CARPOOLNOW
Just-in-Time Carpooling without Elaborate Preplanning

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Abstract: Carpooling reduces the number of cars on the road, reduces gas consumption, and saves participants money. In order to free carpooling from rigid schedules and preplanning, just-in-time carpooling allows a large member base of passengers and drivers to be matched with each other automatically and instantly, allowing for on-the-spot arrangement of rides. A mobile phone call or text message initiates an automatic process in which drivers and passengers are matched to a shared ride wherever and whenever they need it, without the scheduling constraints of traditional carpooling. This program faces a number of challenging barriers in technology and behavioral science. These include the creation of a seamless interaction between mobile phones and the internet server, voice recognition and SMS solutions, safety of mobile phone use and driving, and motivation, safety, and trust among participating members of the carpooling community.

1 INTRODUCTION

Changes are rapidly occurring as our culture becomes more mobile and "nomadic," able to access information and communicate anywhere at any time. Nomadic travel schedules, increasingly breaking away from the 9-to-5 work schedule, have become chaotic and greatly distributed. This may be one of the reasons for a decline in carpooling, despite the increasing pressure for alternative transportation options (Ungemah et al., 2007). Our dynamic carpooling project grew out of these observations in a Technology Benefiting Humanity course taught by the senior author at UCSC.

The most pervasive modern-day "nomadic device" for our less predictable lifestyles is the cell phone. Cell phones are small and portable, and most people have one. In November 2007, worldwide mobile telephone subscriptions reached 3.3 billion, which is equivalent to over half of the global population, and in the United States the percentage of mobile telephone subscribers is even higher at 85 percent or 259 million subscribers (Virki, 2007). Additionally, the most common feature used on a cell phone other than making a phone call is the sending or receiving of text messages. Since so many people have cell phones and because they are the ultimate "nomadic device", we are evaluating the feasibility of a dynamic, just-in-time carpooling service that allows users to utilize cell phones to connect to potential drivers or passengers.

2 THE PROBLEM

Transportation is a major issue in our world today. Traditional problems of transit, once thought of as a strictly civil engineering difficulty, are increasingly being revisited and recognized as a critical environmental crisis. Transportation accounts for about 29% of all greenhouse gas emissions (Transportation and Climate, 2009). There is also a growing awareness of the environmental impact associated with the fabrication of cars, especially from the nickel-metal hydride batteries in more fuel-efficient hybrids.

The dominant form of personal transit today is the private passenger car. Very often, these cars are used with only a single rider. For instance, in the UK the average car only has 1.5 people in it (Hartwig & Buchmann, 2007). An over abundance of cars creates many well-documented problems for urban areas, such as increased traffic, increased pollution, parking congestion, and the need for expensive

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infrastructure maintenance. In addition to these large-scale problems, driving alone is expensive to individuals. The rising cost of oil affected motorists on a more personal level when gas prices reached an all time high in July 2008 of slightly higher than \$4.00 per gallon. US households spent an average of almost \$7,500 on transportation in 2004—second in spending behind housing. The average operating cost (gas, maintenance, and tires) of driving a car in 2008 is 17 cents per mile (Behind the Numbers, 2009). When this expense is added to ownership costs (full-coverage insurance, license, registration, taxes, depreciation, and finance charge), the total expense for driving a car 15,000 miles per year is about \$8,121 per vehicle. Given the dramatic economic downturn in 2008, these expenses will no longer be affordable for many US citizens.

The expenses, both environmental and fiscal, of single occupancy vehicles can be reduced dramatically by utilizing the empty seats in these vehicles. Carpooling targets these empty seats: it takes cars off the road reducing traffic and pollution, and may provide an opportunity for social interaction. However, traditional ways of scheduling carpools often limit users to consistent schedules and fixed rider groups--carpooling to the same place at the same time with a set person or group of people.

3 DYNAMIC CARPOOLING

Dynamic carpooling overcomes some of the traditional carpooling restrictions by allowing a large membership base of passengers and drivers to be matched with each other automatically in real time, allowing for on-the-spot arrangement of rides. Dynamic carpooling thus opens the domain of carpooling to not only traditional employment trips but also to irregular trips, including so called "last mile" trips, which are also the most difficult to service by most public transit systems.

Because dynamic carpooling relies heavily on frequent access to the ride matching service, it is essential that accessing the service be as easy as possible for users. Access should be quick, simple, and convenient. Providing this access to users could occur via a mobile phone service. Mobile phones are ubiquitous in today's society; they travel with most people everywhere they go. Because of this, and the other benefits cell phones provide such as easy interfacing with the internet and possible location awareness, mobile phones are an excellent platform for access to a dynamic carpooling service.

If the primary mode of interaction is by mobile phone, access would be available at any time and any place. Passengers could arrange a ride wherever and whenever they needed it, without the rigid planning of traditional carpooling. Additionally, this would allow drivers to designate any trip available for carpooling at the time of the trip.

4 SYSTEM IMPLEMENTATION

A dynamic carpooling system relies on two underlying sources of information: quick and easy route announcement by the members (member end) and flexible and intelligent route matching by the system (server end). Multiple methods of route announcement, including email, text messages, and voice telephone calls, would be similarly handled by the server. The message would announce the member's name (which would be detected automatically by his or her telephone number), an indication of the starting location, and whether the member is a driver, a passenger, or either depending on the quality of the match for the trip. If it is a voice call, automatic speech recognition would be used to recognize these indices. Given the simplicity of the dialog and the system’s protocol to check the accuracy of the recognized information, this part of the process could be essentially error free.

4.1 Related Work

Existing solutions could be broadly classified into two types, based on their approach. First is the ride share bulletin board (e.g., PickupPal, 2009) in which the drivers and riders post their carpooling plans. The users manually search the existing posts to find a match, which is time intensive and requires internet browsing access.

The second type uses automated route-matching solutions to match up a rider and a driver. For example, iCarpool (2009) uses high precision trip matching to find the best carpool match. Although arrived at independently, our system shares a similar conceptual framework as Aktalita (2009), which combines the Web, a geo spatially enabled database, and a Java enabled cell phone to provide real-time dynamic carpooling between drivers and passengers.

Both of these types of solutions require the member’s access to a computer, a browser enabled phone, or a java enabled cell phone. In contrast, we expect that the more ad hoc and easy the carpooling solution the more popular it would be. A simple call or a text message from a phone would simply trigger a precision route-matching algorithm.

4.2 Prototype

We developed a prototype to check the feasibility of this system.

1. A passenger submits a request for a ride or a driver offers a ride. If a member has the flexibility to be either a passenger or a driver, then they will also be given the option to select both.
2. Once submitted, the system tries matching the request with a corresponding valid match.
3. If a match is found, the result is sent back to the two matching members.

The prototype is implemented in the Python programming language. MySQL is used as the database for storing the entries. Members who request a ride and members who want to offer a ride send a Short Message Service (SMS) message containing information about the ride to a mobile number. The SMS message containing the information is forwarded to an email address. A Python script uses Post Office Protocol (POP3) to fetch the email message and then parses the email to extract the data required for the database. The primary database entries that are important are: driver, passenger, or either, source/destination locations, and the time window in which the user needs or could offer a ride. Once we have the matching entries we send back SMS messages to both the member who requested the ride and the member who offered the ride.

5 PSYCHOLOGICAL FACTORS

Psychological research on multitasking in human performance, establishing trust, motivation to participate, and community adhesion contribute to the possible influences on people's decision to participate in a carpooling service. We begin with a short history.

5.1 Carpooling and its Decline

Historically, carpooling has had varying points of popularity. It first appeared in U.S. policy during World War II because of oil and rubber shortages and did not reappear again until the mid 70s because of an oil crisis (Ferguson, 1997). Carpooling became a research topic in the late 1970s as the federal government began to provide carpool demonstration projects. This was a time when carpooling seemed to have great promise. In terms of demographic characteristics, studies at the time revealed that carpoolers were not different from people who drove alone (Oppenheim, 1979).

However, hope for the marketing of carpooling came to a decline in the mid 1980s as baby boomers moved to the suburbs in great numbers, creating road congestion and fewer carpools despite the marketing for it (Pisarski, 1987). Increasing household vehicle availability, lowering of real marginal fuel cost, and higher average educational attainments among commuters were found to be significant influences on the decline of carpooling (iCarpool, 2009). In 1980, 19.7% of commuters carpooled to work where only 10.7% of the US population carpooled in 2005. Use of public transportation was also low with less than 5% of workers using buses, trains, or subways (Sharpe, 2007).

5.2 Safety of Mobile Phone Use

Experimental studies of driver performance and case reports of crashes inform us about the risks involved in cell phone use while driving.

Experiments on driver performance in simulated driving studies point to the decreased safety of operating a motor vehicle while talking on a cell phone. It has been shown that both handheld and hands-free cell phone use increases mental workload, which interferes with an individual’s information processing abilities (Törnros & Bolling, 2005). The speed of the vehicle is also slowed by cell phone use, but only in a handheld condition, possibly to compensate for the increased workload.

Initiating a call on a cell phone poses an even greater traffic safety hazard (Törnros & Bolling, 2005). There was more lateral deviation in the lane when dialing a number on a cell phone than when just conversing on the phone. This was true for both handheld and hands-free conditions.

Treffner & Barrett (2004) found that driving while talking on a hands-free cell phone detracts from the driver’s ability to control the car, compared to driving in silence. There was no effect of conversation difficulty, indicating that it is the mere act of talking on the cell phone that impairs performance, not the degree of complexity for the conversation.

Event-related brain potentials (ERPs) and reaction times were examined in hands-free and handheld conditions (Garcia-Larrea et al., 2001). ERPs were collected that reflected the speed of processing, allocation of attentional resources, and preparedness to respond to a visual task. The ERP data from this study suggest that using a cell phone at the same time one is performing a visuo-motor task impacts two physiological mechanisms. The first is a general decrease in attention allotted to sensory inputs. This is likely due to the effects of the situation being a “dual-task,” meaning that the addition of a conversation divides the resources that would otherwise be focused on only the task of driving. This decrease in attention is seen in both the hands-free and handheld conditions. The second finding is that there is a weakening of preparedness to respond with a motor action, but this was limited only to the use of a handheld phone.

With regard to case reports of crashes, a study done in Japan revealed 129 crashes to be cell phone related in the month of June, 1996 (Yomiuri, 1999). At the time of the crash, 42% of people where answering the phone, 32% were dialing on the phone, 16% were talking, 5% were in the process of hanging up the phone, and the status of the remaining 5% was unknown.

Hospital emergency room cases were documented in Perth from April 2002 to July 2004 (Yomiuri, 2009). The increased risk was estimated by comparing cell phone use in the 10 minutes prior to the crash to how a person was driving in the week before to the crash. The risk of crashing increased fourfold when drivers were talking on a cell phone. This was true for both handheld and hands-free phones.

In sum, it is a common misconception that a hands-free cell phone would be a better choice for drivers than a handheld phone. Cell phones should not be used while driving, whether or not it is hands-free or permitted by law.

5.3 Establishing Trust

One of the greatest barriers to carpooling is trust, which is obviously multidimensional (Paine et al., 2008) and fits with the theory that behavior has multiple influences (Massaro, 1998). Ability, integrity, and benevolence are three dimensions of trust identified by Bhattacherjee (2002). We have identified a number of features to instill trust to attract new members and to maintain a comfortable membership. Carpooling membership can build on current internet practices. Buyers and sellers know each other’s history on eBay, Amazon.com readers have access to summaries and reviews written by other users of the site, and social networking sites have various protective devices such as age requirements or credit card enrollment.

As much evidence as possible about members should be mutually available without compromising their privacy. Members could produce a simple personal profile page that would primarily aggregate other web presences. Members could easily link to their professional or personal pages, which would allow a member's pre-existing web presence to be utilized to bring the information necessary for trust building. It is also conceivable to extend the information on a profile to include driving data not available elsewhere on the web, such as a traffic record from the DMV and their insurance status.

To further promote trust members would have the option of creating "favorites" and "blocked" lists of members. The service would give preference to users on a member's "favorites" list and exclude those on the "blocked" list. Manually created lists could prioritize carpools with acquaintances and avoid particularly awkward matches. Automatically created and updated smart lists could let members set parameters for their matches, allowing for a user-customized matching routine. For instance, a member could block smokers and prefer dog lovers. There would also be a way for users to decline a match made by the service. Having this degree of control over the matches may increase the trust in any service.

5.4 Motivation to Participate

Although a high-degree of trust is important, it may be insufficient to compel individuals to participate in carpooling. Individuals with a pro-social attitude who also have a high degree of trust—as opposed to individuals with a pro-self attitude and any level of trust—are more likely to participate in carpools (Flannerlly & McLeod, 1989). For those with pro-self attitudes who believe that driving alone is preferable, marketing will have to focus on both attitude change and trust.

Trust is also critical in terms of reliability, referred to in the literature as “cybertrust,” or “trust in … information and communication technologies” (Flannerlly & McLeod, 1989). Users must trust that the technology is reliable or else they are unlikely to use it or recommend it to other users, and could even discourage its use. This technological trust is important for the development of our user-interface, data security, ease of use, and numerous other features of the design and implementation.

5.5 Community Adhesion

To ensure the success of and the need for dynamic carpooling, community involvement and adhesion is necessary. In other words, its success is dependent on the participation of the community and the willingness of the community to work together. Community involvement and adhesion is facilitated through the acknowledgement and definition of a problem. The public must express dissatisfaction with the current transportation options and recognize that others also struggle with getting to and from different places. Acknowledging this helps the community define the problem as a need for alternative transportation services and to see carpooling as a viable solution.

5.6 Socialization Via Carpooling

Dynamic carpooling might have significant impacts on the local community. In many communities, for example, there is still sufficient free space so that much of what we do does not have to be public. In big cities like New York, on the other hand, citizens are surrounded by each other and most have learned to behave more overtly. New Yorkers can be described as not respecting the distinction between people they know and strangers (Acocella, 2008). Initiating interactions with strangers implies a good deal of trust and comfort. Dynamic carpooling may likely lead to an expansion of a person's network of acquaintances, if not friends.

5.7 Survey of Feasibility

An online survey was administered to all faculty, staff, and students at our university, to investigate whether transportation was considered a problem and to measure the potential for community involvement and adhesion around the topic of transportation. Some of the survey results are shown in Tables 1-4.

Table 1: The percentage of each group making up the survey results based on 1945 respondents.

Faculty	Staff	Undergrads	Grads
5%	31%	55%	9%

Table 2: Survey results (% of 1945 respondents).

Females	66%
Males	33%
Access to Car	71%
Live on Campus	20%
Drive Alone	30%
Carpool	6%
Bus	26%
No Convenient Bus Stop	40%

Table 3: Survey results (% of 1945 respondents).

Why Would You Carpool?	
Better for the environment	82%
Save Money	81%
Meet New People	47%
More Convenient than Bus	67%

Table 4: Survey results (% of 1945 respondents).

Why Wouldn't You Carpool?	
Inconvenient	58%
Difficult to Organize	64%
Like to Travel Alone	12%
Wouldn't Feel Safe	16%
Other	16%

The survey provided some informative outcomes. One might have guessed there would not be enough cars and free seats to support carpooling in a university community but, in fact, almost 3 out 4 people have access to a car, and 3 out of 10 people drive to campus alone. Carpooling would also seem to be attractive to 4 out of 10 people because they don't have a convenient parking place. At least 78% of the respondents said they would carpool with faculty, staff, undergrads, grads, and members of the opposite sex.

As can be seen in Tables 3 and 4, the majority of community would carpool for the environment, to save money, convenience, and half of them would be interested in meeting new people. Although more than half the respondents view carpooling as inconvenient and difficult to organize, we expect just-in-time carpooling would alleviate these concerns. Finally, only a small fraction do not appear to be among the potential membership because of valuing being alone in commuting or safety concerns. Even these individuals might eventually be recruited to a successful carpooling service.

6 BUSINESS OPERATIONS

The aforementioned research indicates that we must take a multi-dimensional approach to the operation of a dynamic carpooling service. This approach must at a minimum include a consideration of driving safety, trust, attitude change, and community adhesion and do so in complex ways. Moreover, the service must provide a benefit to both the drivers and the passengers. The benefits to the passenger are straightforward; the benefits to the driver come in the form of a quicker commute (because it allows use of the HOV lanes) with almost zero cost (since the passenger is taking the same route as the driver) and, of course, a financial incentive.

There are many issues to be resolved regarding the payment by passengers for rides. The amount each rider pays must be balanced: it needs to be enough to be beneficial to the driver but not so much as to be seen as detrimental by the passenger(s). The carpool service should handle the payment to the driver, making the experience simpler for both driver and passenger, and provide its primary source of income. Once the service reaches a critical number of rides, it should be economically self-sufficient. What is truly amazing about dynamic carpooling is that it requires so little. It uses the vehicles, infrastructures, routes, drivers, and technologies that are already on the road today. With our sustained effort, we believe these can be made to work together to bring a greener future to private transportation today.

One Internet-based ride-share matching service, ZoomPool (2009), has independently begun work to add several mobile applications to their service to incorporate dynamic carpooling options. This membership service performs multiple security filtering to facilitate trust and encourages vouching and other forms of recommendations among members. The service shares the transportation costs automatically between drivers and passengers to decrease the awkwardness associated with negotiating finances. ZoomPool aims to decrease the barriers to carpooling resulting in a verifiable improvement in personal carbon footprint. It is a recently launched company that has yet to prove its model.

REFERENCES

Acocella, J. (2008). You got a problem with that? Smithsonian, May, 26-29.

Aktakita (2009). Retrieved on January 18, 2009, from http://aktalita.com/.

Behind the Numbers (2009). Retrieved on January 18, 2009, from www.aaaexchange.com/.

Bhattacherjee, A. (2002) Individual trust in online firms: Scale development and initial test. Journal of Management Information Systems, 19, 211-241.

Ferguson, E. (1997). The rise and fall of the American carpool: 1970-1990. Transportation, 24, 349-376.

Flannerlly, K.J. & McLeod, M.S. (1989). A multivariate analysis of socioeconomic and attitudinal factors predicting commuters' mode of travel. Bulletin of the Psychonomic Society, 27 (1), 64-66.

García-Larrea, L., Perchet, C., Perrrin, F., & Amenedo, E. (2001). Interference of cellular phone conversations with visuomotor tasks: An ERP study. Journal of Psychophysiology, 15, 14-21.

Hartwig, S, & Buchmann, M. (2007). Empty Seats Traveling," Nokia Research Center Bochum, February 14, 2007.

iCarpool (2009). Retrieved on January 18, 2009, from http://www.icarpool.com.

Massaro, D. W. (1998). Perceiving talking faces: From speech perception to a behavioral principle. Cambridge, Massachusetts: MIT Press.

Oppenheim, N. (1979). Carpooling: Problems and potentials. Traffic Quarterly, 33, 253-292.

Paine Schofield, C. B. & Joinson, A. N. (2008), Privacy, trust, and disclosure online. In A. Barak (Ed.) Psychological aspects of cyberspace: Theory, research, and applications (pp. 13-31). Cambridge: Cambridge University Press.

PickupPal (2009). Retrieved on January 18, 2009, from http://www.pickuppal.com

Pisarski, A.E., (1987). Commuting in America. Westport, Connecticut: Eno Foundation for Transportation, Inc.

Sharpe, R. (2007). We're all alone on our drive to work. USA Weekend Magazine. Sept. 9, usaweekend.com

Törnros, J.E.B, & Bolling, A.K. (2005). Mobile phone use – effects of handheld and handsfree phones on driving performance. Accident Analysis and Prevention, 37, 902-909.

Transportation and Climate (2009). Retrieved on January 18, 2009, from http://www.epa.gov/OMS/climate/index.htm

Treffner, P.J., & Barrett, R. (2004). Hands-free mobile phone speech while driving degrades coordination and motor control. Transportation Research Part F, 7, 229-246.

Ungemah, D., Goodin, G., Dusza, C., & Burris, M. (2007). Examining Incentives and Preferential Treatment of Carpools on Managed Lane Facilities. Journal of Public Transportation, Vol. 10, No. 4, 151-170.

Virki, Tarmo. (2007). Global Cellphone Penetration Reaches 50 pct. http://investing.reuters.co.uk/news. Thu Nov. 9th

Yomiuri, S. (1999). Ban on cell phone use by drivers having impact. The Daily

Yomiuri (2009). Retrieved on January 18, 2009, from http://www.yomiuri.co.jp/newse/1216so04.htm,

ZoomPool (2009). Retrieved on January 18, 2009, from http://www.zoompool.com/.