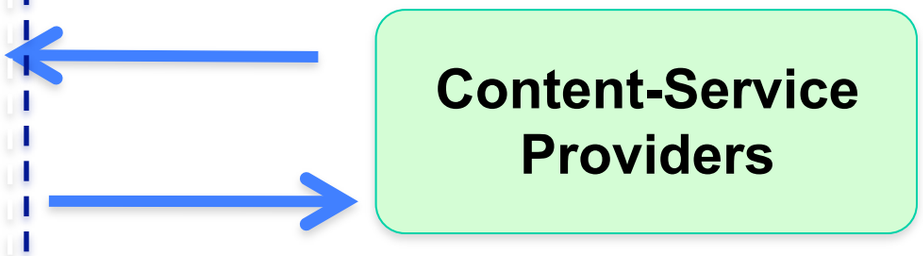
4. Filter data to send

5. Send the filtered data

Step 6 and 7 can be repeated

6. Check easy-to-read reports about continuous data sharing

7. Reconfigure ACLs

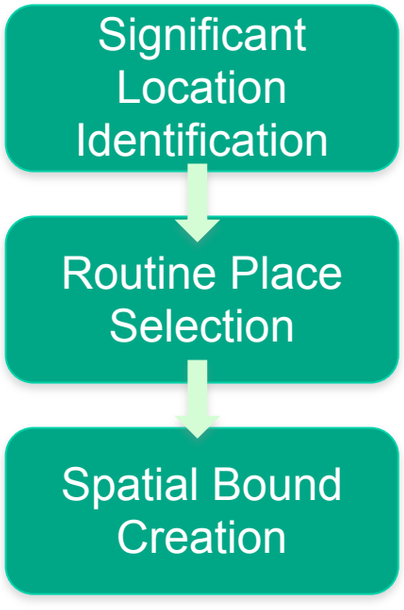


2. Configure privacy policies/ACLs

3. Request data

Granular ACLs: **bounds, precision, frequency across time, space,**

Rule Recommender



M. Mun, et al, CONEXT 2010

Importance of an open platform: avoid silos, promote innovation and transparency

Bootstrap rapid cycle of learning, sharing, deployment

- -~80 % (guesstimate) system components reusable
- -Largest missing pieces: ***authoring***, ***analysis-visualization***, ***feedback***

Facilitate research in methodology, treatment

- -Systems gather usage data automatically for evaluation, iterative improvement
- -Encourage modularity and sharing in methodologies, practice

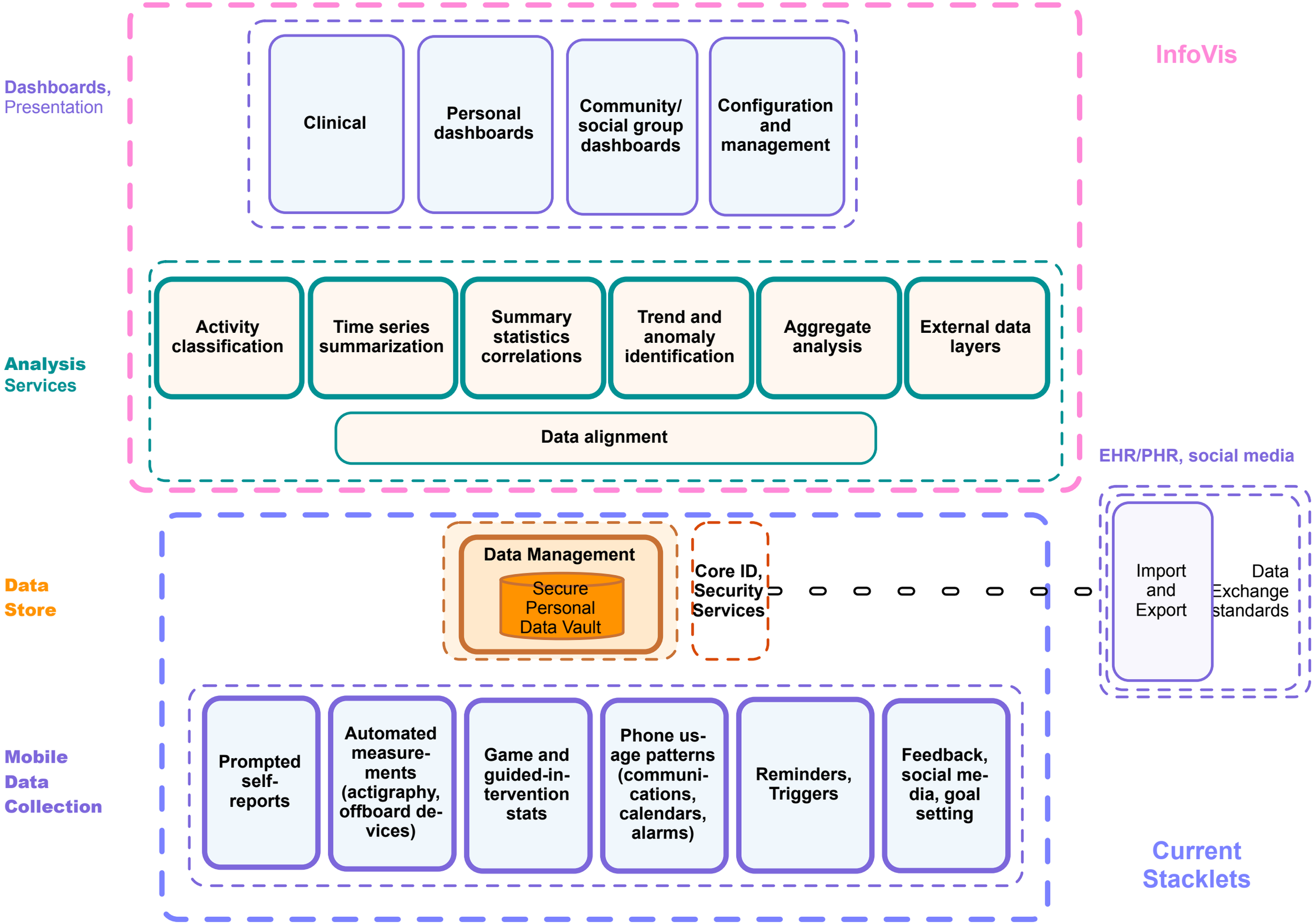
Development in the context of real applications and use

- -Collaborative/participatory design process with continual feedback from users
- -Diverse targeted pilots inform generalization, adaptation, expansion.

Explore balancing of privacy protection and data sharing

- -Variety of privacy/sharing policies
- -STransparency of research and data processes for participants

Open mHealth System: functional components



Closing remarks (aka parting shots)

"Approximately 25 years ago, government and industry invested in expanded access at a crucial time in the Internet's development. The resulting networks and ubiquity of access provided fertile ground for technologies, ideas, institutions, markets, and cultures to innovate. The payoff from this investment created a commercially viable and largely self-governing ecosystem for innovation.

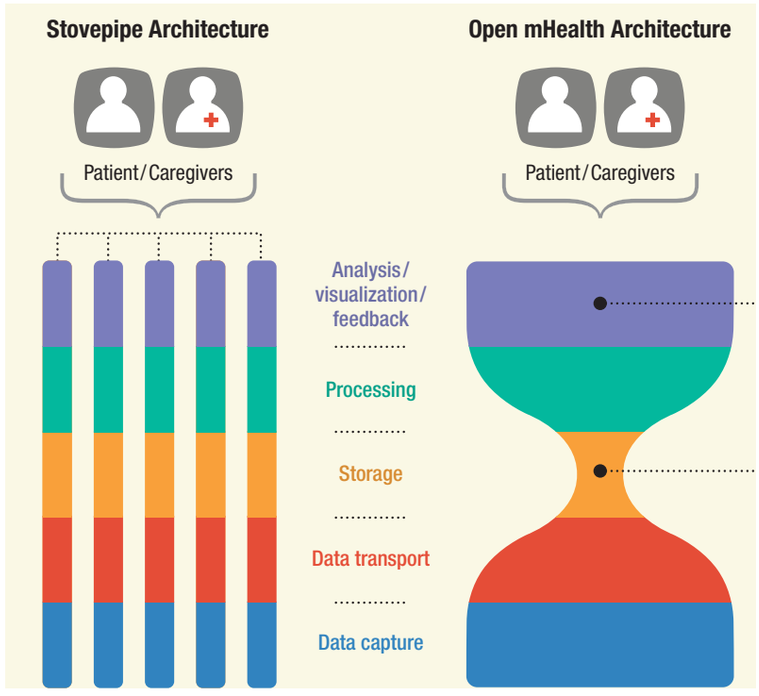
The same can be done for global health. Government, commercial, and nongovernmental entities involved in health IT and innovation should cooperate to define and instantiate architecture, governance, and business models and to steer initial mHealth investments into open architecture."

- D Estrin, I Sim. Open mHealth Architecture: An Engine for Health Care Innovation. Science Magazine, Nov, 2010.

Summer reading recommendations:

The filter bubble, Eli Pariser

Everything is Obvious*, *once you know the answer, Duncan Watts



Open mHealth initiative: http://openmhealth.org

Acknowledgments: Collaborators and Sponsors

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