

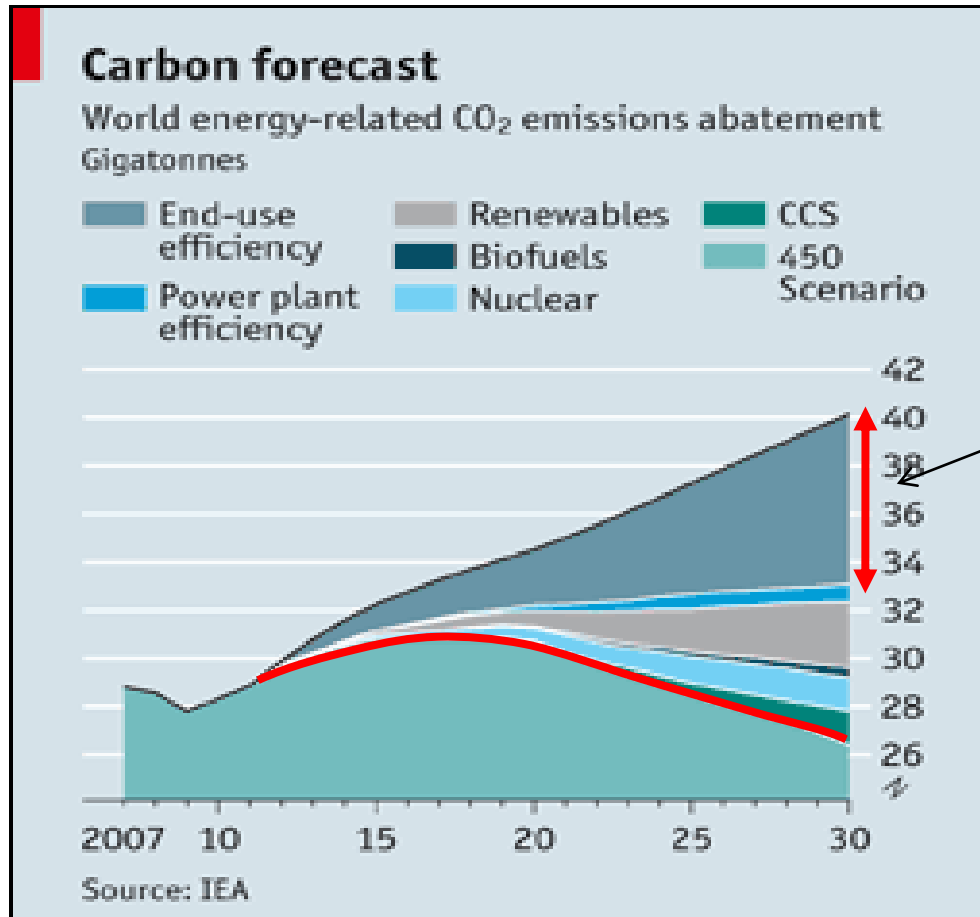
# AI planning, shared mobility, and sustainability

Eric Horvitz  
Microsoft Research

December 2009

# Promise of Efficiency & Conservation

- Copenhagen meeting
- Emissions abatement → 450 ppm by 2030 (~2°).



End-use efficiency

(IEA 10/09)

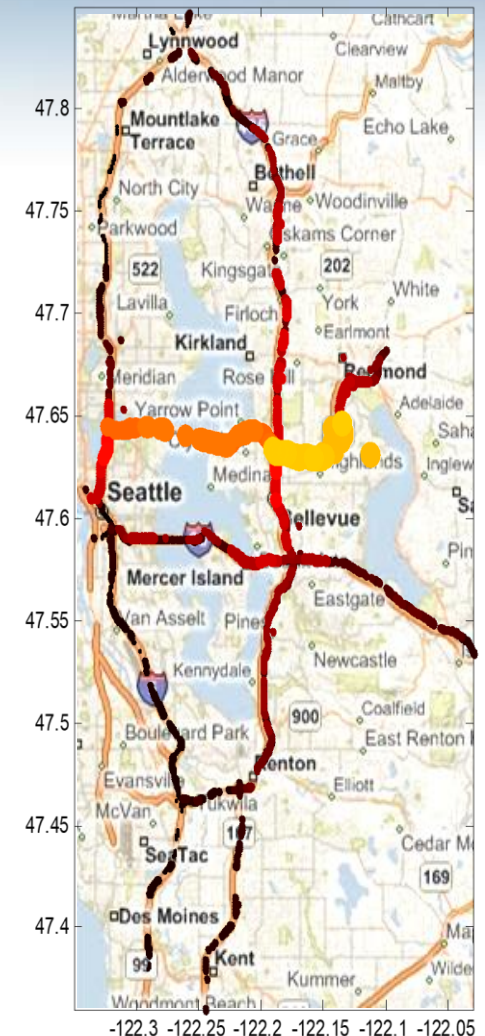
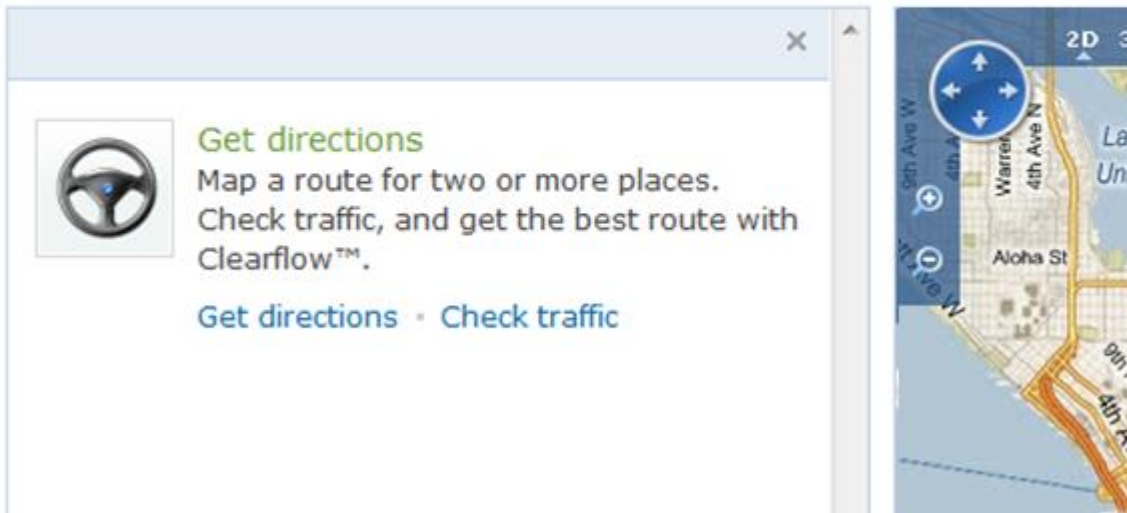
# Data on location, trips, destinations

- Multiple sources
  - GPS, cell tower, wifi
  - Direction requests to routing services
  - > *e.g., MS Multiperson Location Survey*



# Learning from Data on Flows & Trips

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



# 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)

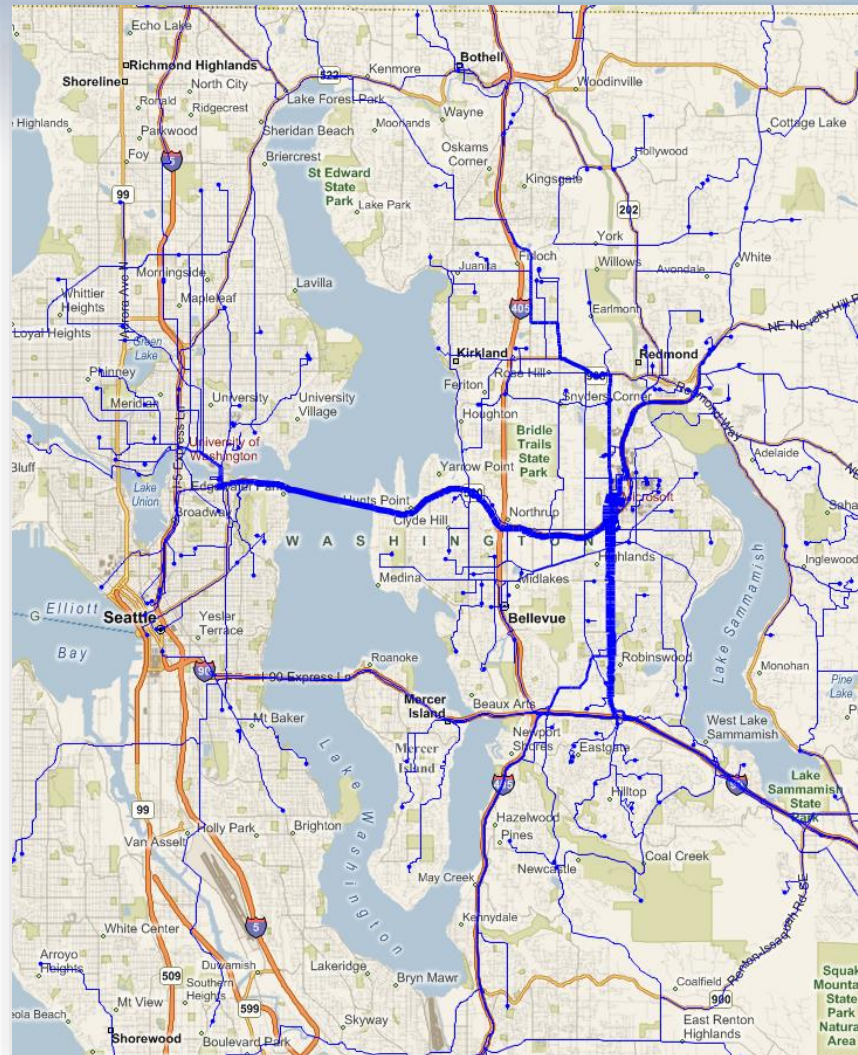
# ABC: Agent-Based Rideshare Project

- Principles of collaboration with varying preferences
- Mechanism design for promoting truthful reporting
- Instant & planned rideshare scenarios

*Collaboration with King County Metro, WashDOT  
MS Facilities, MS Sustainability.*

# Commutes from Flows and Trips

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





# 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

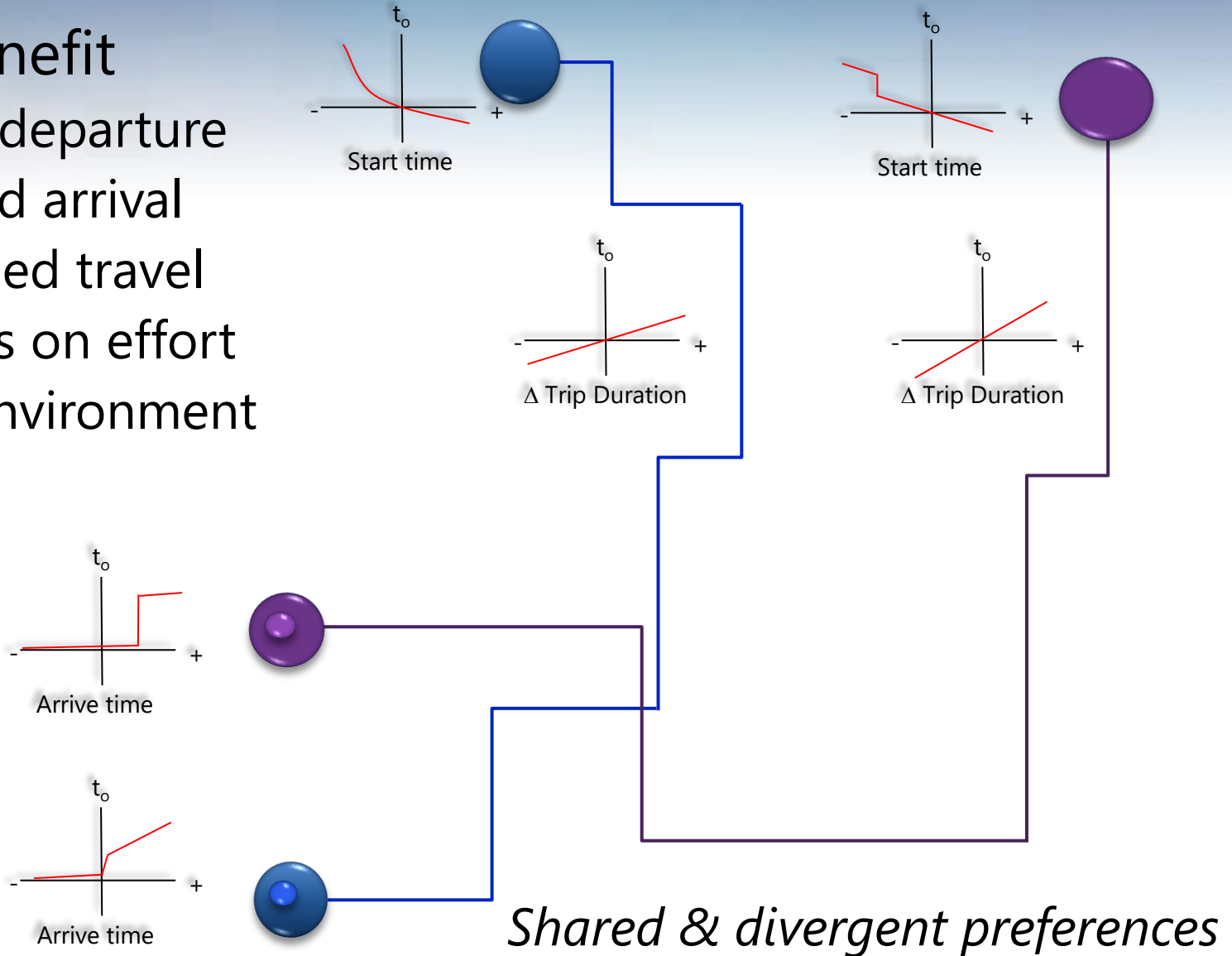
*Optimize for individuals and across a population*

*Collaboration with King County Metro, WashDOT MS  
Facilities, MS Sustainability.*

# Balancing Diverse & Changing Needs

## Cost-benefit

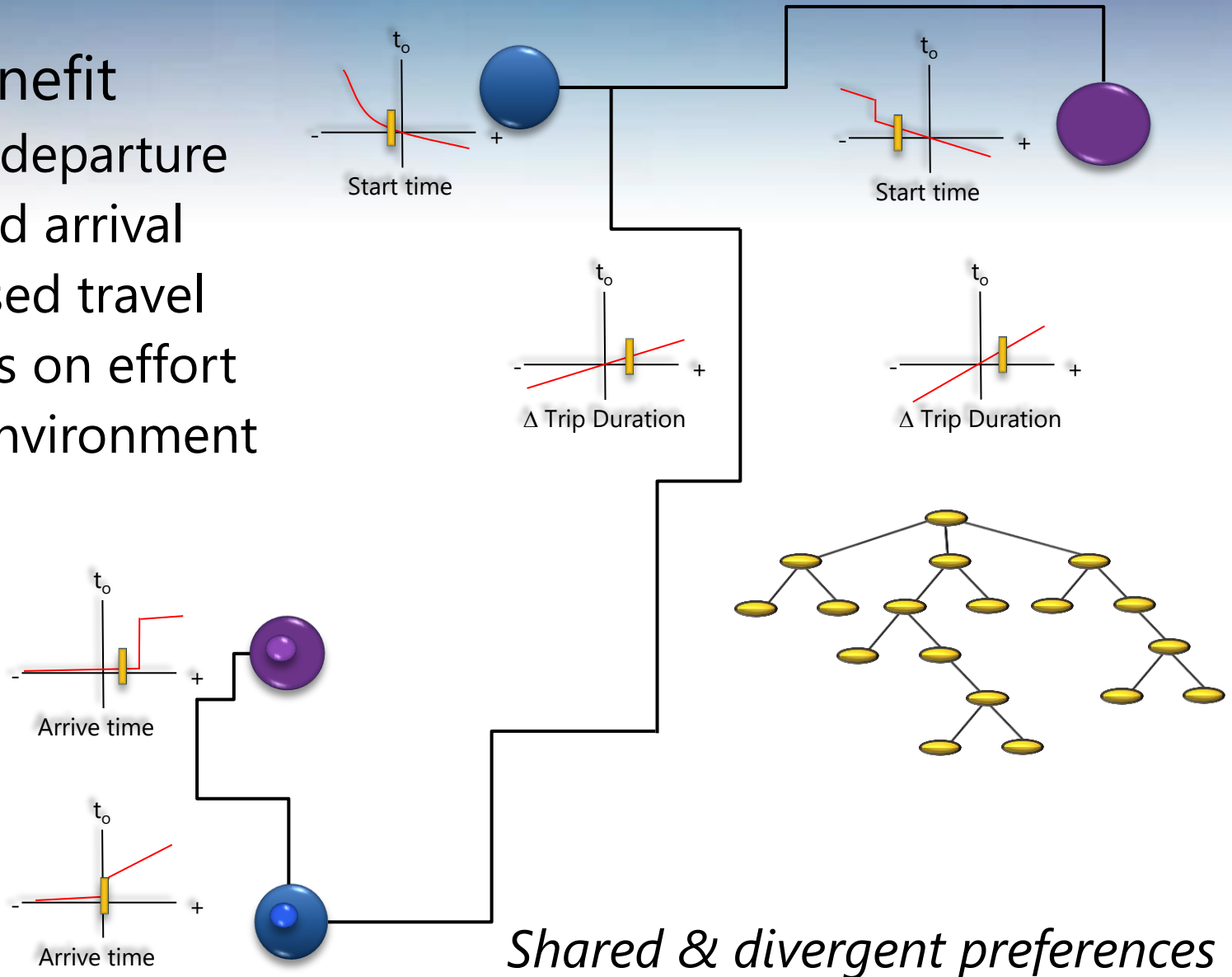
- Earlier departure
- Delayed arrival
- Increased travel
- Savings on effort
- Fuel, environment



# Balancing Diverse & Changing Needs

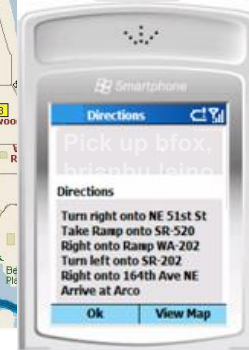
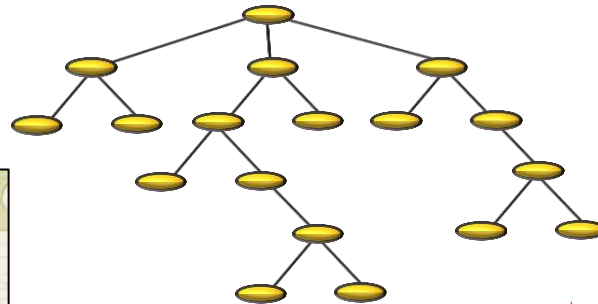
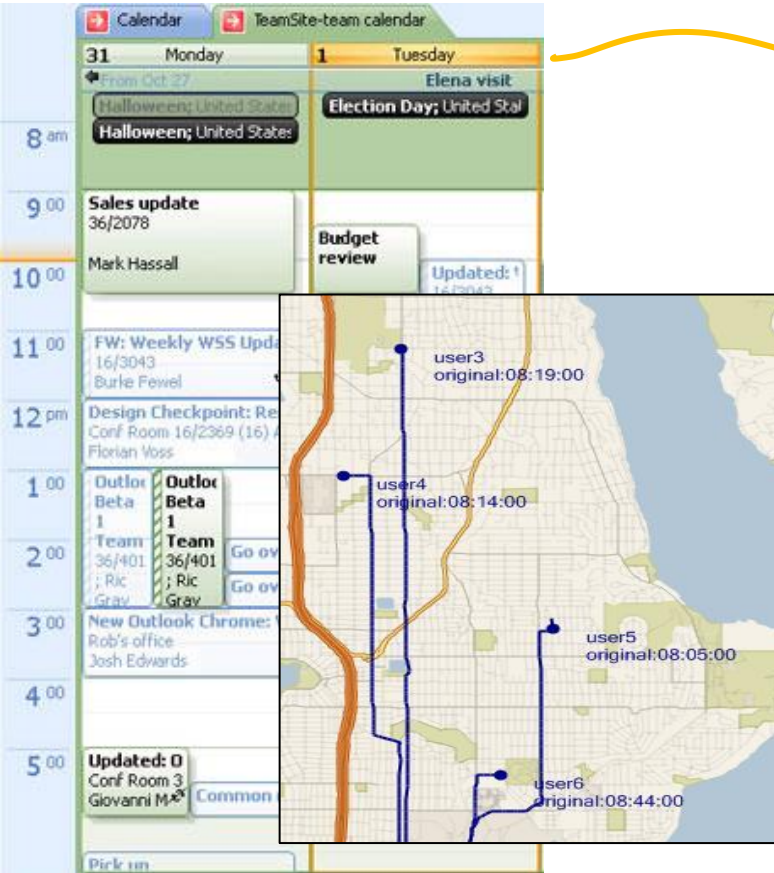
## Cost-benefit

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



# ABC Rideshare

- Identify rideshares, incentives and truthfulness
- Evaluate on GPS trails from MS employees



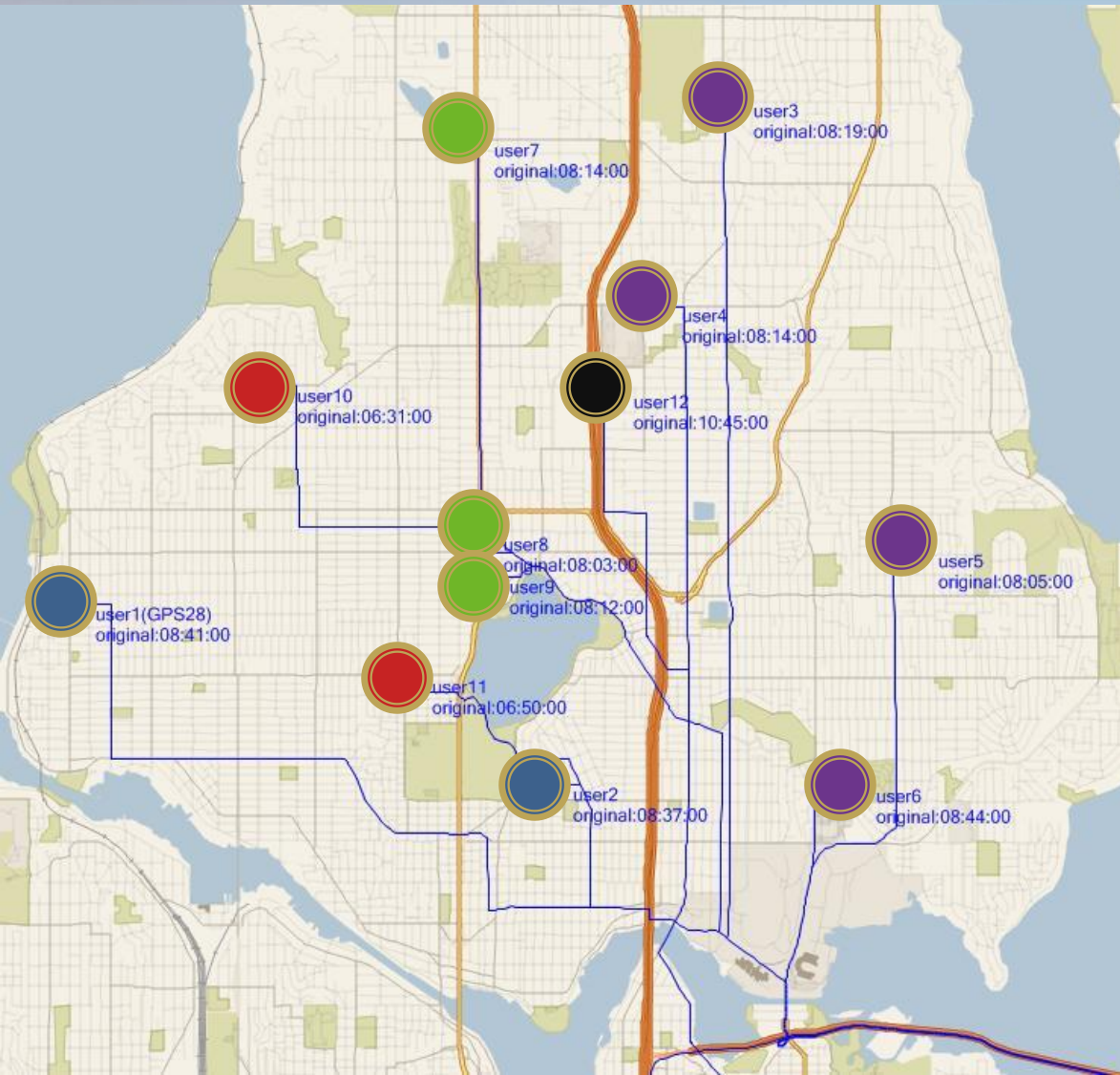
Total Cost  
+  
+ \$735.45

$\Delta CO_2$   
-231.17 tons per year

$\Delta K_m$   
+ \$7  
56.89 km reduction

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

# Ideal Coalescence

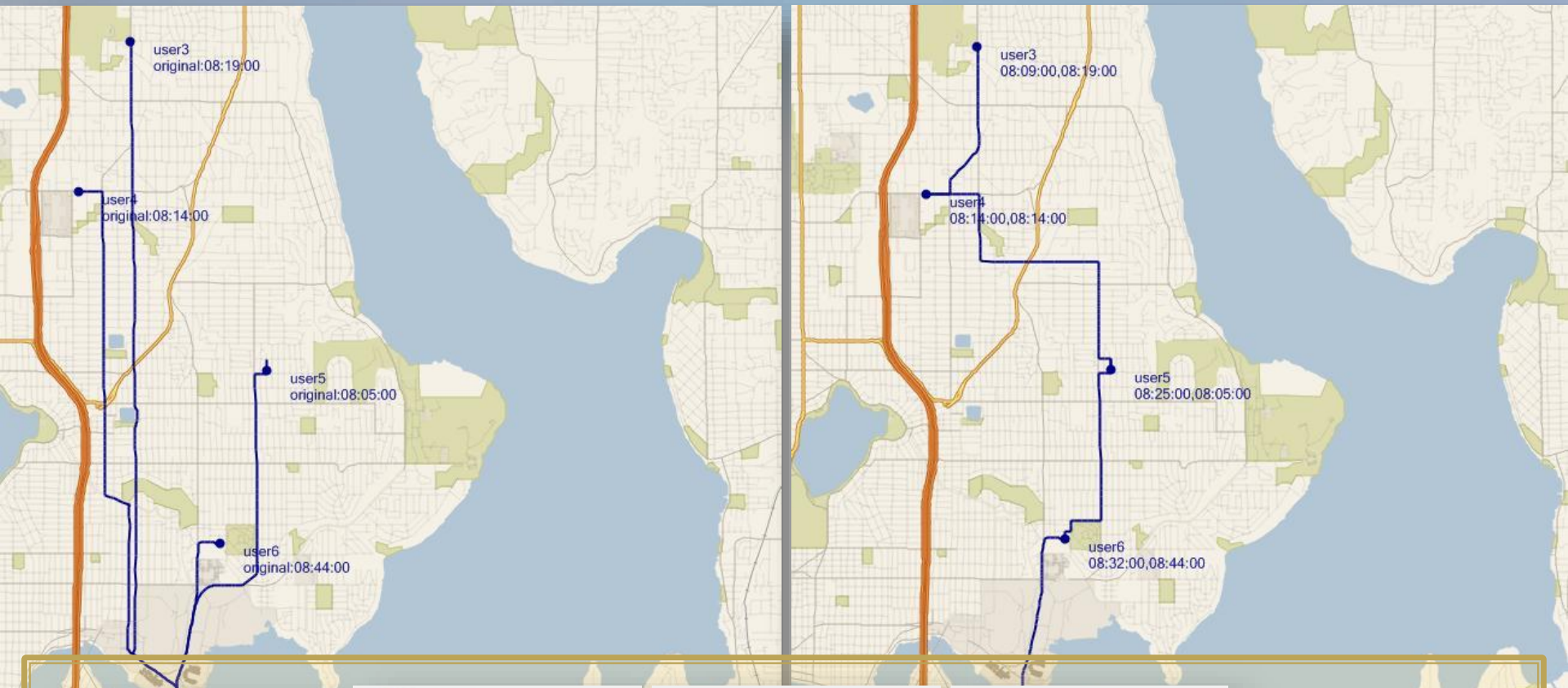


➤ Assignments based on observed trips.

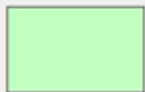
➤ Cost-benefit

- Departure change
- Delayed arrival
- Increased travel
- Savings on effort, fuel, environment

# Ideal Coalescence



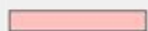
$\Delta K_m$



+ \$7

56.89 km reduction

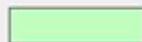
$\Delta$  Minutes



- \$1.76

15.17 mins extra driving  
42.58 mins delay

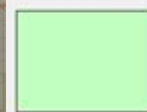
Cognitive Cost



+ \$3

3 drivers less

Net Utility



+  
+ \$8.24

$\Delta CO_2$

3.99 tons reduction per year

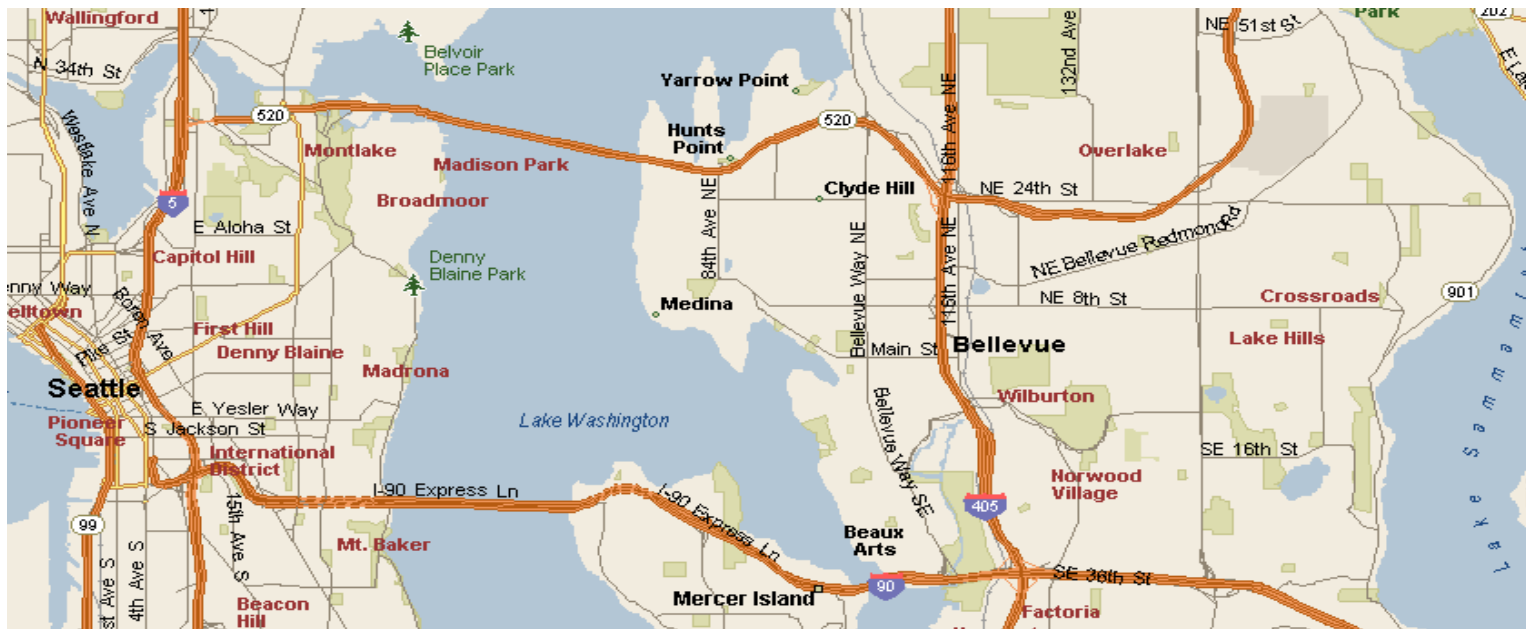
# Plans and Flexibility

- Planned versus “instant” commute
- Owned versus shared cars (e.g., Zipcar)

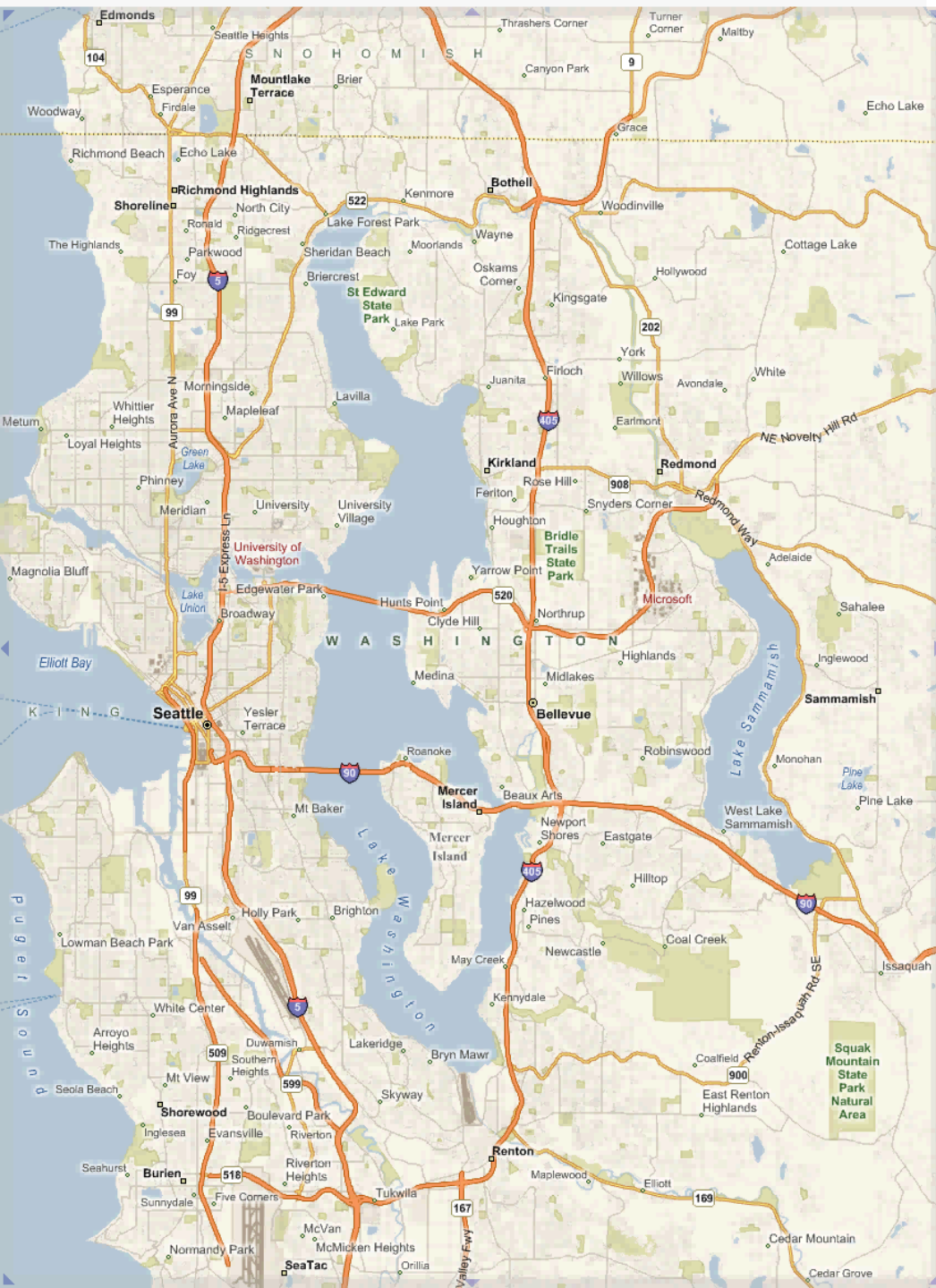


# Planned vs. Instant Commuting

- 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







Current Time:

Activity

$\Delta K_m$   
+ \$0  
0 miles reduction

$\Delta$  Minutes  
- \$0  
0 mins extra driving  
0 mins delay

Cognitive Cost  
+ \$0  
0 drivers less

Net Utility  
+  
+ \$0

$\Delta CO_2$   
0 tons reduction per year

Waiting List

# Videos

ABC rideshare simulator

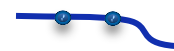
Microsoft commute data

6am 8am

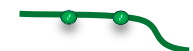
Commute request



Rideshare queued



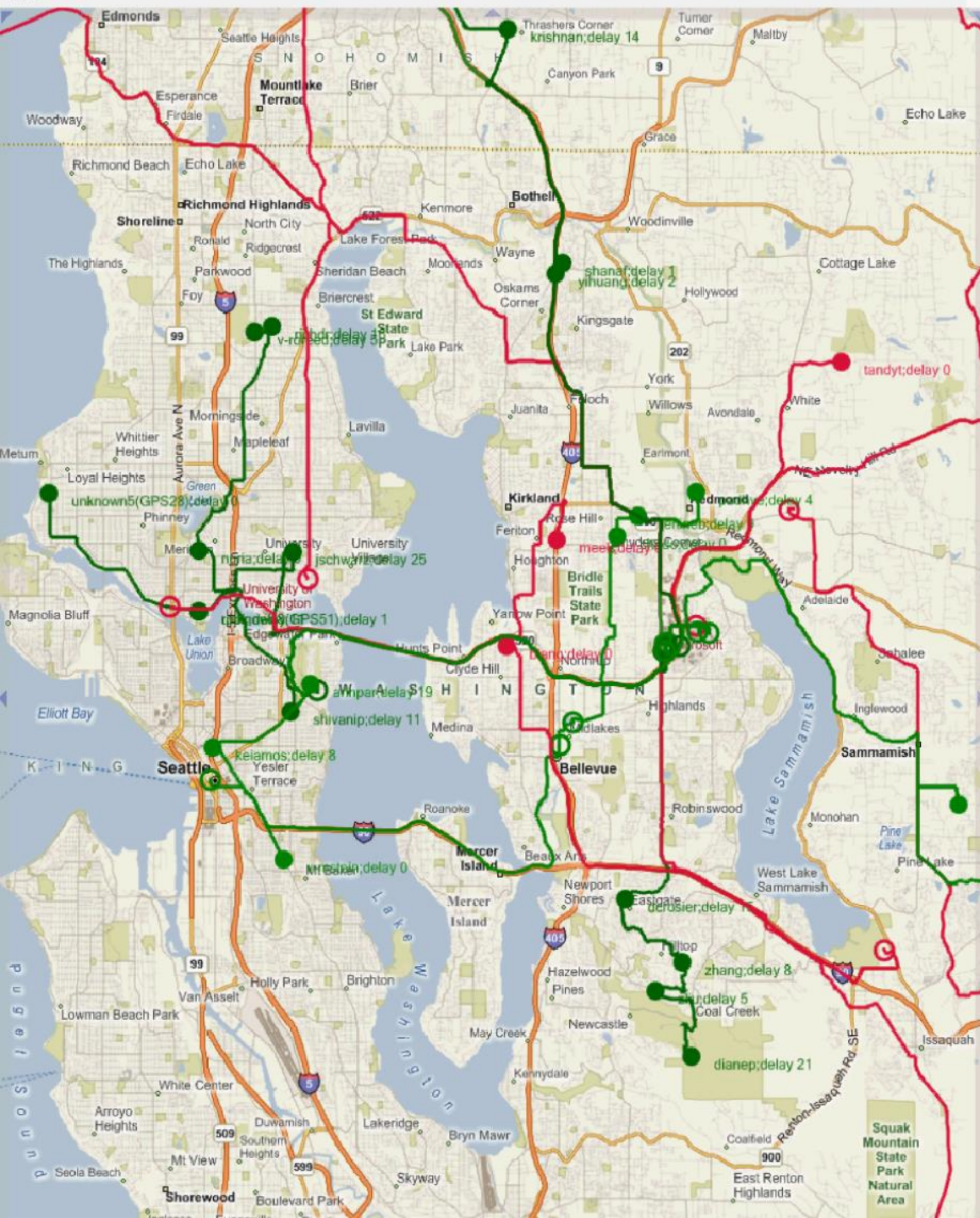
Rideshare starts



Single rider starts



Kamar and Horvitz, 2009



Current Time: 08:55 AM

Activity

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

# Videos

ABC rideshare simulator  
Microsoft commute data

[6am](#) [8am](#)

$\Delta K_m$

+ \$0

0 km reduction

$\Delta$  Minutes

- \$0

0 mins extra driving

0 mins delay

Cognitive Cost

+ \$0

0 drivers less

Net Utility

+

+ \$0

$\Delta CO_2$

0 tons reduction per year

Waiting List

2:v-jahann,hukew:09:03 AM  
2:lilly\_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,l-benkom2 :09:11 AM

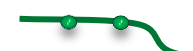
Commute request



Rideshare queued

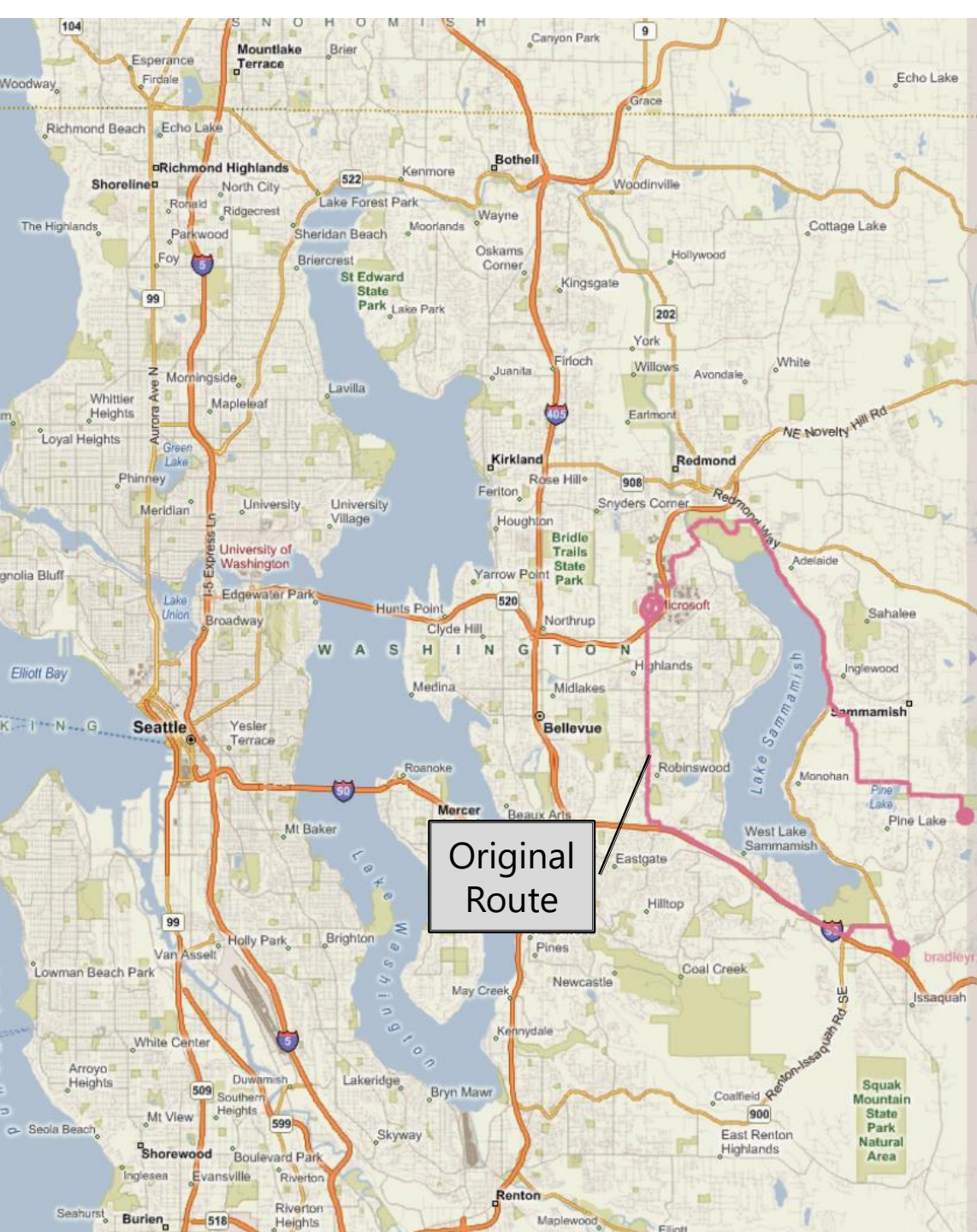


Rideshare starts



Single rider starts





Original Route

Activity  
 driver added: gerryb for bradleyr (1)

$\Delta K_m$   
 + \$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

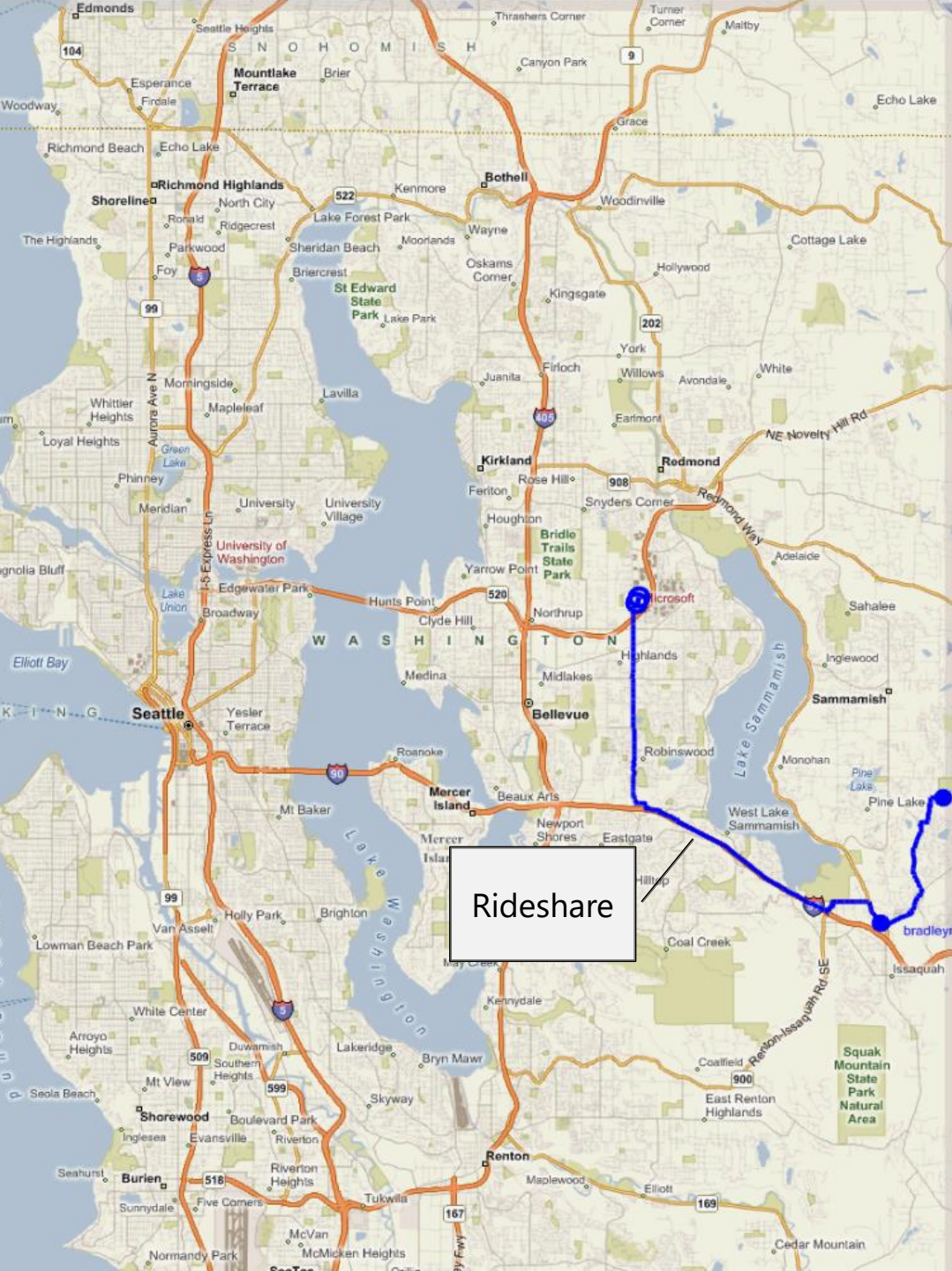
Net Utility  
 +  
 + \$2.53

$\Delta CO_2$   
 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)

$\Delta K_m$

+ \$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

$\Delta CO_2$

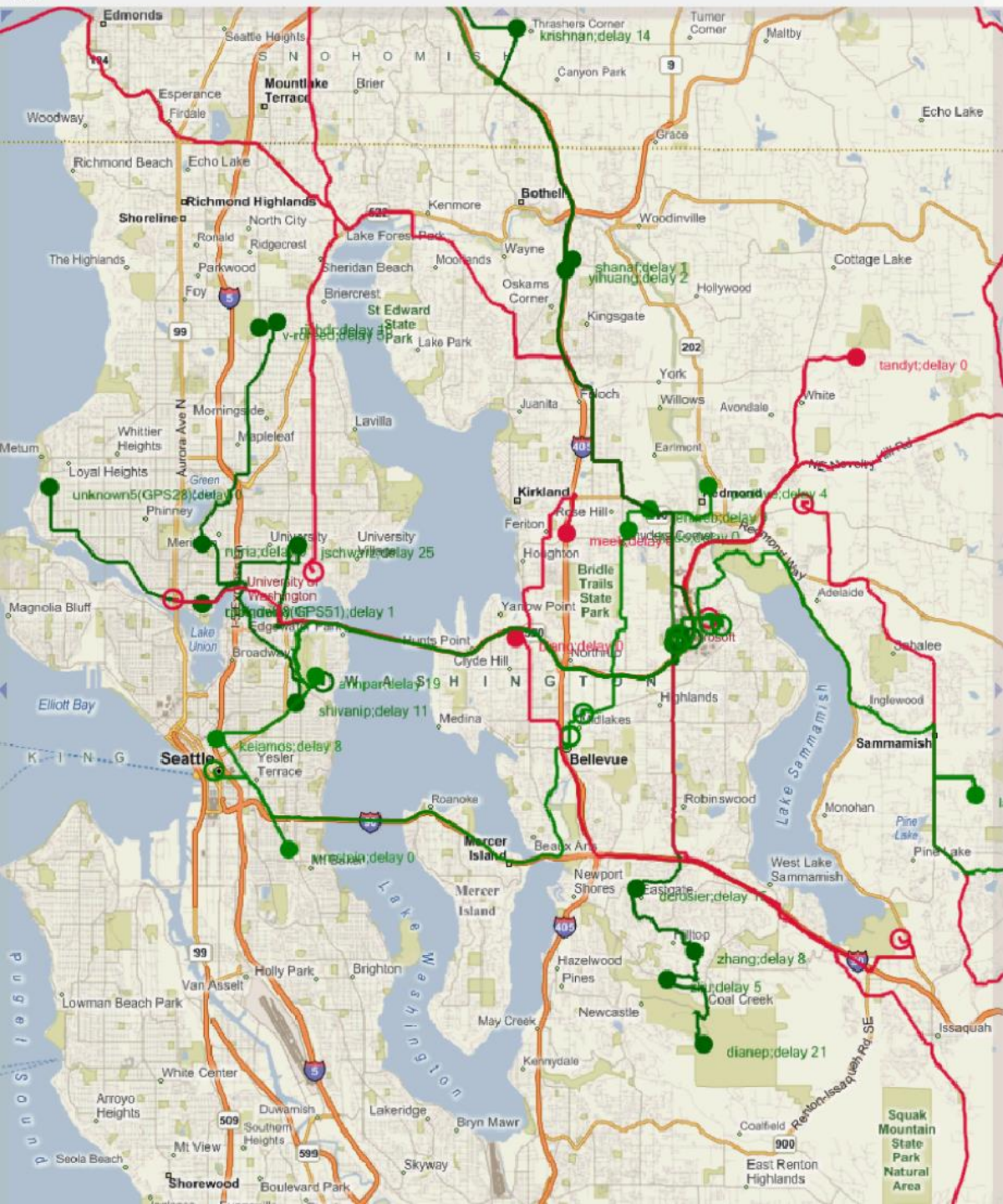
0.98 tons reduction per year

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)

$\Delta K_m$   
 + \$0  
 0 km reduction

$\Delta$  Minutes  
 - \$0  
 0 mins extra driving  
 0 mins delay

Cognitive Cost  
 + \$0  
 0 drivers less

Net Utility  
 +  
 + \$0

$\Delta CO_2$   
 0 tons reduction per year

Waiting List  
 2:v-jahann,lukew:09:03 AM  
 2:lilley\_35,unknown3(GPS14):09:04 AM  
 1:v-tgwlly: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

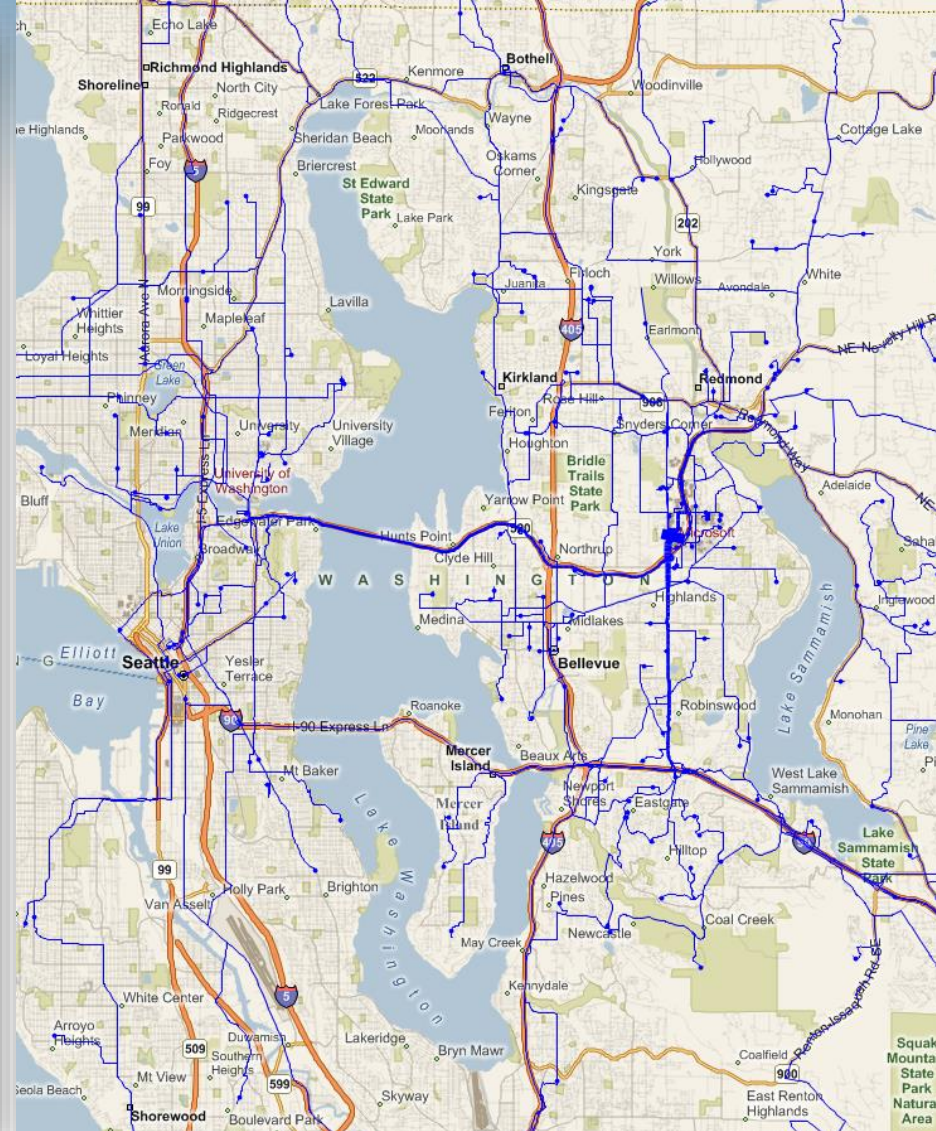
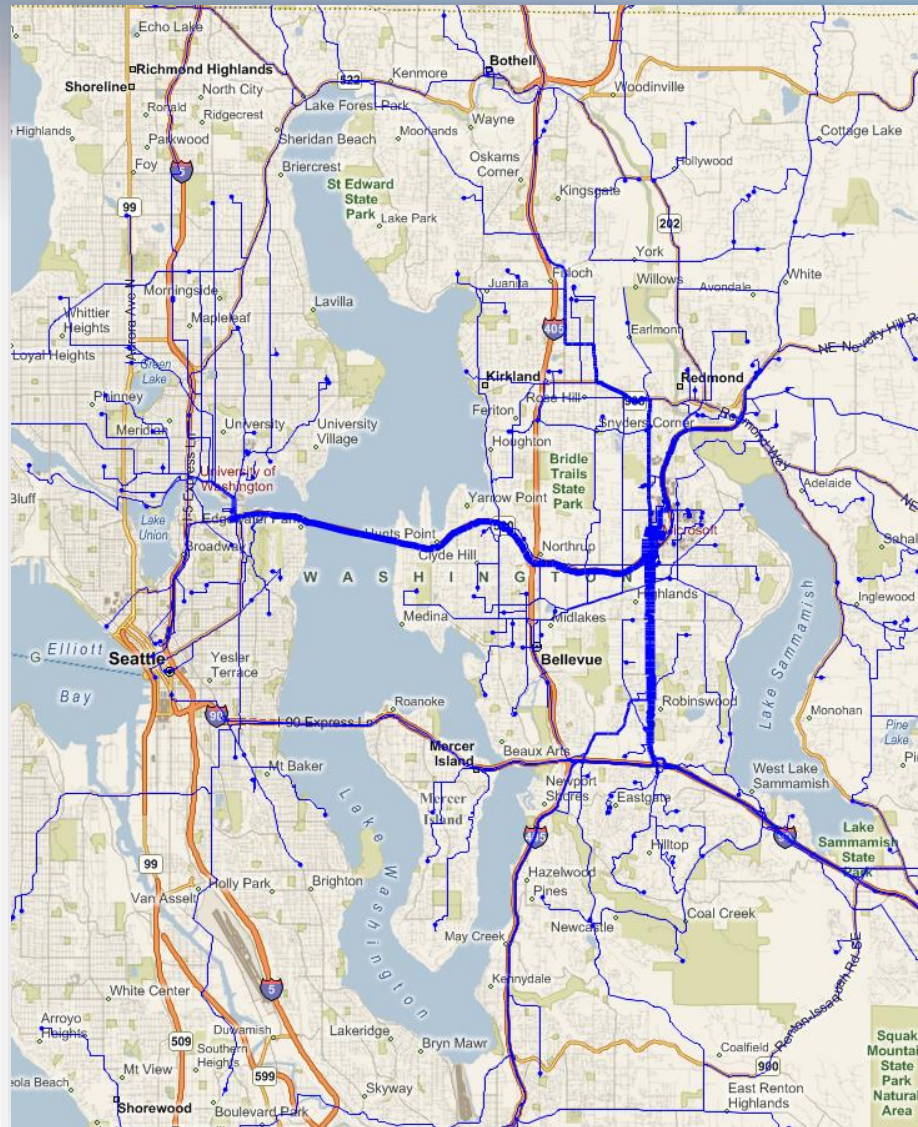
Queue

# Results



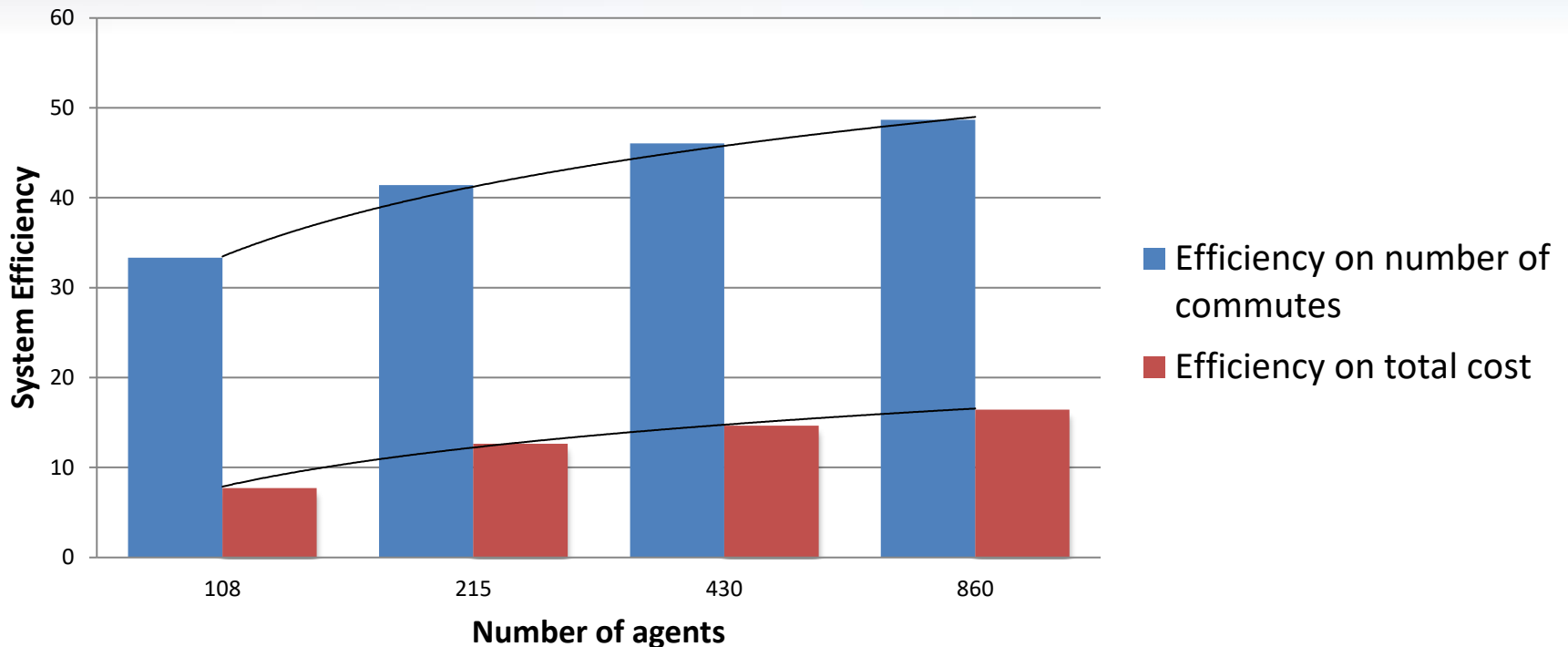
## Normal commute

## Computed rideshares



# Computation Models and Insights

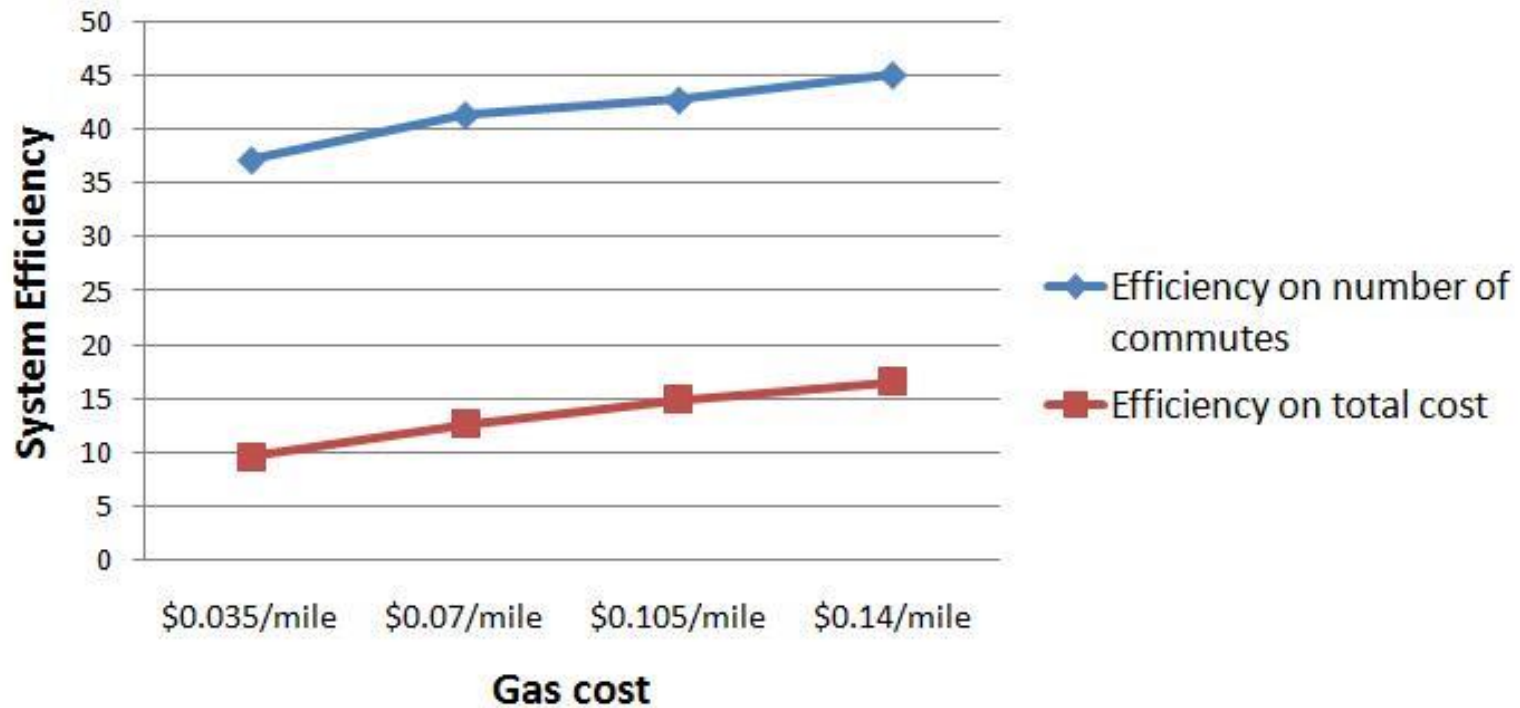
## "What If?" Studies



Number of participants →

# Computation Models and Insights

## "What If?" Studies

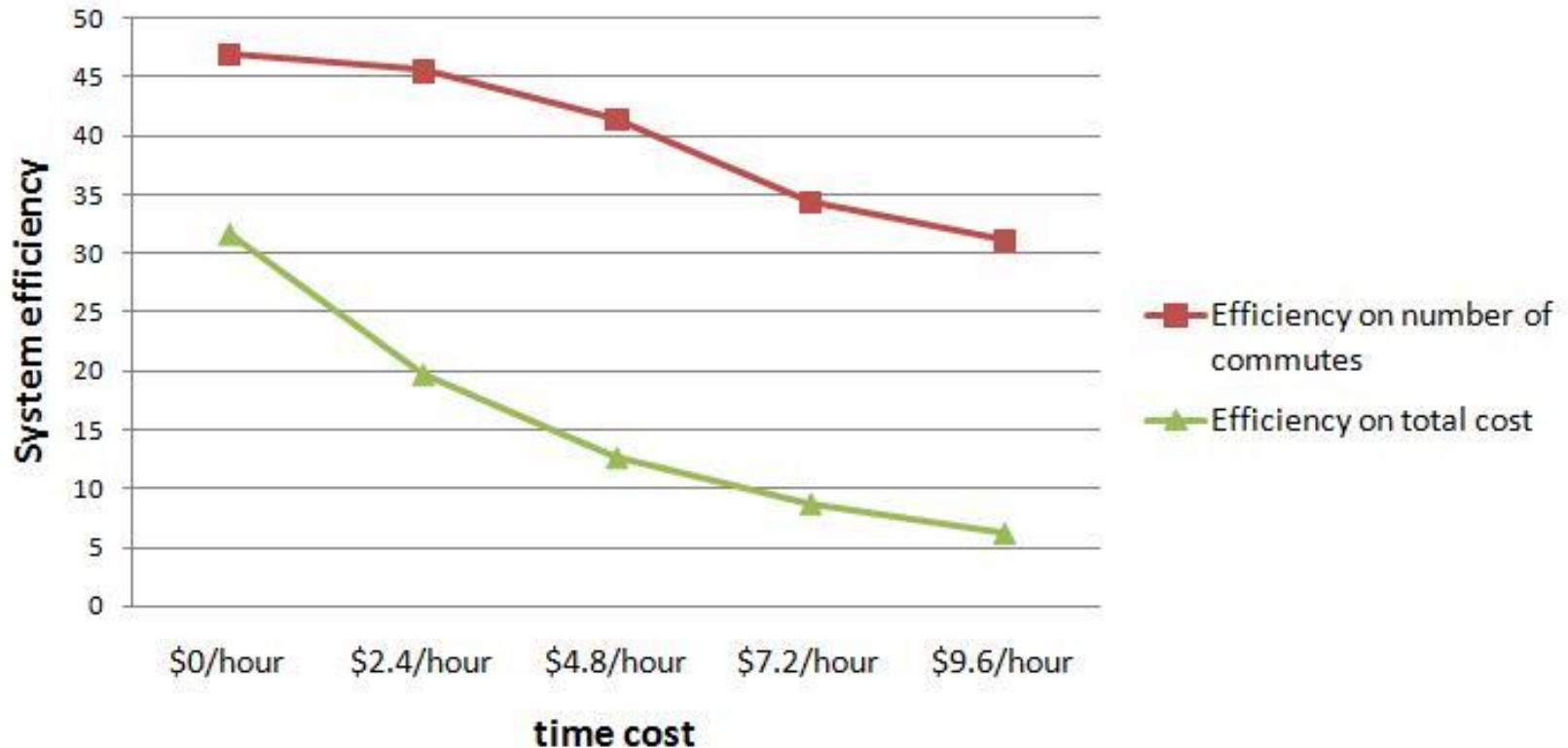


Fuel Cost →



# Computation Models and Insights

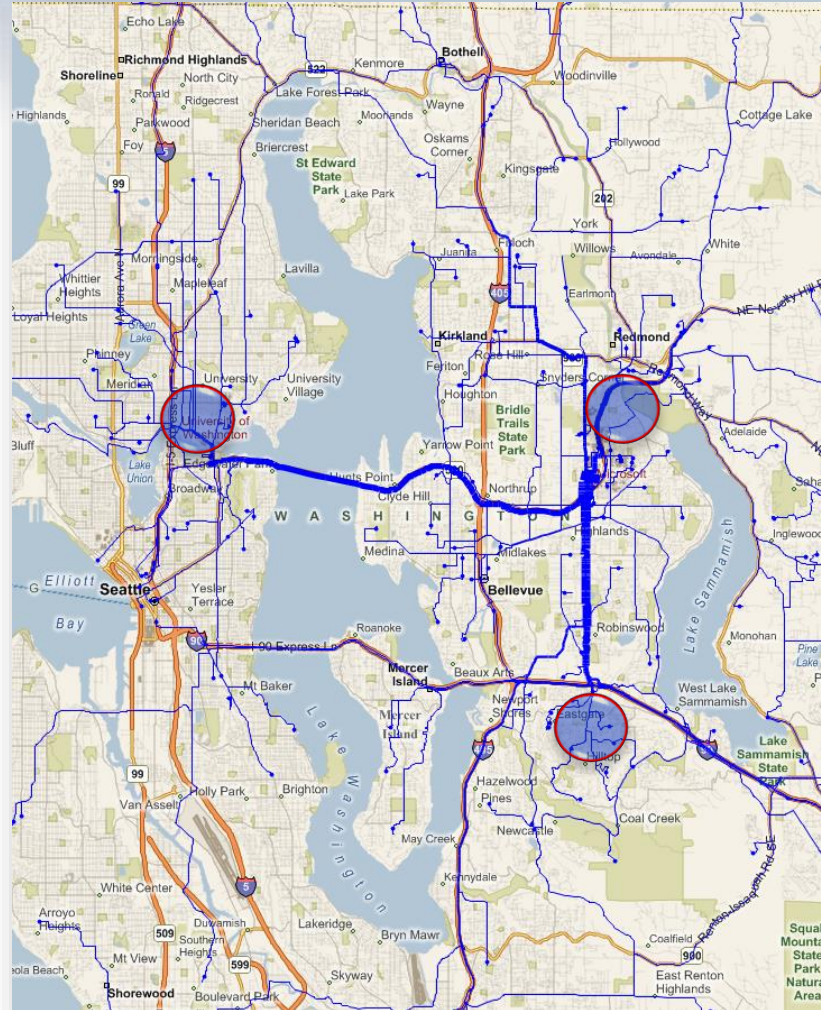
## "What If?" Studies



Cost of time →

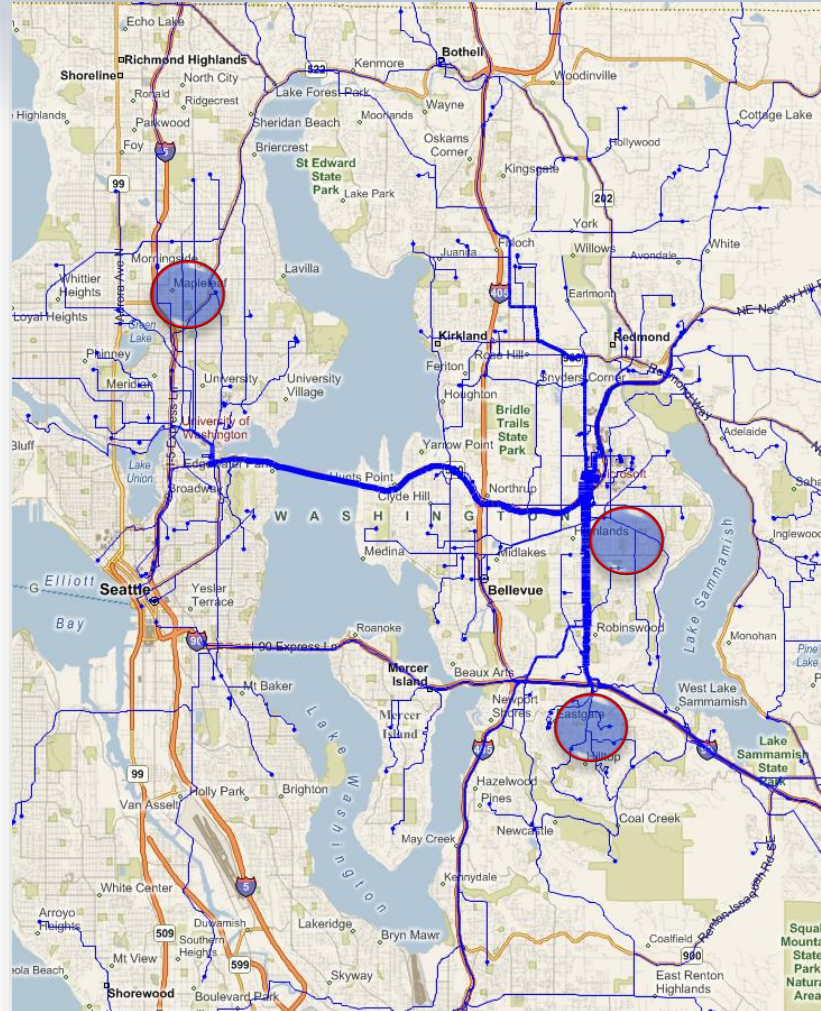
# Computational Models and Design

## Best Park & Ride Locations?



# Computational Models and Design

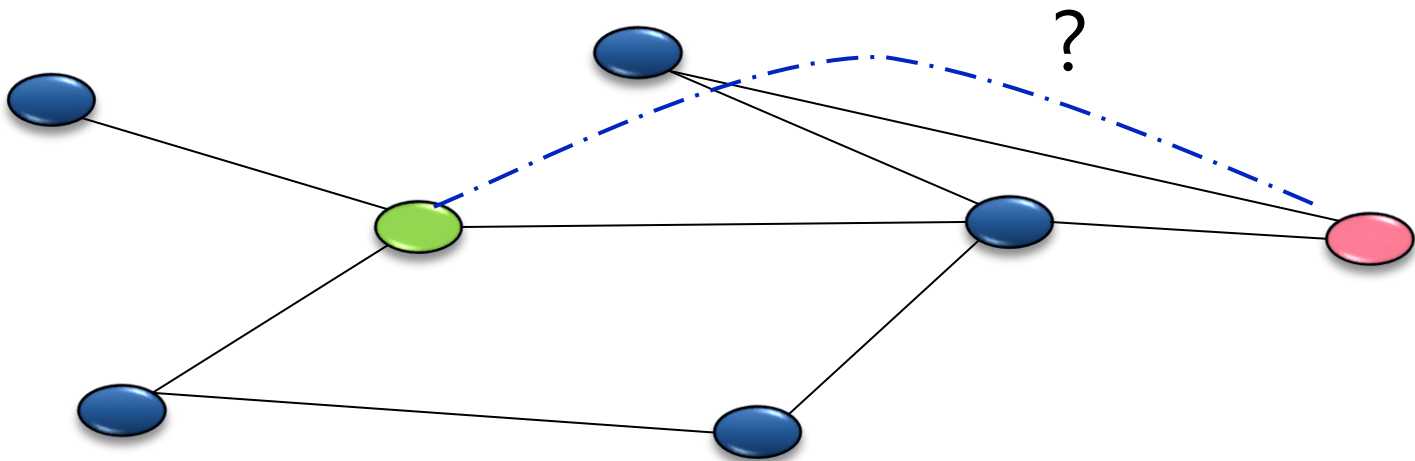
## Best Park & Ride Locations?



# Acceptance, Trust, and Ridesharing

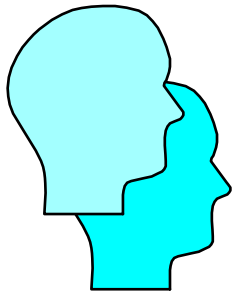
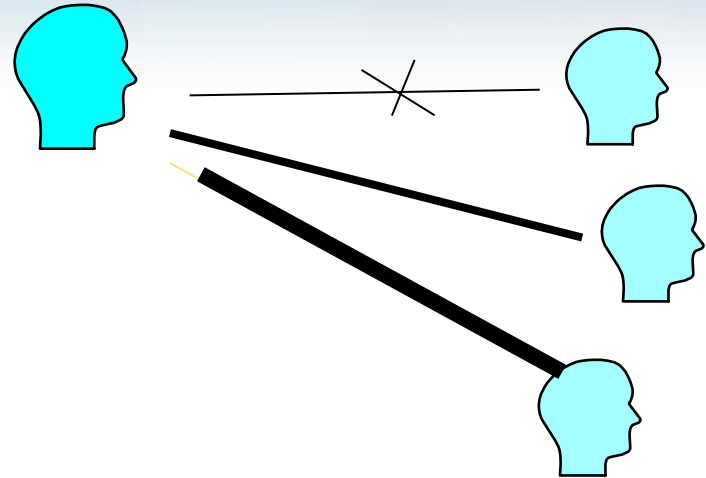
Challenge: Understanding acceptance, perceptions, social considerations

- 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



$$\begin{aligned}U(p_i, p_j) &= d(a_i, a_j) \\ &= f(d(a_{i1}, a_{j1}), \dots, d(a_{in}, a_{jn})) \\ &= \sum_l k_l d(a_{il}, a_{jl})\end{aligned}$$

# Distances and Relationships

The screenshot shows a web browser window displaying a Facebook profile for Eric Horvitz. 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", "Boxes", and a "+" icon. The main content area features a "What's on your mind?" text box with a "Share" button. Below this are tabs for "Eric + Friends", "Just Eric", and "Just Friends", along with a "Settings" link. The "RECENT ACTIVITY" section lists two friend additions: "Eric and Cari L Murphy are now friends" and "Eric and Rob Miller are now friends". A post by Nuria Oliver is visible, with a photo of her and a child, and text expressing happiness and plans to meet in Seattle. Another "RECENT ACTIVITY" section lists "Eric and Christian Borgs are now friends" and "Eric and Lori Horvitz are now friends". A post by Sarah Revi Sterling is also shown, mentioning an NPR slot. The left sidebar contains a profile picture of Eric Horvitz, a "View Photos of Me (1)" link, an "Edit My Profile" link, a "Write something about yourself" text box, an "Information" section listing "Microsoft" and "Stanford Alum '90", and a "Friends" section showing "335 friends" and "See All".

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**

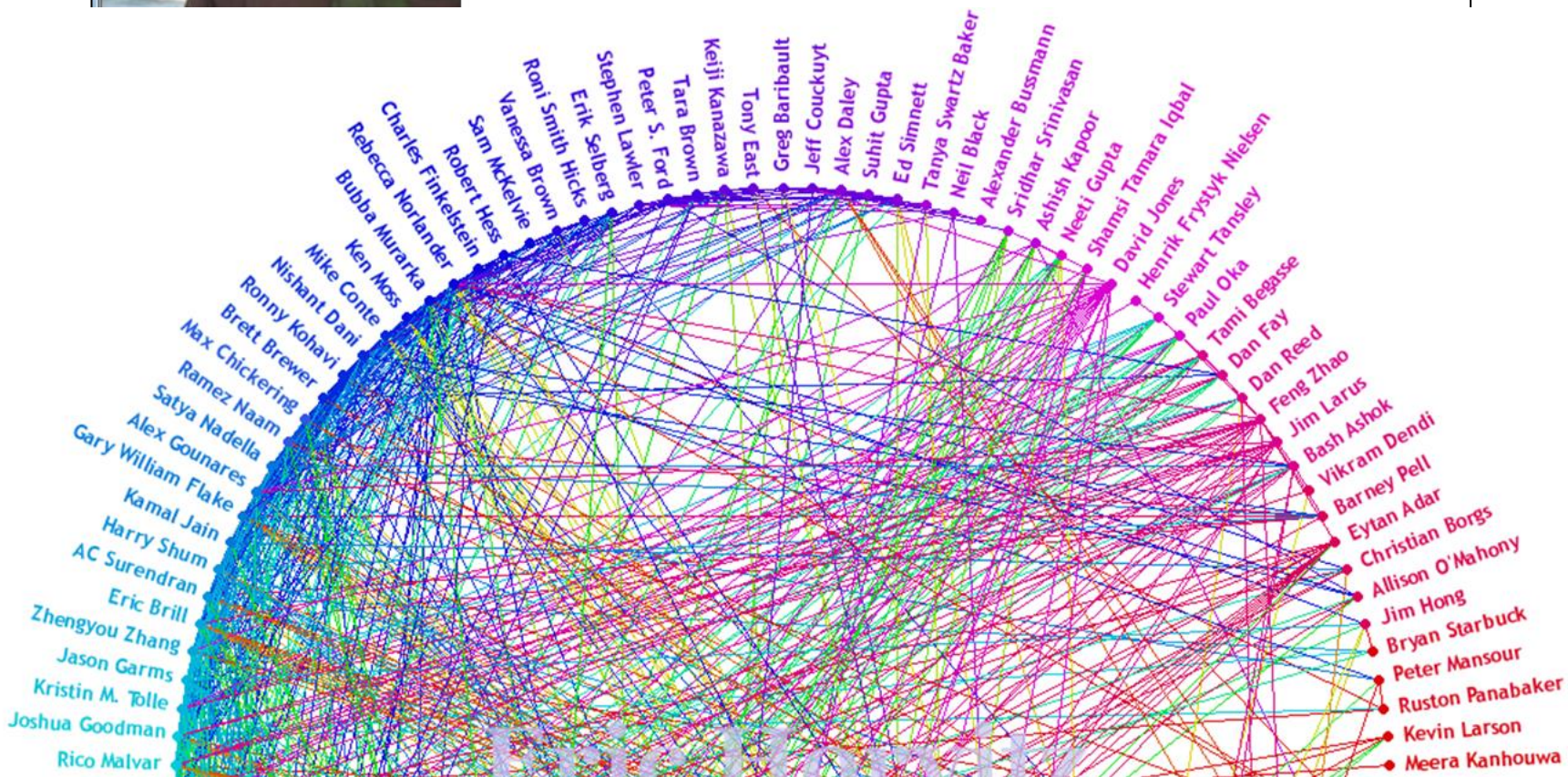
Networks:  
Microsoft  
Stanford Alum '90

Relationship Status:  
Married

**Friends**

335 friends See All

# Distances and Relationships



# Directions

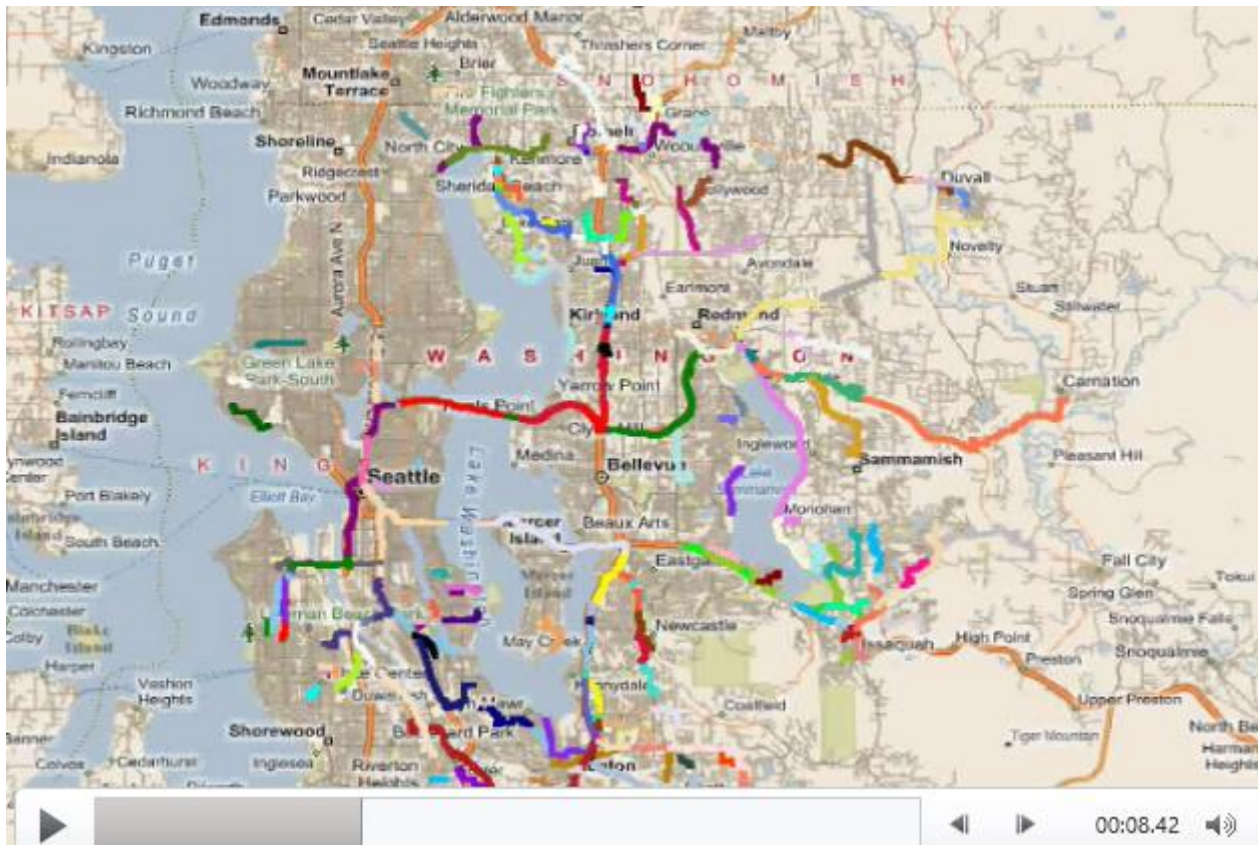
- Studies of preferences & acceptability
  - Flexibility, acceptance, and ease of use
- Implementation directions
  - Shuttle overlay, instant carpool, AM/PM commute
  - Outlook add-in, web service
    - Encode preferences, needs, commitments

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



# Computational Futures

- Autonomous vehicles? ...*Yes*.
- *But...* preferences, incentives, optimization!
  - Direction: Public *microtransit*



# Publications, videos

E. Kamar and E. Horvitz (2009). [Collaboration and Shared Plans in the Open World: Studies of Ridesharing](#), International Joint Conference on AI (IJCAI), July 2009.

Additional detail:

E. Kamar and E. Horvitz (2009). [Generating Shared Transportation Plans Under Varying Preferences: Ridesharing Models and Preferences](#), Microsoft Research Technical Report, MSR-TR-2009-2011, March 2009.

Videos:

ABC Rideshare Simulator at [6am](#), [8am](#).