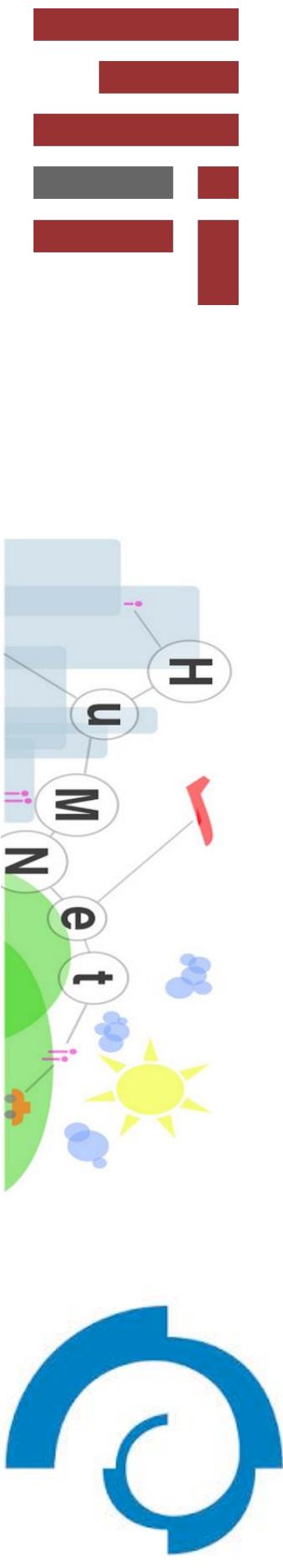




Mining Mobile Device Usage and Data for a recommendation platform

Marta C. González



CITIES ARE NOW HOME TO HALF OF
THE WORLD'S 7 BILLION HUMANS



The Opportunity: We are in the Digital Age

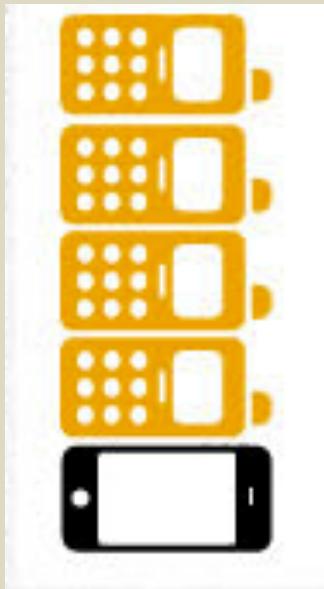
Internet Users

2 Billion



Mobile Phone Users

6 Billion



Average time spent on-line

Trends of the Future

HIGHEST GROWING

27%

Location Based
Services

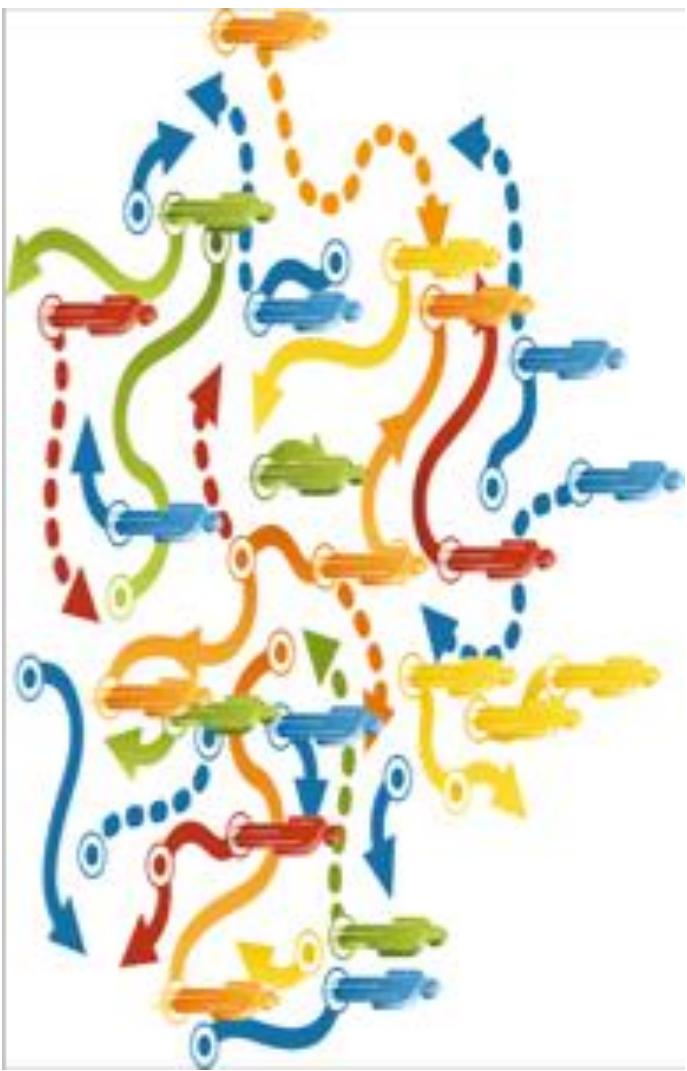


US Internet user per month: 32 HOURS

Travel Smarter! - Future Systems

Should be able to answer:

Where? *Why?* *How?*



The Purpose Behind Traveling

Should be able to answer:

Where? *Why?* *How?*

- The purpose of travelling is not changing one's physical location, but to perform certain activities

The Purpose Behind Traveling

Where? Why? How?



The Purpose Behind Traveling

Where?
Why?
How?



Travel Smarter! - Key ingredients:

Detect trip purpose patterns

Predict future traffic condition



Wifi Activity

Sun Jan 31 00:00:00 EST 2016

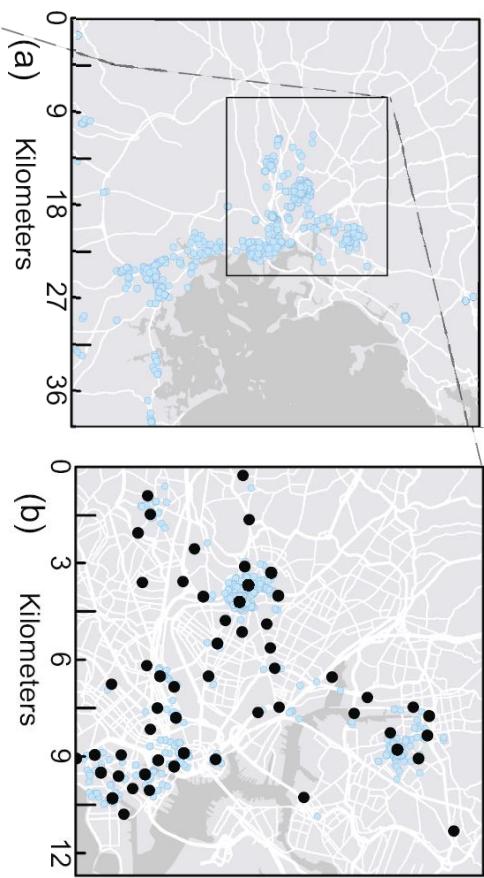
2665



Spatio-temporal Data Mining to Infer Visited Locations

- Phone Records
- Filtered Locations
- Observed Stay
- Potential Stay
- Passby

• Algorithms



- (a) Raw cell phone records as input

● (b) Reducing noisy jumps

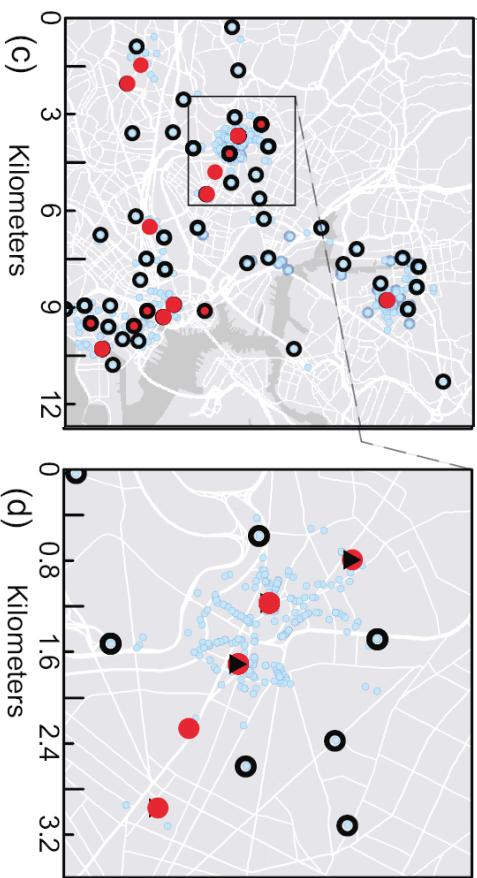
- set roaming distance : 300 meter
- agglomerative clustering to consolidate points that are spatially close to their medoids. (cluster radius=250 meter)

- (c) Detecting “Stay” ●, and “Pass-by” areas ○

- set time duration: 10 minutes

● (d) Detecting “Potential Stay” areas ▲

- extract distinct “Stay” area as destinations;
- flag pass-by points collocating with any of the destinations as “potential stay” areas.

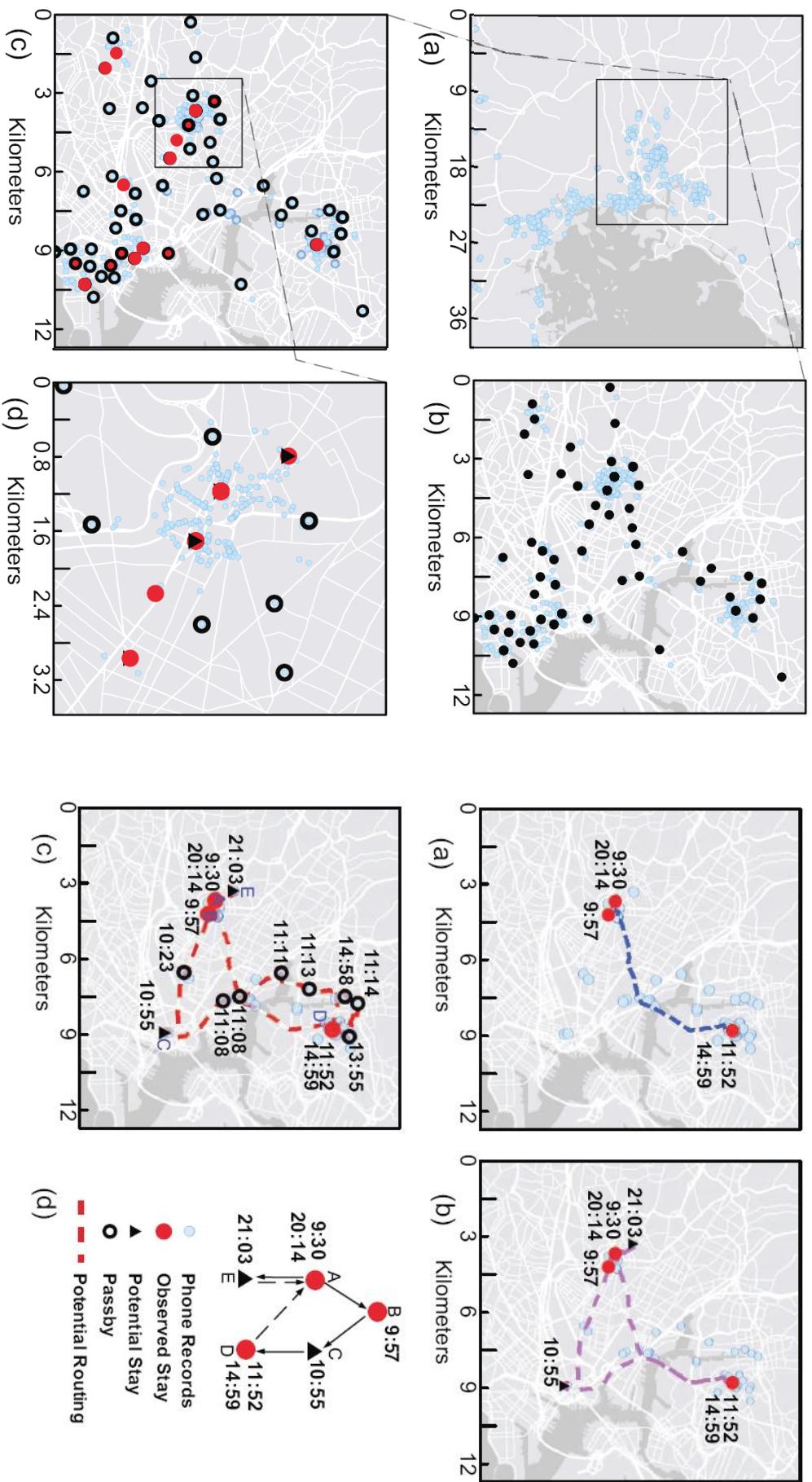


Reference:
R. Hariharan and K. Toyama. Project Iachesis: parsing and modeling location histories. In Geographic Information Science, pages 106–124. Springer, 2004.

Extract Daily Mobility Configurations

- Phone Records
- Filtered Locations
- Observed Stay
- Potential Stay
- Passby

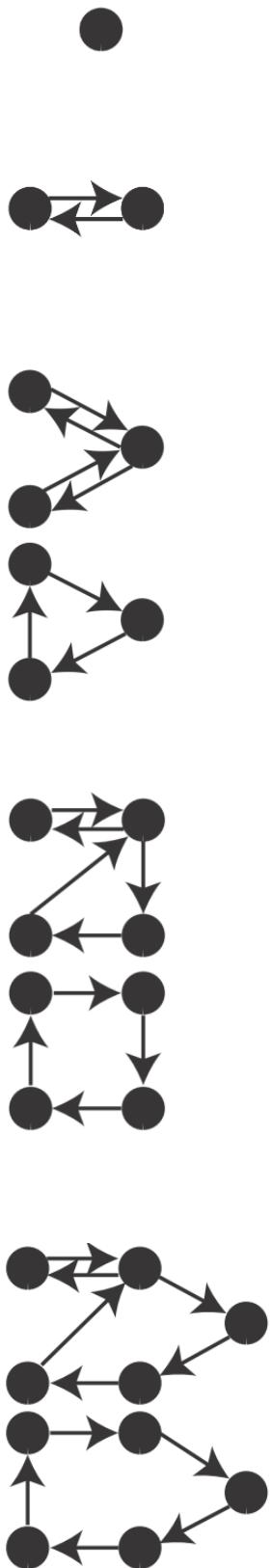
Daily Mobility Networks!



Universal Patterns of Individual Mobility

Daily Motifs

Statistically significant configurations of individual's travel network



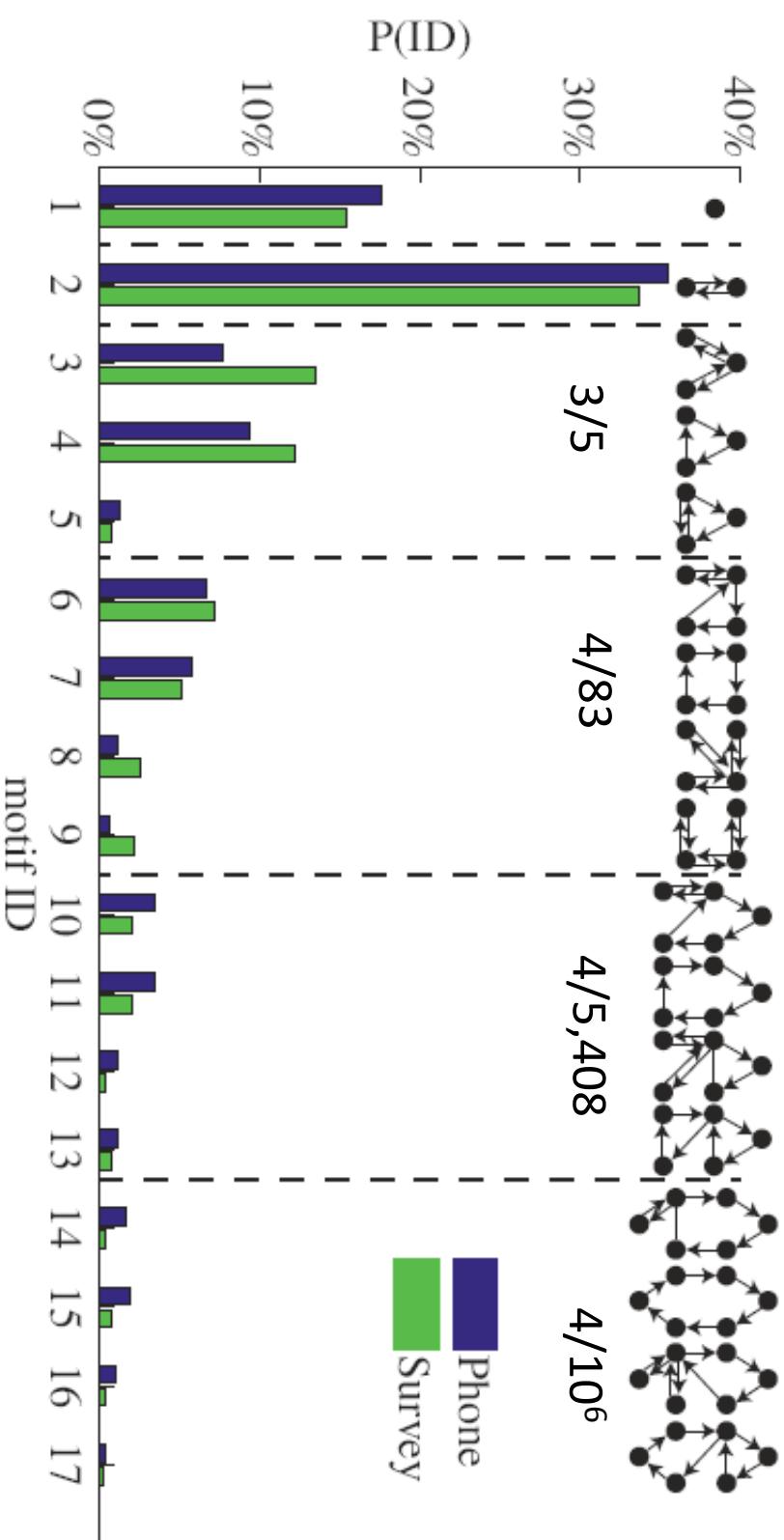
- ❖ Nodes: visited stay regions
- ❖ Directed edges: trips between the nodes

Universal Patterns of Individual Mobility

Daily Motifs

- 17 most frequent motifs account for over 95% of the measured daily trips.

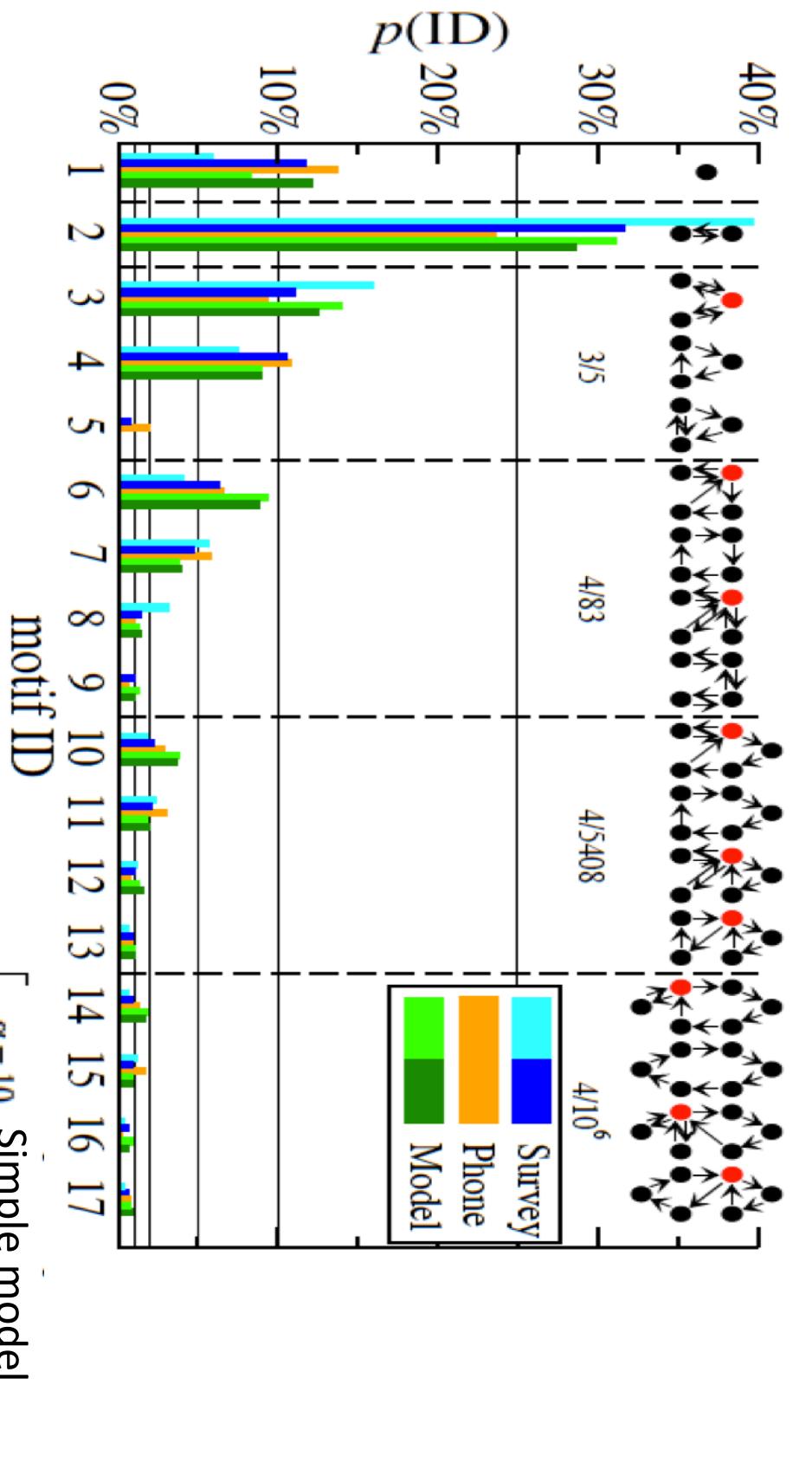
Cell-phone data can be treated as survey data for analyzing human mobility.



Data source: Massachusetts Travel Survey Data and
Cell Phone Data in 2010.

Basic Ingredients of the Model:

Transition between Flexible Activities + Time Budget



JOURNAL
—of—
THE ROYAL
SOCIETY
Interface 2013 Unravelling daily human mobility motifs

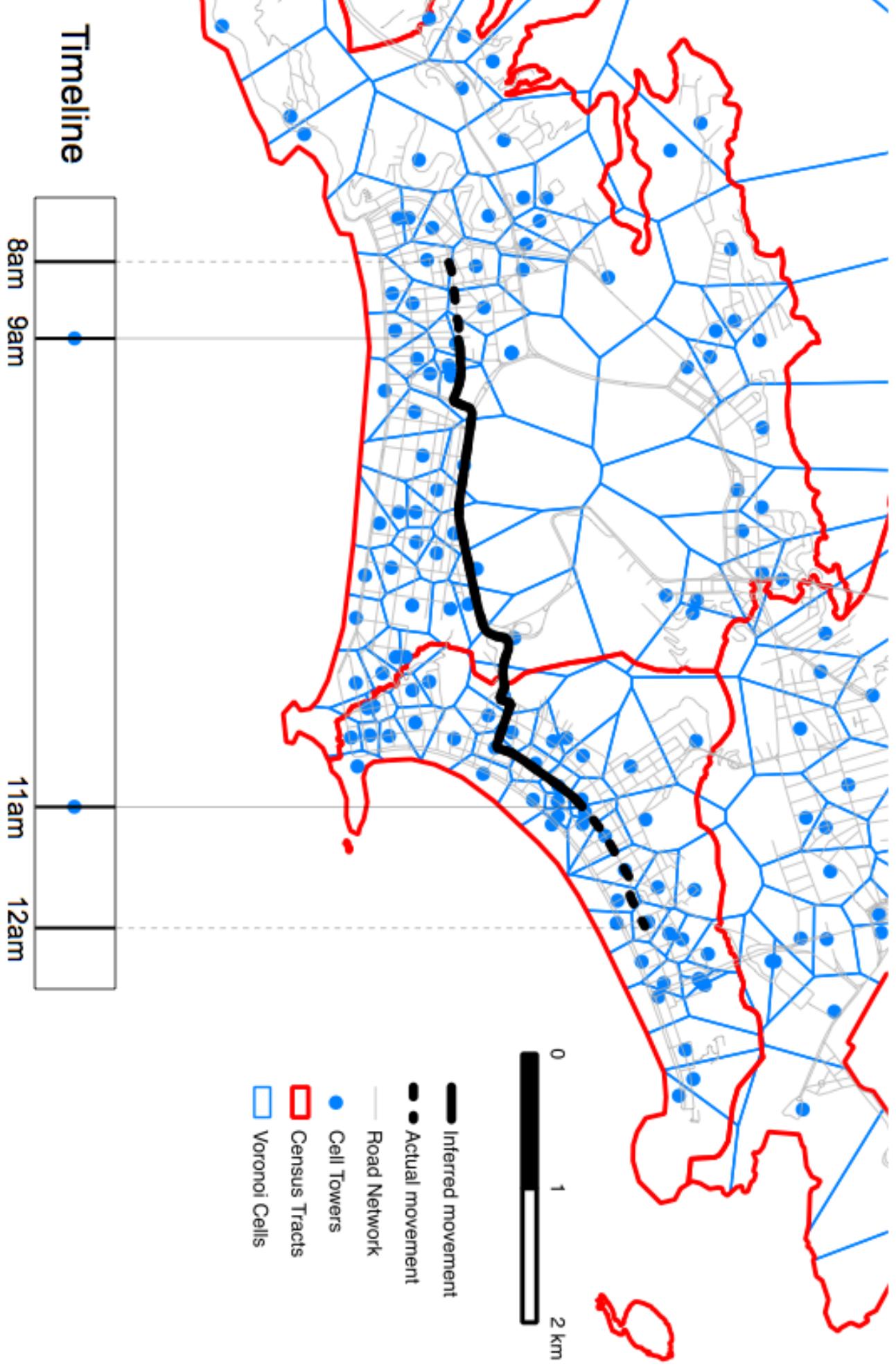
Christian M. Schneider¹, Vitaly Belik^{1,2}, Thomas Couronné³,
Zbigniew Smoreda³ and Marta C. González^{1,4}

Routing on a road network.

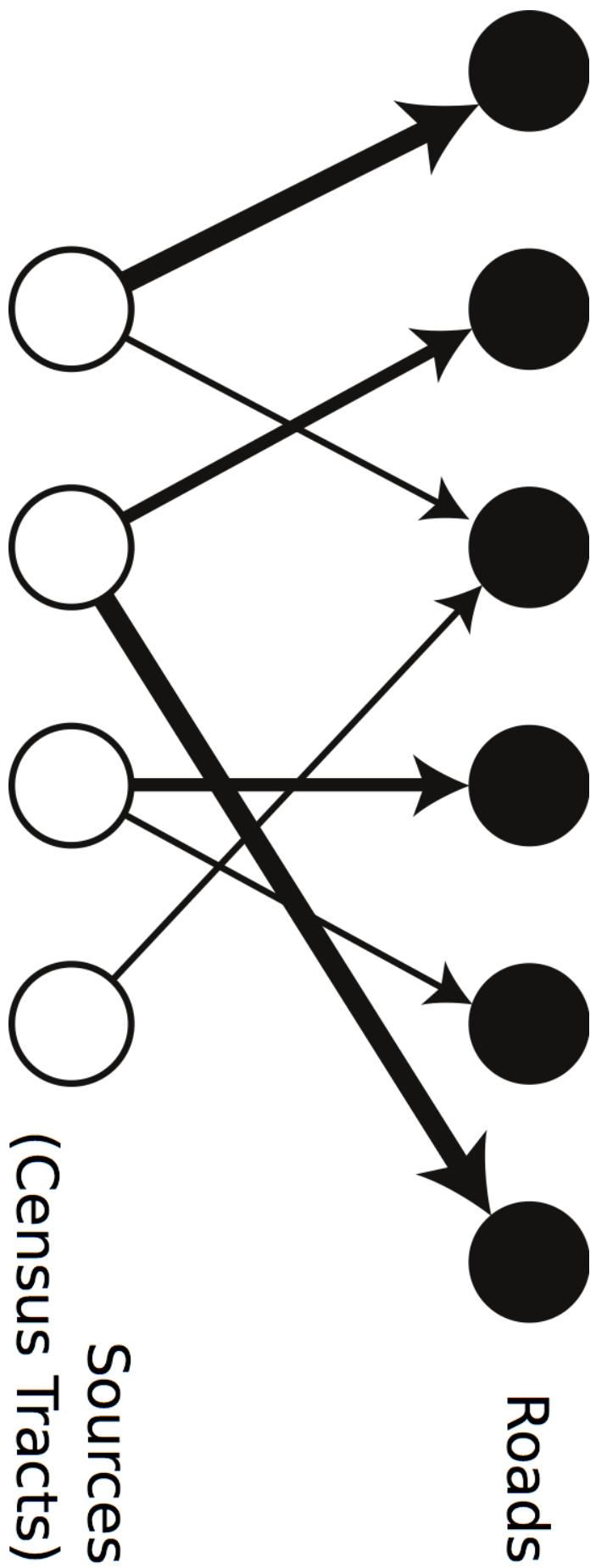
Google: **30min**
pgrouting (out of box): **22min**



Mapping Phones in the Streets: Buenos Aires, Rio do Janeiro, Riyadh, different locations within 30min.



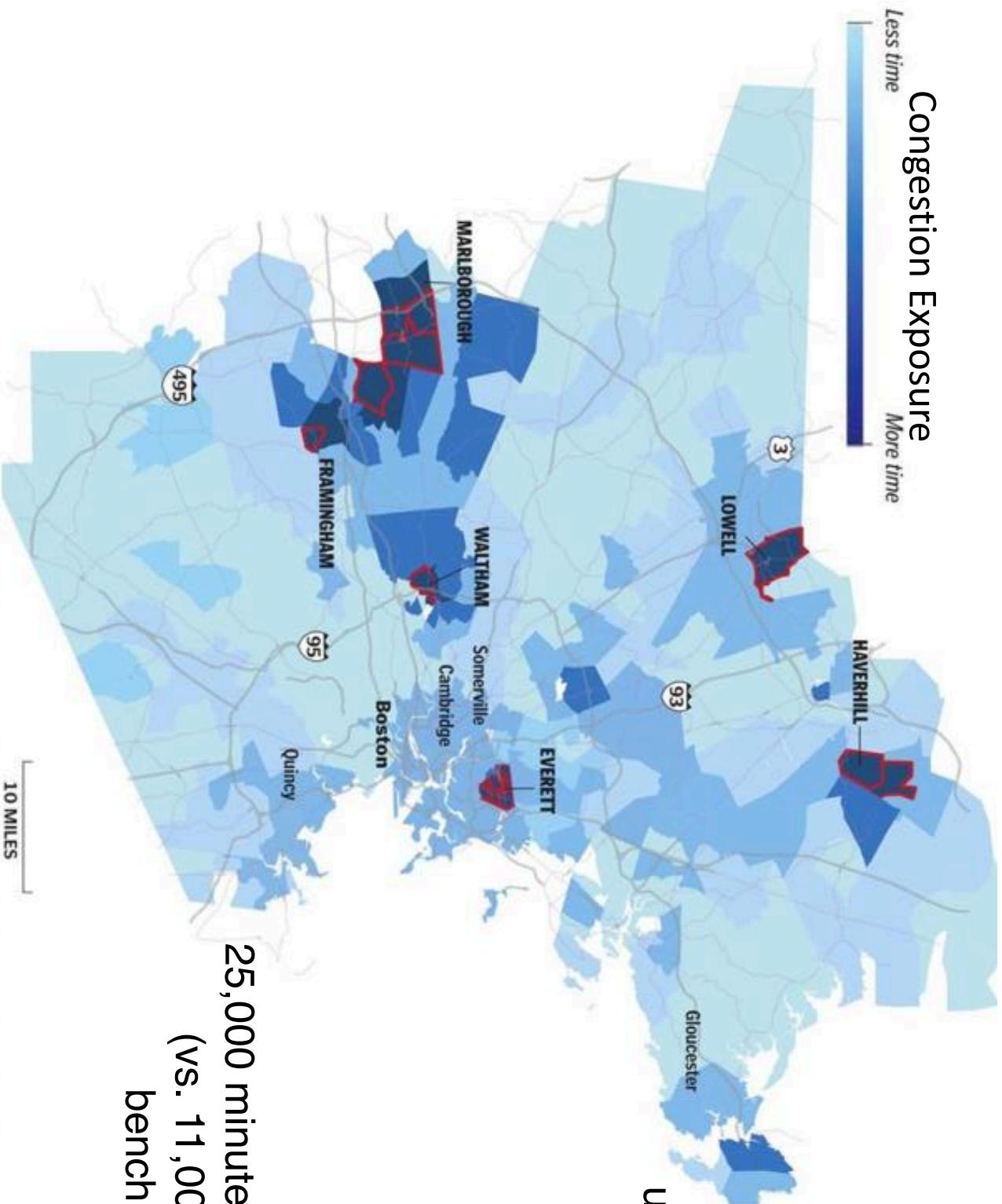
Bi-partite Usage Network



We connect the road used with the Census Track
were the users Live



Calculate Extra Travel Time due to Congestion



25,000 minutes travel time reduction
(vs. 11,000 minutes with a benchmark strategy)

Smart Commute

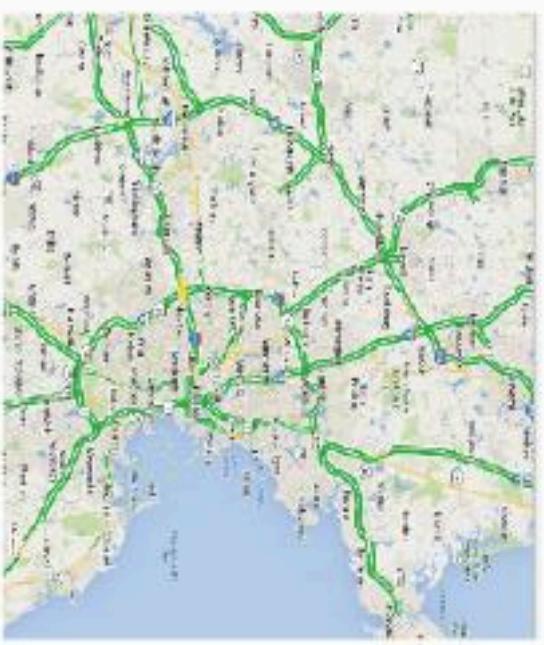
A program that incentivizes drivers to avoid bottlenecks by choosing a different route or mode of transportation for their commute.



Trips originating from these 5
targeted areas



Improvement in commuting time
throughout the metro area



An Integrated Approach for Success

Existing

Best Practices

Providing government incentives directly to commuters

Focuses on bottlenecks

Provides flexibility in commuter choices

Navigation apps with traffic information

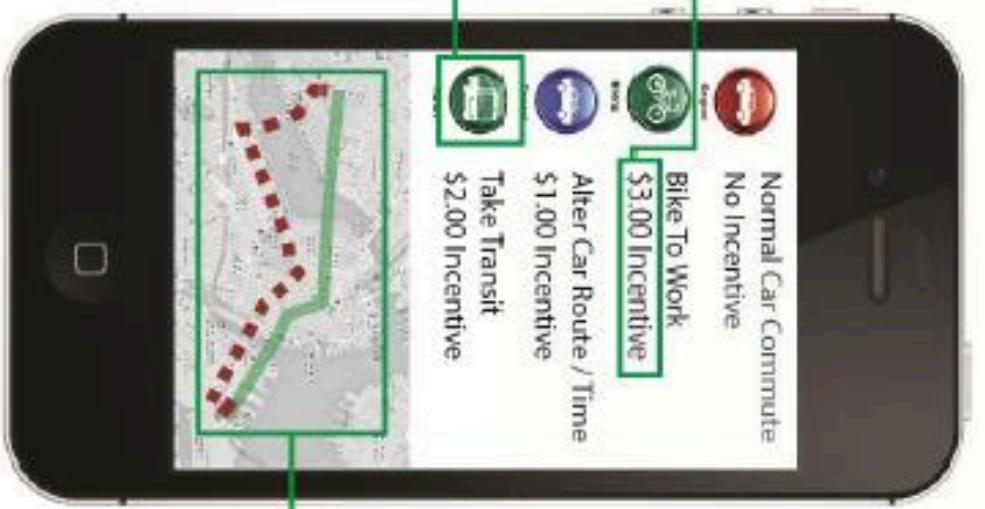
New

Innovations

Targets commuters who create bottlenecks

Mobile app platform allows measurement of success and the ability to optimize performance

Offers drivers re-routing options in addition to alternative modes



Implementation Approach

Stage 1: Strategy

- Publish research approach
- Incentives
- Success
- Form partnerships
- Secure funding

Stage 2: Pilot

- Solicit proposals
- Select host city
- Conduct Pilot

Stage 3: Expand

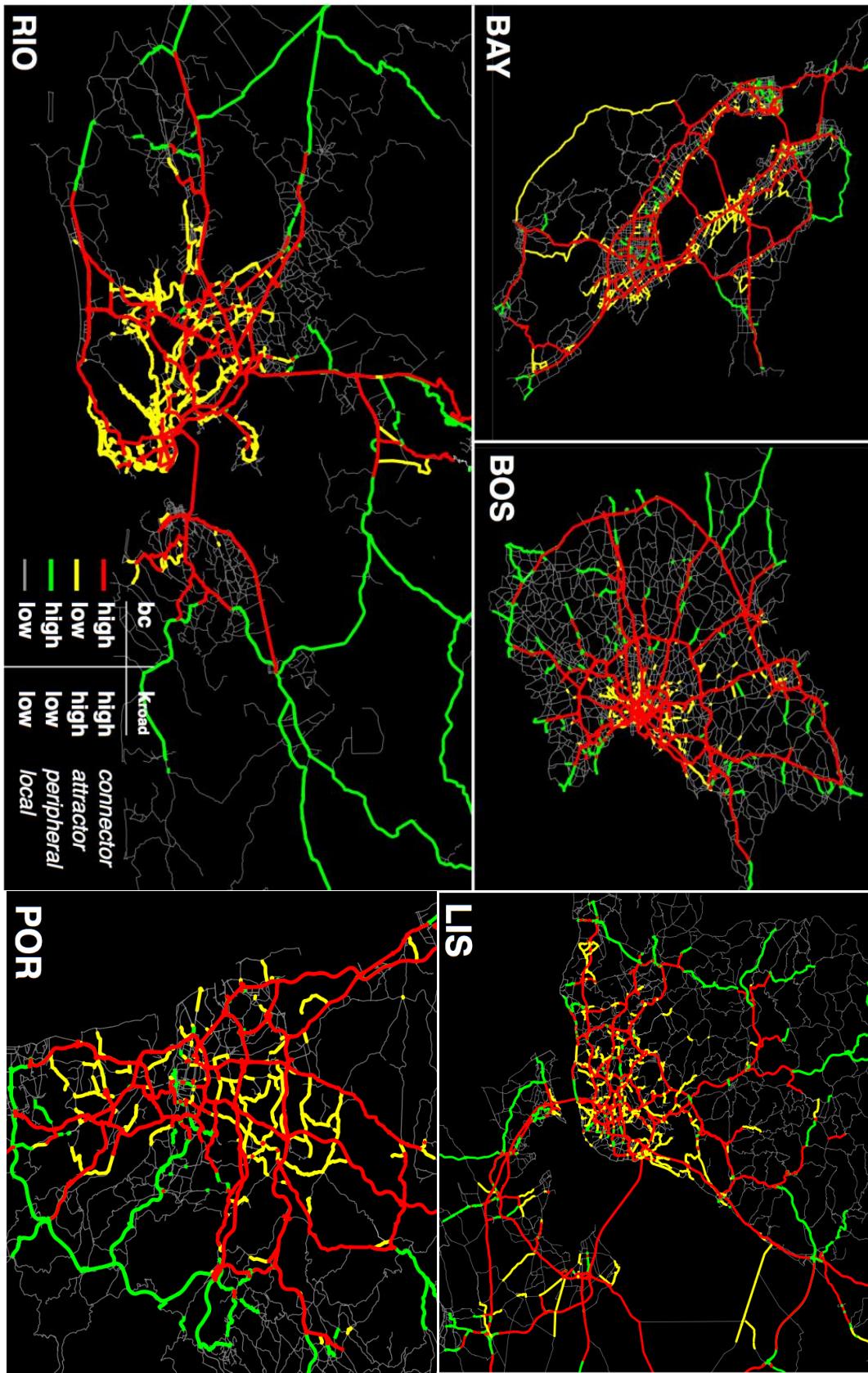
- Advertise findings
- Implement Smart Commute in cities nationwide



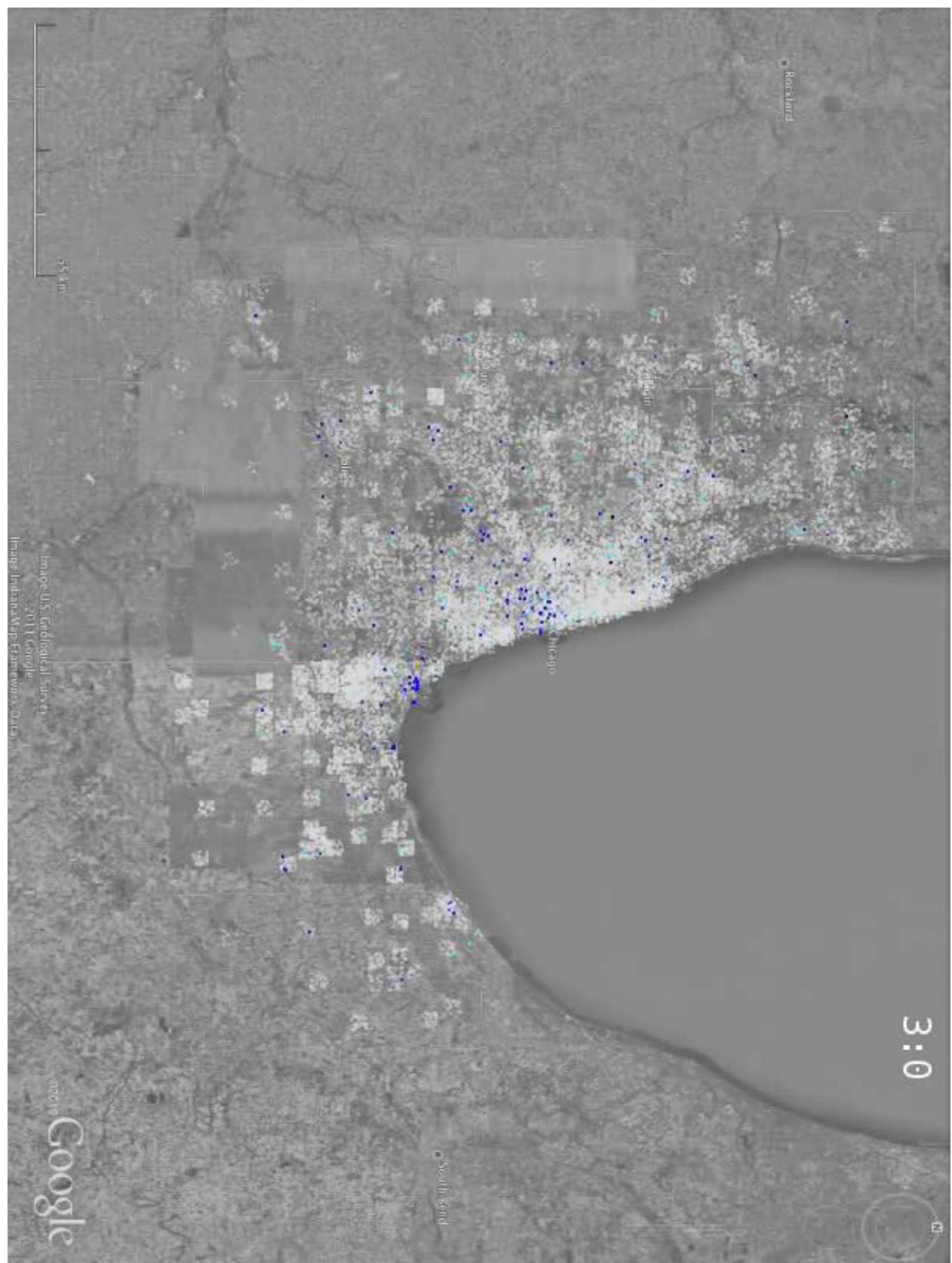
Massachusetts
Institute of
Technology



classify roads based on network topology and usage



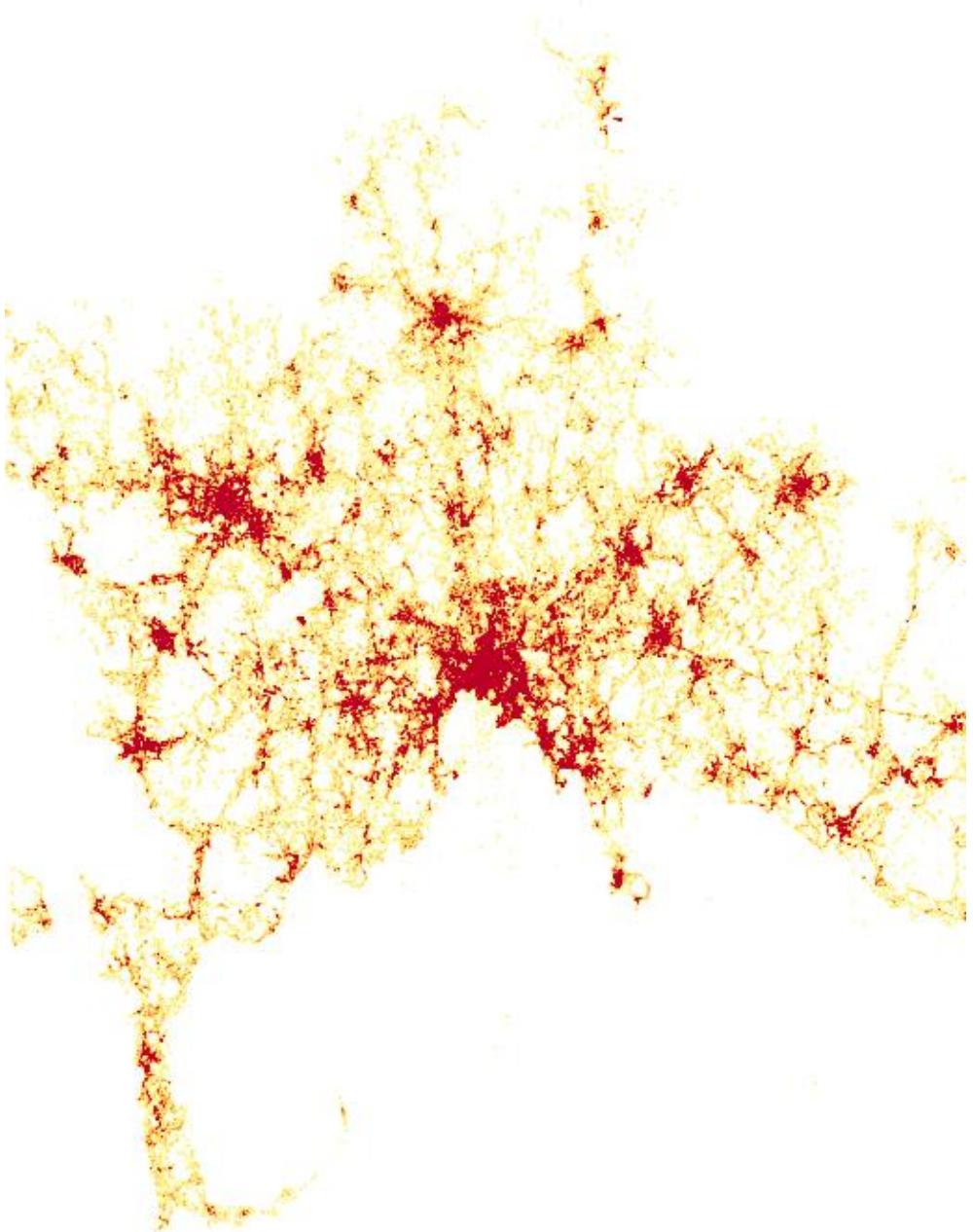
How do we infer purposes with passive data?



Where We Stand – Data

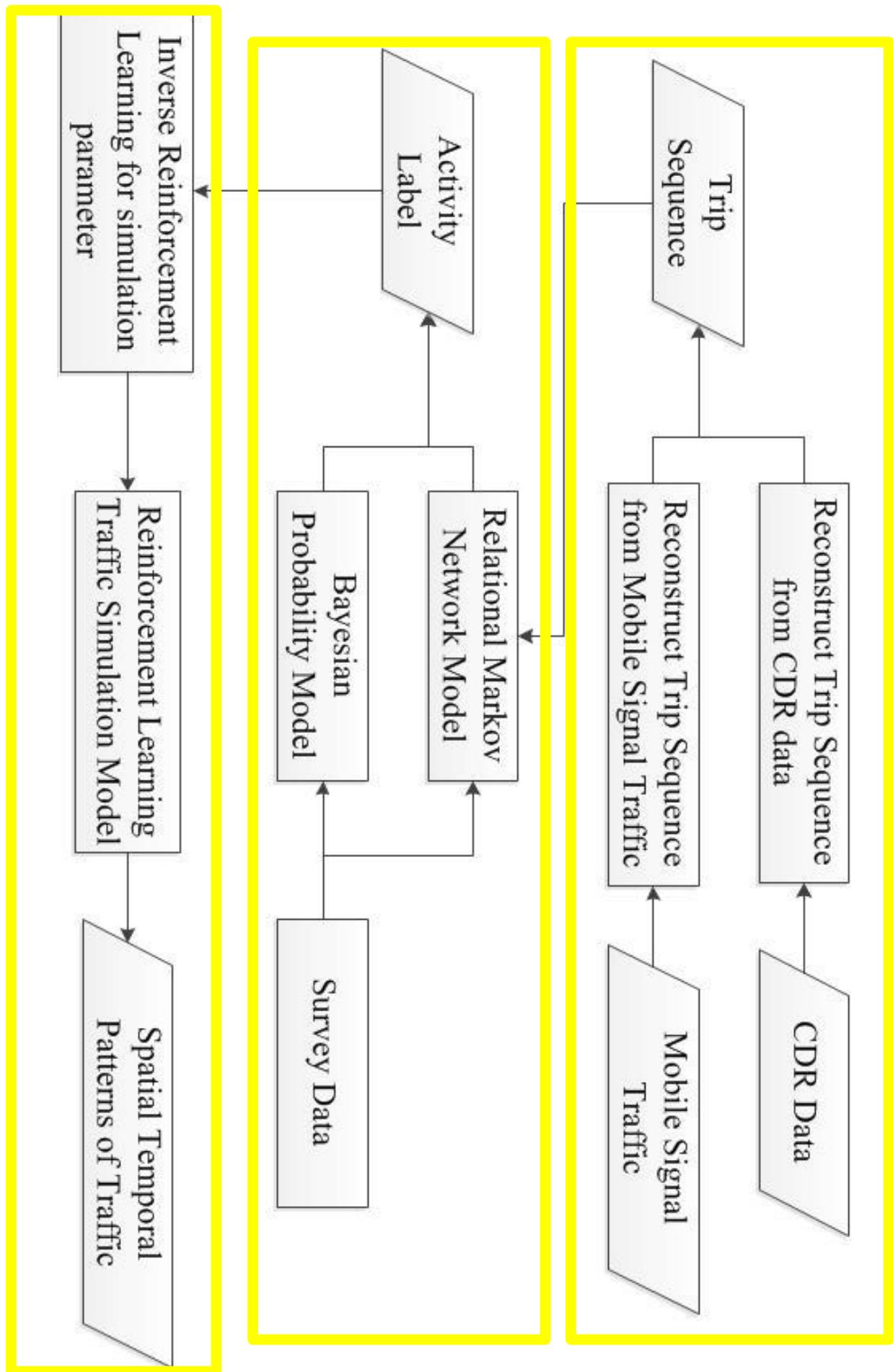
<p>C12. Now, about the household vehicle(s) you told me about earlier, who drives the [VEHYEAR, (MAKECODE, AND MODLCODE)] most of the time?</p> <p>[WHOMAIN]</p> <p>[IF NO MAIN DRIVER, ENTER 99]</p> <table border="0"> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>NO MAIN DRIVER</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>REFUSED</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>DON'T KNOW</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>YES 1</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>NO 2</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>REFUSED 7</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>DON'T KNOW 8</td> </tr> </table> <p>C13. Should [FNAME/AGE/SEX] have been recorded as a driver?</p> <p>(C13_DRVNR)</p> <table border="0"> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>YES 1</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>NO 2</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>REFUSED 7</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>DON'T KNOW 8</td> </tr> </table> <p>C22. Does the [VEHYEAR, MAKECODE, AND MODLCODE] have a commercial license plate? [IF NEEDED: Commercial license plates are obtained if you registered your vehicle as a business vehicle]</p> <p>[VEHCOMM]</p> <table border="0"> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>YES 1</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>NO 2</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>REFUSED 7</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>DON'T KNOW 8</td> </tr> </table> <p>E16. How did [you/She/They] travel? [IF NEEDED: T]</p> <p>(WRKTRANS)</p> <p>PERSONAL VEHICLES</p> <table border="0"> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>CAR.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>VAN.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>SUV.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>PICKUP TRUCK.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>OTHER TRUCK.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>RV.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>MOTORCYCLE.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>LIGHT ELECTRIC VEHICLE (GOLF CART).....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>BUS TRAVEL.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>LOCAL PUBLIC TRANSIT.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>COMMUTER BUS.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>SCHOOL BUS.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>CHARTER/TOUR BUS.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>CITY TO CITY (GREYHOUND/PETERPAN) SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE).....</td> </tr> </table> <p>I have recorded [SCRN.VEHICNT] vehicles.</p> <p>Are these all of the vehicles that are available to the people that currently live in your household?</p> <p>(VEHIN)</p> <p>YES 1 NO 2 GO TO RESULT GT</p> <p>F7. On most school days, how [does FNAME/AGE/SEX/do you] usually leave school? (SCHTRNZ)</p> <p>PERSONAL VEHICLES</p> <table border="0"> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>CAR..... 1</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>VAN..... 2</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>SUV..... 3</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>PICKUP TRUCK..... 4</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>OTHER TRUCK..... 5</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>RV..... 6</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>MOTORCYCLE..... 7</td> </tr> </table>		NO MAIN DRIVER		REFUSED		DON'T KNOW		YES 1		NO 2		REFUSED 7		DON'T KNOW 8		YES 1		NO 2		REFUSED 7		DON'T KNOW 8		YES 1		NO 2		REFUSED 7		DON'T KNOW 8		CAR.....		VAN.....		SUV.....		PICKUP TRUCK.....		OTHER TRUCK.....		RV.....		MOTORCYCLE.....		LIGHT ELECTRIC VEHICLE (GOLF CART).....		BUS TRAVEL.....		LOCAL PUBLIC TRANSIT.....		COMMUTER BUS.....		SCHOOL BUS.....		CHARTER/TOUR BUS.....		CITY TO CITY (GREYHOUND/PETERPAN) SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE).....		CAR..... 1		VAN..... 2		SUV..... 3		PICKUP TRUCK..... 4		OTHER TRUCK..... 5		RV..... 6		MOTORCYCLE..... 7	<p>B1. How many vehicles are owned, leased, or available for regular use by the people who currently live in your household? Please be sure to include motorcycles, mopeds and RVs.</p> <p>(HHNUMVEH)</p> <p>[INCLUDE LEASED OR COMPANY-OWNED MOTORIZED VEHICLES IF THEY ARE USED BY HOUSEHOLD MEMBERS ON A REGULAR BASIS.]</p> <table border="0"> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>NUMBER OF VEHICLES.....</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>NONE..... 0</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>REFUSED..... 7</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>DON'T KNOW..... -8</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>GO TO C1</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>GO TO C1</td> </tr> <tr> <td style="width: 10px; height: 10px; border: 1px solid black; margin-right: 10px;"></td> <td>GO TO C1</td> </tr> </table> <p>C2. I have a few questions about each of these vehicles. Let's start with the newest vehicle.) What is the make, model and year of this vehicle?</p> <p>(KEY (MAKEALPH) MAKE (MAKECODE) MODEL (MODLCODE) YEAR (VEHYEAR) TYPE (VEHTYPE))</p> <p>L1. In the past month, about how many times [have you/has SUBJECT driven a motorcycle or (MCUSED)]</p> <p>NUMBER _____ thru' 99</p> <p>EVAS. Thinking about travel on public transit in your area, please tell me if you agree or disagree with the following statements.</p> <p>(EVASA-EVASH)</p> <table border="0"> <thead> <tr> <th></th> <th>AGREE</th> <th>DISAGREE</th> <th>REF</th> <th>DK</th> </tr> </thead> <tbody> <tr> <td>a. Local public transit provides a good travel experience</td> <td>1</td> <td>2</td> <td>-7</td> <td>-8</td> </tr> <tr> <td>b. Local public transit service is reliable</td> <td>1</td> <td>2</td> <td>-7</td> <td>-8</td> </tr> <tr> <td>c. Local public transit service is safe from crime</td> <td>1</td> <td>2</td> <td>-7</td> <td>-8</td> </tr> <tr> <td>d. Local public transit service is easy to use</td> <td>1</td> <td>2</td> <td>-7</td> <td>-8</td> </tr> <tr> <td>e. The cost of local public transit is reasonable</td> <td>1</td> <td>2</td> <td>-7</td> <td>-8</td> </tr> <tr> <td>f. Local public transit service is fast enough for my needs</td> <td>1</td> <td>2</td> <td>-7</td> <td>-8</td> </tr> </tbody> </table> <p>L2. How much of an issue [is/are] [RESPONSE FROM L2a] to you? Would you say... (VARIABLES LISTED IN BOX ABOVE)</p> <p>A little issue..... 1 A moderate issue..... 2 A big issue..... 3 REFUSED..... 7 DON'T KNOW..... -8</p>		NUMBER OF VEHICLES.....		NONE..... 0		REFUSED..... 7		DON'T KNOW..... -8		GO TO C1		GO TO C1		GO TO C1		AGREE	DISAGREE	REF	DK	a. Local public transit provides a good travel experience	1	2	-7	-8	b. Local public transit service is reliable	1	2	-7	-8	c. Local public transit service is safe from crime	1	2	-7	-8	d. Local public transit service is easy to use	1	2	-7	-8	e. The cost of local public transit is reasonable	1	2	-7	-8	f. Local public transit service is fast enough for my needs	1	2	-7	-8
	NO MAIN DRIVER																																																																																																																									
	REFUSED																																																																																																																									
	DON'T KNOW																																																																																																																									
	YES 1																																																																																																																									
	NO 2																																																																																																																									
	REFUSED 7																																																																																																																									
	DON'T KNOW 8																																																																																																																									
	YES 1																																																																																																																									
	NO 2																																																																																																																									
	REFUSED 7																																																																																																																									
	DON'T KNOW 8																																																																																																																									
	YES 1																																																																																																																									
	NO 2																																																																																																																									
	REFUSED 7																																																																																																																									
	DON'T KNOW 8																																																																																																																									
	CAR.....																																																																																																																									
	VAN.....																																																																																																																									
	SUV.....																																																																																																																									
	PICKUP TRUCK.....																																																																																																																									
	OTHER TRUCK.....																																																																																																																									
	RV.....																																																																																																																									
	MOTORCYCLE.....																																																																																																																									
	LIGHT ELECTRIC VEHICLE (GOLF CART).....																																																																																																																									
	BUS TRAVEL.....																																																																																																																									
	LOCAL PUBLIC TRANSIT.....																																																																																																																									
	COMMUTER BUS.....																																																																																																																									
	SCHOOL BUS.....																																																																																																																									
	CHARTER/TOUR BUS.....																																																																																																																									
	CITY TO CITY (GREYHOUND/PETERPAN) SHUTTLE BUS (SUCH AS A SENIOR OR AIRPORT SHUTTLE).....																																																																																																																									
	CAR..... 1																																																																																																																									
	VAN..... 2																																																																																																																									
	SUV..... 3																																																																																																																									
	PICKUP TRUCK..... 4																																																																																																																									
	OTHER TRUCK..... 5																																																																																																																									
	RV..... 6																																																																																																																									
	MOTORCYCLE..... 7																																																																																																																									
	NUMBER OF VEHICLES.....																																																																																																																									
	NONE..... 0																																																																																																																									
	REFUSED..... 7																																																																																																																									
	DON'T KNOW..... -8																																																																																																																									
	GO TO C1																																																																																																																									
	GO TO C1																																																																																																																									
	GO TO C1																																																																																																																									
	AGREE	DISAGREE	REF	DK																																																																																																																						
a. Local public transit provides a good travel experience	1	2	-7	-8																																																																																																																						
b. Local public transit service is reliable	1	2	-7	-8																																																																																																																						
c. Local public transit service is safe from crime	1	2	-7	-8																																																																																																																						
d. Local public transit service is easy to use	1	2	-7	-8																																																																																																																						
e. The cost of local public transit is reasonable	1	2	-7	-8																																																																																																																						
f. Local public transit service is fast enough for my needs	1	2	-7	-8																																																																																																																						

Explore the Hotspots in a City and
Their Distribution Pattern



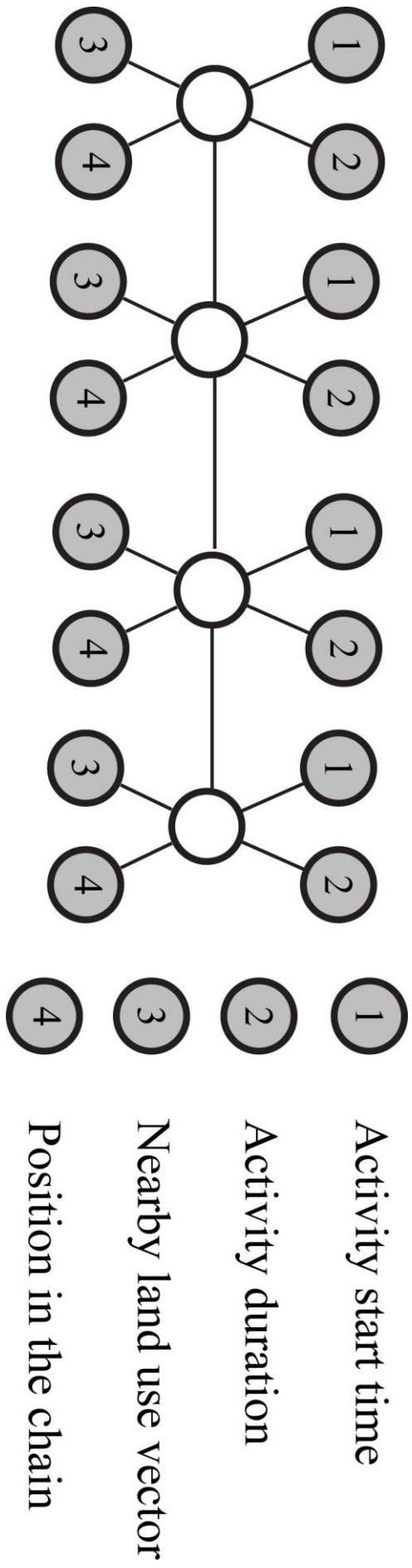
Modeling Approach

Module 1 Module 2 Module 3



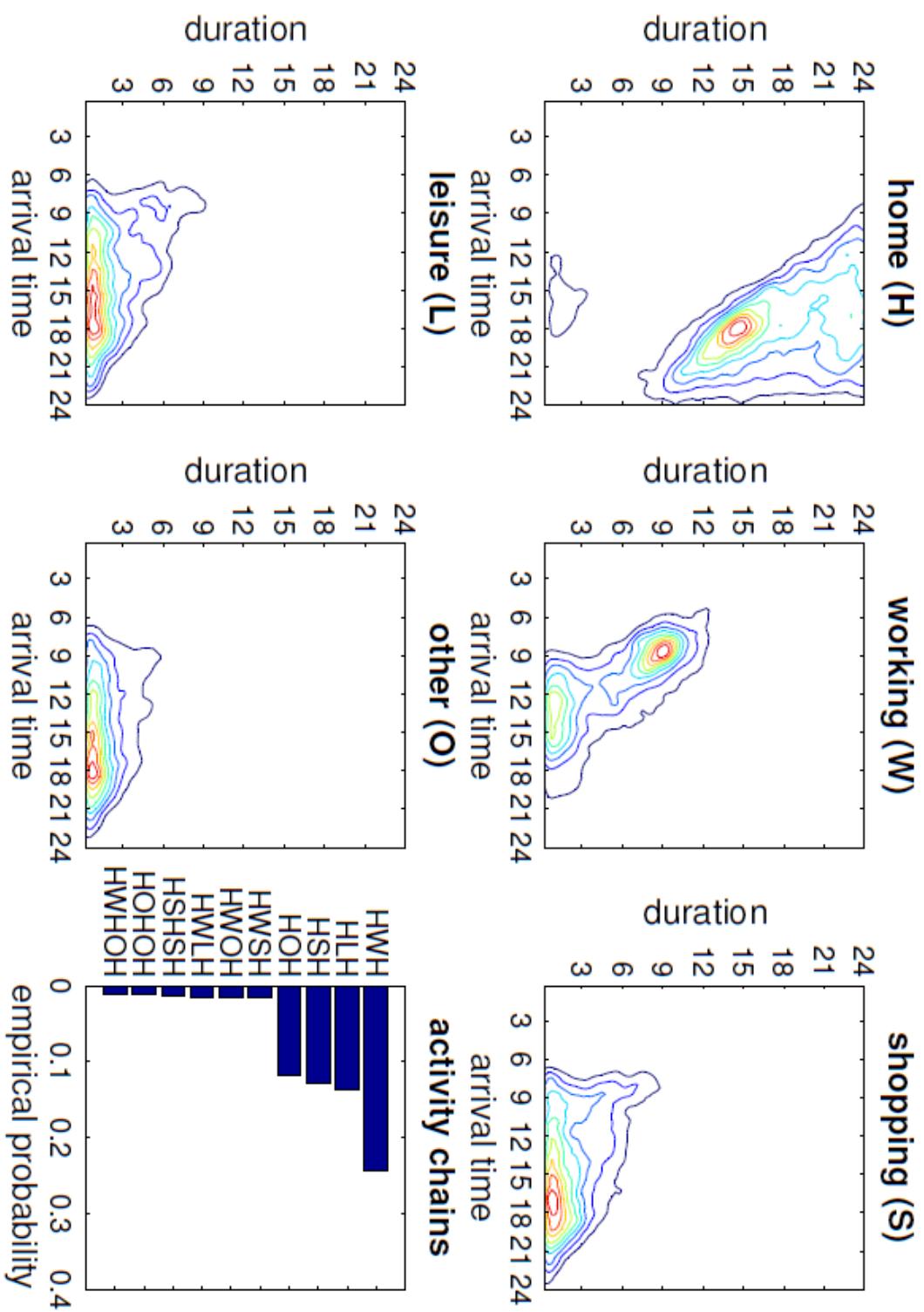
Relational Markov Network Model

- Estimating activity types (home, work, shopping, leisure, other) based on extracted activity features and sequence of activities



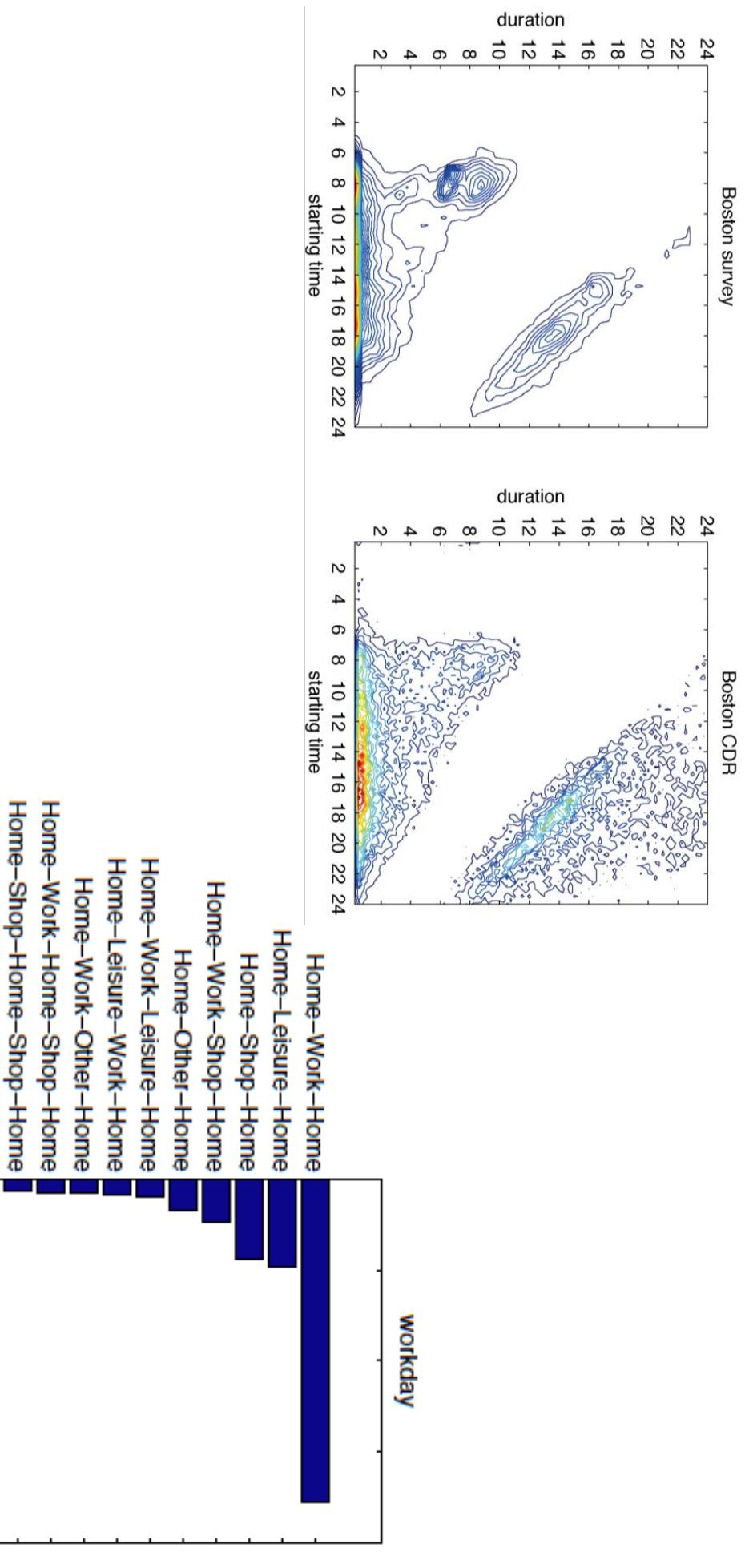
Results: Activity Labeling

- Our Relation Markov Network Model



Explore long term individual level behavior

- The first year's research focuses on daily patterns



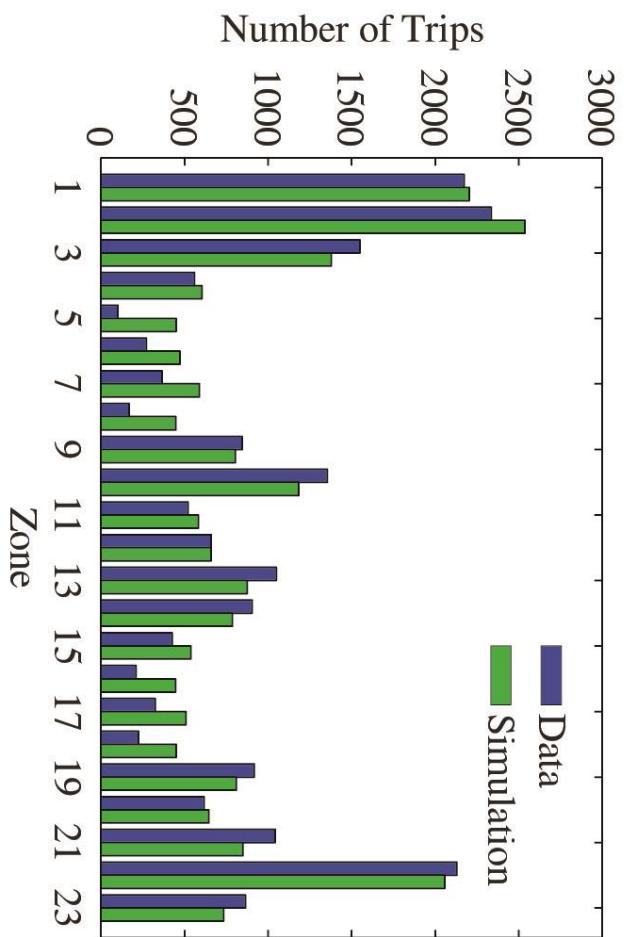
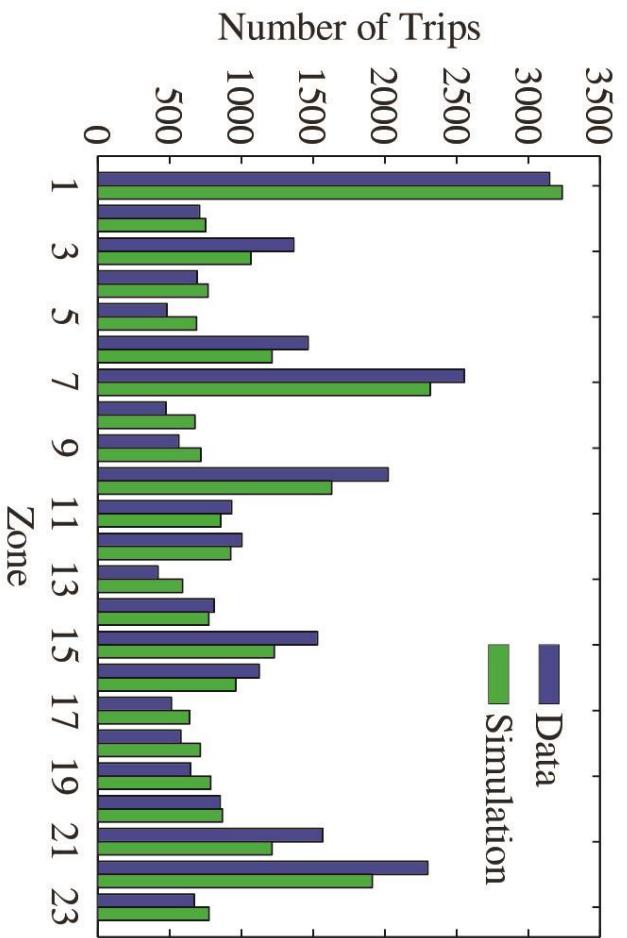
Results: Activity Labeling

- Our Relation Markov Network Model
 - Advantage: don't need labeled training data
 - Performing clustering instead of classification
 - The clusters naturally correspond to activity types

True Labels	Inferred Labels		
	Home	Work	Leisure
Home	100%	0%	0%
Work	2%	77%	21%
Leisure	3%	2%	95%

Results: Traffic Simulation

- Collective activity location distribution

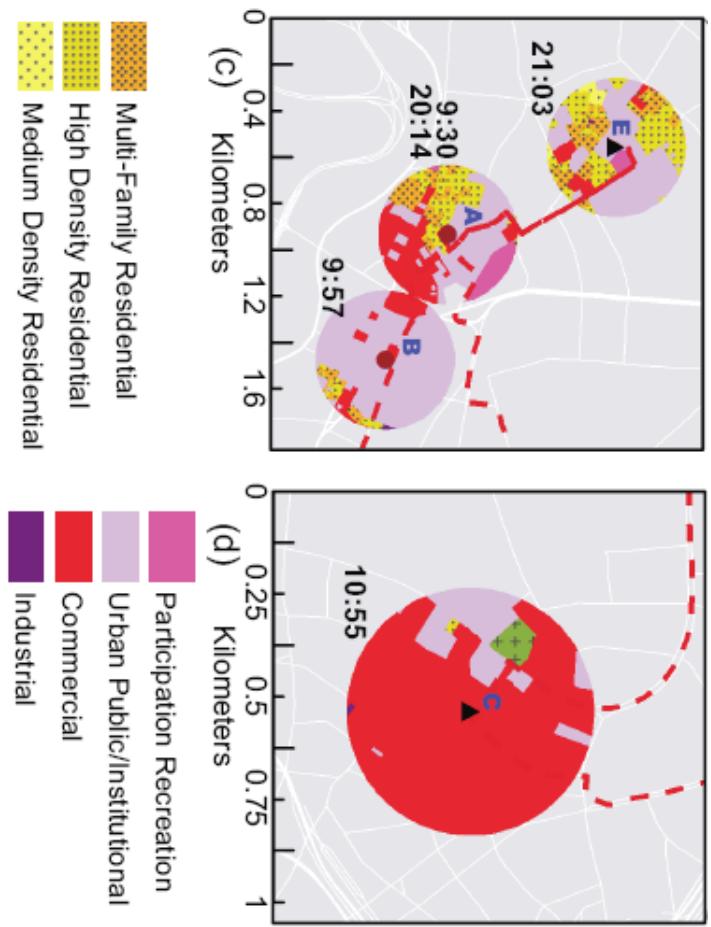


Shopping

Leisure

Current Challenge: How to influence urban behavior?

1. We can group people by the kinds of locations they visit



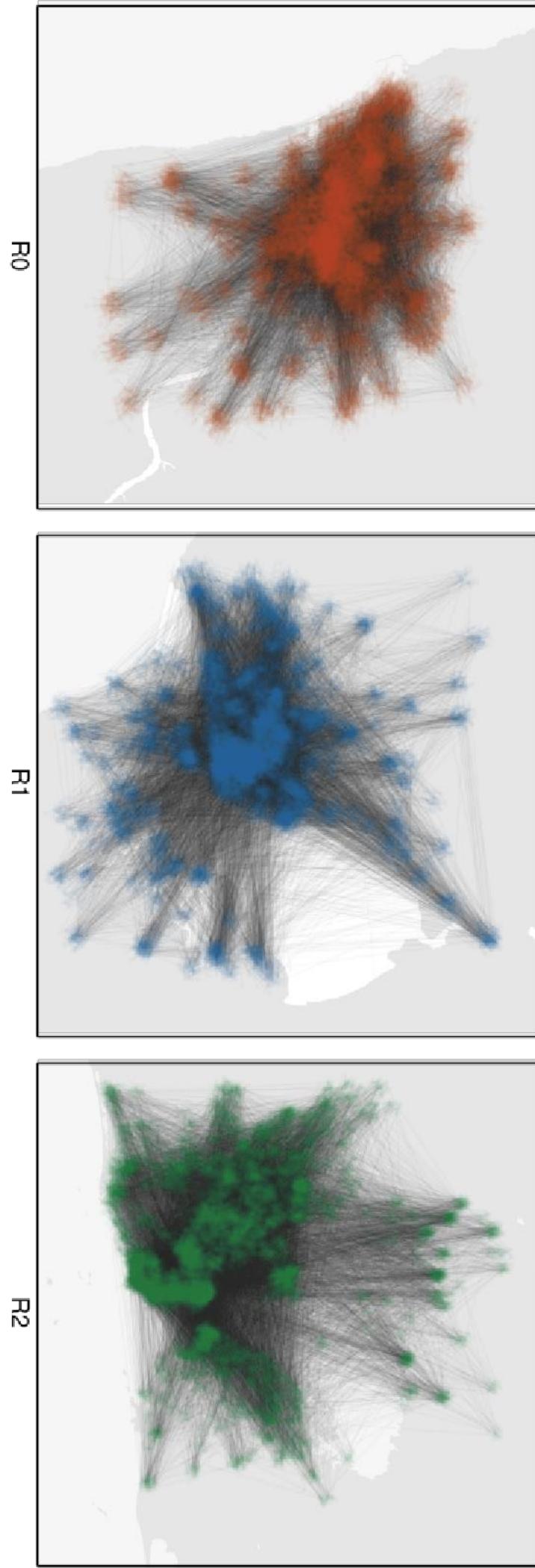
2. Explore Their Social Networks



3. Use On-line Platforms To motivate participation



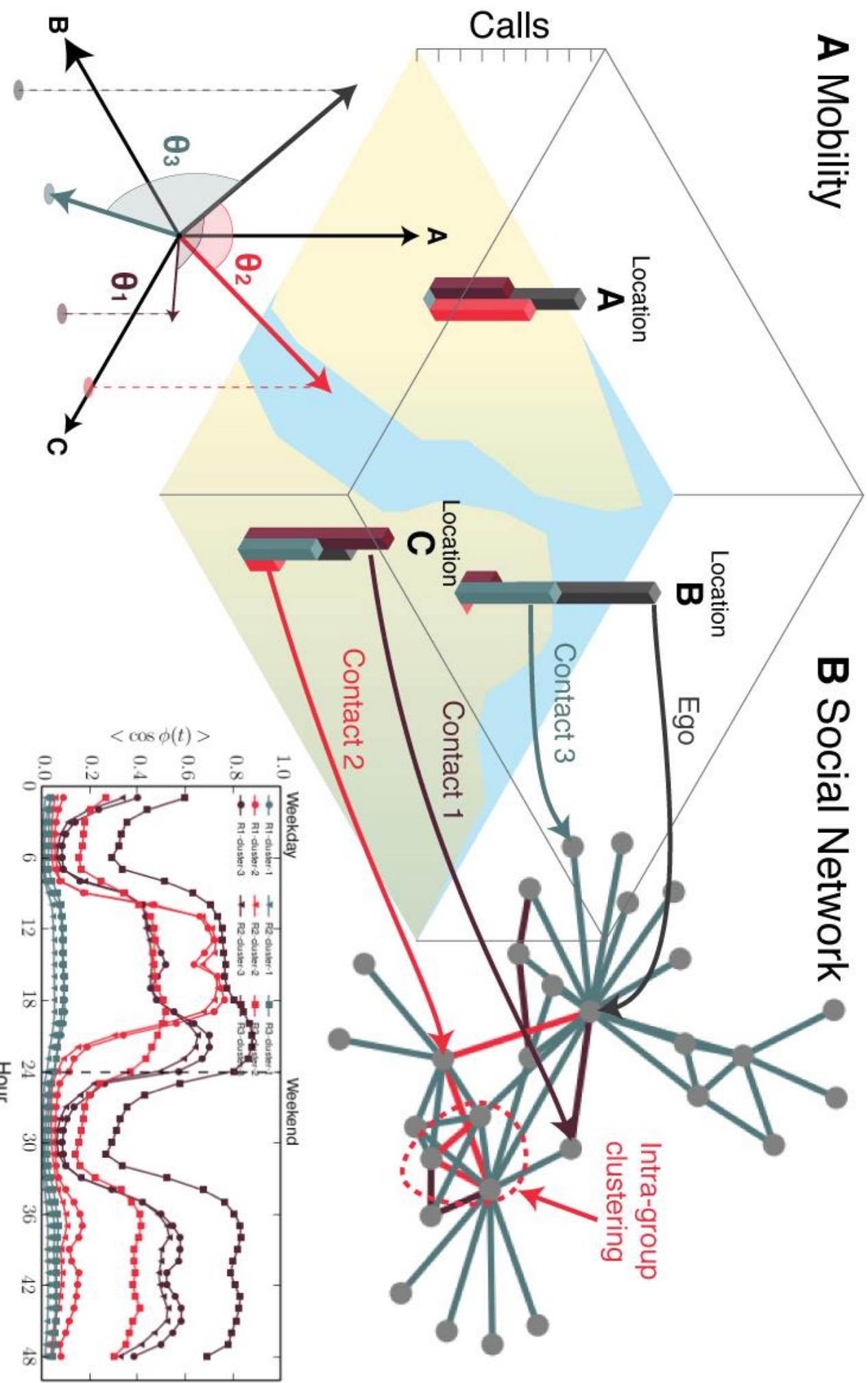
The Geography of Friendship



One hour's worth of calls mapped for each of the three cities we study

Result: Clustering Social Contacts Based on Mobility Similarity

C Cosine Similarity



Outlook

❖ No synthetic population but mobile phone users.

❖ We have developed algorithms to discover:
Activity Purpose, Road usage and Attributes of
Social contacts.

❖ We can design solutions and communicate
them back to the users.

❖ Social Networks insights and Web apps will
be game changers in urban applications!