Proposal for Transportation efficiency 2013 by galen

# Smart Mobility for the 21st Century





Winner

Judges' Choice 2013

## Pitch

A bottom-up mobility-centered approach, to simply get individuals from A to B by intelligently using available data and mobile devices.

## Description

### Video

**RESEARCH PROPOSAL - SMART MOBILITY FOR THE 21ST CENTURY**

GALEN J. WILKERSON

**Summary**

With this mobile app, users go about their daily lives and automatic suggestions are made to get from A to B safely, easily, and efficiently.

We elegantly match mobility demand and supply so travel mode is immaterial, abstracted away from users, greatly reducing emissions and making mobility accessible to all.

**Problem statement**

There are absolutely no mobility solutions that focus on mobility itself. Rather, all are focused on transportation. That is, they are oriented around mode, rather than individuals getting from place to place in the simplest, safest, most convenient, automated, efficient, and cost effective way, so that mode becomes both abstract and immaterial.

Meanwhile, it has become clear that $CO_2$ emissions, in particular from individual automobile usage, are a significant factor influencing climate change [1]. Additional phenomena such as effects on human health, oil dependence, increasing fuel costs, congestion, increasing vehicle miles traveled, habitat impact, and others make it evident that solutions for individual mobility require serious investigation [2, 3].

**Methodology**

PROPOSAL SUMMARY

**Smart Mobility for the 21st Century**

**Team Proposal:** Only team members will be able to edit this proposal.

By: galen

**Contest:** Transportation efficiency 2013
How can $CO_2$ emissions from the world's transportation be reduced?

We propose a user-oriented approach to mobility, where above requirements are met as elegantly as possible - a mobile ’electronic thumb’ to simply get users from place to place.

A background mobile application can feasibly obtain anonymized user location information in a power-conserving way, and send that data to a remote server for processing. It is likely that salient individual mobility patterns can be deduced quickly.

Such an application can learn, for each individual user:

1. Common routes taken and destinations, as well as times visited.

2. Preferred mode(s) of travel under various situations.

3. Characteristics of preferred ride-share partners, using location, social network, and user feedback information.

4. Market-based monetary incentives and rewards.

It is suggested that many of these items can be addressed using Machine Learning. With location information, the application can detect mobility patterns in time, then act on that information. For example, given that a user is departing a building at 5pm, based on past behavior it is determined there is a 90% probability the user is going home. The application can determine this, and also be aware of mode preferences, acceptable walking or waiting time, as well as market value this user places on various modes of transportation, and quickly suggest several most likely appropriate mobility solutions: ”walk to the metro here”, ”take a taxi to X”, ”bus Y arrives in 5 minutes”, ”Meet Fred at Z in 3 minutes, for a $2.00 ride home”.

Through user feedback and actual mobility choices during application usage, the system can improve its performance. Through a large-scale adaptive system such as this, market value for seats in automobiles, mileage, etc. can be determined to maximize marginal benefit for all parties.

Such a system can also be linked to online payment systems to allow easy mobile monetary transactions. Of course, verification, feedback, reporting and recommendation systems can also be included, to reduce safety and reliability issues in the case where the ride-share mode is chosen.

It is also possible that funds from ride-share or other usage can be used to incentivize adoption of the application, perhaps even paying users to use it.

Such an application faces many challenges, not the least of which are sociological or legal. However, these types of challenges have been surmounted by many very popular existing applications.

**Key Research Questions**

Major research questions here are:

In the domain of Sustainabilty Economics:

- Can the modern density of mobile telecommunications allow users collaborate constructively to reduce environmental impact while maintaining standards of living?

- Similarly, in developing countries, can individual mobility ”leap-frog” a very climate-damaging phase of individual automobile ownership, while allowing development to continue?

In the Computer Science domain:
- Can Machine Learning solve problems of routing, mode- or rider-matching?
- How do location information and social networks influence mode choice?
- Can such an application be run effectively and meet power, computation, and bandwidth constraints?

- Will the resolution and error of internal GPS work for such an application?
- Can market value for mobility be determined dynamically?
- Can an application work from a user point of view, in terms of elegance and usability?
- How can market (and other) incentives be used to encourage adoption of software?

**Expected Contribution to Knowledge**

- A paradigm shift from transportation to individual mobility supply and demand.
- Mobile applications to mitigate transportation energy consumption and other problems. - New, intelligent ways to share resources.
- Machine Learning to understand user behavior.
- Use of mobility information to predict user matching.
- Influence of social networks on mobility and user matching.
- A better understanding of mobility economics.
- Developments in mobile/smart phone technology for large-scale projects.

**References**


1. Lee Chapman, Transport and climate change: a review, Journal of Transport Geography 15 (2007), no. 5, 354 – 367.

2. James J. MacKenzie et. al., The going rate: What it really costs to drive, WORLD RESOURCES INSTITUTE, 1992.

3. T. Litman, Reinventing transportation exploring the paradigm shift needed to reconcile transportation and sus- tainability objectives, Tech. Report 1670, Transportation Research Record, 1999.

See also works by A-L. Barabasi, S. Pentland, N. Eagle, M. Gonzalez and many others.

See applications such as Zimride, iCarShare, Mitfahrgelegenheit, openpaths.cc, Funf, Paco, and couchsurfing.org.


## Summary

**Video**

**Phone**: 'I see you are leaving "work", would you like to:'

ride to "*home*" with a friend in 6 minutes? (~15 min, $1.00)
bus to "*home*" coming in 5 minutes?  (25min, $2.00)
metro to "*gym*" in 6 minutes? (10min, $2.50)
walk to "*gym*"?  (20min, $0, healthy!)
something else?
nothing *[shake phone]*

The density of mobile devices and availability of data allow a new 'bottom-up', elegant, automated approach to individual mobility, where ***users simply get from A to B and transportation mode becomes less relevant.***

That is, ***our phones can be 'electronic thumbs' accessing the ambient flow of transportation.***

Since the chain of empty seats from A to B is tangible, we propose to ***treat 'mobility' as a product***, where feedback about overall quality of experience is the guiding principle, and machine learning with mobile devices is the means to deliver it.

Overall quality of experience may perhaps include transportation mode, but also includes obvious features - trip time, cost, waiting time, comfort, health, safety, emissions, social networks, and similar factors.  Navigation becomes optimization in an abstract space of quality.

Geo-location, data-mining of available transportation services, machine learning techniques, market incentives, and modern mobile application technologies enable a great increase in the ability to detect and provide useful information to users in a real-time, safe, convenient, anonymous and secure way.

This mobility model has large implications for efficiency in the context of a changing macro-scale energy environment, where fossil fuels are more scarce and expensive, and environmental consequences of energy usage are very evident.   Implementation in the 'developed' world can be used to bootstrap such a mobility system in developing countries, where (especially non-smart) mobile device usage is growing, and energy intensity of mobility is on the rise.

*Using current technology,* (mobile) web '3.0',  great strides in mobility and sustainability are available to us, right now.

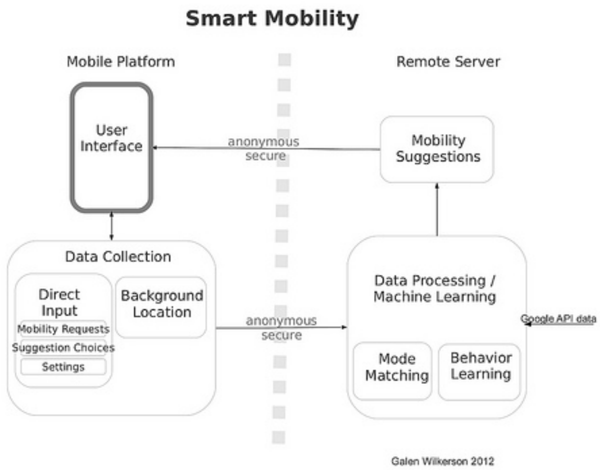
## Category of the action

Reducing emissions from transportation

## What actions do you propose?

We expect to first 'bootstrap' our application by providing automated, useful information for already-available modes of transportation.  As user-ship of the application increases, this enables automated ride-sharing, since the app can (optionally) collect secure, anonymized mobility information.

The general architecture is illustrated in this figure.




(1) **Begin with publicly-available transportation supply**: This phase has elegant, automated utility as its focus.

Working with local startups and online APIs (e.g. google transit), assimilate transportation data for prototyping and testing. We estimate that data collection and assimilation is non-trivial, and will pose a major limitation on implementation. However, we can continue to develop recommender algorithms and use new data as it becomes available. There has been a great recent growth in the assimilation and availability of public transportation data.

(a) **Work out user schedule detection algorithm**: We would like to automatically make mobility recommendations based on user location. Course-grain sampling using low-battery background location detection, together with location matching and routing to commonly-visited destinations and common routes requires statistical pattern-matching. Some research needs to go into this development. It can be simulated initially.

(b) **Develop quality of service model:** We see 'routing' as a navigation in an unknown high-dimensional space, composed of locations, travel time, cost, required walking time or distance, waiting time, delays, safety, health, comfort, mode, and other unforeseen user parameter preferences. We would like to simulate this routing and identify significant dimensionality using principle component analysis and machine learning.

(c) **Work out user/mode clustering and matching algorithm (recommender)**: Tuning routing parameters in this quality-of-service space to optimize user-feedback ratings. Identifying default settings is also important here.

(d) **Implement userID-anonymity and location-privacy:** Using latest research on user- and location-anonymization, we would like to develop a data model where no identifiable user information is sent or maintained remotely. There are a variety of techniques for this, which require testing and research in implementation.

(2) **Expand to individual mobility (e.g. rideshare):** This section anticipates larger-scale usage of the application, to the point where it can include rideshare supply and demand in its choice of

modes.

(a) **Work out user matching algorithm:** User-matching based on mobility patterns may be possible, as there is evidence that users can be usefully clustered by the types of locations they visit, possibly sampling a minimum number of locations. It is also possible that social network information can be (anonymously) used, along with quality of service preferences.

(b) **Expand quality of service model to include social/sharing aspects:** Navigation in quality-of-service space becomes more complex in the social context of rideshare. This needs to be carefully considered and studied. Feedback needs to be expanded and integrated with machine learning/recommender systems.

(c) **Consider robustness/incentives of quality of service (liability, safety, cost, etc.):** With rideshare, the financial ability to incentivize becomes an interesting research question - how to tune price to account for supply/demand elasticity? Here, we also wish to develop strategies to avoid worst-case scenarios. Safety is a primary goal of this project, as is simplicity and user satisfaction.

(d) **Consider social impact (social mobility) and other social factors:** As the user-base increases, so does social impact. Here we consider social repercussions of such an interactive system. While safety and comfort are concerns, we also do no wish to reinforce social class, gender, age or race differences. We want to build a certain amount of social mobility into the system, while keeping it useable.

(3) **Test and research each of the above with many different user groups on a very small, limited scale before any kind of widespread availability is considered:** We would like to do extensive real-world testing to see how usable, robust, simple, and useful it is. Certainly many unforeseen factors will arise in this stage. The goal is to remove uncertainty and especially unforeseen negative outcomes.

(4) **Learn from above to improve quality of service and expand to other modes, devices and user-bases. Besides safety, of particular concern is the lack of availability to those without (expensive) mobile devices:** At this point, the application has been developed for major smart-device platforms. Non-smart text- or voice-based customers are considered, which enables portions of the back-end server to be used with a different interface. Here, testing needs to expand into other user-bases, perhaps including developing countries.

Please see the reference on expert recommender systems (Bouneffouf et al.), and Planning, as well as 'reality mining' papers by Pentland and Eagle, among others. Methodologies for many of the above tasks are already highly-developed and simply need to be implemented in this context/application.

The paper by Song et al. describes the predictability of human mobility patterns, implying that with a small amount of information, a great deal of utility can be delivered, since major patterns are easily known.

The paper by de Montjoye et al. demonstrates a need for careful security and userID-/location-anonymity. Implementing good location-anomymity raises the bar for other location-aware applications (twitter, facebook, etc.), since location privacy is *extremely easy* to erode in the current data environment.

Note that in the "full-world" paradigm, although more total resources are consumed, a saving grace is that more sharing is possible. *It is a simple observation that sharing opportunities grow on the order of N^2 with population N, even if many individuals do not cooperate.* This is a possible fundamental mechanism to avoid a Malthusian catastrophe, encouraging us to imagine other sharing opportunities.

## Who will take these actions?

Graduate students and post-docs in Computer Science at Berlin, in collaboration with several startup companies here and abroad.

There have already been discussions with a variety of companies and universities who can provide various aspects of the above mentioned actions.

## Where will these actions be taken?

Largely in Berlin, Germany for testing and implementation at Berlin, perhaps in cooperation with relevant local start-up companies.

Depending on the initial phase, collaborations farther afield could be developed, particularly with Copenhagen, Denmark, Boston area, or Silicon Valley start-ups or universities.

The community in Berlin is particularly suited to this type of innovation for a variety of reasons. At the juncture of publically-minded idealism, creativity, and startup innovation, it is the most dynamic, exciting place in Europe for this kind of thinking at the moment.

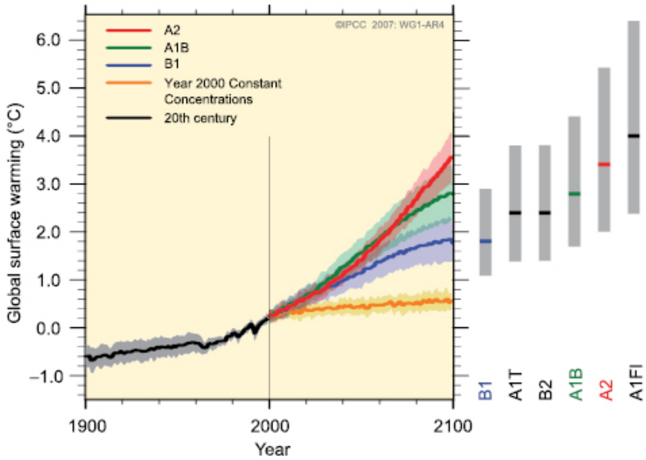
Also, Germany has a long history of environmental and energy interest. Mitfahrgelegenheit (German ride-share) and Mitfahrzentrale are at least 20 years old, partly spurred by the central European tradition of hitch-hiking, and partly due to very high gas prices. More recently, due to the nuclear accident in Japan, Germany has committed to an "Energy Change", moving away from nuclear energy. Energy reduction and efficiency is very much on Germany's mind, while being Europe's major economic power. Berlin in particular, having a large amount of immigration, is faced with maintaining multi-culturalism while also holding onto this economic well-being. Due to its history, Germany knows the great costs of failure.

Copenhagen, Denmark also has a long tradition of sustainable energy production and environmentally-friendly transportation.

The Boston area has particularly seen research in 'Big Data', mobility, and Complex Systems. All of these are part of this project.

## How much will emissions be reduced or sequestered vs. business as usual levels?

Emissions reduction is hard to estimate or predict, since this is a *very different* model of mobility.  This entirely information-based solution lies perhaps near the B1 scenario of the IPCC projections, affecting fuel intensity, both local and global, as software and information is (somewhat) geography-free and can be de-coupled from energy.




(IPCC)

Since automobiles often contain just above one person for most trips, even in countries with high gasoline prices, a small increase in sharing can have very high returns.

As an extremely conservative estimate, EIA.gov statistics reveal that even a very small percentage decrease in auto emissions yields a large net reduction.   (E.g. A reduction of 0.01% (1/10000) of 2011 motor gasoline consumption levels for the US alone would reduce CO2 emissions by approximately 108900 metric tons.)

**The potential, also for developing countries, is far greater**.  The IPCC states that "Economic development and transport are inextricably linked."  Are they?

## What are other key benefits?

Large areas of countries such as the United States are not currently well-served by public transportation.  This has very negative environmental, social, and financial implications. Development of information-based mobility allows large numbers of people to have mobility choices, where before they had none.

As fossil fuel prices increase, ride-share costs can be adjusted (as they currently are with mitfahrgelegenheit.de, for example) to reflect a price that is to the benefit of both drivers and riders, filling a large gap in current mobility for society.

This has much larger national energy and foreign policy implications, since it begins to ***de-couple energy consumption from quality of life, economic well-being, and development***, critical to our future on the planet.

This offers mobility for those who:

- do not have public transportation

- are unaware of local transportation resources

- cannot afford a car

- cannot drive for other reasons (age, health, etc.)

- live in 'developing' countries

## What are the proposal's costs?

Development of an incipient prototype would probably take 2 years, with approximately 3 workers/students doing research and development.  At USD$ 2000/month, this would be USD$144,000.

Since there are related startups and companies in Germany and elsewhere, it is possible that these costs could be reduced to USD$50,000 - $70,000 for only 1 or 1.5 students/workers, allowing collaboration for implementation by these startups.

A possible larger danger (not caused by this idea proposal, but facing us all in the future anyway) is that information becomes the new 'oil' and that we see the same inequality of information availability as we do with fossil fuel.  This is already evident in the global digital divide.  We have to be careful to continue to implement proper incentives and be extremely careful about user AND ***location anonymization.***

The cost of NOT implementing these types of solutions is extremely high.  Fossil fuels have a very high energy return on investment.  This means that, as fossil fuels become more difficult to obtain, unless quality of life is gradually de-coupled from energy availability through sharing and cooperation, there will be major international economic challenges, which are also reflected in foreign policy, national stability, and many other factors.  This instability will be exacerbated by the consequences of past energy use - global warming, obesity and metabolic syndrome, consumption, reduction in biodiversity, and many other problems.

As this proposal does not involve new physical technology, but is information- and communication-based, this means that the cost/benefit ratio is ***extremely*** low.   Once algorithms are in place, the application is limited mostly by the availability of transportation data.   As the application gets 'bootstrapped', it may be possible to collect information about some modes of transportation directly from the app, even if online information is not available.  Once user density is high, much is possible.

## Time line

From Actions above: 3-4 years to begin with.

(1) 1-2 years

(a) 3-6 months

(b) 3-6 months

(c) 3-6 months

(d) 3-6 months

Near the end of this period, it is feasible that an 'initial bootstrap' version of the application be released. This can begin to generate revenue through the usual methods to become self-sustaining.

(2) 1 year (perhaps overlapping with (1))

(a) 3-6 months

(b) 3-6 months

(c) 3-6 months

(d) 3-6 months

In this phase, since some payment is required, a very small user fee can be included, allowing the financing model to change.

(3) 1 year (overlapping with (1) and (2))

(4) During (1-3) and in long term.

## Related proposals

**Open Car Pool** - Unfortunately, many current transportation systems are exactly that - transportation systems - focusing on particular modes, rather than on *mobility itself*. ***Our main goal is mobility with a particular quality of experience.*** Preference for particular vehicles or co-riders is part of this overall quality.

**Sustainable Digital Dividend** - Though a very nice idea, what seems interesting is - how to change our system with information sharing using ***currently available technology and the current vehicle fleet.*** Many ideas are very 'sexy', using hot new technology, but it is not clear how these address the underlying problem.

**Climate-Friendly Cities** - Mobility is a key factor in urban form and function. ***Efficiency is the hidden "resource"***, and the first step in being sustainable, both on an individual and community level. Unfortunately, public transit does not serve suburban areas well, so there needs to be a solution at various densities, time- and distance- scales.

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439.7075 (2006): 462-465.

**Location Anonymization:**

de Montjoye, Yves-Alexandre, et al. "Unique in the Crowd: The privacy bounds of human mobility." *Scientific reports* 3 (2013).

Also see related web/applications:

Zimride

Mitfahrgelegenheit/carpooling.com

eRideShare

Lyft

Öffi

waymate.com

uber.com

Google Transit

Google Maps Transit

Mobile data collection:

openpaths.cc

Funf

Paco

City Sense

Also relevant in terms of sharing resources and an example of feedback, safety, community responsibility, and social aspects of such an application model is couchsurfing.org.