The RideNow Project

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ABSTRACT

Social-physical systems are distinguished by having thousands of distributed, goal-seeking agents, interacting at human time scales. A project to facilitate surface transportation is a very focused and useful starting point to explore social-physical

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RideNow Project Summary

Social-physical systems are distinguished by having thousands of distributed, goal-seeking agents, interacting at human time scales. A project to facilitate surface transportation is a very focused and useful starting point to explore social-physical systems.

RideNow uses cell phones and the internet to supporting integrated public transit and ridesharing. Two problems that must be solved are approximating the personal automobile's convenience and changing peoples' behavior.

Intellectual Merit

While the project has a pragmatic goal it challenges the state of the art in several disciplines and integrates their approaches.

Real-time control of spatio-temporal systems: RideNow will need a moving object database. It will use one of the research prototypes available or create its own, thereby providing a real-world assessment of the state of the art.

Relationship Models: Unlike the relationships sought through dating sites, RideNow will look for specific common activities that might be pursued for their own sake. Specification and matching of interests and personality will be done using indirect methods like collaborative filtering. The lasting contribution will be a testable predictor of successful relationships.

User Interfaces: The RideNow user interface challenge is not ease of use, but minimal cognitive and perceptual load for someone who is engaged in another activity: driving, working, walking, or dining. While such interfaces are available to pilots, RideNow's must be easier to learn.

Behavioral Studies: RideNow will explore new methods of eliciting preferences for not yet existent transport options. Surveys will be eschewed in favor of direct measures and observations of behavior that might give a truer picture of future behavior.

Market Formation: A simple theory of how a market of buyers and sellers of rides grows from nothing to sustainability, and possibly to monopoly will be investigated.

Integration of Social and Technical Systems: Experience has shown that the so-called "hard" requirements of systems are easier to satisfy than the soft requirements related to human needs. This project will make these needs more concrete and evaluate their interaction with rational measures.

Broader Impacts

Congestion & Pollution: Ridesharing has the potential to reduce automobile traffic with no investment other than in information technology.

Productivity: Commuting is often considered wasted time. To make ridesharing attractive, RideNow must increase the business or personal value of that time.

Loneliness: The national decline in social capital has worried social scientists for many years. To succeed, RideNow must cultivate interpersonal trust.

1 Computer Mediation of the Social-Physical World

We are moving towards the singularity that David Gelernter described in *Mirror Worlds*[1]: the internet is accumulating such a complete model of our world that we will drive the world through the internet. The world will be the biggest cyber-physical system of all with the internet supplying the "cyber" part. Internet services will measure and act upon our world just as surely as a robot's brain measures and acts upon its much smaller environment. Social-physical systems are distinguished by having thousands of distributed, goal-seeking agents interacting at human time scales. The principles of spatio-temporal reasoning, statistics, real-time scheduling, and feedback all apply to such systems. Because it contains many independent, human agents, a social-physical system cannot be controlled; it can be nudged toward better outcomes. The internet services function more as markets than as controllers. Elements of social science—economics and behavior—will apply.

1.1 Examples of Future Social-Physical Systems

Consider a national medical emergency brought about by a disaster. There are thousands of people in need of treatment, thousands of medical professionals, and thousands of pieces of medical equipment. They are scattered around the country but have communications capability. The thousands of agents, each with their particular needs, capabilities, constraints, and preferences make this a problem in which simply satisficing is a great challenge. How do we manage the resources to achieve good outcomes?

Consider the world's news business, currently being overturned by the internet. There are thousands of stories at any moment, tens of thousands of news gatherers, bloggers, analysts, and distributors. Each story has locations, times, and requires the attention of particular people who understand it. Many hundreds of editors must sort through the developing stories and decide how to route them to the interested audiences. Each person has specific skills, opinions, and a location. She can communicate with anyone via mobile devices. She may sell her information and skills to the highest bidder or simply to people she likes. How can we organize this chaos or promote viable business models?

Consider ten thousand political activists or freedom fighters trying to take over their country. They operate as a network of individuals with plenty of communication but no central command. They are dispersed around the country, and each agent has unique knowledge about people and places in many parts of the country. They form small teams for certain objectives. They trust each other to varying degrees. How can they use the internet to pursue multiple objectives, measure progress, and shift resources to crucial areas—all the while battling an enemy that has many resources of its own?

1.2 Surface Transportation

The foregoing projects are beyond anyone's capability today. We have chosen a much smaller project to explore the use of the internet as a mediator of the world: regional surface transportation. It involves solving the spatio-temporal problem of linking and scheduling thousands of buyers and sellers of transportation, at a time scale of minutes. It raises many of the issues mentioned above and has practical payoffs if successful: reduction of congestion, pollution, wasted time, and loneliness.

1.2.1 Vision

Instead of using a personal car, a person uses her cell phone to travel. She enters her destination; and, within minutes, a proposal employing one or more vehicles is presented to her. The pick-up occurs within minutes of her start time, no matter how soon it is. Her trip, along with possible transfers of vehicles, is monitored via her phone and phones in the vehicles. She enjoys the companionship because she and her partners have a relationship beyond ridesharing. Payment and feedback are handled gracefully.

The RideNow system employs a combination of ideas from 511.org, Google Transit, Zipcar, Facebook, eBay, and eHarmony. It exploits cell phones and the web. It is the central nervous system of the entire surface transportation system for a region. It links drivers and riders in an attempt to match the convenience of personal vehicles. It can be a service that helps the environment, improves the quality of lives, and supports community.

By observing all the empty seats in the traffic around you, you can tell that this vision is possible. However, it is impossible without advances in two areas: real-time control and human behavior.

Real-time control of thousands of moving agents

Consider a thousand or more active vehicle trajectories, defined by predicted times, points on a map, and capacities, and another thousand potential passengers defined by times, start points, and end points. There are also several hundred "wild card" vehicles, e.g. taxis, that can be assigned arbitrary trajectories. RideNow assigns each rider to one or more vehicles whose trajectories will carry her from start to end, allowing for reasonable waits at pick-up locations. The vehicles report their position every few minutes, causing the predictions to be updated. Each participant is sent a "time and place to rendezvous message" at suitable intervals. Congestion throughout the region is monitored and RideNow revises predicted arrival times continually. Vehicles are re-routed, and plans are changed dependably. The performance of individuals, fleets, and RideNow itself is improved using the data exhaust from operations.

Changing human preferences and habits

Many people have pursued this vision and failed because they never attracted a critical mass of drivers and riders. It is a market-formation problem. Furthermore, it has human nature and habits working against it. As *Bowling Alone*[2]and other research shows, even if technicians create a system that approaches the convenience of a personal car; people have many other reasons for driving alone. There is uncertainty, fear, and the desire for solitude or control. Furthermore, the motivational structure for ridesharing must include positive as well as negative elements to sustain participants' commitment. In certain times and places carpooling, hitchhiking, and ridesharing are common.[3] We need to explain this behavior to understand how to promote it today in the megalopolis.

1.2.2 RideNow's Structure and Document Overview

Figure 1 shows a model of the crucial pipeline of RideNow. A person enters the service as a *Subscriber*. Her level of *Enthusiasm* determines how often she proposes giving or receiving a ride, thereby becoming a *Proposer*. The service matches

proposing drivers and riders for time and location *Feasibility* and offers various partnerships to her, making her a *Decider*. She accepts a partnership based on its *Compatibility* with her needs, and then becomes a *Partner*, someone who actually participates in a ride. Compatibility is based upon two personal attributes, her perceived *Cost* of the trip and her *Relationship* with the proposed partners. Finally, being a successful Partner increases her Enthusiasm, so the model has a positive feedback loop. The red boxes identify which of the following three sections address questions about the components and their interactions.

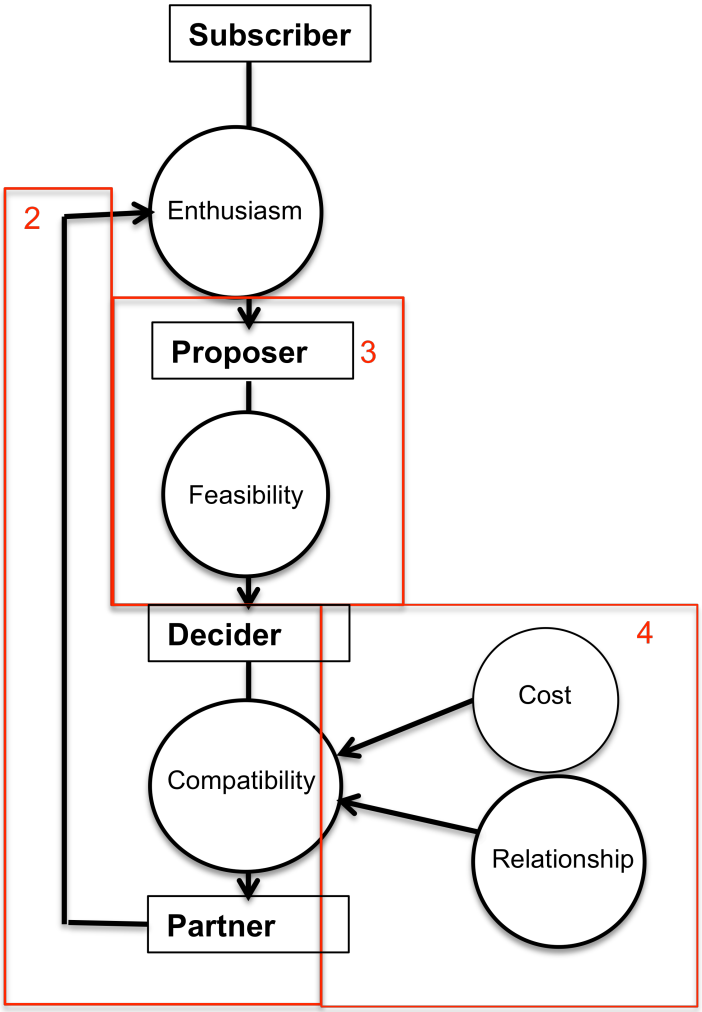

Figure 1. RideNow's Pipeline

2 Is there a tipping point?

Ridesharing can succeed only if there are enough riders and drivers. The density of users traveling similar routes must be high for matching to occur. If there is no tipping point at which a service attracts a self-sustaining critical mass, it is not going to succeed.

The feasibility for ridesharing can be estimated for a region, corridor, or an employer hub using information from planning data maintained by the metropolitan planning

organizations or employers. Their databases are based on household activity and travel surveys. The information includes origin/destination flows by time of day by various modes, distributions of trip purposes, as well as demographic information. This will allow us to obtain upper limits of potential ridesharers, by age groups or other demographics, as well as origin/destination areas.

Generally, analysts have asked the question of how many people in a whole region might rideshare. We are asking a complementary question: how big does a group of willing ridesharers need to be in order to self-sustain. A ridesharing system, like a market, becomes self-sustaining when more people are joining and participating than dropping out. One needs a model that estimates where the tipping point is, thereby predicting the cost and timing of a recruitment campaign. A preliminary search of the economics literature has not found any theory of how new markets grow, only how they reach equilibrium.[4]

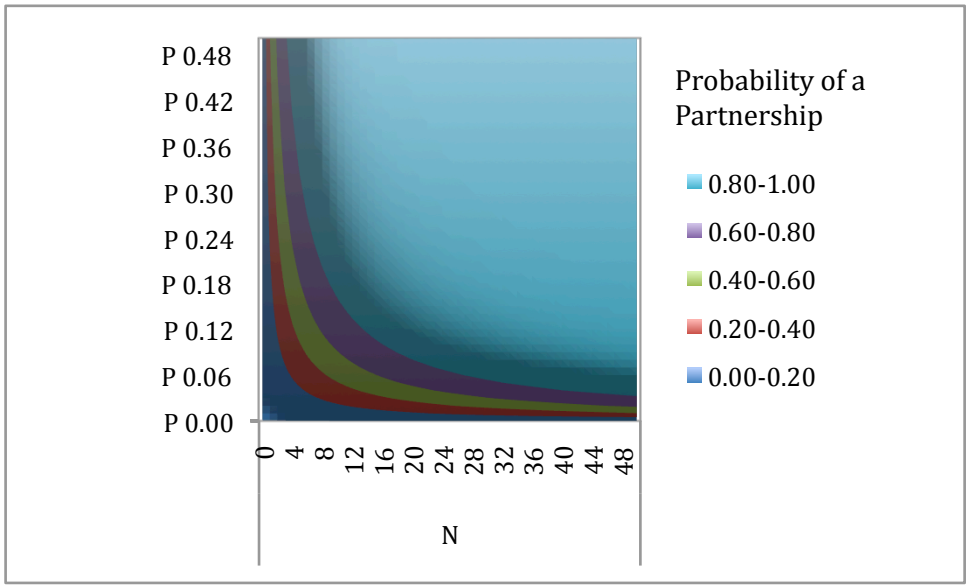

Figure 2. Effect of P and N on Successful Partnering

2.1 Does success increase exponentially with participants?

A very useful paper by Hall and Quershe[5] proposed a model for the effect of mutual compatibility. Suppose the number of feasible drivers for a given rider is Poisson distributed with mean N. Let P be the probability that one of those drivers is compatible with the rider. Then the probability that the rider actually gets a ride is $1-e^{-PN}$. Figure 2 shows how the probability of success depends upon P and N; e.g., if there are 20 drivers each with 0.20 probability of saying "yes", the rider has a better than 80% chance of getting a ride. Raising either N to 50 or P to 0.35 makes the other parameter irrelevant. At this level of abstraction, the same reasoning applies if we ask the question whether a given driver can find a partner among N riders.

The authors went on to measure P for subscribers to a real system, Los Angeles Smart Traveler. The responses of drivers called with a rider's request was

Yes	9%
Maybe	11%
Not Today	28%
No	16%
No Answer	36%.

Sadly, the Smart Traveler system arbitrarily limited the number of drivers approached to 10 while Figure 2 suggests that calling 20 or more would have significantly improved performance. Also, this study was published in 1997, before widespread cell phone use, so the "No Answer" category might be smaller now.

2.2 How do successful partnerships affect subscribers' enthusiasm?

Consider a range of subscriber populations from 50 to 750. Suppose each person's enthusiasm starts at 20%, the probability of making a proposal each day. If a proposal succeeds, she increases her enthusiasm by moving the probability half the distance to 1.0. If the proposal fails, she halves the probability. As enthusiasm increases, the number of proposers increases, the number of feasible partners increases, and the probability of a proposal succeeding increases, according to the exponential formula above. This causes enthusiasm to increase further—a virtuous, positive feedback cycle.

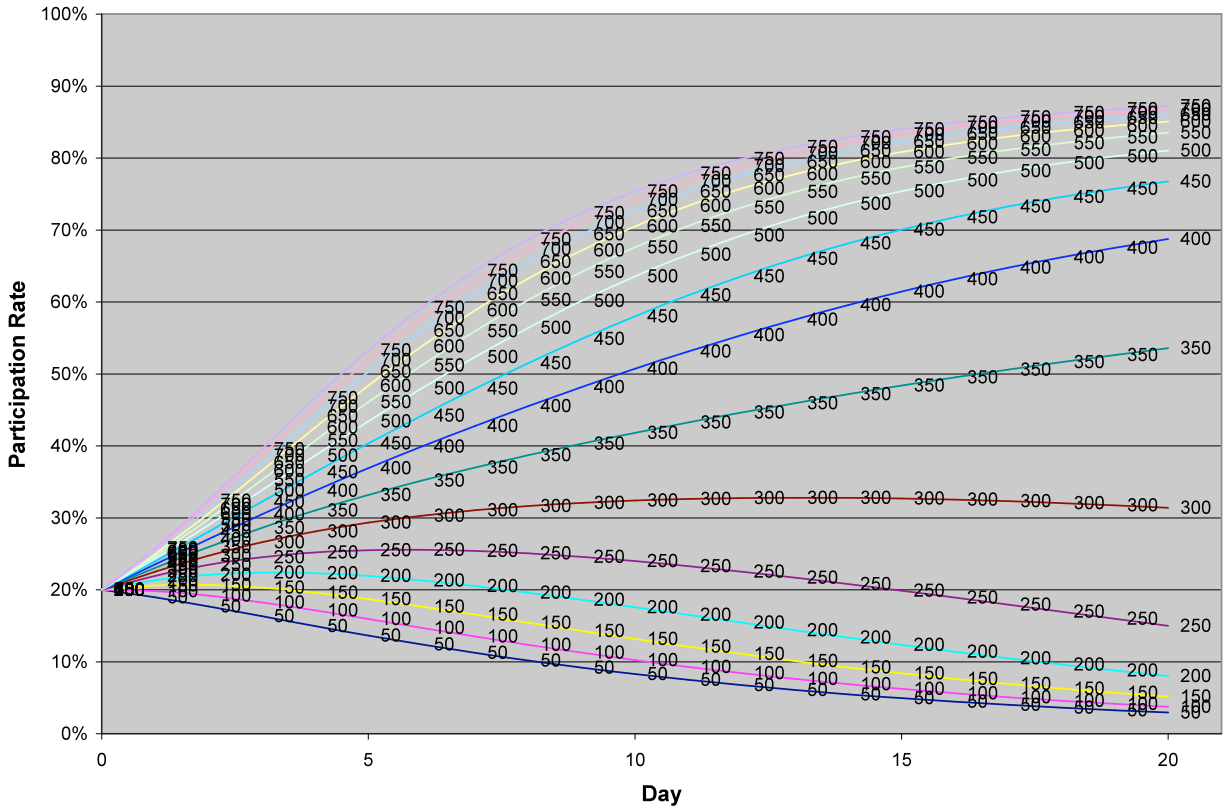

Figure 3. Effect of Subscriber Numbers on Enthusiasm over 20 Days

Figure 3, generated by simulation, illustrates the effect of size on enthusiasm. Apparently, a subscriber base of 350 is sufficient to cause increasing enthusiasm: over 50% of subscribers make daily offers or requests after 20 days have passed.

This is a straw man theory. Measurement of real market systems is needed to find a dependable theory. The system needn't be a ridesharing service; we can use any nascent service in which there are "buyers" and "sellers" who make more deals as the size of the market increases. If there is a powerful positive feedback effect, then a service that achieves critical mass also has the chance of monopolizing a regional market.

3 How can the number of feasible partnerships be increased?

Real data collected in Eastern Massachusetts considered two people to be feasible partners if their source and destination are within a mile and start times are within thirty minutes of each other. It showed that 60% of morning commuters had a feasible match.[6] Apparently, that was not enough.[20]

3.1 Can cell phones increase the feasibility of partnerships?

Traditional carpools are difficult to set up and reduce one's travel flexibility. The internet and cell phones can greatly expand the options and convenience.

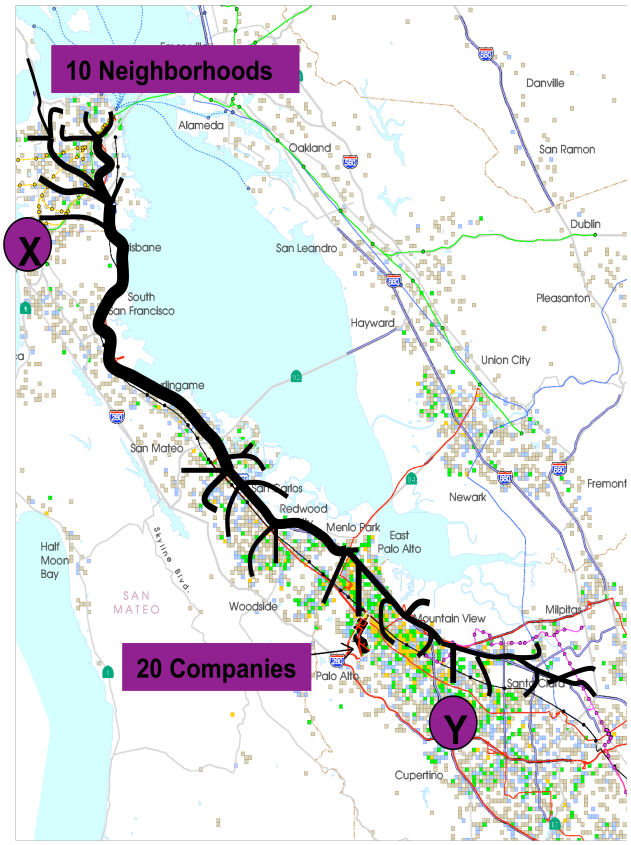

Figure 4. The Dispersal of Sources and Destinations for Commuters

A concocted example, depicted in Figure 4, suggests how hubs can increase the number of feasible matches. Suppose there are 1,000 drivers starting from ten

different home neighborhoods and going to twenty different companies. For simplicity, assume they are equally distributed among neighborhoods and companies, 100 in each neighborhood, 50 in each company. On average there are about 5 people in a typical neighborhood X who are also driving to company Y. So there are about 5 feasible partners for someone seeking a ride. If the basic probability of compatibility between rider and driver is 0.1, then the chance of a partnership is about 0.4.

On the other hand, suppose we have an intermediate hub that all 1,000 commuters pass through at about the same time, allowing passengers to switch from someone from their neighborhood to someone going to their company. In this case there are about 100 people the rider can start with and about 50 he can continue with. The number of feasible trips has increased by more than a factor of 10 and the probability of success goes up to 1 (=0.993)! Generally, if there are D drivers, N neighborhoods, and C companies, the potential number of drivers for a given rider is about D/max(N,C) if transfers are allowed and D/NC if they are not. So a hub has a dramatic effect.

In most regions there are few large hubs *per se*, but major highways and bridges constitute virtual hubs. For example, the San Francisco Bay Area's US 101 is a sort of 40-mile hub running from San Francisco to Silicon Valley; it is fed by hundreds of neighborhoods and drained by hundreds of companies. Transfers could occur anywhere along that highway.

This is where cell phones become crucial. Arranging the rendezvous without them would be unthinkable. However, if the two drivers can be in communication, then adjustments for traffic and confusion can be made. The method of rendezvous will have to be very carefully designed and tested to make this idea realistic.

3.2 How can we find feasible matches quickly?

We believe that a modern computer system (i.e. clusters of processors accessing common disk data) can find feasible matches and can function in real-time for thousands of people per minute. Furthermore, we expect that it can find enough matches in populations of a few thousand subscribers to produce a feasible 50% reduction in drivers.

Here is a simple approach to compete with general moving object databases:

The data structure is a directed graph where each vertex represents an intersection of streets, freeways, or rail lines. Edges represent planned travel by a driver, bus, train, or other vehicle. Each edge is labeled with its arrival date and time at its starting vertex, distance to the ending vertex, the driver, and the predicted speed of the driver on this edge.

Every pair of vertexes with a passage between them always has two edges representing the choices of walking and a taxi ride, with an arrival time signifying that travel can begin immediately.

From the driver's price, the rider's waiting time, and the rider's value of time, one can compute the cost to the rider for traversing the edge. Plausible prices are 0 for walking, $2.50/mile for taxi, $.25/mile for a friend, etc. Train, bus, and vans charge their standard fares. The rider's value of time varies, but $1/minute is a guess for a

commuter, i.e. waiting for five minutes costs the rider $5, walking a mile costs $20.

When a driver proposes, RideNow inserts her chosen route by adding to the edge list at every vertex along the route. When a rider proposes, it finds matches by performing a cheapest path search in the graph. The cheapest path is not usually the shortest, which is likely to be a direct taxi ride or a very long walk.

To find cheap paths we will adapt a shortest path algorithm.[7] The path may involve switches among drivers, but the algorithm should prefer continuing with the same driver because switching vehicles will involve a wait that adds to the rider's cost. Suboptimal paths are found to give a rider more choices.

RideNow needs information about traffic. It can obtain it from public sources or reports from active travelers, as did the service Dash Express.[8] The information can be used for both prediction of general congestion patterns and real-time control. Historic will be used to initialize the speed component of edges as they are added to the graph. As the time associated with the edge approaches the present, current information will be used to adjust the speed component, possibly using models to predict congestion patterns that move down a highway. RideNow will re-compute arrival times to detect breakdowns in rendezvous plans and take corrective action.

Performing these computations for many users in real-time presents a challenge. The first step in this research is to try a simple algorithm on a large volume of real trip data and compare its performance with more general moving object database products.[9]

4 How can people be induced to rideshare?

Virtually all analysts of ridesharing agree that human preferences are the primary obstacle to success. Why do so many of us drive alone? Table 1 lists some reasons and possible ways of mitigating them.

Over the years, a variety of approaches have been proposed to estimate the number of people who would give up solo driving in favor of ridesharing.[6] [10] Some were from the perspective of ridesharing unit formation, and included assessing area wide maximum potential by estimating possible matches and identifying characteristics of people who would share rides. Another set of estimation methods centered on decision approaches and included utility maximization, simulation models, and games. Still another approach used demand/supply relationships in traffic equilibrium flows, to estimate the effects of high occupancy vehicle lanes. The approaches can be categorized roughly into three areas:

- **Rational Choice:** It includes predictability, time urgency, and control versus physiological, psychological, and behavioral penalties.
- **Emotional Choice:** This category is crystallized with the theory of planned behavior[11], claiming that people make their decisions with the combination of attitude, subjective norms, and perceived behavioral control.
- **Habit:** Even if a change is justified, people often act the same way they did before.[12] [13]

Most of the investigators—probably attuned to environmental concerns and themselves prosocial—seem to hope for positive attitudes about ridesharing, but are usually disappointed.[14] Refreshingly, a paper by Ory[15] faces reality: people have adapted to

their driving routine, are generally satisfied with it, and may even like it. Unless the costs become exorbitant, the negative aspects of driving alone are not powerful enough to bring about change.

Driving Alone Advantage	**Mitigation**
Plan-free travel: We have our car with us all the time, can start a trip any time and change plans any time.	Quick scheduling with cell phone Easy re-scheduling. Critical mass of subscribers**.**
Reliability: Your car it is always available. Car pools, taxis, or other services are not.	Maintenance of a highly-disciplined social network Rendezvous prediction Critical mass of subscribers
Safety: There are bad drivers and bad people.	Vetting of subscribers, including driving records. Partner feedback Real-time monitoring of contacts. Need-to-know disclosure of personal information
Control	Rendezvous prediction Discovery and honoring of personal preferences
Status: Cars are like jewelry for men. [15]	Positive incentives for sharing Upscale image
Asociality: Many people prefer sometimes to be alone, or find the habits of some other people distasteful. [16]	Positive incentives for sharing Matching personal preferences Easy withdrawal from commitments
Habit: For a century, Americans have driven cars and become comfortable with the system.	Low-commitment ways to try new habits.

Table 1. Why Driving Alone is Preferred

We believe the way to change behavior is

- Rational: Reduce the difference in convenience and reliability between driving alone and ridesharing to an acceptable level.
- Emotional: Discover and promote positive inducements for ridesharing.

We formalize these two complementary approaches as *cost* and *relationships*. The probability that a feasible driver/rider pair is compatible for a given trip is made up of these components: C, the costs and R, the relationship.

Compatibility might be proportional to R/C. On the other hand, these two components might not trade off against each other in a simple way; i.e. a great or terrible relationship trumps costs and an exorbitant cost trumps a neutral relationship. This question will be investigated.

4.1 How should cost be evaluated?

Section 2 and 3 presented ideas for reducing cost, but did not address the subscribers' perception and opinions about cost. Any service must have a firm grip on service

quality metrics. These quality metrics are out-of-pocket cost, mean travel time, travel time variance, and lead-time for arranging

We chose to combine all such measures into a cost measure. The components of a cost function are

- Out-of-pocket payment—negative for a driver.
- Value of Travel Time * Increased time of trip
- Value of Office Time * Time to arrange
- Value of Option to Change Mind * Lead time for partnering
- Probability of no-show * Penalty for lateness

The utility curves for each of the items are unknown, but we guess they would be super-linear. The cost function may not be additive; there may be a "deal breaker" threshold for each one.[17]

- Charging to share out-of-pocket costs is fine; much more is not.
- Increasing travel time by less than 10% is not noticed.
- Increasing travel time by more than 30% is unacceptable.
- Waiting is more frustrating than moving slowly.
- Lunch hour time is more valuable than commuting time.

Some other cost-related questions:

- What is the effect of owning a car?
- What is the tradeoff between probability of getting a match and the effort required to announce trips or monitor for answers?
- Would subscribers be comfortable with an auction system?[18]
- How much would subscribers pay the service itself, and what combination of subscription costs and per-trip fees is appropriate?

For each of these questions, each demographic group will have a distribution over people, since preferences differ. Simple surveys will not be useful in discovering a behavioral cost function. We plan to measure behavior *in vivo* through a novel preference elicitation method. Individuals will use a GPS-enabled cell-phone application to track their own movements. A web-based application will then prompt them to reflect on particular transportation incidents from the previous week, answering questions about how far in advance the trip was planned, and how acceptable various alternative transportation modes would have been. We have used a related technique before in a different realm, eliciting privacy preferences.[19]

4.2 How powerful are relationships among travelers?

As any parent learns, offering exciting, new experiences can be a superior way to motivate people. If ridesharing is viewed as a life enhancer, it will not be abandoned when costs fail to motivate. While this thesis is not obvious, experience and much research has proven that the negative aspects of driving alone are insufficient to change behavior permanently.

Further we hypothesize that finding ways to make travel time more productive and pleasant should be found in the relationship among the travelers. Anecdotes suggest that good relationships are one of the most valuable outcomes of ridesharing, but they are usually serendipitous. Can we predict good relationships the way eHarmony *et al.* claim to? If we find that different demographics have distinctly different social needs and desires, then promoting distinct services may lead to better results.

4.2.1 How is relationship measured?

Some have suggested degrees of separation should be considered, e.g. $R=1/2^s$ where s=0 if we are friends, s=1 if we have a friend in common, etc. These can be gleaned from social networking sites to which subscribers belong.

An orthogonal measure is common declared interests, e.g. country music. These can be discovered from a questionnaire like those of dating services, but focused on the less intimate questions; e.g. "Do you like to talk while driving?"

As with costs, the interaction of these aspects in not well understood. We will conduct studies of different demographics to assess relationship prediction. Our targeted, personal scenarios related to their actual previous trips will probe for the value of rides with people with various kinds of relationships (e.g., a boss, a co-worker, a fellow wine enthusiast, or a native speaker of a foreign language one is studying)

4.3 Demographics

Specific groups might demonstrate significantly different attitudes about ridesharing. In our surveys and behavior studies we shall compare the traits of several of the following demographics. This will be especially important in understand the role of relationship opportunities as well as acceptable cost ranges.

4.3.1 Millennials

In *Bowling Alone*, Putnam observes significant variation in social capital between generations. Some believe that the generation born between 1985 and 2005 might be more prosocial than earlier ones.[20] Young people contemplating buying their first car might have very different cost functions from older suburbanites. We will explore the decision-making process for buying one's first car.

4.3.2 Co-workers

A study[21] shows that ridesharing programs restricted to companies are more successful. For a large company co-workers share a location and a reasonable level of social capital. They either know potential partners or are open to meeting co-workers. A program of lower level workers occasionally partnering with executives might increase the social capital of the business.

4.3.3 Ticket Holders

People attending entertainment and sports events share a narrow time window, a parking problem, and a common interest. Are they more likely than commuters to be in a social mood? Are they more willing to share a ride once than committing to carpool to work?

4.3.4 Students

Many subjects and skills can be learned and practiced orally. Students at the same school share narrow time windows, interests, and social life. What subjects and interests are best to practice orally, e.g. foreign languages?

4.3.5 Patients

People with periodic doctor's visits, e.g. chemotherapy patients, might share rides. Could ridesharing enhance the health-related social networks already on the internet? Is information or emotional support more valued?

4.3.6 Parents

Many parents find themselves chauffeuring their children for many hours a week. Often, they arrange with other parents to drive but these arrangements take time to set up and change with each year. How do attitudes change with the children's ages?

4.3.7 Singles

The current generation uses eHarmony.com, Match.com, Jdate.com, etc. without reservation. Would single people look on ridesharing as an opportunity for relationship exploration or as creepy?

5 Research Plan, Duties, and Previous Work

Figure 5 shows a rough plan of what we plan to do over the three years.

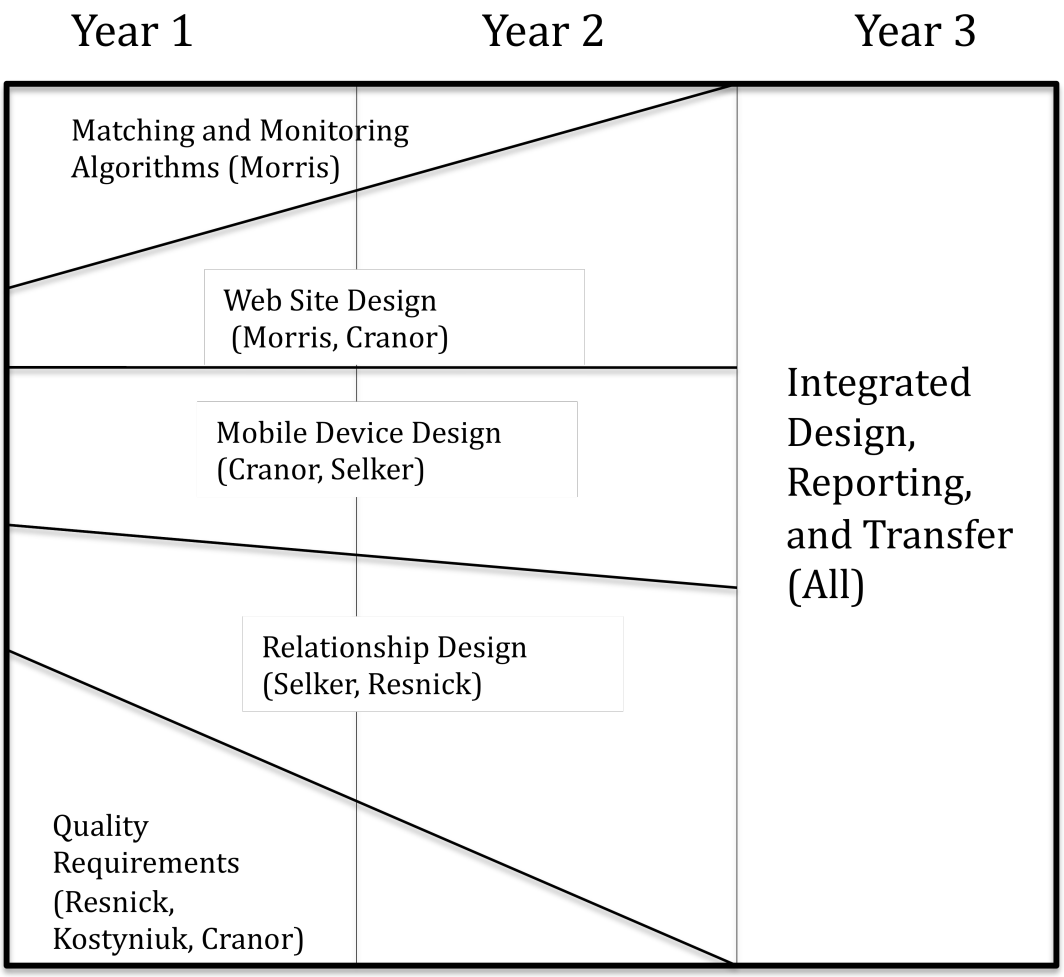

Figure 5. Effort Allocation Plan

5.1 Matching and Monitoring Algorithms

The work on matching and monitoring algorithms is aimed at discovering how good the basic feasibility and control system can be. There are several moving object data base systems available, but their performance may not be adequate.

1. Obtain access to large database of travel routes.
2. Evaluate performance of existing moving object data base systems, e.g. Hermes.[21]
3. Implement tailor-made algorithm based on shortest path algorithms.
4. Transfer algorithms to cloud computing system, e.g. Google, Yahoo, or Amazon.
5. Measure performance—both quality of matches and speed.

5.2 Web Site Design

The web site design requires extensive subscriber tracking to measure satisfaction and discover new requirements as well as a frictionless interface. The basic services of the web site to not require major innovation. However, services don't generally perform significant tracking of subscribers' requirements, interests, and behavior. Such information is important for both research and operation.

1. Build operational web site that includes subscriber tracking and analysis.
2. Develop reputation management subsystem.
3. Integrate with matching module.
4. Integrate with relationship subsystem.

5.3 Mobile Device Design

The mobile device software design is a challenging user interface problem because interacts with drivers as well as riders.

1. Study existing designs of GPS navigators.
2. Design a drivers' and riders' interface.
3. Try a voice-only design on a phone, with or without a Bluetooth® headset.
4. Test users on several designs.

5.4 Relationship Design

1. Study existing dating services, especially eHarmony.com
2. Develop extensive list of potential activities for travelers.
3. Survey several demographics.
4. Develop questionnaire and other devices for creating a subscriber profile suitable for matching.

5.5 Quality Metrics

1. Create a tool that will generate highly personalized, specific scenarios for subjects to respond to. Respondents would carry a tracking device for a week. Process the resulting data to generate a questionnaire about scenarios based on the specifics of their actual transportation, using data on cost and availability of public transport and taxi services for the routes they actually traveled.
2. Adapt scenario generation tool to suggest requirements of a service proactively.

5.6 Market Formation

1. Create a simulation model of how a market of buyers and sellers of rides grows from nothing to sustainability.
2. Add measurement module to web site to compare real participation rates with theory.

5.7 The Consortium

We don't aspire to create a complete system but rather to create prototype modules, e.g.

the questionnaire, that can be adopted by real services. There are hundreds of such services, some listed in dynamicridesharing.com, a wiki maintained Dan Kirshner and Jim Morris.[22] We will recruit these services into a consortium that will advise on our work, share data, and be the immediate recipients of the modules and reports.

5.8 Previous Work

5.8.1 James Morris

Supported by an NSF grant between 1985 and 1987, he directed half of the Carnegie Mellon/University of Michigan EXPRES project, which produced a prototype predecessor to FastLane. He personally sheparded the first ten proposals through the system. According to *Science* magazine and NSF, for a couple of years the project managed a "few hundred proposals … before NSF officials realized that they had bitten off more than they could chew." It also produced a book.[23]

Supported by NSF grant IRI-8902891 between 1989 and 1992 he worked on collaborative writing tools with Neuwirth, Kaufer, and Chandhok. It resulted in seven papers, some listed in his biosketch. Five Ph.D. students were supported.

With the aid of Carnegie Mellon Silicon Valley faculty and students, he has developed an extensive design for a ridesharing service with use cases, requirements, business cases, and user interfaces.[24] [25] [26]

5.8.2 Paul Resnick

He received support from NSF to investigate recommender and reputation systems, (IIS-9977999 "The Design of Reputation Systems", 9/15/99-8/31/03; IIS-0308006 "Recommender and Reputation Systems: Principles and Practices", 7/1/03-6/30/08). A grant to investigate online community design is winding down (IIS-0325837; "ITR: Collaborative Research: Designing On-Line Communities to Enhance Participation – Bridging Theory and Practice", 9/1/03-5/31/09) and one on manipulation resistance in recommender systems is just underway ("III-Small: Manipulation-Resistant Recommender Systems", IIS-0812042, 8/1/08-7/31/11; co-PI).

Support from those grants has led to 22 publications based on research using all the methods to be employed in this proposal: development of new algorithms and mechanisms, empirical analysis, theoretical analysis, lab experiments, and field trials with eBay, Slashdot, online support communities, and MovieLens. He is co-editing a book about the design of on-line communities, intended for practitioners and students.

The doctoral dissertation projects of Cliff Lampe, Derek Hansen, Xin Li, and Tapan Khopkar were supported by these grants. More than a dozen other master's and Ph.D. students have also been supported.

He implemented and studied a ridesharing system at the University of Michigan.[27] [28]

5.8.3 Lorrie Cranor

Lorrie Cranor is PI on NSF Cyber Trust Award #0524189, "Supporting Trust Decisions," awarded in September 2005. In its final year, this project is pursuing several parallel threads related to understanding and supporting user's decisions about online privacy and security, especially those related to phishing. This work has resulted in 12 peer-reviewed conference papers.

She is Co-PI on NSF Cyber Trust Award #0627513 "User-Controllable Security and

Privacy," awarded August 2006. The objective is to develop new interfaces that combine user-centered design principles with dialog, explanation and learning technologies to assist users in specifying and refining policies. This work has already resulted in five peer-reviewed conference papers.

She is PI on NSF Cyber Trust Award #0831428, "Usable Cyber Trust Indicators," awarded August 2008. The goal of this research is to systematically study the effectiveness of cyber trust indicators and develop approaches to making these indicators most effective and usable.

She is Co-PI on NSF Cyber Trust Award #0831407 "Usable Security for Digital Home Storage," awarded August 2008. The goal is to explore architecture, mechanisms, and interfaces for making access control usable by lay people faced with increasing reliance on data created, stored, and accessed via home and personal consumer electronics.

She is producing an ethnographic survey of commuters with Ph.D. student Kursat Ozenc.

5.8.4 Ted Selker

Ted Selker has served on NSF review committees several times. His work in automotive research resulted in papers, many systems, and MS theses by students. A study for the USPS included a real-time, dynamic scheduling system with a map. He ran an experiment using PDA's to schedule VIP airline passengers. He is a prolific inventor and has consulted on Morris's design project, emphasizing the possibilities for positive motivations.

5.8.5 Lidia Kostyniuk

She has an extensive background in travel behavior research and practical experience in transportation planning, including demand estimation for public transportation and ridesharing. She has no previous NSF grants.

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