

Computation & Crowds: Models for Dynamic Ridesharing

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Microsoft Research

Article:

Collaboration and Shared Plans in the Open World: Studies of Ridesharing,
IJCAI 2009, Pasadena, CA, July 2009.

People, Crowds, and Services

- Computation at center of opportunistic planning & coordination among people
- Principles for weaving together collaborations in light of related goals and preferences
- *Rideshare as theoretical & practical example*

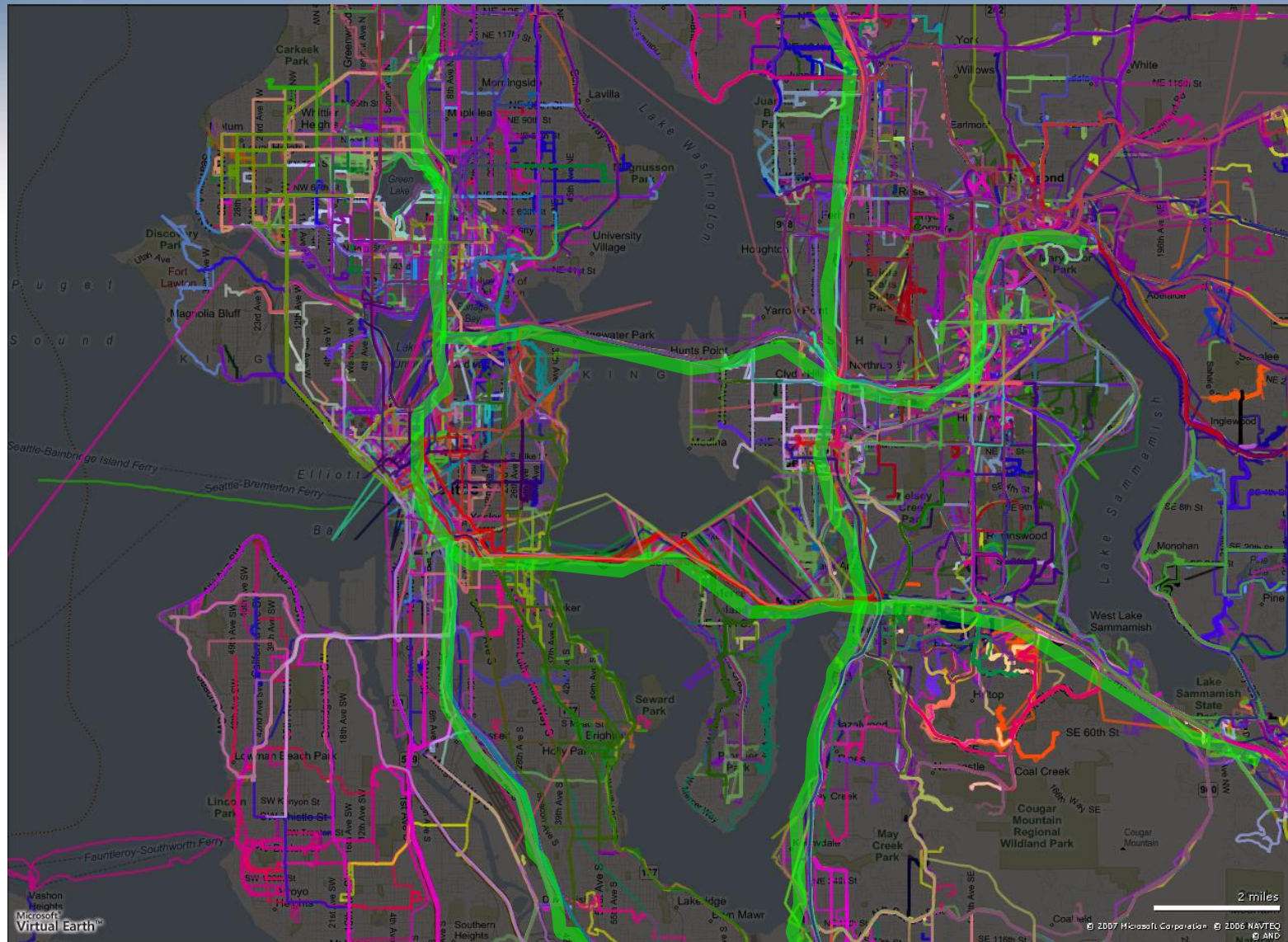
Data on location, trips, destinations

- Multiple sources

- GPS, cell tower, wifi
- Direction requests to routing services

> *e.g., MS Multiperson Location Survey*

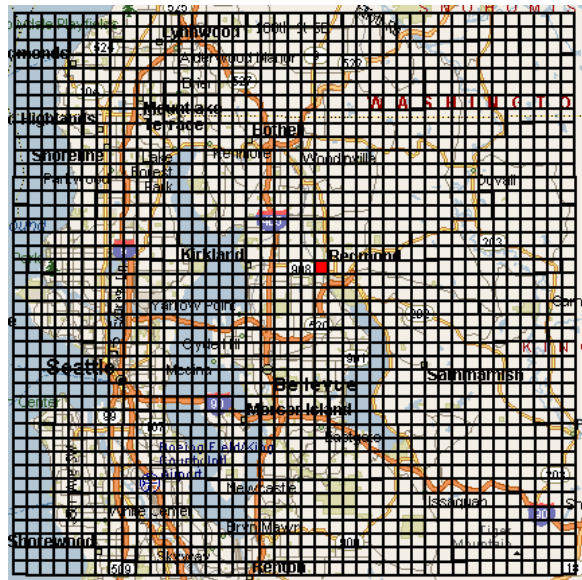
Data on location, trips, destinations



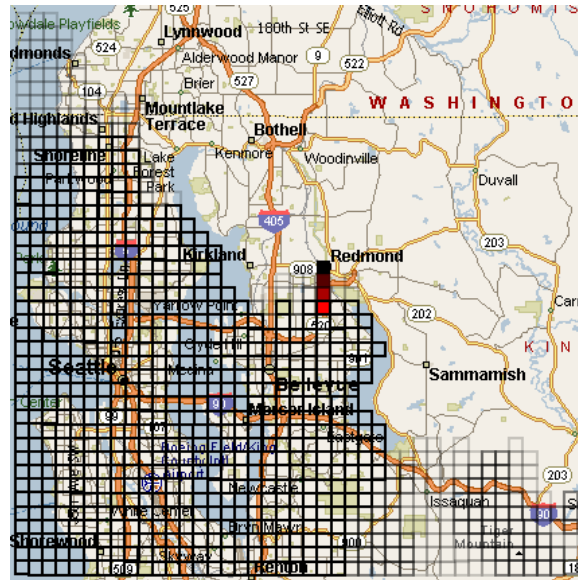
Data on location, trips, destinations

- e.g. Predestination algorithm

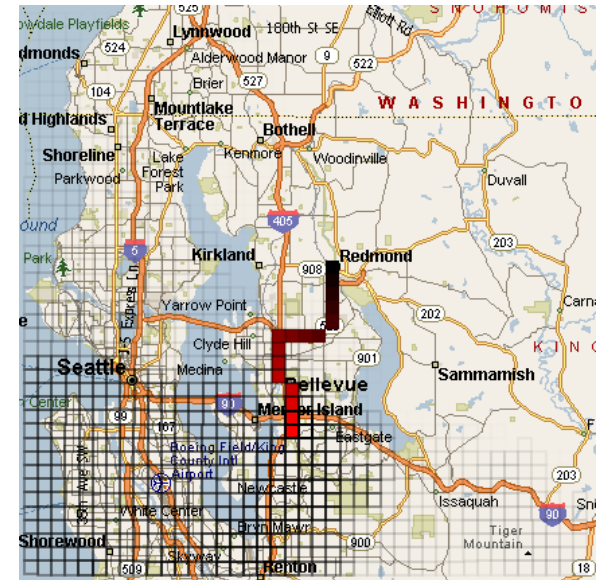
Assign probabilities to each cell as trip progresses



Trip starts



Inference as trip progresses

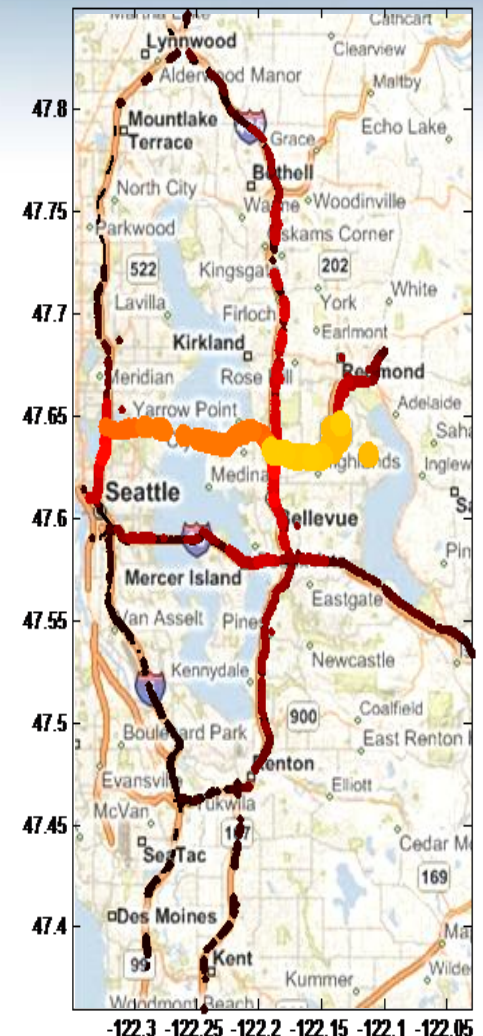
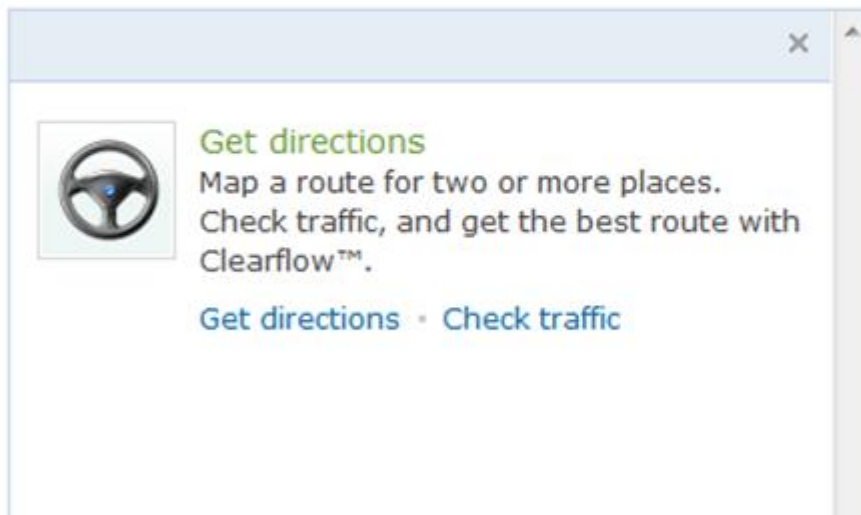


Narrowing of destination possibilities

- Median error 2 kilometers at trip's halfway point

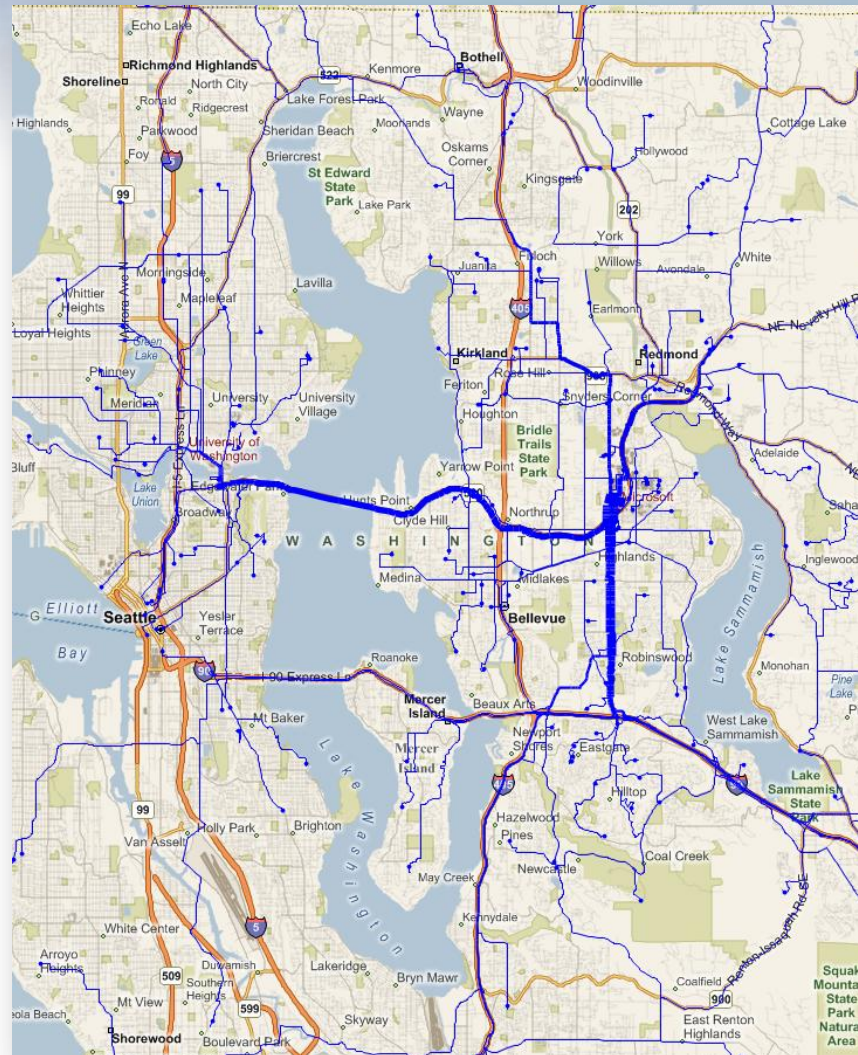
Learning from Data on Flows & Trips

- 5 yrs of GPS trails
- ~500,000 km
- Multiple projects
 - Clearflow (now in 72 cities)
 - Community sensing



Commutes from Flows and Trips

- e.g., Extract AM/PM commutes to/from Microsoft



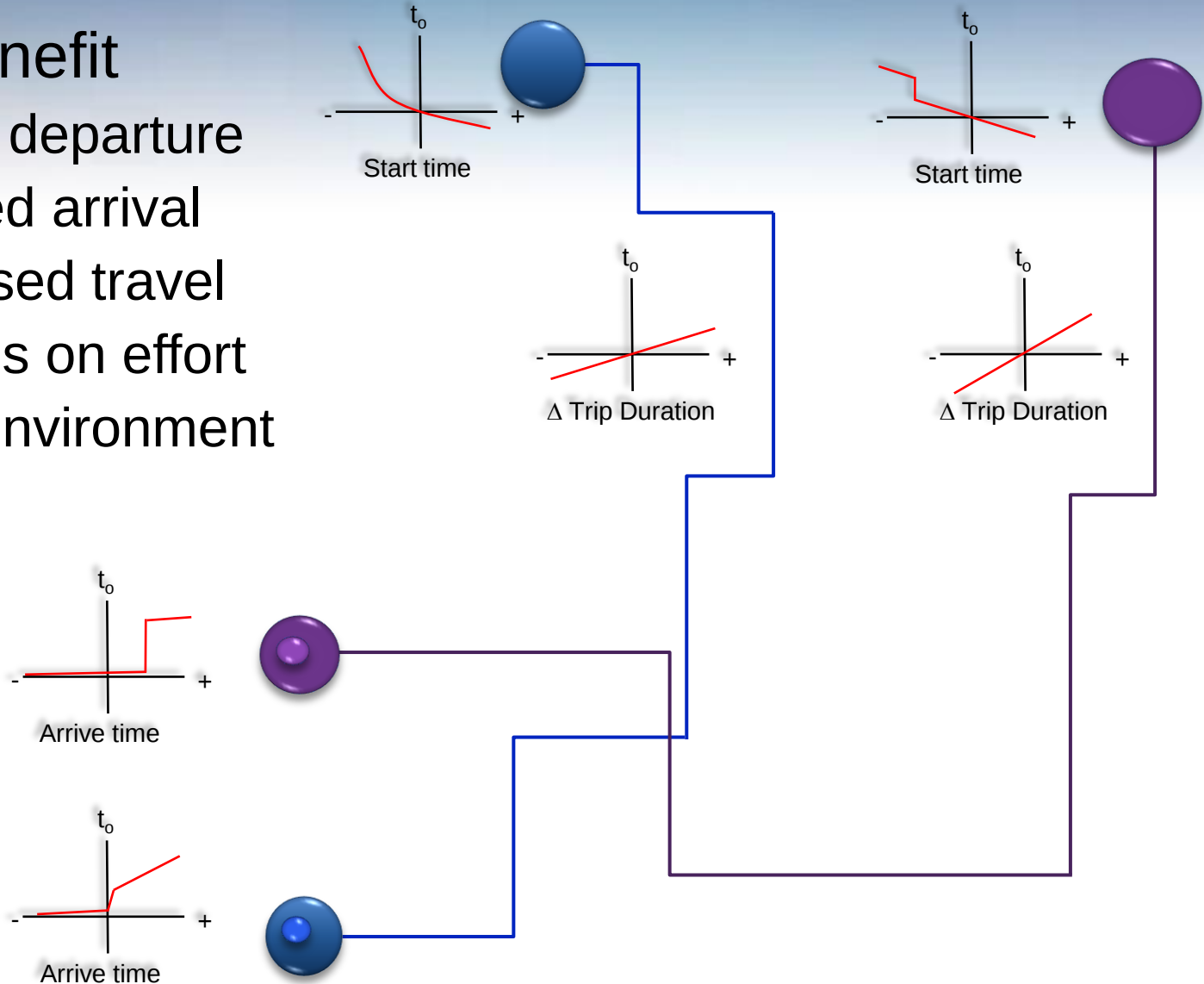
Toward Effective Rideshare Systems

- Ongoing computation in support of collaboration
- Changing needs & preferences
- Acceptance, trust, convenience, cost
- Range of scenarios
 - Spectrum across immediacy vs. planned
 - General vs. special situation
 - Owned car vs. shared vehicle (e.g., Zipcar style)

Balancing Diverse & Changing Needs

Cost-benefit

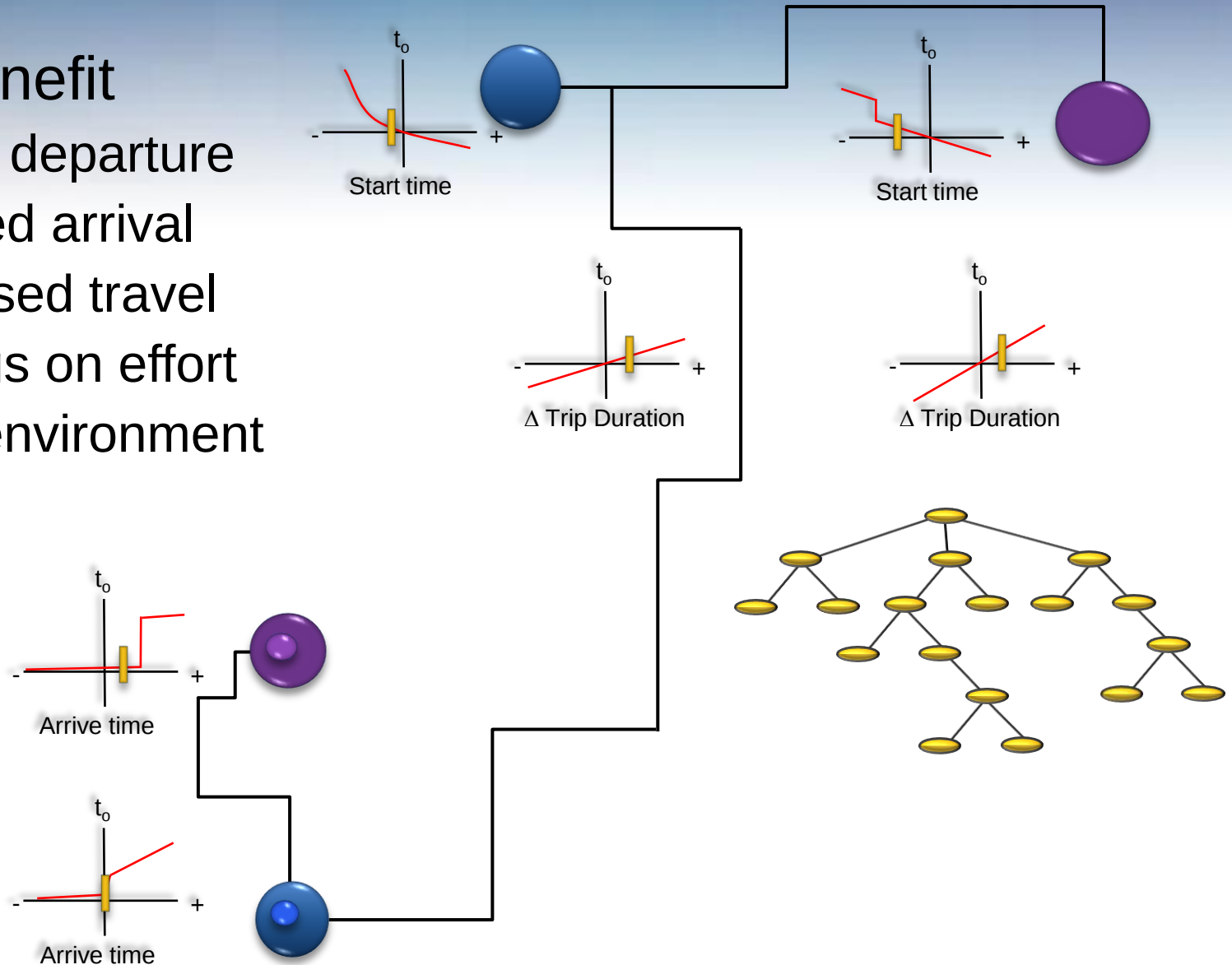
- Earlier departure
- Delayed arrival
- Increased travel
- Savings on effort
- Fuel, environment



Balancing Diverse and Changing Needs

Cost-benefit

- Earlier departure
- Delayed arrival
- Increased travel
- Savings on effort
- Fuel, environment



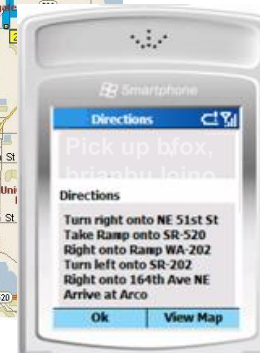
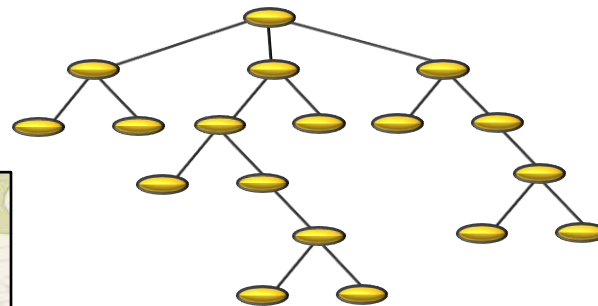
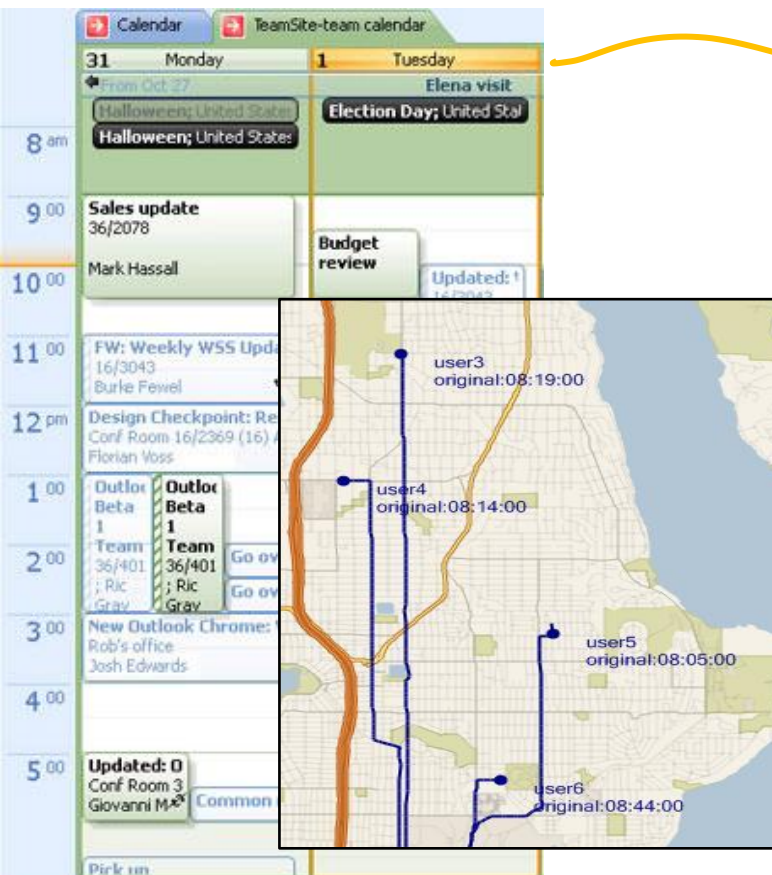
Agent-Based Carpool (ABC) System

- Instant & planned rideshare scenarios
- Methods for promoting fairness in reporting needs
- Social relationships, comfort, communication
- Prototype for running system & analytical bench

Optimize for individuals and across a population

ABC Rideshare

- Cost-benefit methods to find ideal rideshares
- Evaluated on GPS trails from MS employees



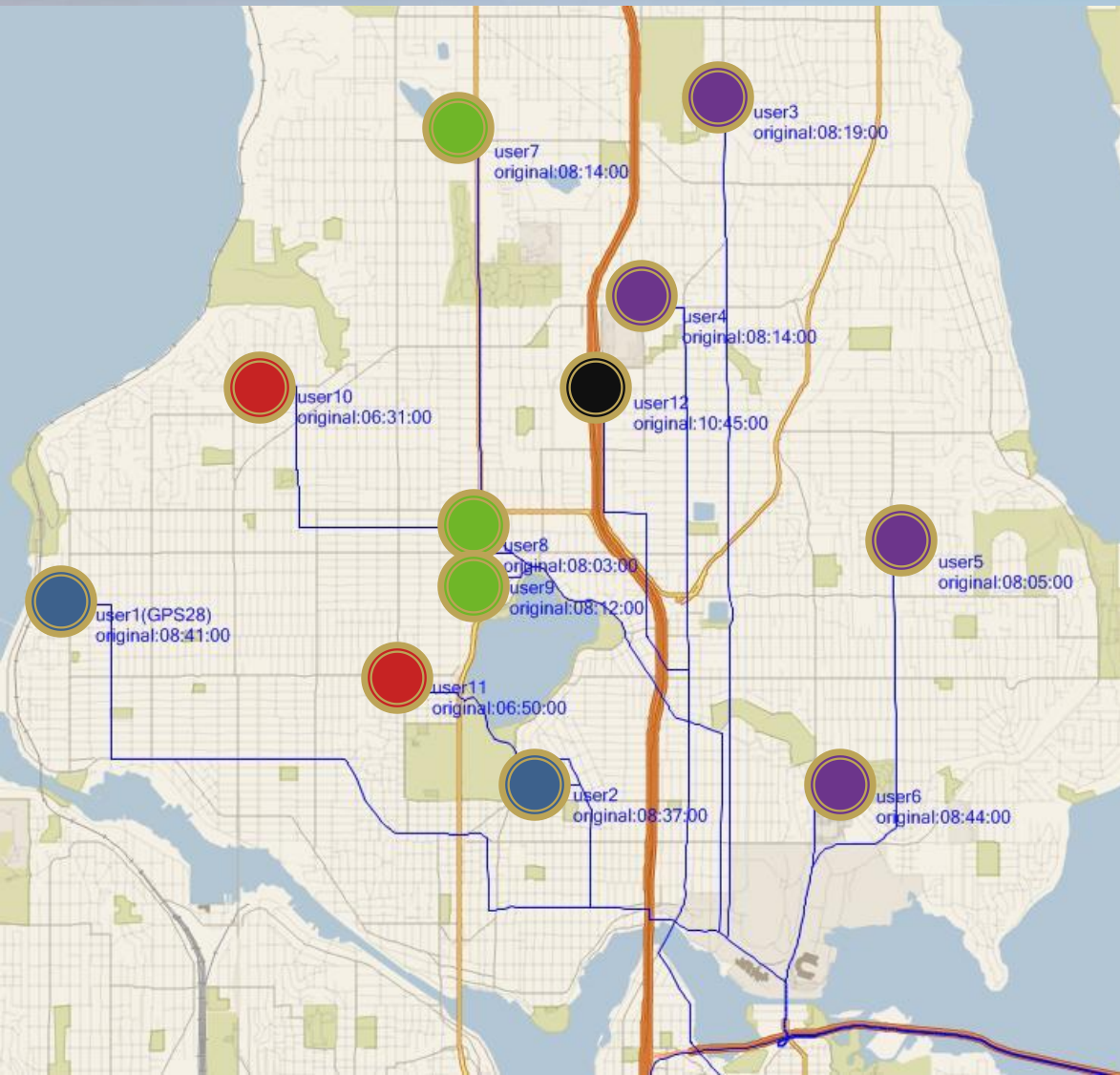
Total Cost
+
+ \$735.45

ΔCO_2
-231.17 tons per year

ΔK_m
+ \$7
56.89 km reduction

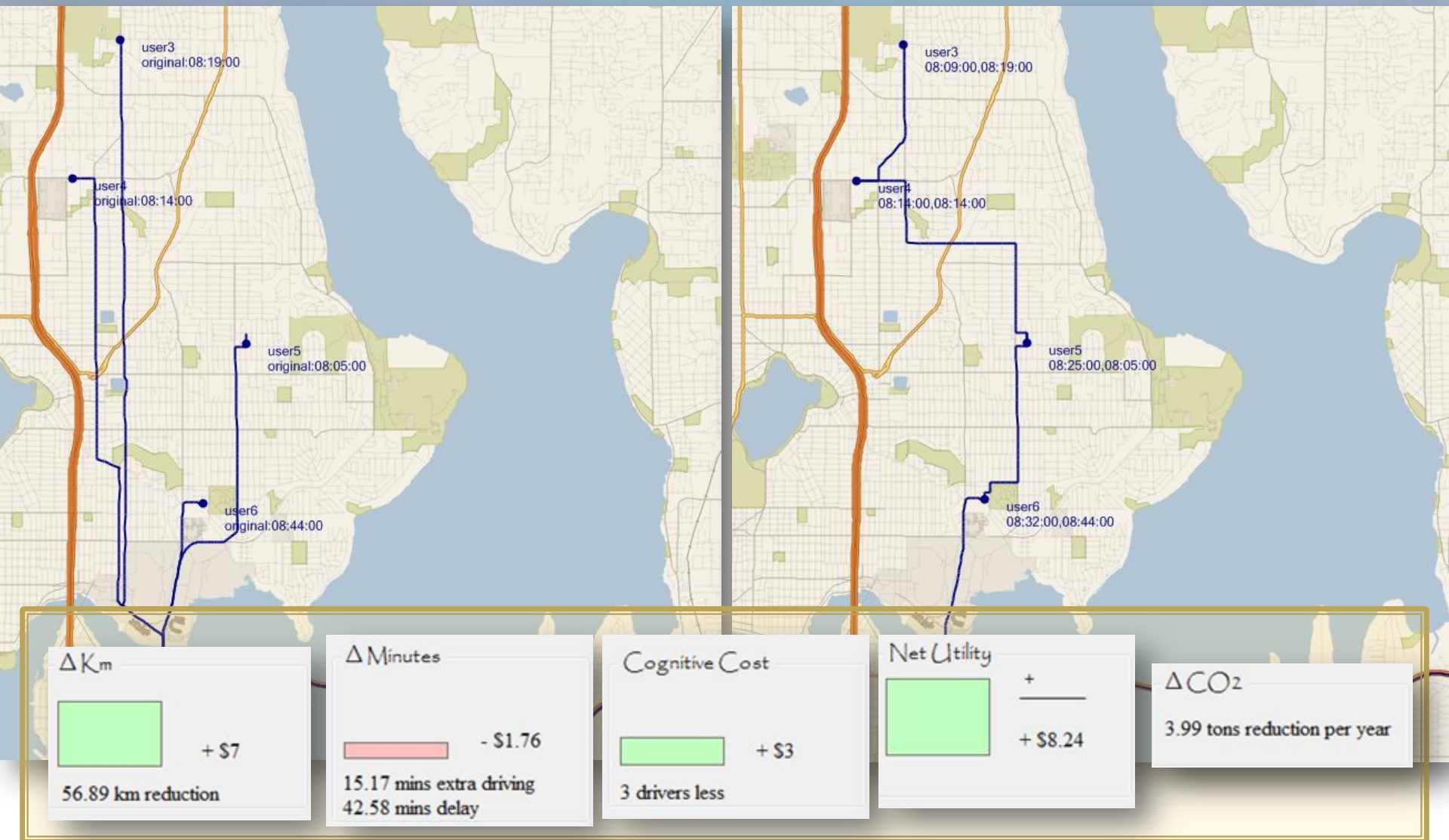
$\Delta Minutes$
- \$1.76
15.17 mins extra driving
42.58 mins delay

Ideal Coalescence



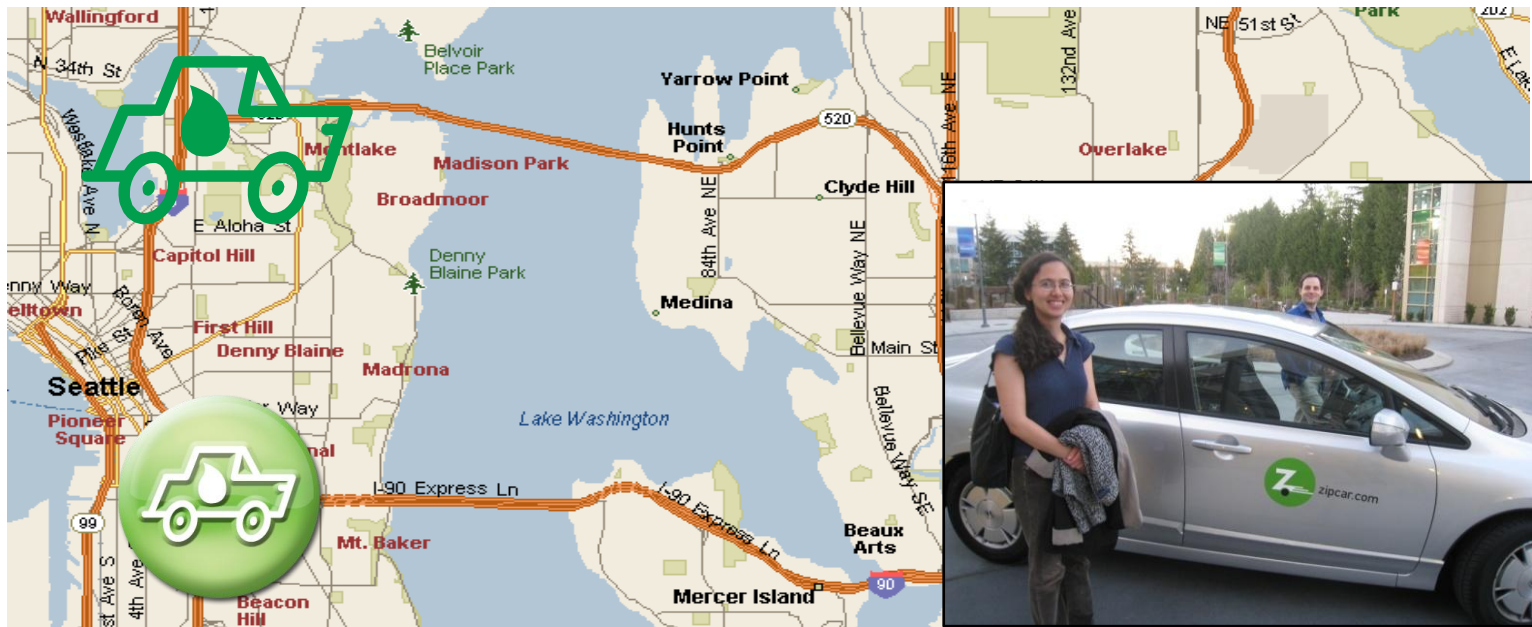
- Assignments based on observed trips.
- Cost-benefit
 - Departure change
 - Delayed arrival
 - Increased travel
 - Savings on effort, fuel, environment

Ideal Coalescence

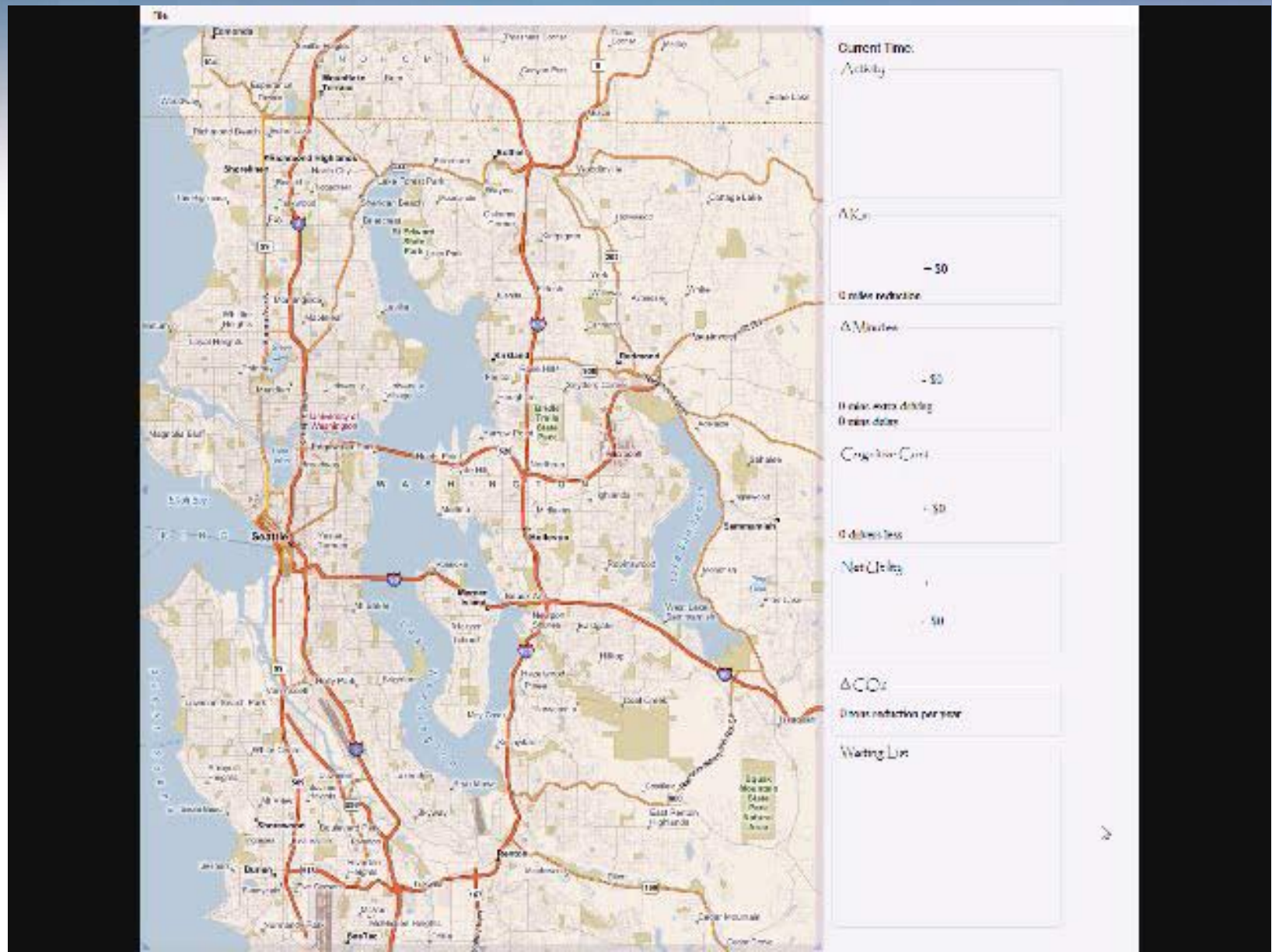


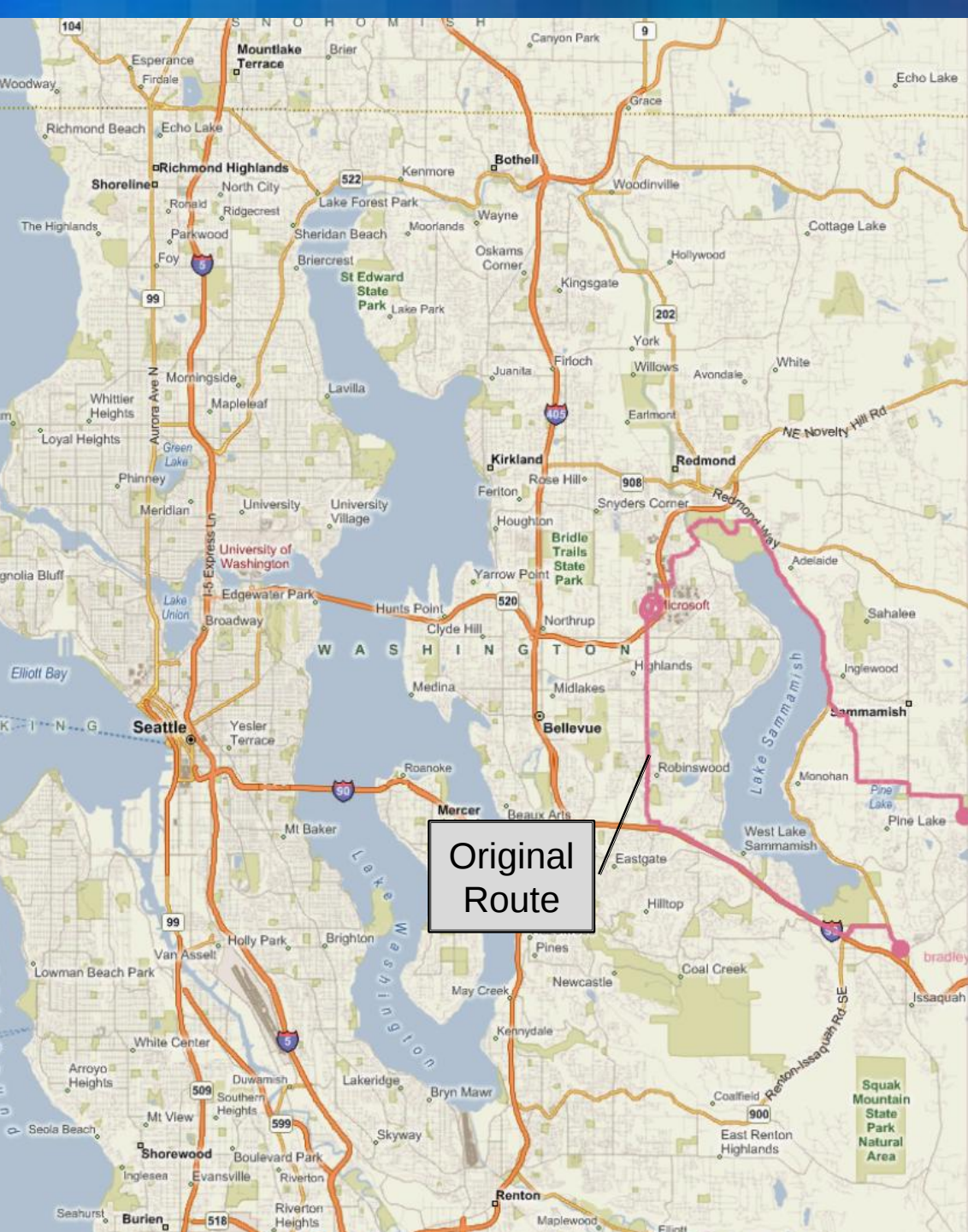
Planned vs. Instant Commuting

- Planned commute
 - ABC notified of AM/PM needs day in advance
- Instant: Commute requests on the fly
 - ABC notified 15 minutes before trip start time



Execution with Real-World Workload



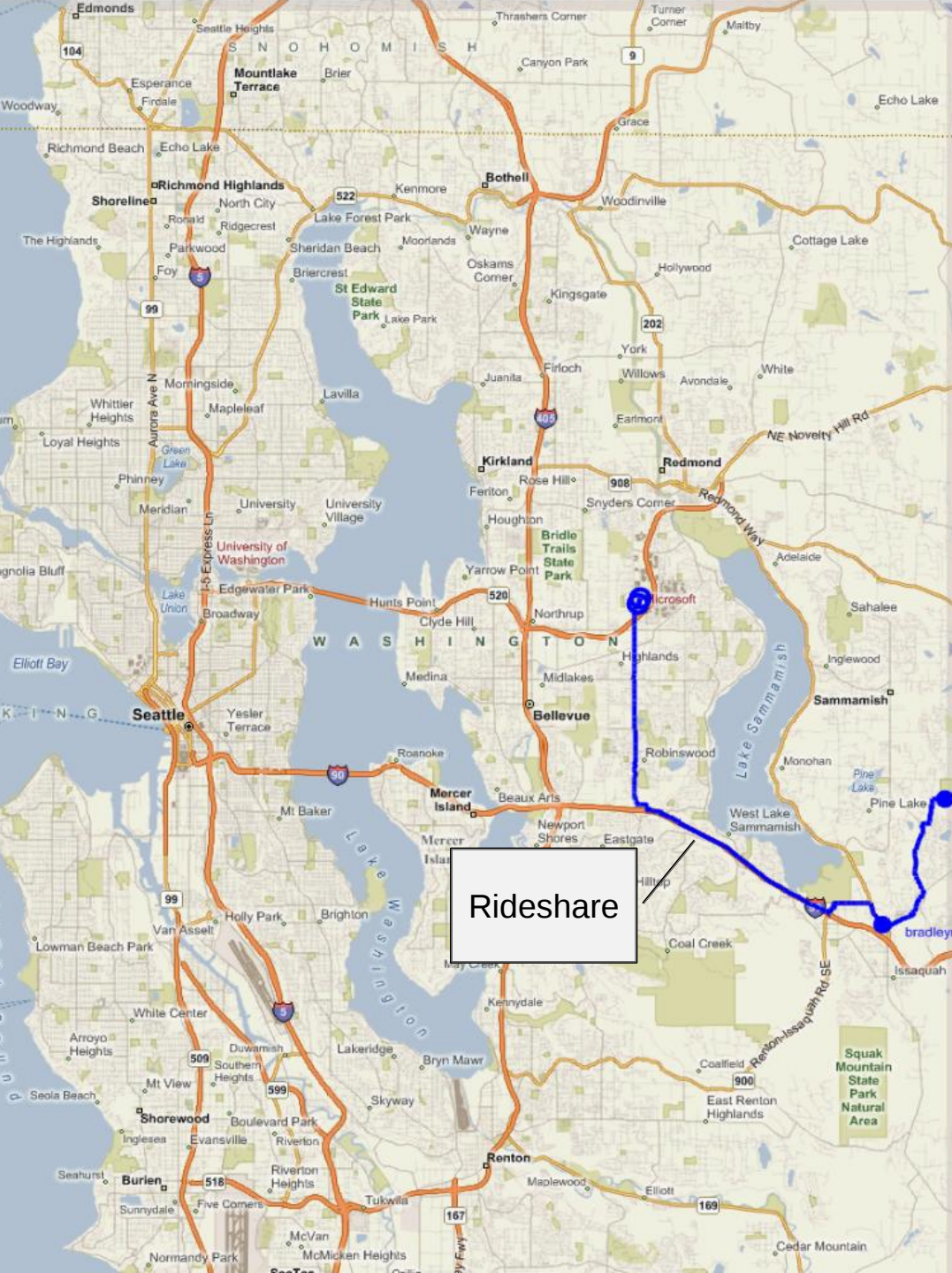


Original Route

Activity	driver added: gerryb for bradleyr (1)
ΔK_m	+ \$1.72 13.96 km reduction
$\Delta Minutes$	- \$0.19 -5.53 mins extra driving 17.37 mins delay
Cognitive Cost	+ \$1 1 drivers less
Net Utility	+ + \$2.53
ΔCO_2	0.98 tons reduction per year
Waiting List	2:gerryb,bradleyr:06:28 AM 2:dbarker,jasonv:06:31 AM 1:pfgoerty:06:33 AM

New user
($<30min$)





Current Time: 06:09 AM

Activity

driver added: gerryb for bradleyr (1)

ΔK_m

+ \$1.72

13.96 km reduction

Δ Minutes

- \$0.19

-5.53 mins extra driving
17.37 mins delay

Cognitive Cost

+ \$1

1 drivers less

Net Utility

+
+ \$2.53

ΔCO_2

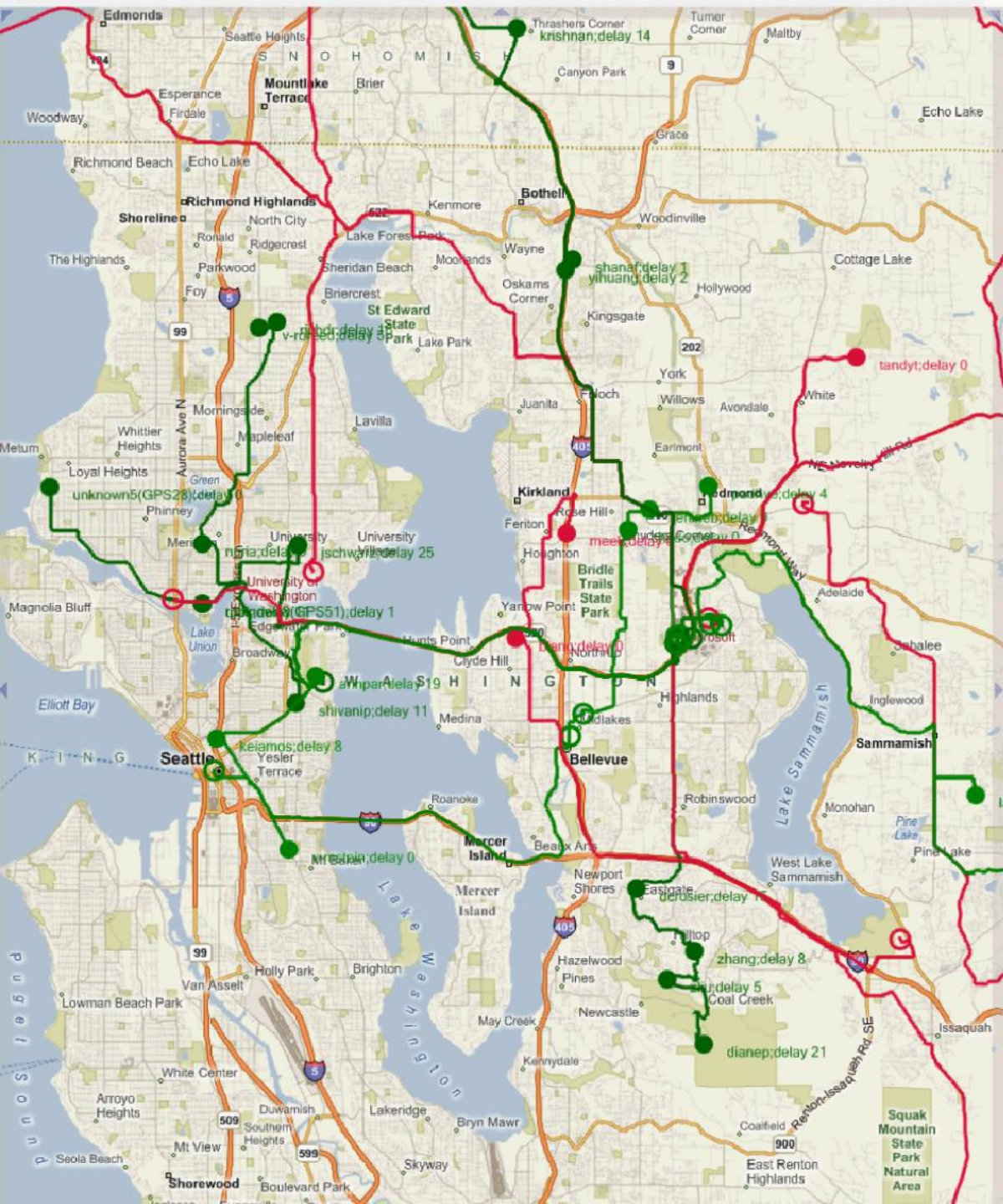
0.98 tons reduction per year

Waiting List

2:gerryb,bradleyr:06:28 AM
2:dbarker,jasonv:06:31 AM
1:pfgoerty:06:33 AM

Cost-benefit
Analysis

Queue



Current Time: 08:55 AM

Activity

trip ended: ggoodall (3)
trip ended: dbnck (1)

ΔK_m

+ \$0

0 km reduction

Δ Minutes

- \$0

0 mins extra driving

0 mins delay

Cognitive Cost

+ \$0

0 drivers less

Net Utility

+

+ \$0

ΔCO_2

0 tons reduction per year

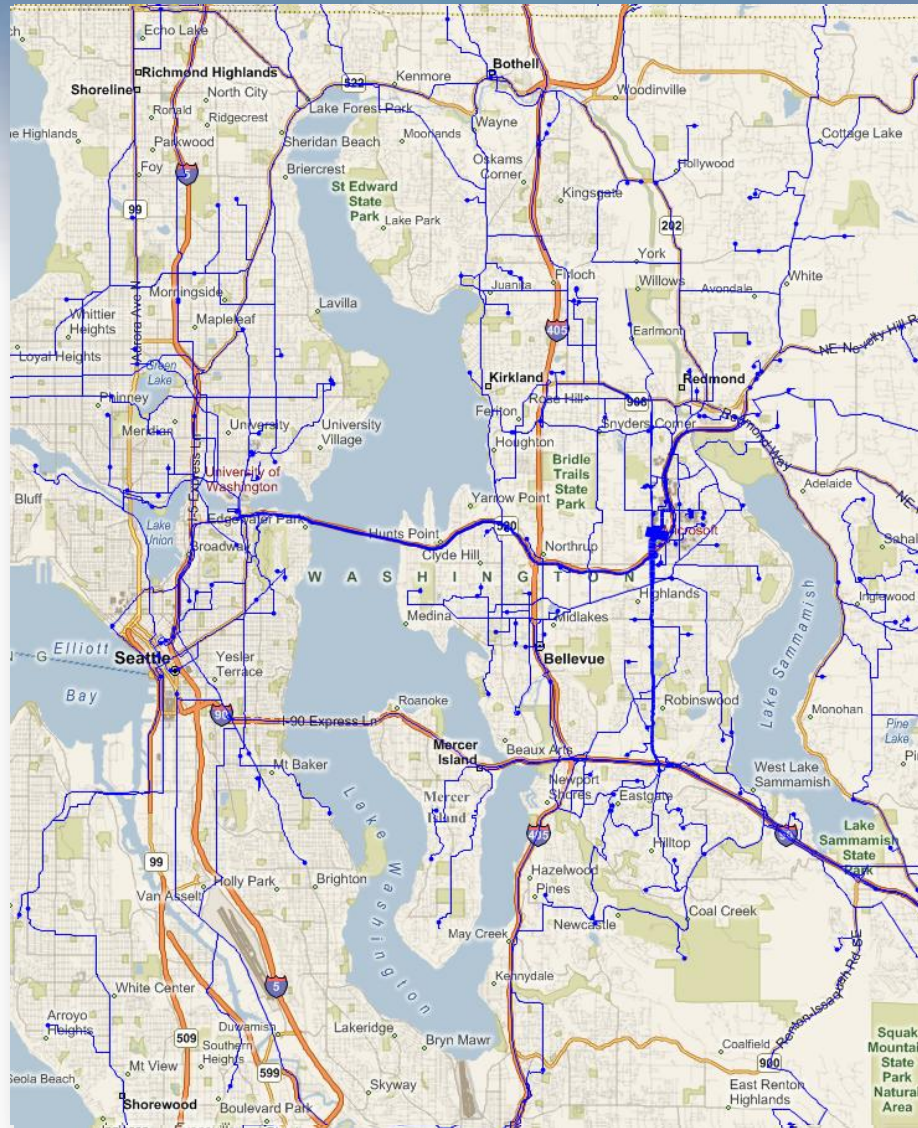
Waiting List

2:v-jahann,lukew:09:03 AM
2:liley_35,unknown3(GPS14):09:04 AM
1:v-tgwily:09:10 AM
1:a-delock:09:14 AM
1:tammyw:09:14 AM
2:egibbs,t-benkom2 :09:11 AM

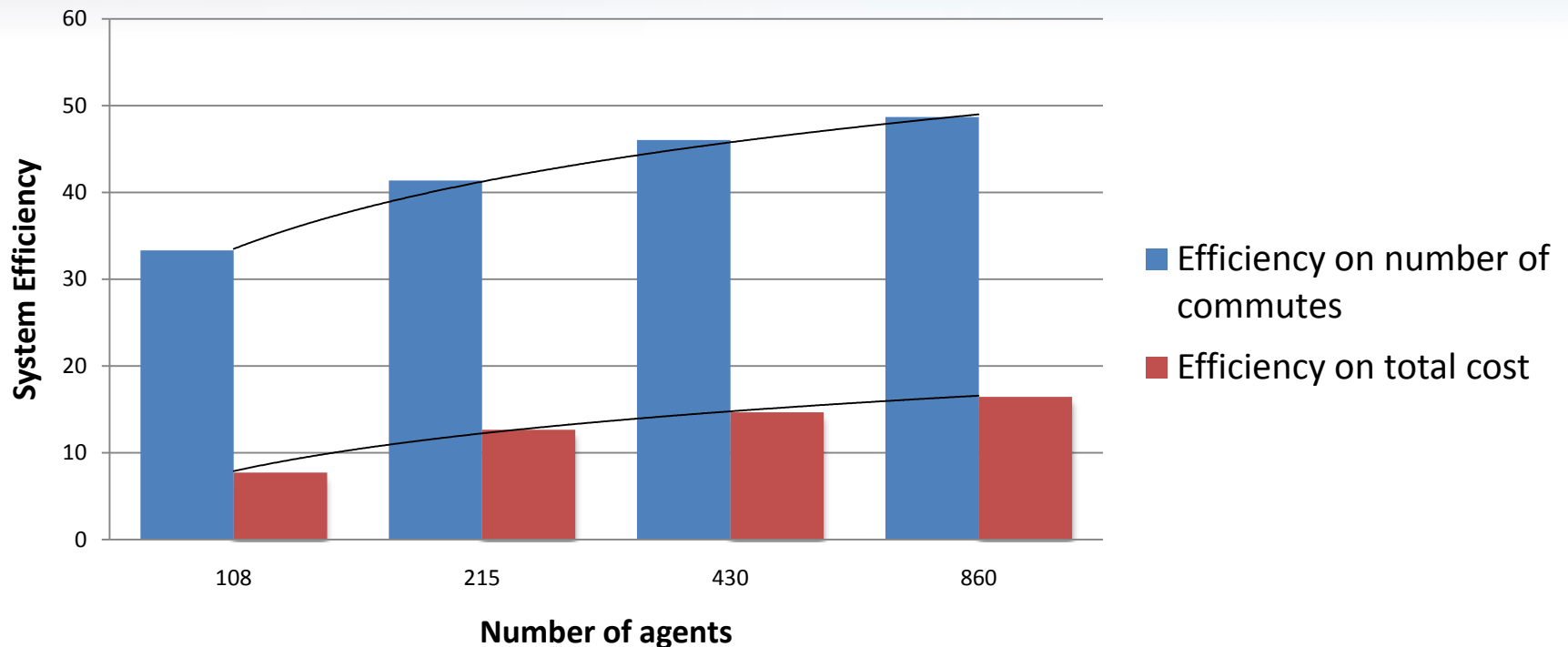
Trip Activity
-Green: share
-Red: single

Queue

AM Commute

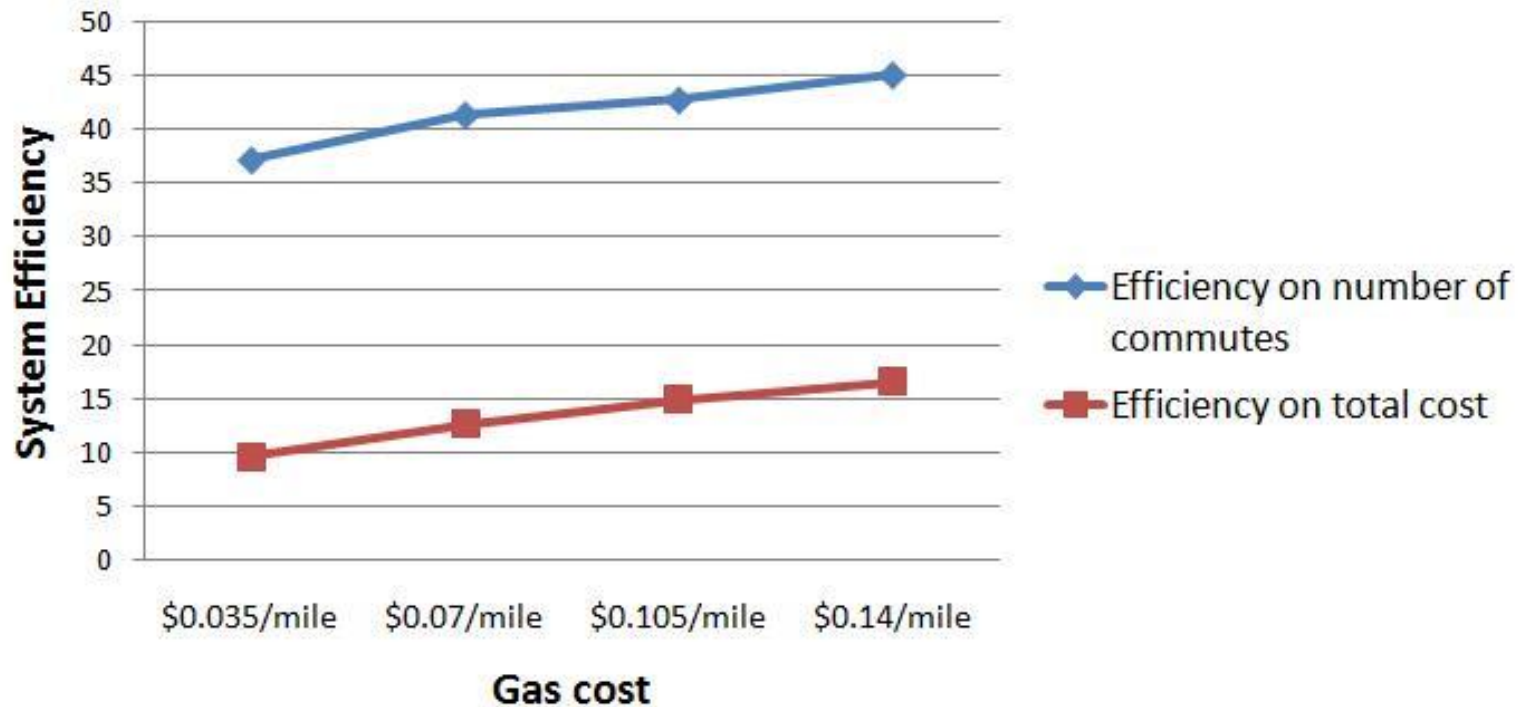


Beyond Real-Time: "What If?" Studies



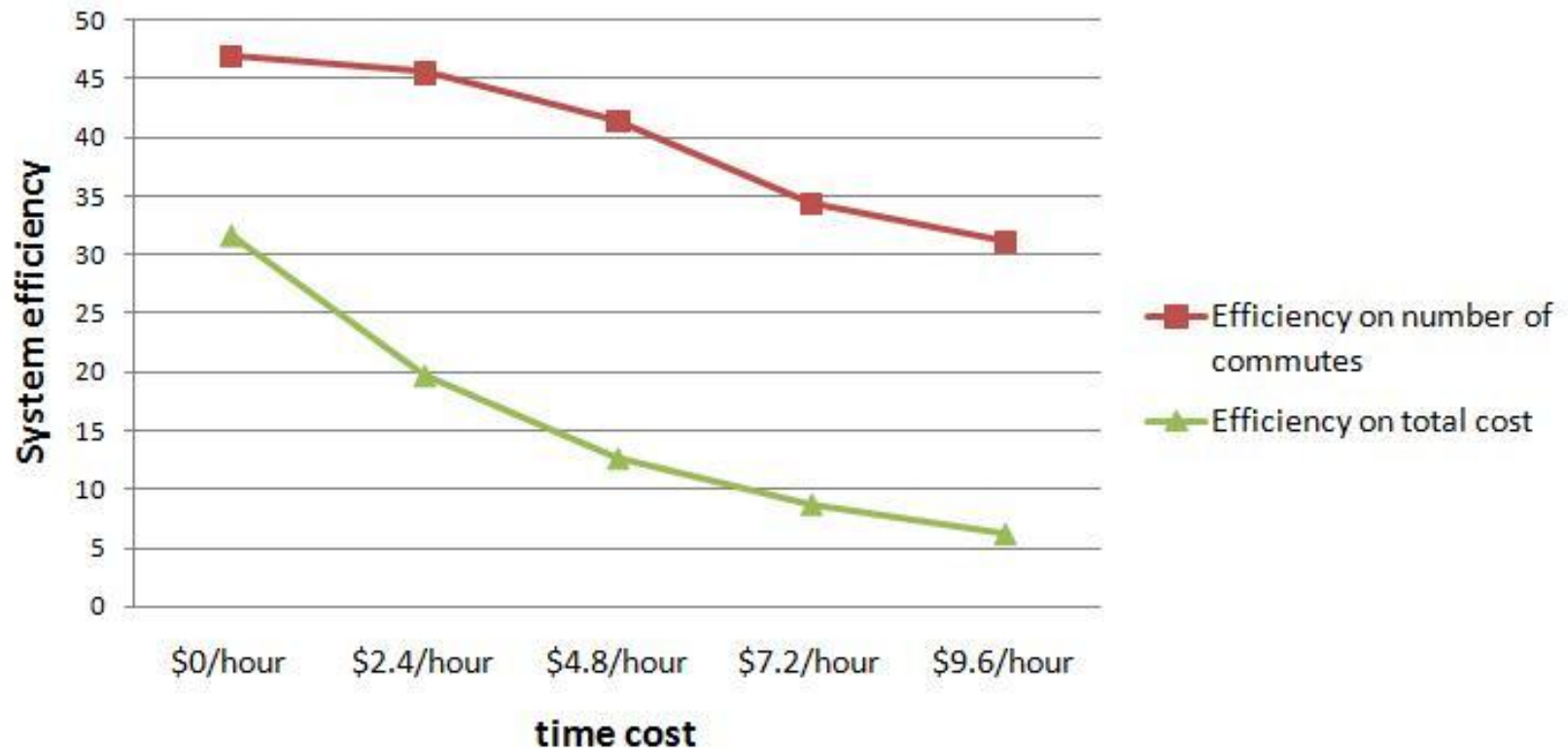
Number of participants →

Beyond Real-Time: "What If?" Studies



Fuel Cost →

Beyond Real-Time: "What If?" Studies

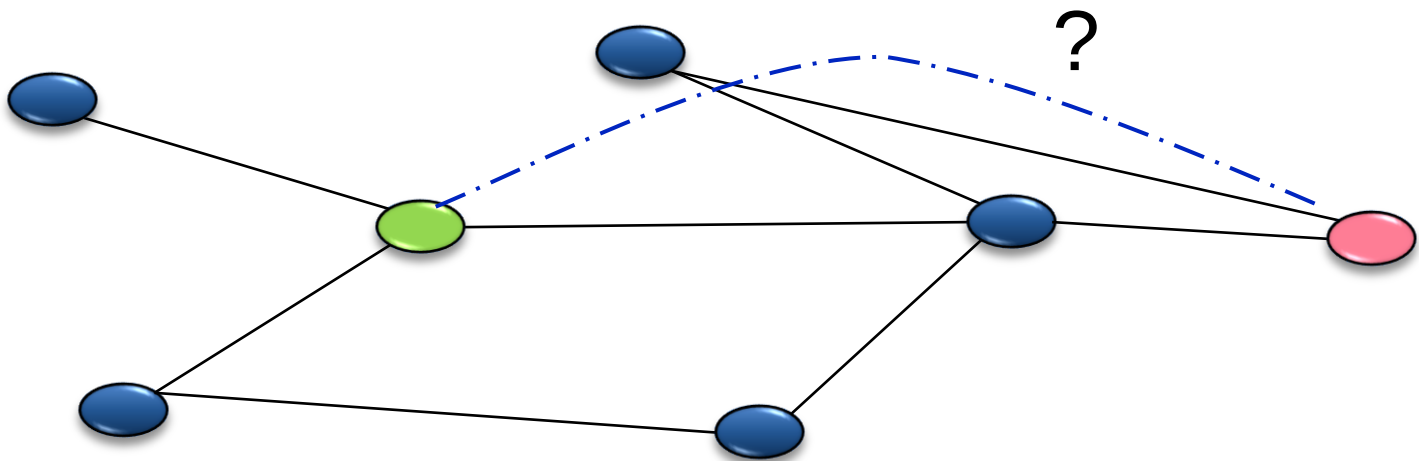


Cost of time →

Acceptance, Trust, and Ridesharing

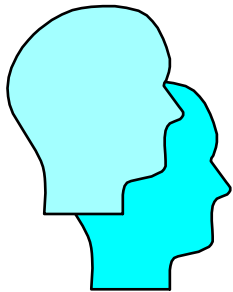
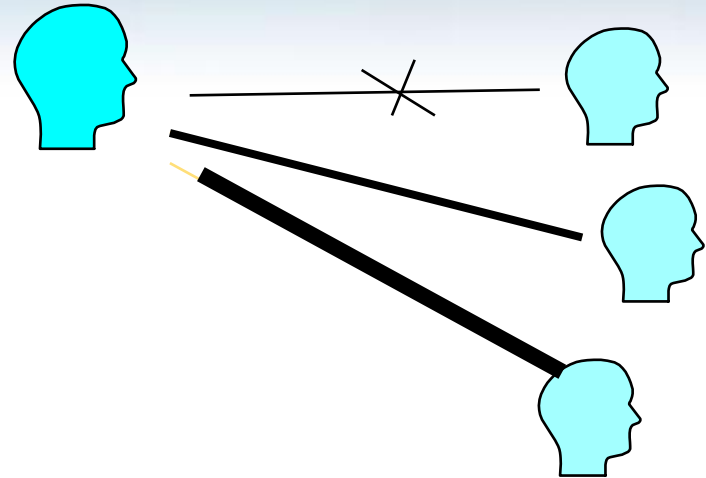
Challenge: Understanding acceptance, perceptions, social considerations

- Address concerns, leverage opportunities
- Trusted organizations
- Referral, reputation
 - e.g., existing online social networks (e.g., link distance bounds)



Integrating Preferences about People

- Optimization allows for smooth insertion of:
 - Constraints
 - Preferences



$$U(p_i, p_j) = d(a_i, a_j)$$

$$= f(d(a_{i1}, a_{j1}), \dots, d(a_{in}, a_{jn}))$$

$$= \sum_l k_l d(a_{il}, a_{jl})$$

Distances and Relationships

The screenshot shows a web browser window displaying Eric Horvitz's Facebook profile. The browser's address bar shows "Eric Horvitz's Home..." and the Facebook logo. The profile page has a navigation bar with "Wall", "Info", "Photos", and "Boxes". A large profile picture of Eric Horvitz is on the left. Below it are links for "View Photos of Me (1)" and "Edit My Profile". A text box for "Write something about yourself." is present. The "Information" section lists "Networks: Microsoft, Stanford Alum '90" and "Relationship Status: Married". The "Friends" section shows "335 friends" and a "See All" link. The main content area is titled "What's on your mind?" with a text input field and a "Share" button. Below this are tabs for "Eric + Friends", "Just Eric", and "Just Friends", along with a "Settings" link. The "RECENT ACTIVITY" section shows two entries: "Eric and Cari L Murphy are now friends." and "Eric and Rob Miller are now friends.", each with "Comment" and "Like" links. A link for "2 more similar stories" is also present. Below this is a post from Nuria Oliver, dated March 31 at 10:22pm, with "Comment", "Like", and "See Wall-to-Wall" links. Another "RECENT ACTIVITY" section shows "Eric and Christian Borgs are now friends." and "Eric and Lori Horvitz are now friends.", with "7 more similar stories" link. Below this is a post from Sarah Revi Sterling, dated March 21 at 8:50am, with "Comment", "Like", and "See Wall-to-Wall" links. At the bottom, a post from Prasun Dewan is partially visible.

Eric Horvitz's Home... Facebook | Eric ... X

Wall Info Photos Boxes +

What's on your mind?

Share

Eric + Friends Just Eric Just Friends Settings

RECENT ACTIVITY

Eric and Cari L Murphy are now friends. · Comment · Like

Eric and Rob Miller are now friends. · Comment · Like

2 more similar stories

Nuria Oliver Eric!!!! how are you?? thanks for your post on IJCAI! I am so happy!! are you going to CHI? I'll be there. Would be great to catch up during a coffee break!!
I hope that all is going well in Seattle!
n
March 31 at 10:22pm · Comment · Like · See Wall-to-Wall

RECENT ACTIVITY

Eric and Christian Borgs are now friends. · Comment · Like

Eric and Lori Horvitz are now friends. · Comment · Like

7 more similar stories

Sarah Revi Sterling nice NPR slot!!
March 21 at 8:50am · Comment · Like · See Wall-to-Wall

Prasun Dewan Eric, Just heard your NPR interview! In fact, when Lee

View Photos of Me (1)
Edit My Profile

Write something about yourself.

Information

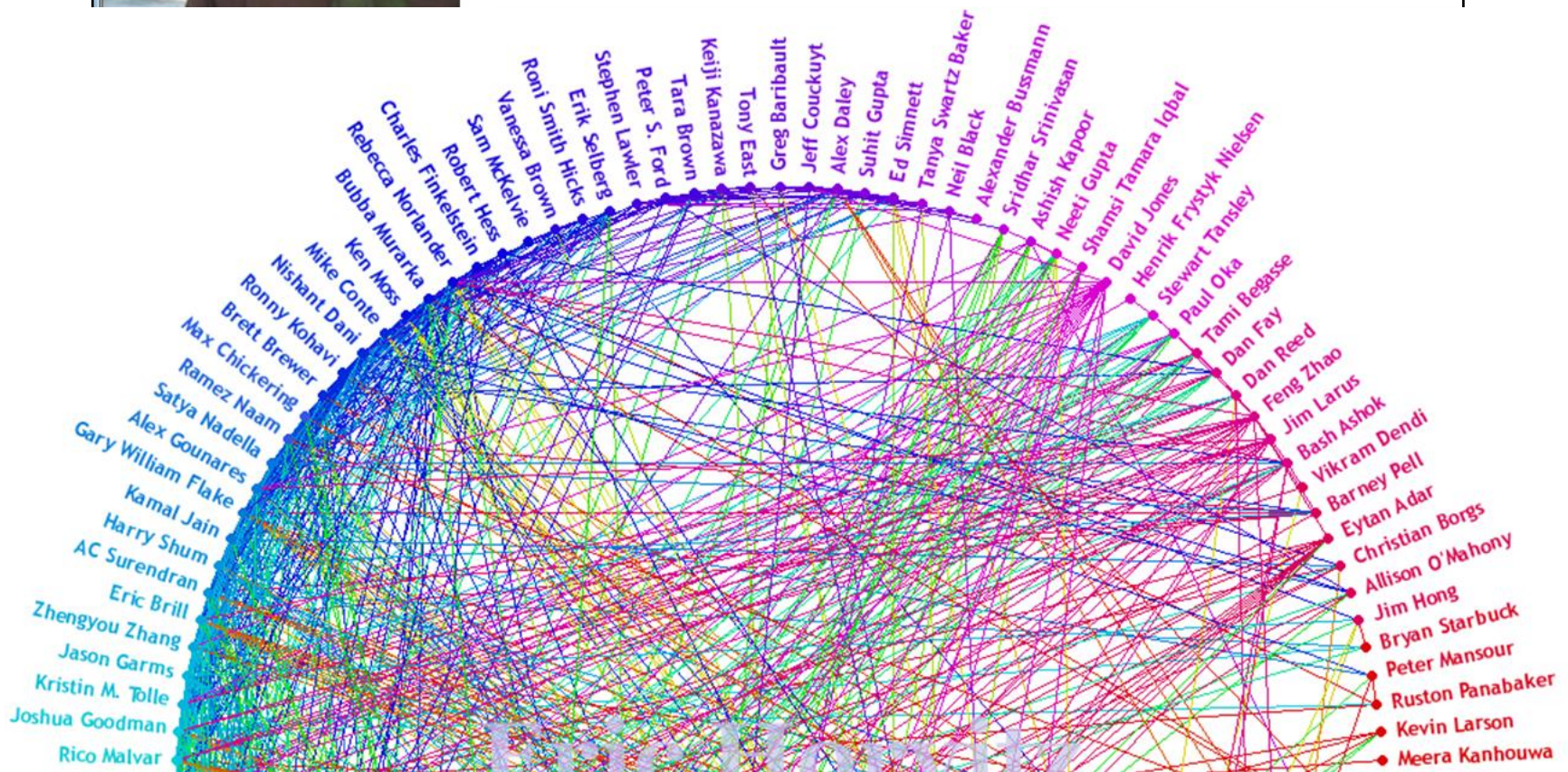
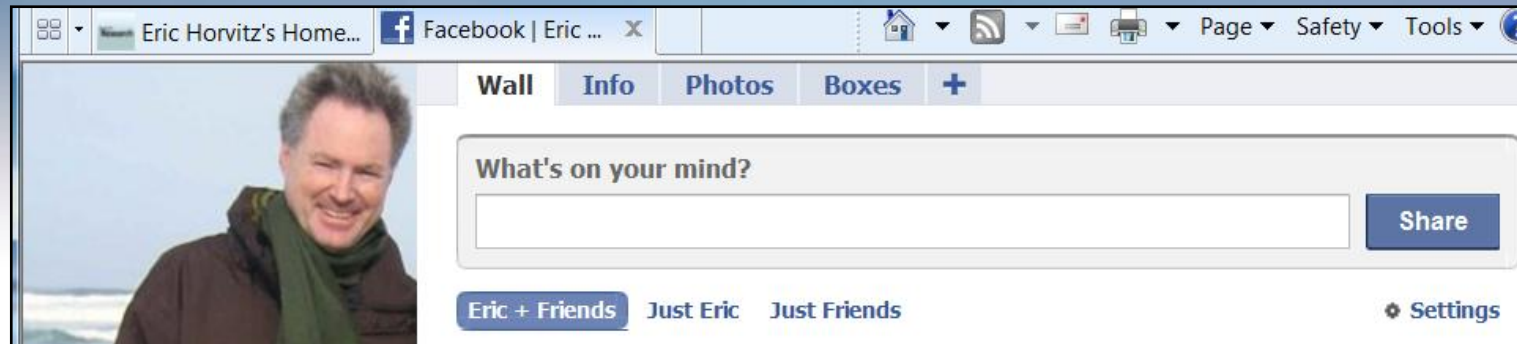
Networks:
Microsoft
Stanford Alum '90

Relationship Status:
Married

Friends

335 friends See All

Distances and Relationships



Directions

- Studies of preferences & acceptability
 - Flexibility, acceptance, and ease of use
- Implementation directions
 - Shuttle overlay, instant carpool, AM/PM commute
 - Outlook add-in, web service
 - Encode preferences, needs, commitments

*Collaboration with MS Real Estate & Facilities,
MS Sustainability, King County Metro*

Extending Principles to Other Areas

- Identified methods that harness computing for coordination among people
- Computing services integrate data about know-how, availability, location, and goals.
- Other location-centric coordination

Extending Principles to Other Areas

- e.g., Related work: Creating meshes of people for emergency assistance

