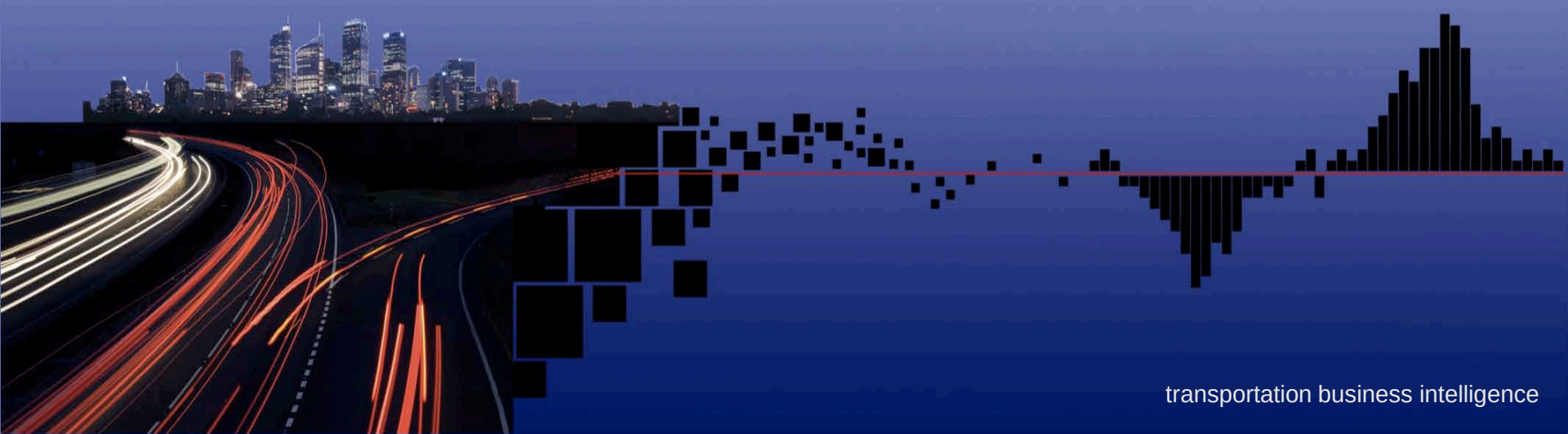
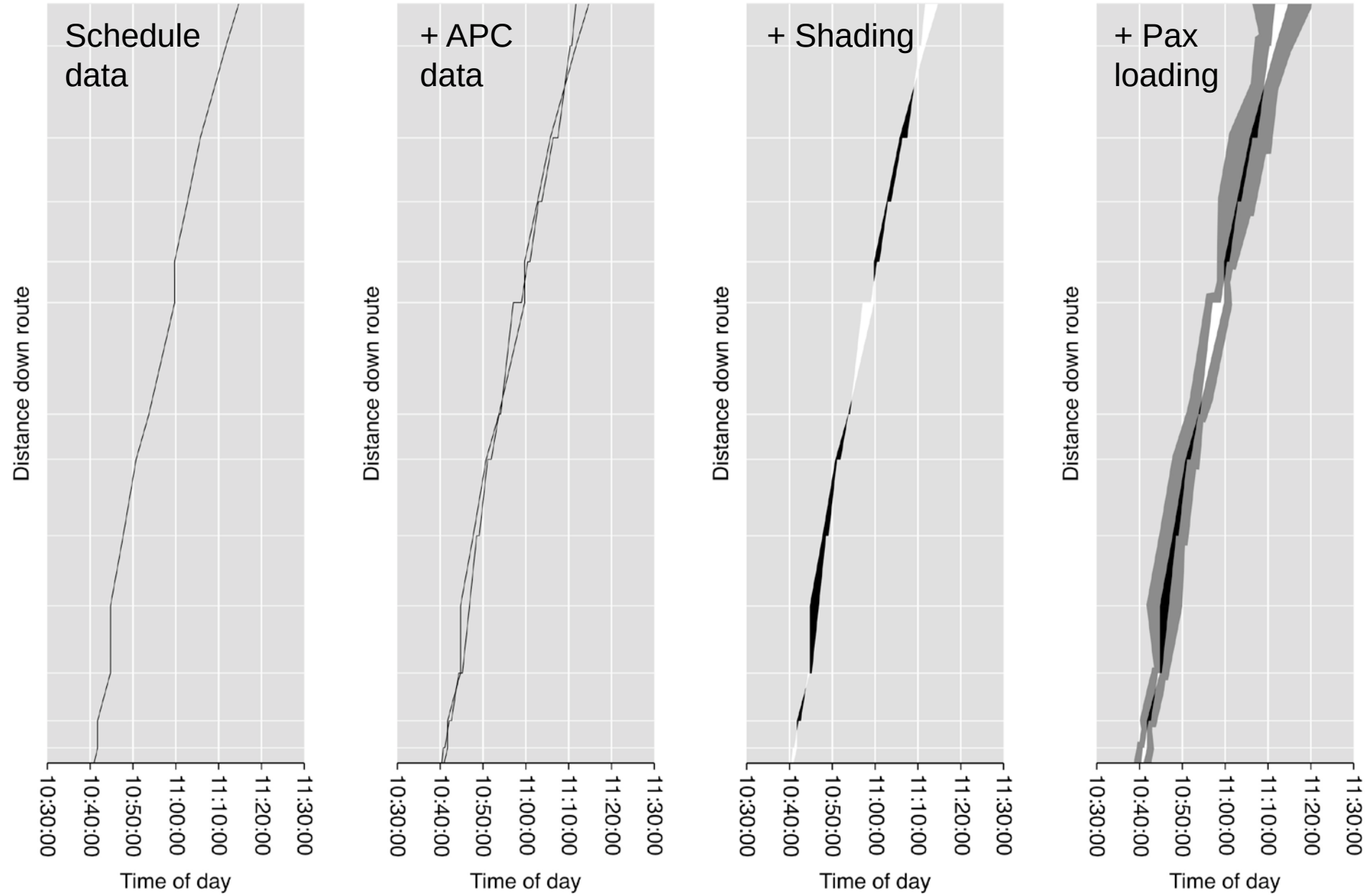
Oct 2011

Visualizing Bus Schedule Adherence and Passenger Load through Marey Graphs

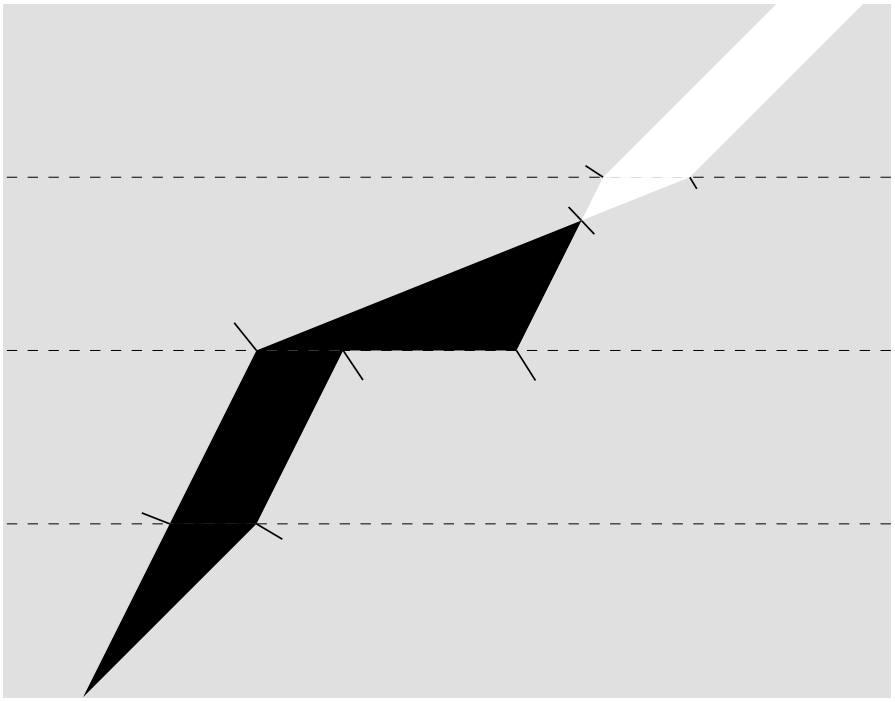
ITS World Congress

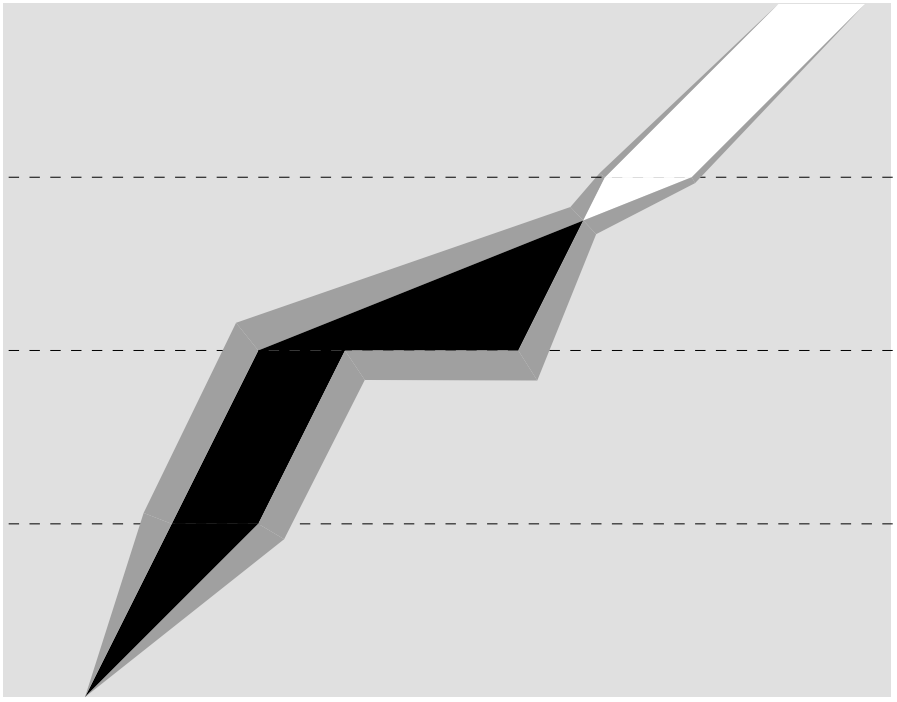


Constructing Marey Graphs



Depicting Passenger Load





For ICM:
Bay Tripper
Current Technology Research

Raja Sengupta

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Bay Tripper Research

ICM Task: Port from Iphone to Android

Bay Tripper Claim to Fame

- Cool client design – Eric Mai
- Real-time Transit Routing – Jerry Jariyasunant
  - Based on NextBus relationship (Jerry)

BayTripper: Client Side Features and Usage

September 28, 2011

BayTripper

Home | About Us | Media | Feedback

Real-Time Transit Information for Mobile Phones

Thanks for checking out BayTripper!

We are a couple students from UC Berkeley who created this app to help users in San Francisco get around by finding their way through transit and bike routes. This is part of a research project trying to understand how to get more people to get out of their cars and onto bikes, public transportation, or just walk!

Download BayTripper now for FREE!

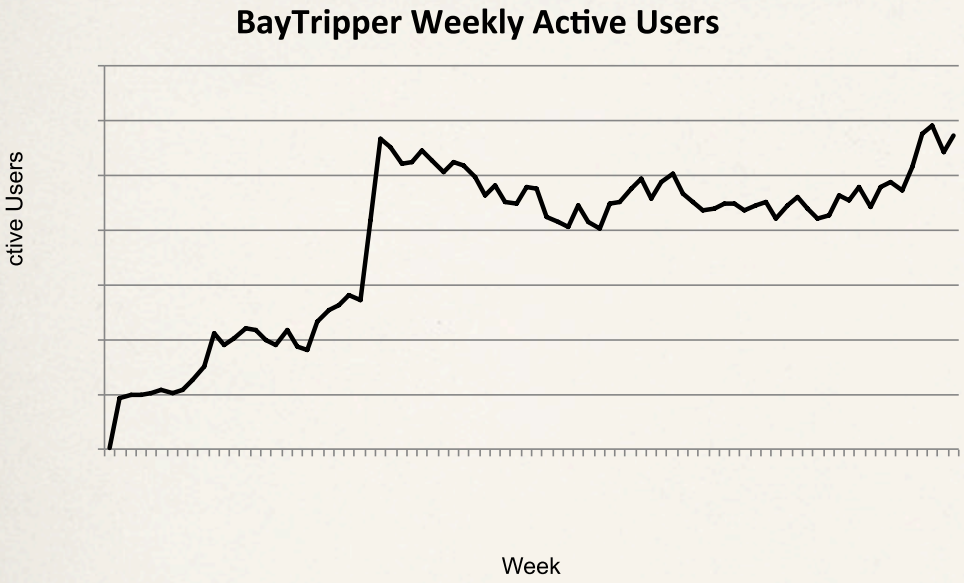
Our app lets you...

- Get real-time arrivals for MUNI and BART
- Plan a trip with our Real-time Transit Trip Planner
- Plan a bike trip with your own personal preferences for safety and hill tolerance (powered by www.bikesy.com)
- Look up schedules for Caltrain, BART, and Bay Area Ferries (Blue and Gold Fleet, Golden Gate Ferry, Alameda Harbor Bay Ferry) to Sausalito, Larkspur, Alameda, Oakland, Vallejo, and more
- Look up local transit maps from Muni, BART and Caltrain
- Call a taxi from a list of popular cab companies in San Francisco

The transit trip planner uses real-time data provided by NextBus, which takes into consideration the actual location of buses, delays and tries to help users avoid missed transfers. At this time, users can only plan trips within San Francisco (including Treasure Island).

Follow us on Twitter for updates on BayTripper!

Usage Statistics

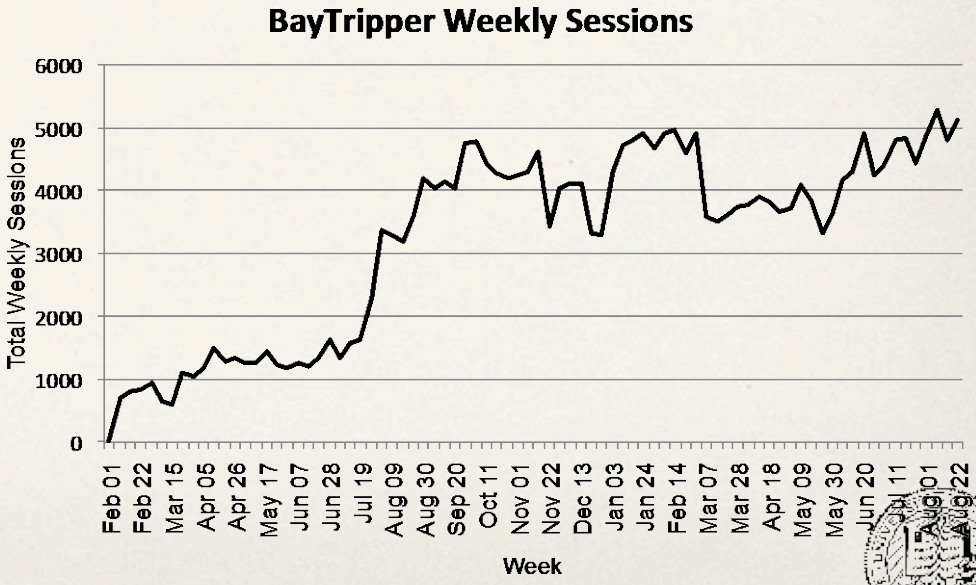


Active Users represent 11.3% of total downloads.

"Users stop using the average applications quickly. Long term audiences are generally 1% of total downloads" - Pinch Media http://www.techcrunch.com/2009/02/19/pinch-media-data-shows-the-average-shelf-life-of-an-iphone-app-is-less-than-30-days

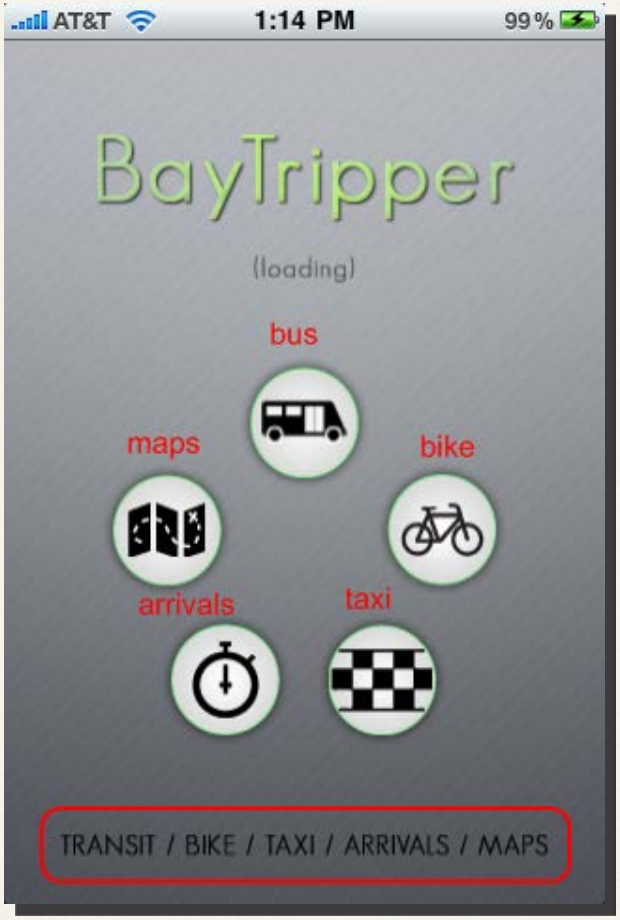
1,142 active users and 5,126 total sessions the week of August 22.

BayTripper has not been publicized. Steady usage increases have come through word of mouth.



Usage Statistics

BayTripper Features



App Store › Navigation › Civil Systems @ UC Berkeley

BayTripper

Description

BayTripper is an easy and fun way to get around the whole Bay Area on bike and also tap into real-time routing information for San Francisco, California on BART and MUNI.
...

...More

Civil Systems @ UC Berkeley Web Site › **BayTripper Support ›** **Application License Agreement ›**

Free App

Category: Navigation
Updated: Mar 23, 2011
Version: 2.43
iOS 4.0 Tested
Size: 4.8 MB
Language: English
Seller: Jerald Jariyasunant
© 2009 UC Berkeley

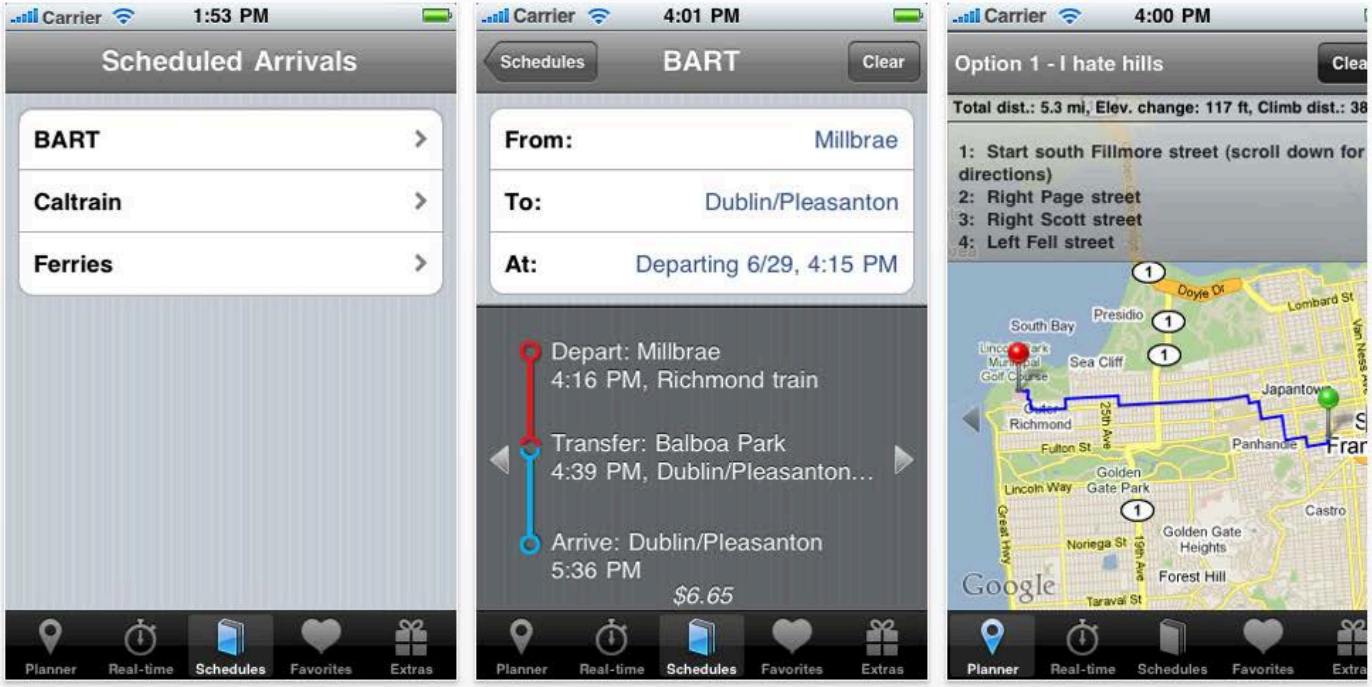
Rated 4+

Requirements: Compatible with iPhone, iPod touch, and iPad. Requires iOS 3.0 or later

What's New in Version 2.43

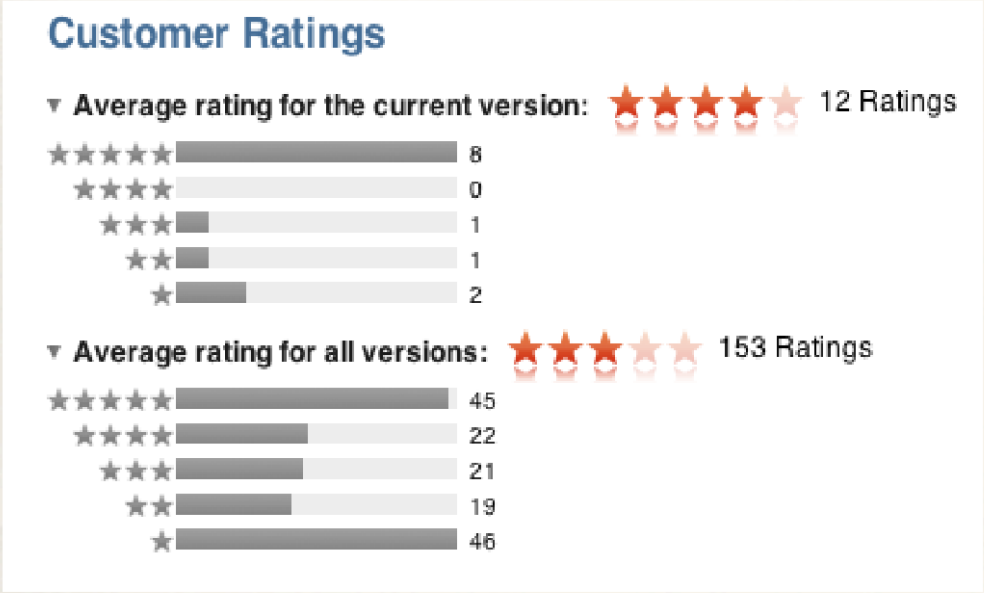
Fixed the favorites problem: you can favorite SF Muni stops again.

iPhone Screenshots



BayTripper Demo

BayTripper Reviews



"Thanks for the fix with that MUNI bug! Awesome app, I use this everyday and sometimes to plan long bike rides on the go." - shuffleman

"Hey this app is the beat sf app hands down! It's got everything you need and a map!" - klok99ah

"Loveeeee it. Just let me rearrange my faves. A+" - Pont0005

Bay Tripper: Server Side

- Real-time Transit Routing – Jerry Jariyasunant
  - Based on NextBus relationship (Jerry)

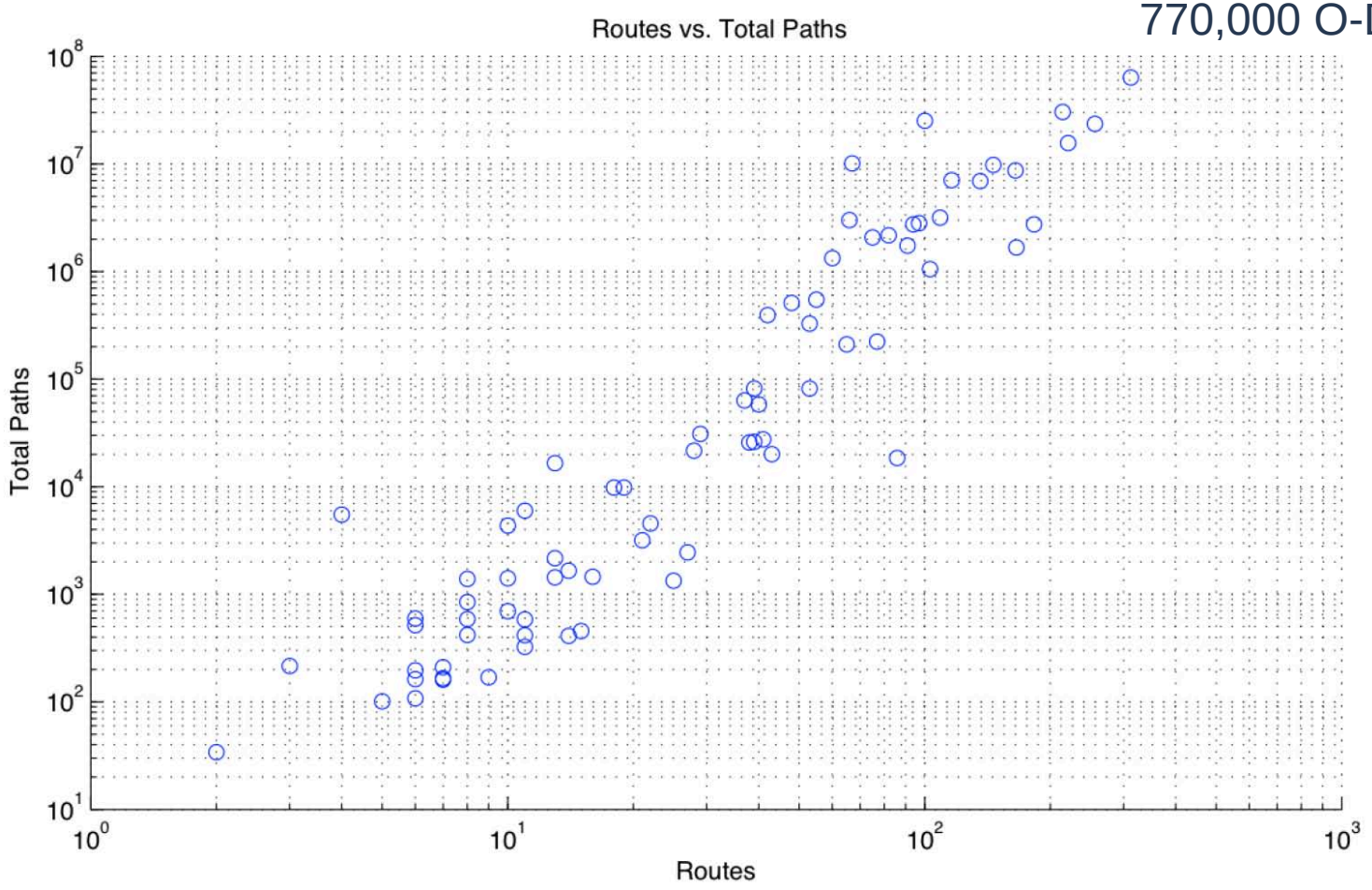
Real-time Routing: Challenges

- High dimension Routing Problem
- Bus data provider web API limits data per request
  - Cannot ask for database dump
- Serve the customer within 2-3 seconds (R. Jain, T. Raleigh, C. Graff, and M. Bereschinsky, "Mobile internet access and qos guarantees using mobile ip and rsvp with location registers," IEEE Int. Conf. Commun., vol. 3, pp. 1690–1695, 1998.

  T. Erl, Ed., Service-oriented architecture (SOA): concepts, technology, and design. Prentice Hall, 2005)
  - Solution: Querying NextBus per customer query

Complexity of real-time transit routing 1

770,000 O-D's

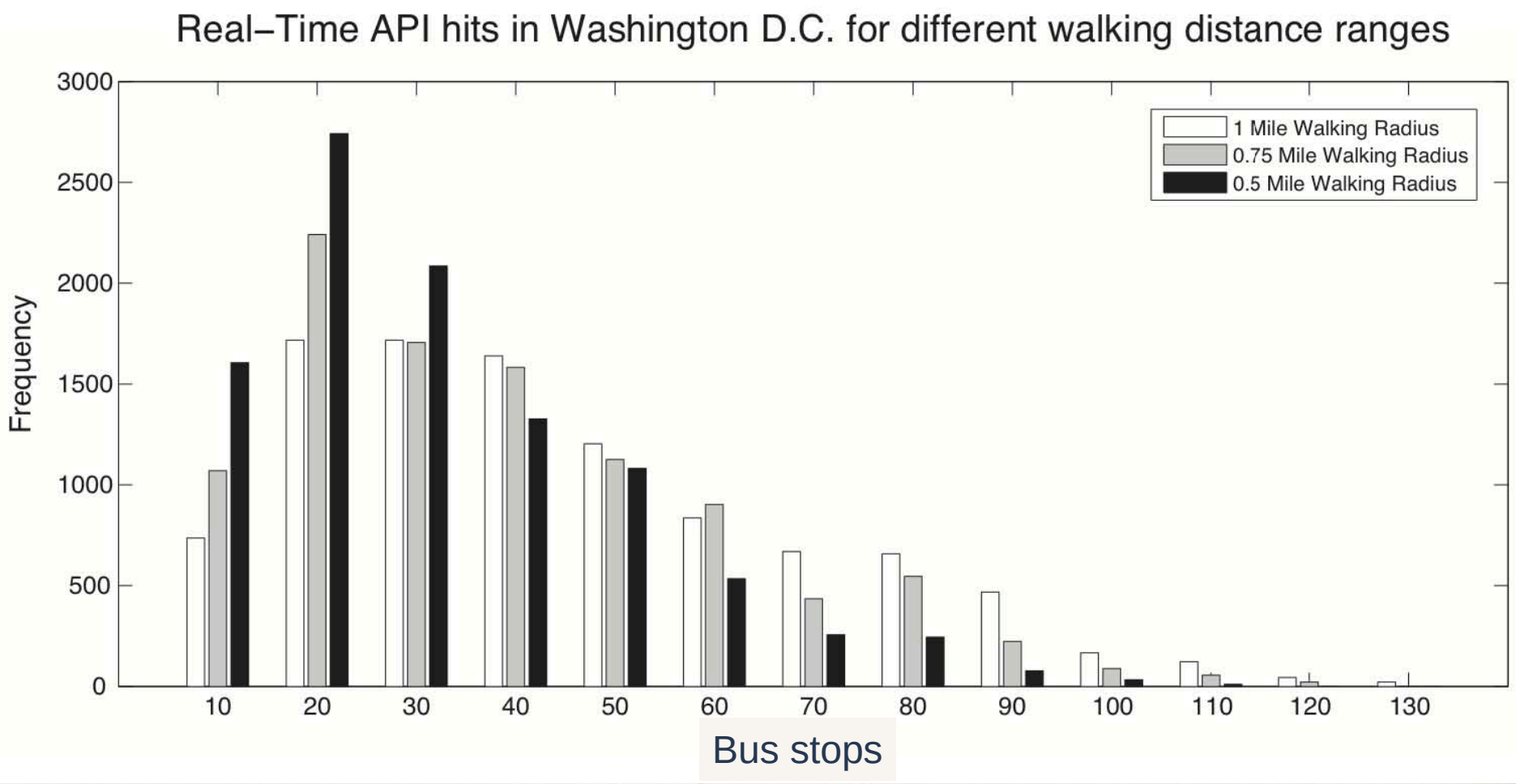


Technical Approach: Real-time routing for transit

- Map user O-D to set of networks OD's
  - Line sources and sinks
- For each network OD pre-compile a list of routes
  - Based on GTFS specification and schedule (off-line)
    - Hundreds to thousands of routes for each O-D
    - Real-time Query NextBus for data for each list
      - Reduces hundreds of routes to 10's of stops
- Pick the minimum off each list and return to client

Similar to: H. Bast, S. Funke, P. Sanders, and D. Schultes, "Fast routing in road networks with transit nodes," Science, vol. 316(5824):566, 2007.
Geisberger, R. Sanders, P. Schultes, D. and Delling, D., "Contraction Hierarchies: Faster and Simpler Hierarchical Routing in Road Networks",: Experimental Algorithms, Lecture Notes in Computer Science(2008) 319-333

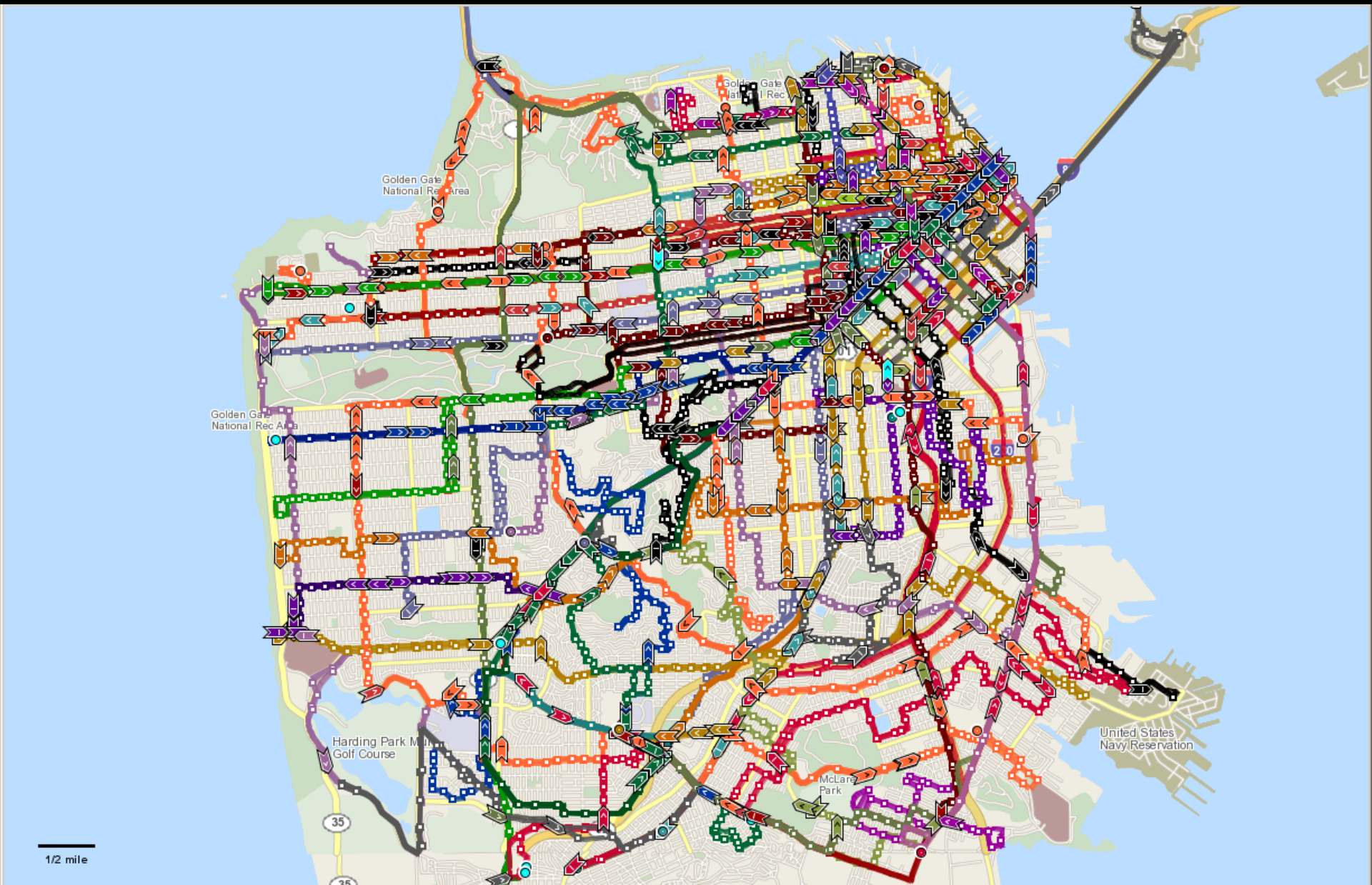
Complexity of real-time transit routing 2



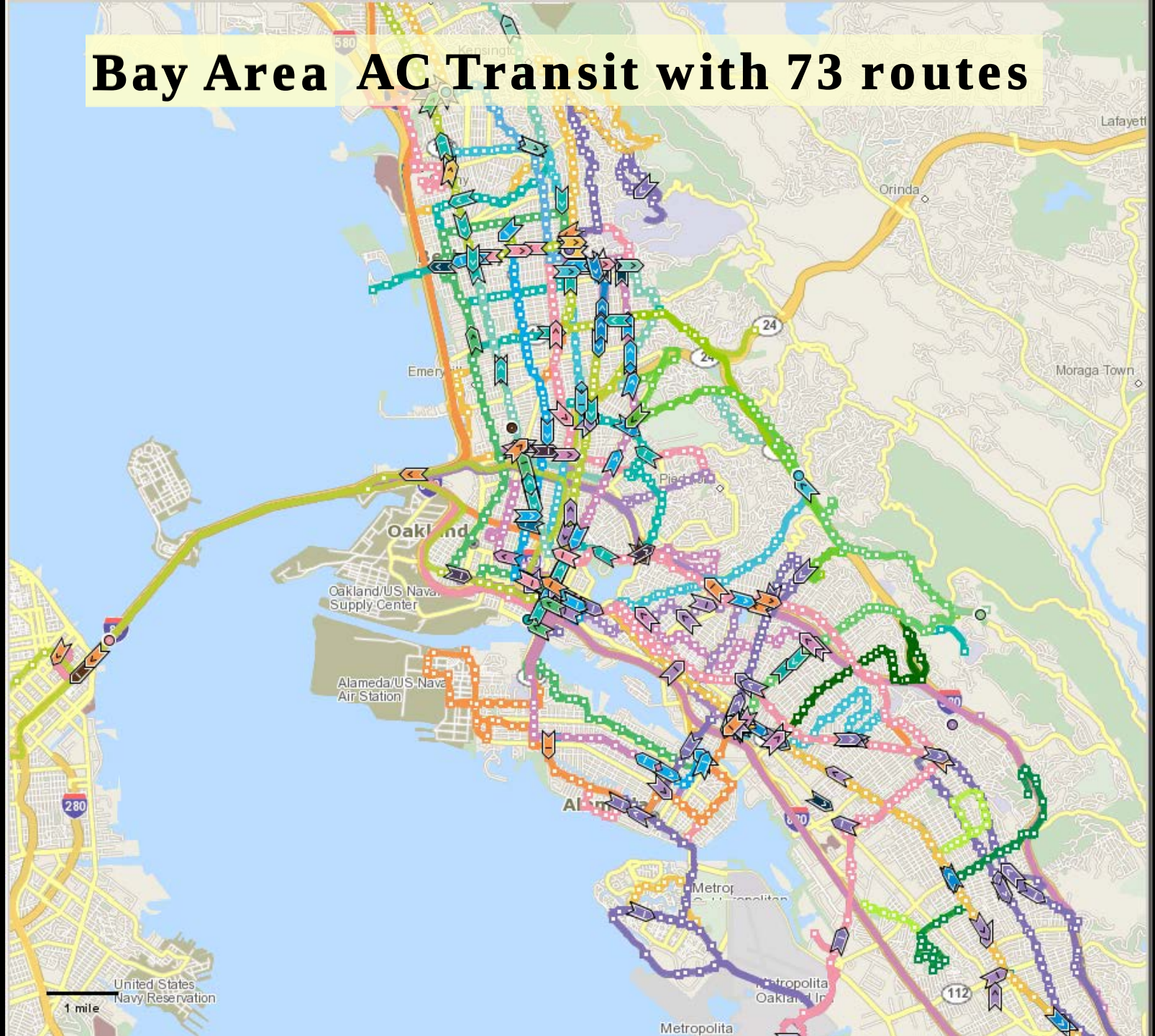
Server Tools

- Behind the scenes of BayTripper: Routing Algorithms
- Custom Tools to import any transit agency (GTFS) into our system and run a real-time transit trip planner (If they use NextBus). Currently hold data on 77 agencies nationwide.
- Use Graphserver, an open-source multi-modal trip planner to do custom biking directions for personalized hill tolerance and safety level
- Recently ran 10,000 simulations per agency to test robustness
- Walking/Driving directions next

San Francisco MTA with 87 routes



Bay Area AC Transit with 73 routes




Los Angeles MTA pilot with 192 Routes
Glendale
Los Angeles
Pasadena
Sierra Madre
Monterey Park
East Los Angeles
Pico Rivera
Whittier
Hawthorne
El Segundo
Santa Monica
Culver City
Beverly Hills
La Crescenta-Montrose
La Canada Flintridge
San Gabriel
2 miles

Current Technology Development Research

Behavior Change Technology

- Past: Safer Driving
  - Networked Traveler – Slow Traffic Ahead
- Changing Mode Choice Behavior
  - UCTC, Caltrans
- Shopping Behavior
  - CITRIS Seed

Mode Choice Behavior

- The basic idea
- Technologies

The Quantified Traveler

Visualizing GPS Data but for the traveler

Raja Sengupta

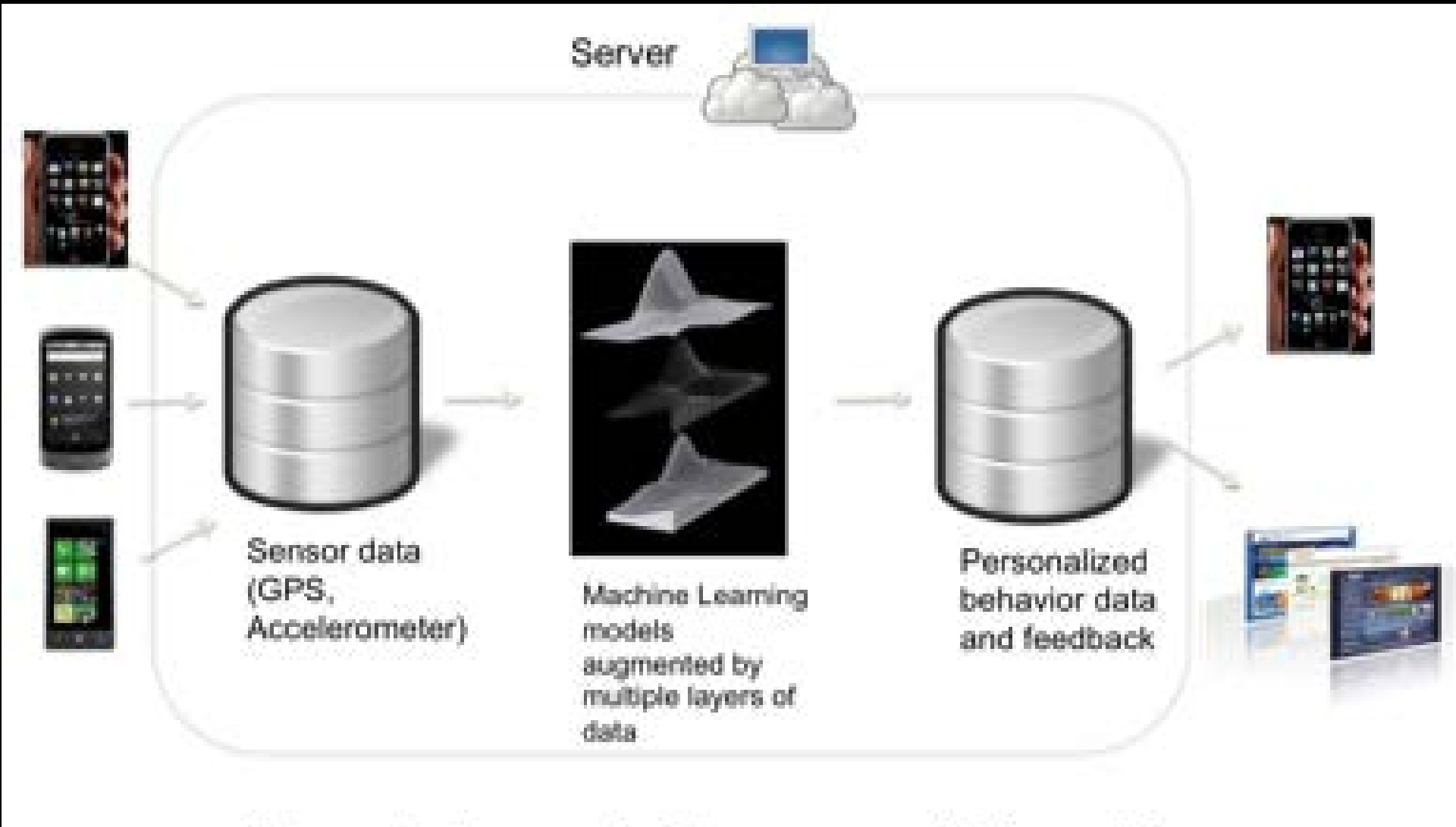
CEE: Systems, UC Berkeley

Nudging Behavior

Quantified Self

- Applications that
  - Record behavior
  - Process data
  - Feed it back
- Goals
  - Better understand patterns
  - Adapt behavior more intelligently
- Examples
  - Fitness
  - Mood
  - Sleep
  - Spending habits

Our Quantified Traveler System



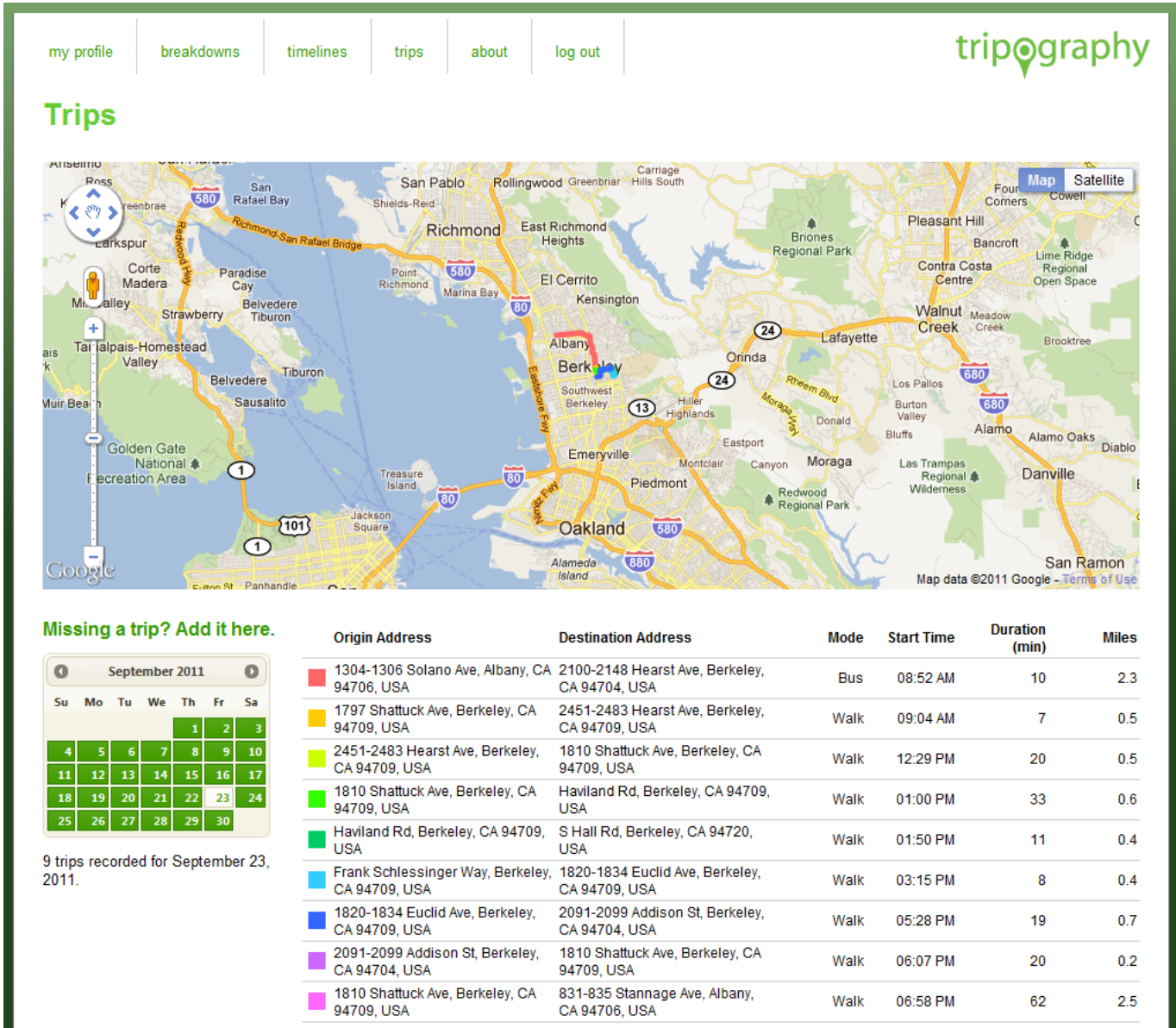
Quantified Traveler

Smartphone tracking

Trip determination

Website feedback

Social Comparisons



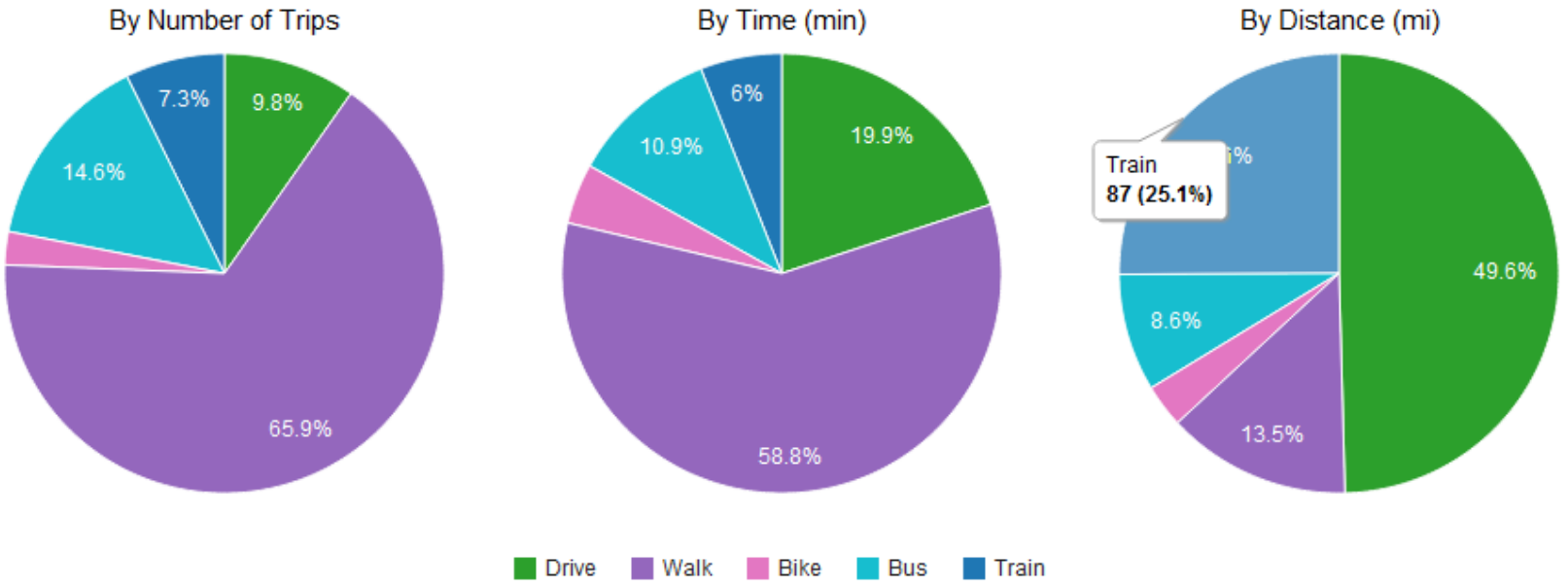
Origin Address	Destination Address	Mode	Start Time	Duration (min)	Miles
1304-1306 Solano Ave, Albany, CA 94706, USA	2100-2148 Hearst Ave, Berkeley, CA 94704, USA	Bus	08:52 AM	10	2.3
1797 Shattuck Ave, Berkeley, CA 94709, USA	2451-2483 Hearst Ave, Berkeley, CA 94709, USA	Walk	09:04 AM	7	0.5
2451-2483 Hearst Ave, Berkeley, CA 94709, USA	1810 Shattuck Ave, Berkeley, CA 94709, USA	Walk	12:29 PM	20	0.5
1810 Shattuck Ave, Berkeley, CA 94709, USA	Haviland Rd, Berkeley, CA 94709, USA	Walk	01:00 PM	33	0.6
Haviland Rd, Berkeley, CA 94709, USA	S Hall Rd, Berkeley, CA 94720, USA	Walk	01:50 PM	11	0.4
Frank Schlessinger Way, Berkeley, CA 94709, USA	1820-1834 Euclid Ave, Berkeley, CA 94709, USA	Walk	03:15 PM	8	0.4
1820-1834 Euclid Ave, Berkeley, CA 94709, USA	2091-2099 Addison St, Berkeley, CA 94704, USA	Walk	05:28 PM	19	0.7
2091-2099 Addison St, Berkeley, CA 94704, USA	1810 Shattuck Ave, Berkeley, CA 94709, USA	Walk	06:07 PM	20	0.2
1810 Shattuck Ave, Berkeley, CA 94709, USA	831-835 Stannage Ave, Albany, CA 94706, USA	Walk	06:58 PM	62	2.5

Quantified Traveler

my profile | breakdowns | timelines | trips | about | log out

tripography

How You Get Around

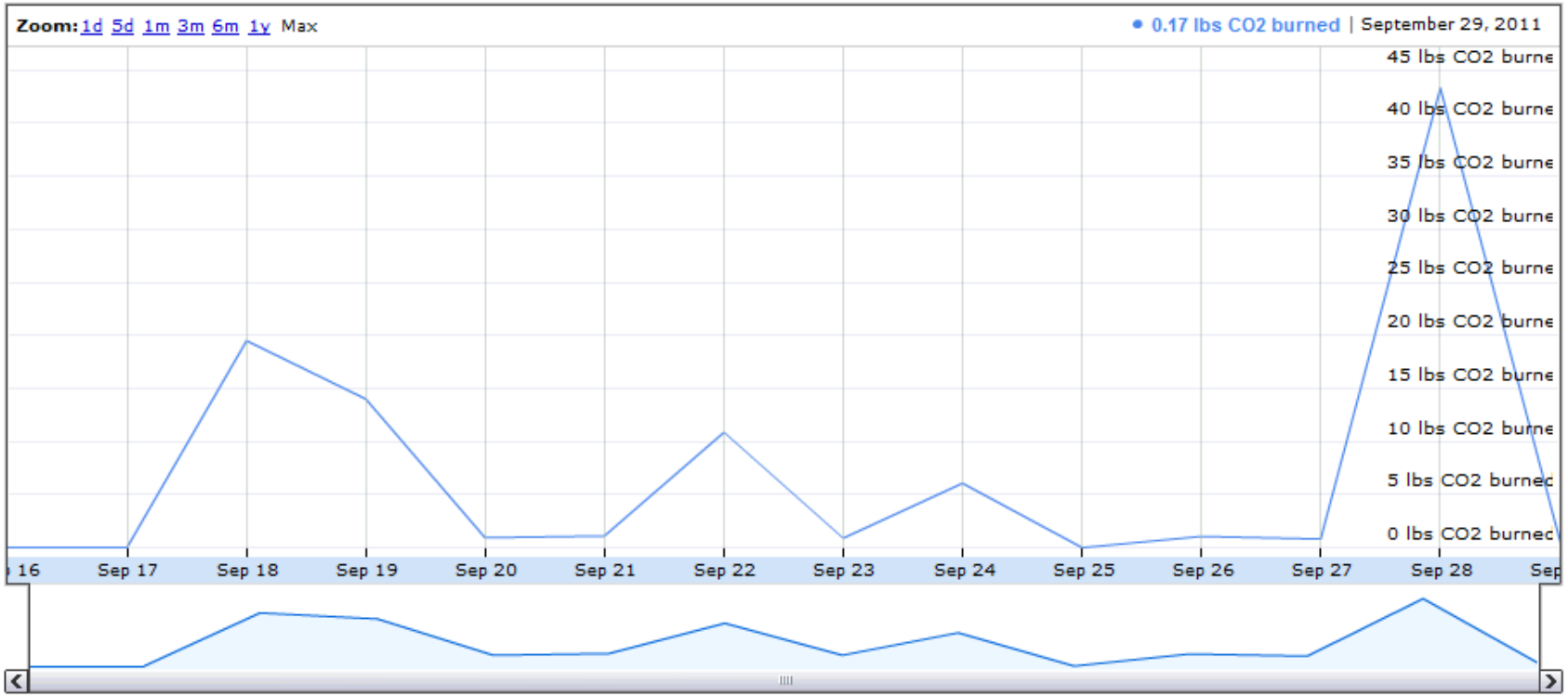


Quantified Traveler

my profile | breakdowns | timelines | trips | about | log out

tripography

Cost | Calories | Time | Emissions



Quantified Traveler: Social Comparisons

summary | breakdowns | timelines | trips | about | log out

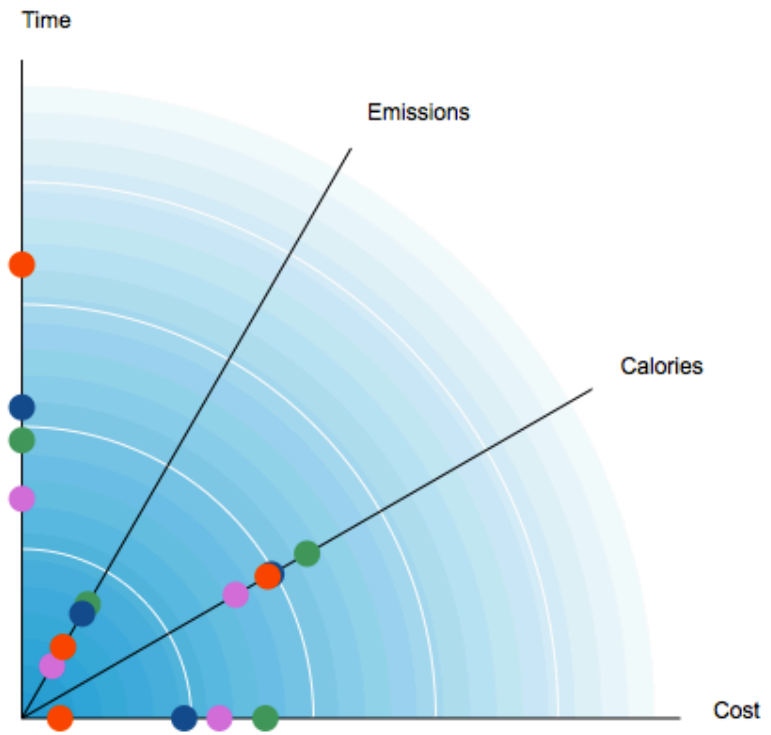
tripography

dvizzini

Total Trips Logged 82
Total Miles Logged 347
Total Time Logged 1736 minutes

Average Travel Statistics

- Bay Area
- National
- Study Group
- You



July Field Test: Procedure

- Participant group: 28 young professionals
- Duration: 2 weeks of self-tracking
  - First 5 days: No feedback.
  - 5th day: Users receive feedback website link

    information on environmental, health, financial and time footprint of travel behavior.
  - Day 6 to 14: Regular updates by e-mail.
- Survey administered before and after experiment

  Questions on:
  - awareness of impacts of transportation behavior
  - attitudes toward sustainable travel behavior

Travel Patterns of 25 Subjects

Figure 3: Mode split by number of trips made (Drive: 30.34%, Walk: 43.65%, Bike: 13.50%, Bus: 4.63%, Train: 7.49%, Light Rail: 0.39%)

Figure 4: By total travel time (Drive: 45.11%, Walk: 24.63%, Bike: 10.49%, Bus: 11.39%, Train: 8.12%, Light Rail: 0.25%)

Sample Survey Questions

Category	Sample Question
Awareness	I know how much CO_2 I emit from my daily transportation.
Self-Efficacy	I can get exercise when traveling.
Perceived Norms	My friends actually engage in sustainable transportation behavior (carpooling/biking/walking/taking public transit)
Setting Goals	I would consider setting a goal to reduce my carbon footprint.
Attitudes on Sustainable Behavior	I value the benefits to society when I take sustainable modes of transportation.

Table 2: Sample questions given to participants at the beginning and end of the study

Survey Results

	Mean (before)	Mean (after)	Standard Deviation (before)	Standard Deviation (after)	t-statistic	p-value
Awareness	2.91	3.75	0.22	0.27	2.8210	0.0106
Perceived norms	5.64	5.60	1.17	0.98	0.2483	0.8065
Setting goals	4.14	4.36	0.90	1.05	1.0141	0.2060
Attitudes toward sustainable behavior	5.12	5.38	1.18	0.95	2.2326	0.0372

Table 3: Comparison of participants' survey answers before and after tracking and feedback

Results

- 1016 trips logged during the 2 weeks (approx. 2.9 per day and person)
- All users visited website at least once; good user feedback on website

- Survey results:
  - All awareness questions (environment, health, money, time) showed positive change; environmental awareness was strongest.
    - E.g., “I know how much CO2 I emit from transportation”
  - Statistically significant positive changes attitudinal questions on sustainable transportation
    - E.g., “We should raise the price of gasoline to reduce congestion and air pollution
  - Positive correlation between car use and attitudes toward sustainable travel

Evaluations to Date

- 45,000+ miles of travel collected
- 10 Students in DeCal class
- 25 Subjects in July Experiment
- 25 BetaTesters recruited by MileSense

Quantified Traveler: Under the hood

- July Field Test System
  - 1 Hz GPS data
    - 25% battery drain per hour (Nexus One)
    - Iphone- 7% (moving, 3% not moving)
  - Not deployable at scale
  - Mode Determination Excellent
- Can we bring energy consumption down to make it deployable at scale while maintaining accuracy of trip determination, mode determination, GHG estimates, ….
  - **October design now being evaluated**

The Mode Determination Problem

Computer science community's definition

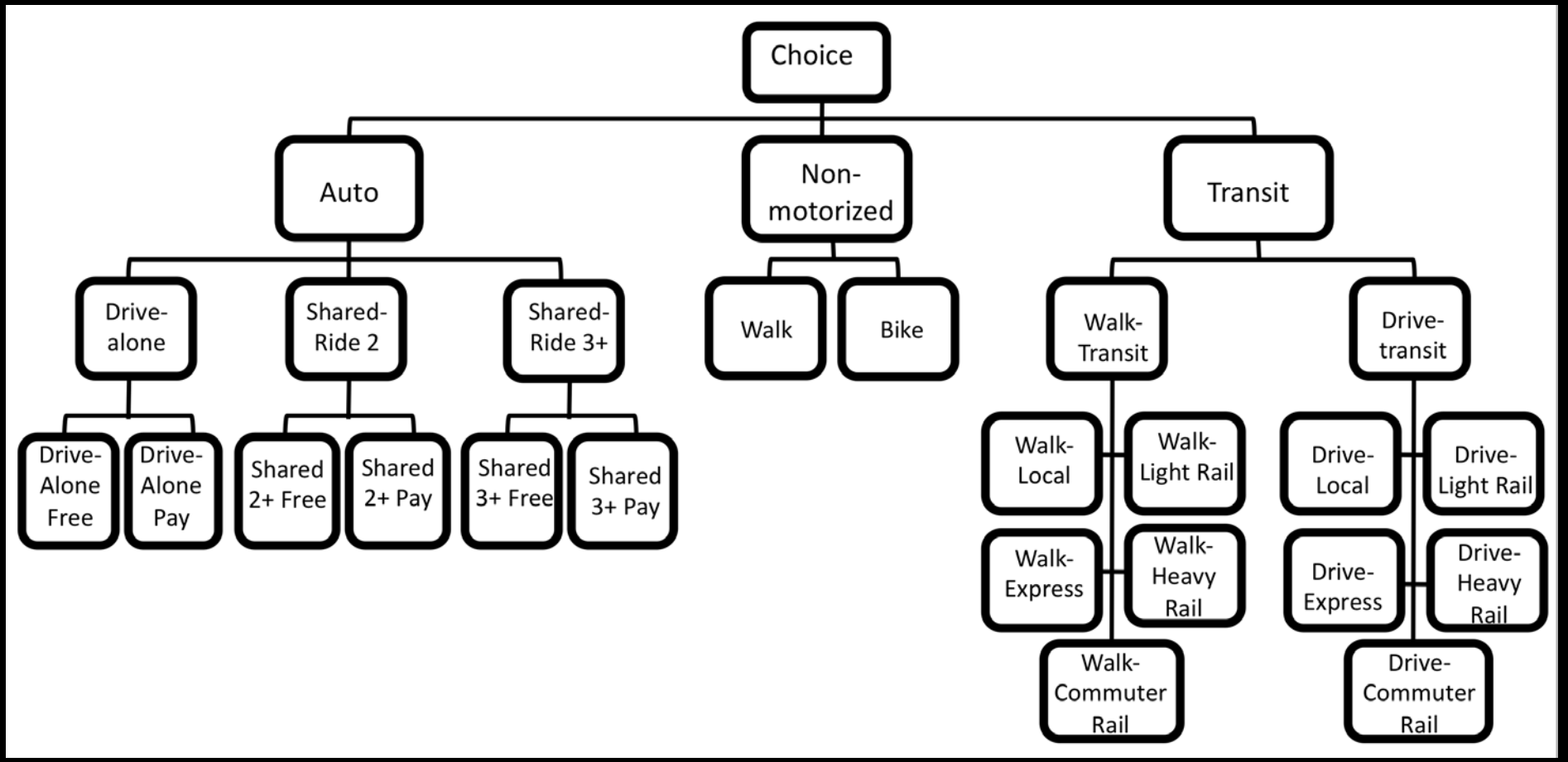
- Instant mode determination: identify the transportation mode used <u>at each time instant</u> (*as walking, biking, driving etc.*)

Can we link?

Transportation community needs

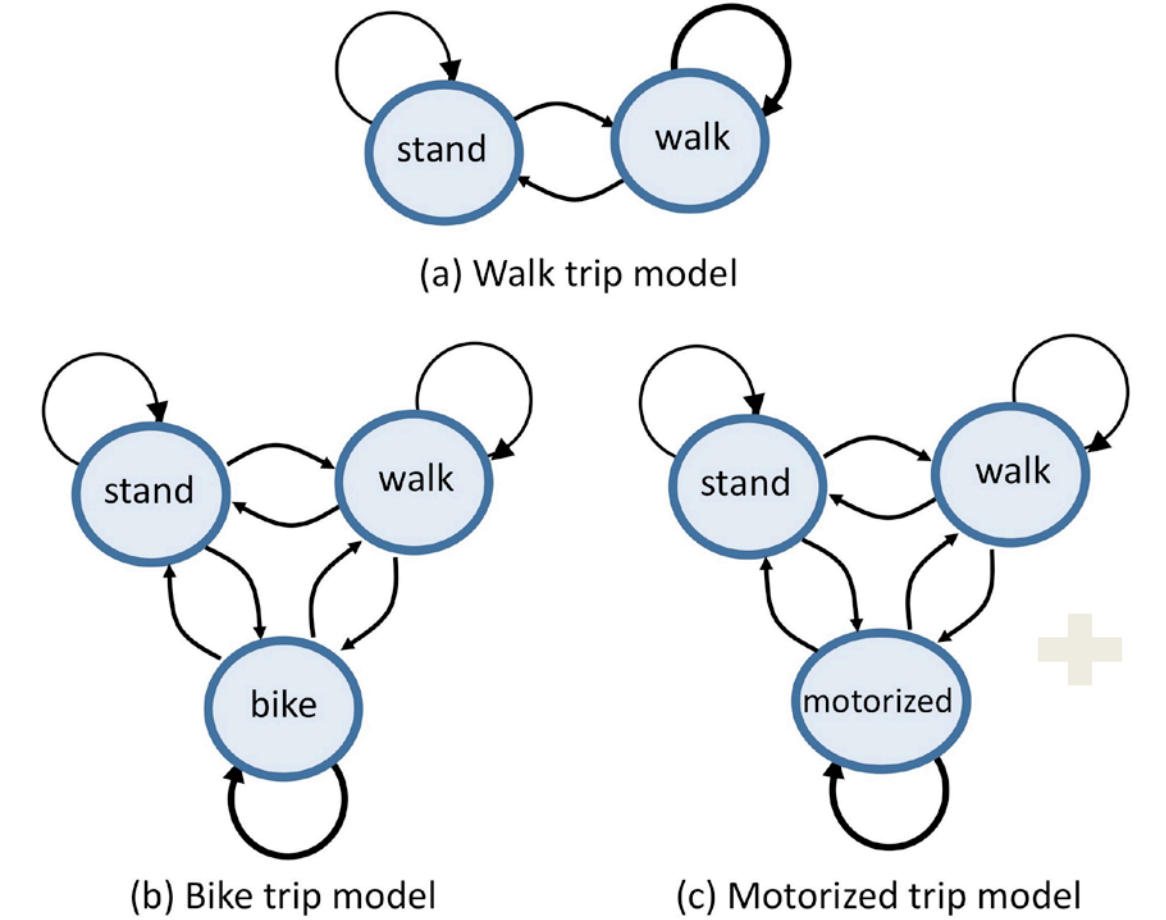
- Trip mode determination: identify the <u>main</u> transportation mode used (*as walk, bike, shared ride, walk-transit etc.*)

Eighteen modes defined for the Bay Area*



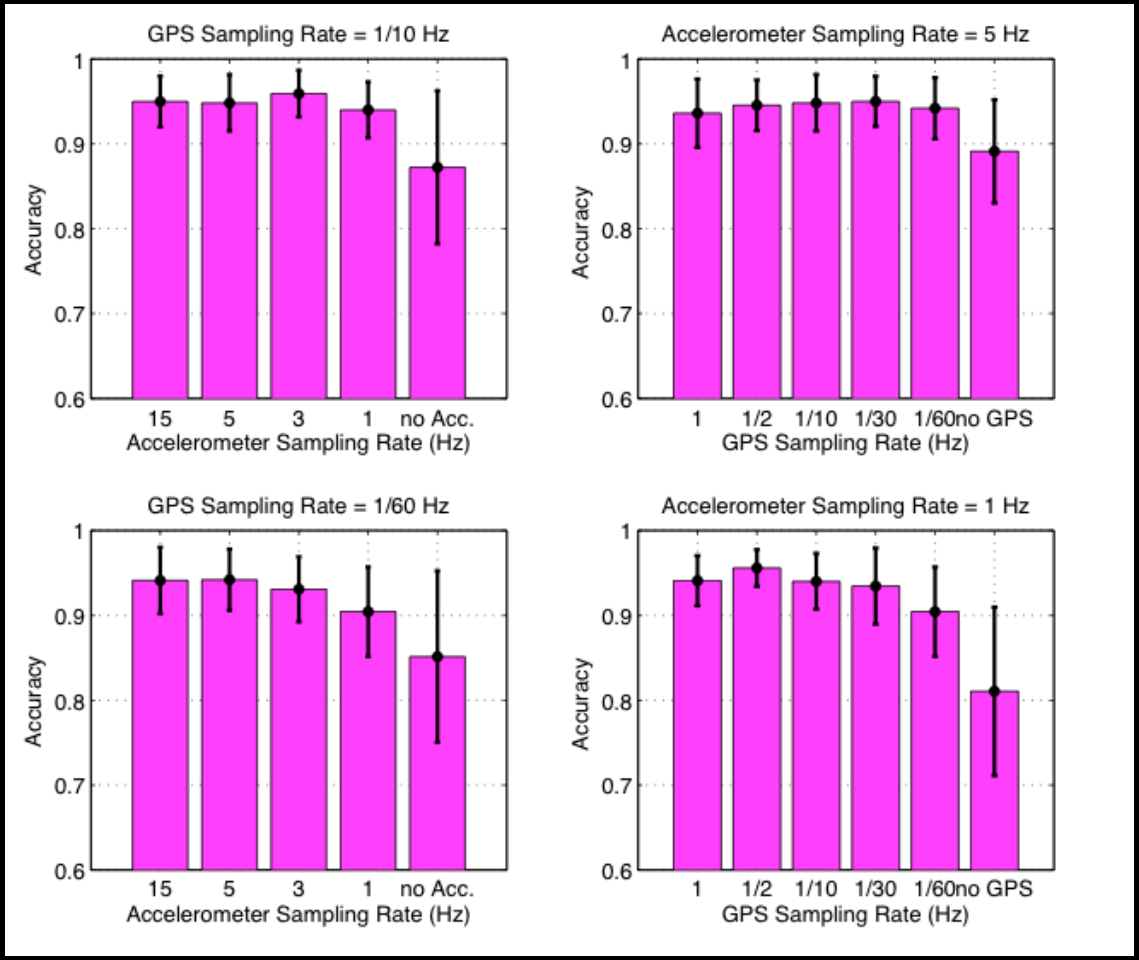
- Activity-based travel model specifications: Coordinated travel - regional activity based modeling platform (ct-ramp) for the San Francisco Bay Area

Identifying the Trip Mode (HMM)



Map-matching

July 2011: Playing with Sampling Rates



Results – detecting trips

(a) Confusion Matrix before Map Matching (%)

	Predicted			
Actual	Auto-trip	Transit-trip	Bike-trip	Walk-trip
Drive-trip	**77.0**	20.2	0.1	2.7
Transit-trip	44.0	**56.0**	0	0
Bike-trip	0	0	**97.5**	2.5
Walk-trip	0	3.9	3.0	**93.1**

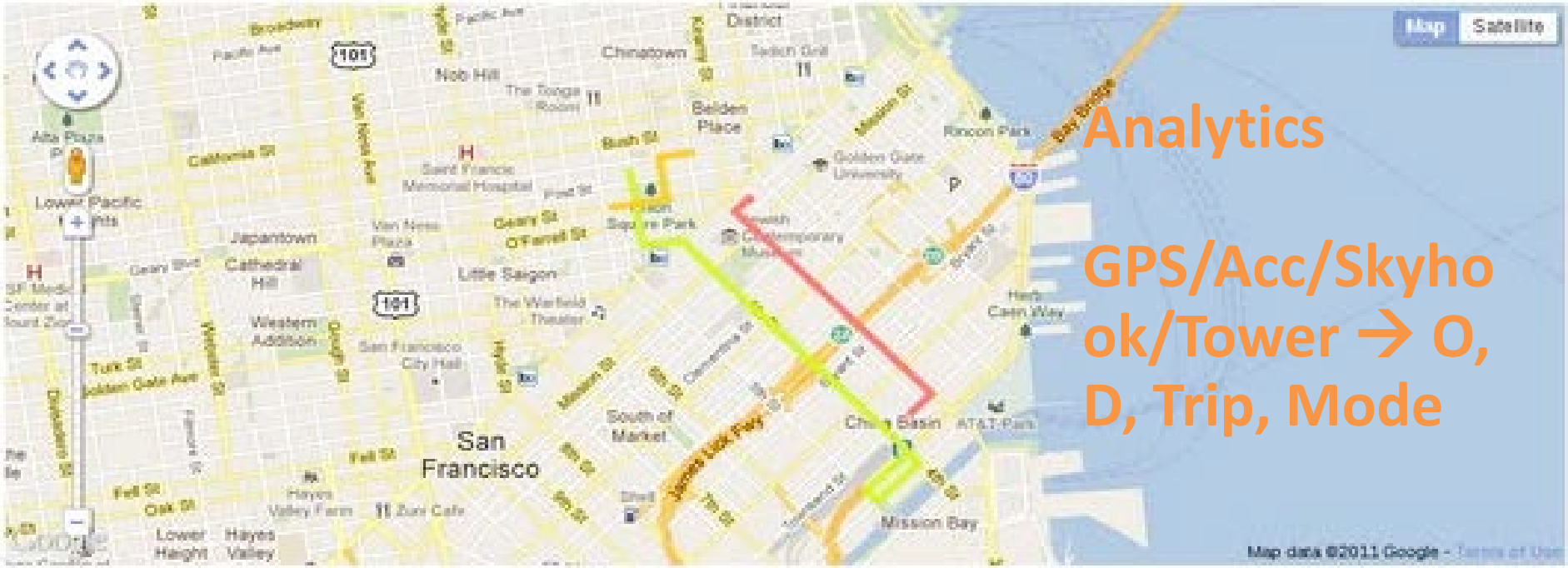
(b) Confusion Matrix after Map Matching (%)

	Predicted			
Actual	Auto-trip	Transit-trip	Bike-trip	Walk-trip
Auto-trip	**85.9**	11.3	0.1	2.7
Transit-trip	0	**100**	0	0
Bike-trip	0	0	**97.5**	2.5
Walk-trip	3.9	0	3.0	**93.1**

Accl 5 Hz, GPS 1 min

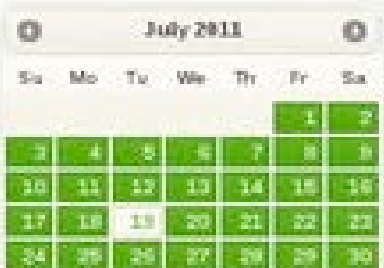
Current Solutions: Energy

Trip Explorer



Analytics

GPS/Acc/Skyhook/Tower → O, D, Trip, Mode



Color	Origin Address	Destination Address	Mode	Start Time	Duration (min)	Notes
	Mission Bay, San Francisco	South Beach, San Francisco	Light Rail	09:14 AM	16	
	Downtown, San Francisco	Tenderloin, San Francisco	Walk	05:47 PM	6	
	Downtown, San Francisco	Mission Bay, San Francisco	Bus	10:29 PM	30	

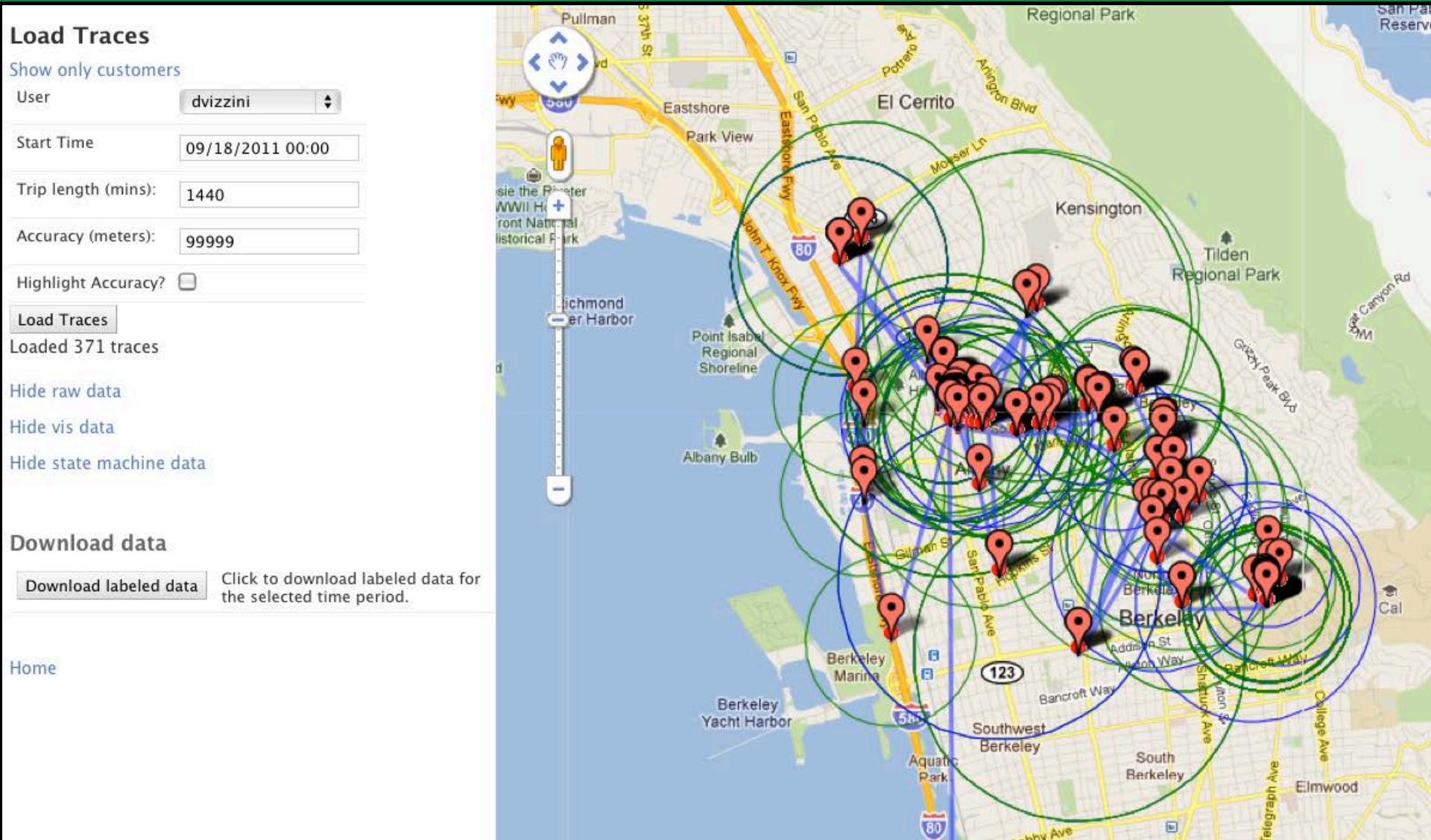
Battery Depletion – Quick and Dirty Calculations

- Looking at 44298 50-second increments (4908 of which were in transit modes) one can ascertain delation rates in an unsophsticated but reasuring manner
- All data has been filtered of screen, phone call, SMS usage and charging periods

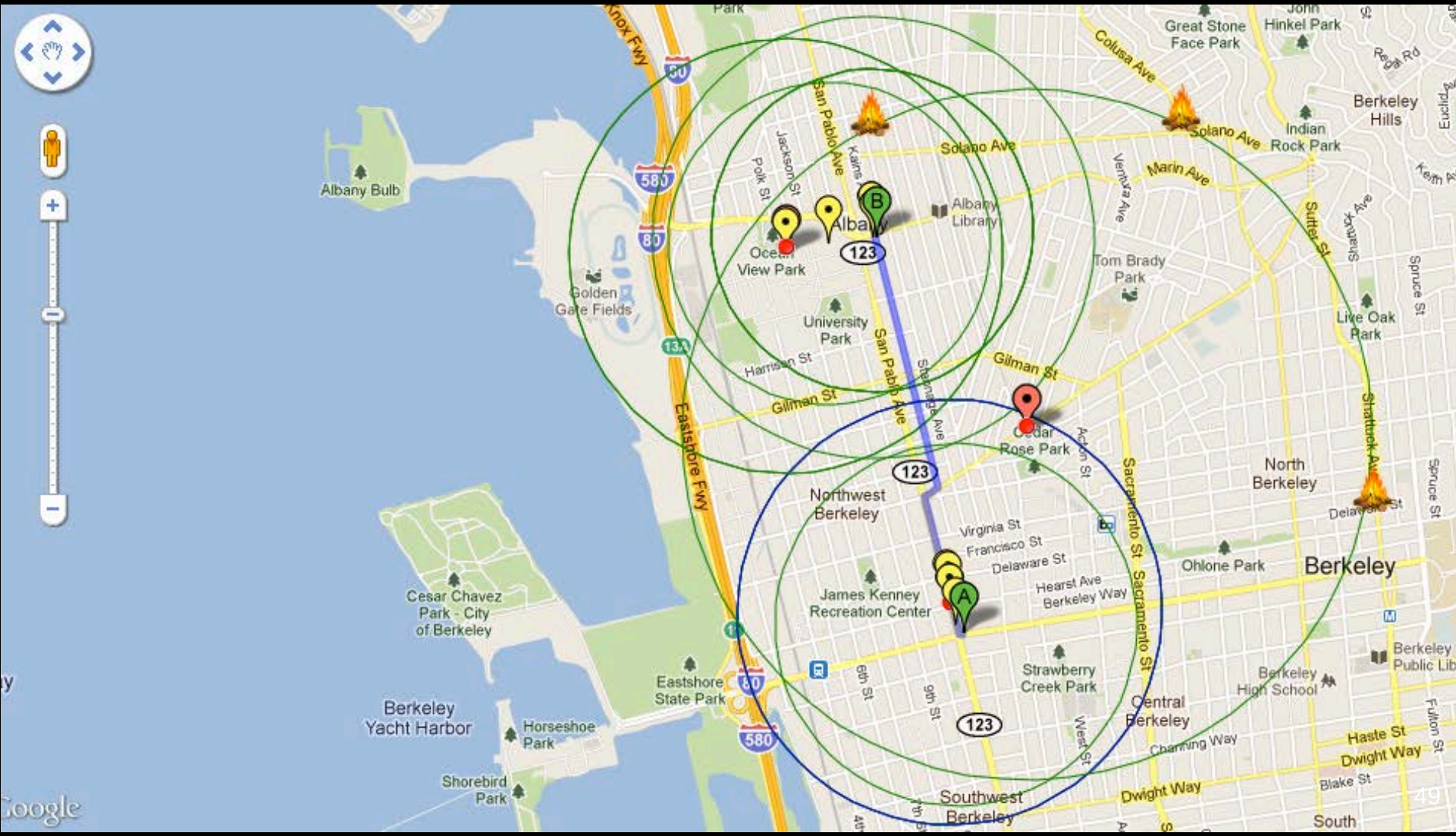
	Observed (per hour)	Esimated depletion per hour	Std Error
Not Transit Modes	-2.37%	-0.45%	0.04%
Transit Modes	-5.48%	-4.57%	0.27%

- ~25% per day if one's commute is 2 hours

The Price of Battery Efficiency: Sparsity of data



The Price of Battery Efficiency: Hotspots



July Solution: Mode Determination

- Combination of accelerometer features and GPS speed
  - Examples of accelerometer features:
  - Sum of features centered around 1 Hz
  - Normalized variance
  - Spectrum peak value and frequency
  - 1,2,3 hz power
- Map Matching
  - Source Data: GTFS (Google Transit Feed Specification)
  - Buses: look at stop sequences (and locations of bus stops)
  - Trains: look at shape files for track locations

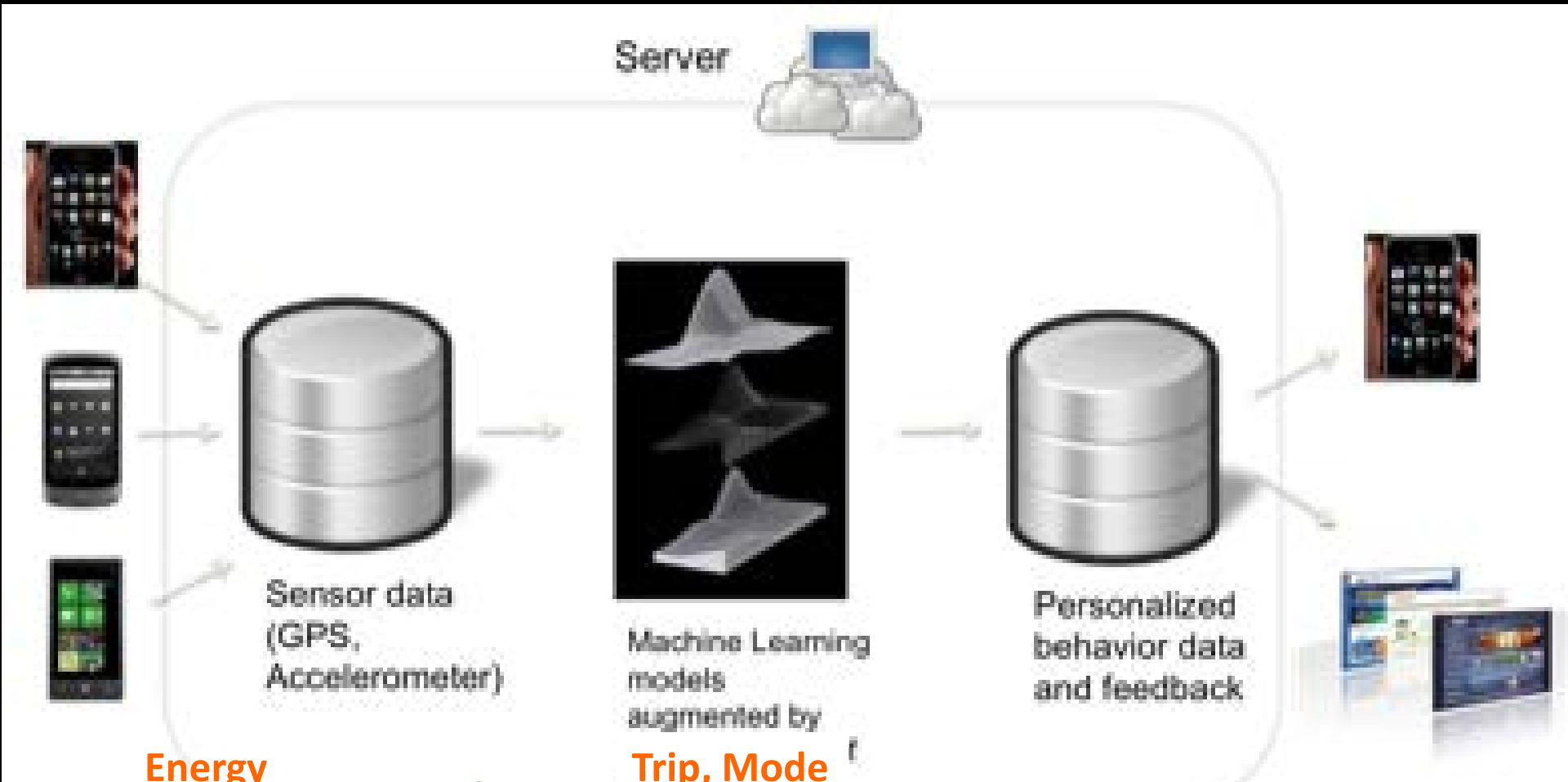
Trip & Mode Determination: Accuracy

- How many people in Quantified Traveler
  - 6 people
- How much time being spent on correction?
  - Mike and John 1 minute a day/person
  - Stasa and Adam 10 minutes a day/person
    - No accelerometer in background
    - No routes for the Google Shuttle
    - BART underground system problem
  - Jerry 20 seconds per person per day (drivers)
    - 4 months, 25 people

Collaborators

- Adam Bemo
- Andre Carrel
- Venky Ekambaram
- DJ Gaker
- John Gunnison
- Jerry Jariyasunant
- Mike Nole
- Siddika Partak
- Daniel Vizzini
- Professor Joan Walker

Engineering Challenges



Energy Consumption **VS** **Trip, Mode Accuracy**

Motivation

- NetDiary instead of Travel Diary
  - Can smartPhones improve travel demand surveys?
- Education and Awareness
  - How sustainable am I? What are my alternatives?
- Persuasion
  - Change mode-choice for sustainable travel
  - Travel feedback programs
  - People persuade people. Can computational systems persuade people?