Free University of Bolzano

Faculty of Computer Science

Thesis

Dycapo: On the creation of an open-source Server and a Protocol for Dynamic Carpooling

Daniel Graziotin

Thesis Advisor: Prof. Paolo Massa, Ph.D.

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Abstract

Carpooling occurs when a driver share his/her private car with one or more passengers. The benefits of carpooling, also called ridesharing, are environmental, economical and social. Dynamic Carpooling is a specific type of Carpooling which allows drivers and passengers to find suitable lifts close to their desired departure time and directly on streets. This dissertation describes Dycapo, an open-source system to provide Dynamic Carpooling services. After a review of the state of the art, the two main "components" are described, namely the protocol and the server architecture. Dycapo Protocol is an open REST protocol for sharing trip information among dynamic transit services, taking inspiration from OpenTrip, a previously proposed protocol. Dycapo Server is a prototype providing a Web Service for Dynamic Carpooling functionalities, implementing Dycapo Protocol. Our aim with the release of an open protocol and open source code is to provide a missing standard and platform that providers of Dynamic Carpooling services can adopt and extend.

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1 Introduction

1.1 General Information

Private car travelling is an efficient and wasteful way of transportation. Most cars are occupied by just one or two people. Average car occupancy in the U.K. is reported to be 1.59 persons/car, in Germany only 1.05 [Hartwig, S. and Buchmann, M. (2007)]. Such an inefficient transportation system causes problems such as a waste of resources, in terms of gasoline and time. It causes pollutes in the air. It stresses the parking. One solution is carpooling, i.e. the share of a private vehicle between one or more passengers.

1.2 Dynamic Carpooling

Dyamic Carpooling (also known as Dynamic Ridesharing, Instant Ridesharing and Agile Ridesharing) is a new implementation of Carpooling service which enables the formation of carpools on short notice. Dan Kirshner, one of the founders of this new concept, defines it as follows:

"A system that facilitates the ability of drivers and passengers to make one-time ride matches close to their departure time, with sufficient convenience and flexibility to be used on a daily basis."[1]

[1] Kirshner, D. (Accessed Sept 5th 2010) - http://dynamicridesharing.org

2 State of the art

2.1 Researches

During the research phase eleven papers were analyzed to obtain the state of the art. In this section a brief summary of each paper is presented. The whole research results are available in the project website, Research section.[2]

2.1.1 Sociotechnical support for Ride Sharing

[Resnick, P. (2003)]

Lists barriers and changes to be done to reduce them. Provides scenarios and current status: Reports about High Occupancy Vehicles (HOV) lane on streets of San Francisco and Oakland. There should be no fees on bridges for HOVs. Suggests conventions between drivers and passengers (e.g. pickup points near public transportation stops). Regarding security, suggests to give priority to female passengers, to not leave them alone waiting for a ride. Reports that there are no stories about rape, kidnapping or murder and the most common problem is bad driving.

Research Agenda needed: location awareness devices. Instant ridesharing limited to fixed pickups and dropoff locations. User Interface design: simple interfaces for passengers and drivers. Routing matching algorithms: short window of opportunity to match passenger and driver. Time-to-pickup algorithms: to help passenger decide whether to use carpooling or Public Transportation System. Safety and reputation system design: authenticate passenger and driver before making the match, monitor arrival at destination, feedback system. Social Capital impacts: potential for creating new social connections; passengers/drivers matching according to their profiles creates bridging across class, race and religious views. An important area of research is document whether use of Dynamic Carpooling does create social connections and which of those connections provide social capital

2.1.2 Pilot Tests of Dynamic Ridesharing

[Kirshner, D. (2006)]

Presents three pilot tests done in the USA, all of them failed. Reasons of failure are the following: too complicated rules and user interface, too weak marketing effort, too few users. After 1 month, 1000 flyers distributed to the public and a proposed discount on parking, only 12 users were using the system. Adds idea of saving money when parking. Adds idea of using social networks to allow car pooling on the fly. Thinks about using a web – and mobile- service, writes some user stories.

[2] Graziotin, D. (Accessed Sept. 5^{th}2010) - http://dycapo.org/Research

2.1.3 The smart Jitney: Rapid, Realistic Transport

[Murphy, P. (2007)]

Focuses on environmental benefits. Asserts that dynamic car sharing would lower GHG emissions in a better way than electric/hydrogen/hybrid cars would do. Introduces idea of Smart Jitney: an unlicensed car driving on a defined route according to a schedule Installation of Auto Event Recorders on cars, enforcing security Challenges are all focused in convincing the population to use the service Proposes a cooperative public development of the system

2.1.4 Auction negotiation for mobile Rideshare service

[Abdel-Naby, S. et al. (2007)]

Proposes use of Agents and complex algorithms for person matching and auction mechanisms.

2.1.5 Casual Carpooling enhanced

[Kelley, L.K. (2007)]

Thinks about areas without HOV lanes. Proposes the use of RFID chips to quickly identify passengers and drivers. Readers should be installed at common pick-up points. Complaints that it would cost less to pay passengers and drivers for using the service than to build a HOV lane.

2.1.6 Empty seats travelling

[Hartwig, S. and Buchmann, M. (2007)]

Suggests to use the phone as a mean of transport, creating a value in terms of a transport opportunity and communication. Points out some factors limiting carpooling arranged via websites: trip arrangements are not ad hoc, it is impossible to arrange trips to head home from work or to drive shopping. Notice that people are not widely encouraged to practice carpooling by local governments. Collects obstacles and success factors in terms of sentences, and their solution. Challenge is more in the definition of a path leading from existing ride share services to a fully automated systems.

2.1.7 Interactive systems for real time dynamic multi hop carpooling

[Gruebele (2008)]

Proposes a dynamic multi-hop system. Problems of static carpooling are that matching drivers and passengers based on their destinations limits the number of possible rides, and with high waiting times. Carpooling is static and does not lend itself well to ad hoc traveling. Carpool are very dependent on participant punctuality. Asks governments to integrate carpooling in laws, to push for its use. Perceived quality of service is increased even driving the passenger away from destination. A driver and a passenger should not be matched only if they share the same or similar destination because perfect matching would require high waiting times. Speaks about social aspects: in a single trip with 3 hops a passenger might meet 3 to 10 people, therefore passengers may be socially matched. Suggests to link the application with some social networks like Facebook, MySpace and use profile information to match drivers and passengers. Security improvement: use of finger-prints, RFID, voice signature, location of vehicle on the map, using user pictures, assigning random numbers to be used as passwords.

2.1.8 Instant Social Ride Sharing

[Gidófalvi, G. et al. (2008)]

Proposes matching methodologies based on social connections. It assumes there exist a social network database that is used to determine the strength of the social connection between passengers and drivers, to calculate a priority of match. Gives some algorithms and SQL queries. Assumes that there is already a large scale of users, no barriers are taken into account.

2.1.9 Combining Ridesharing & Social Networks

[Wessels, R. (2009)]

Imagines a mobile and web system that interacts with social networks profiles that should improve security and trust by users. Users can register to the system in a traditional way (e.g., by giving email, username, password), then complete their profiles by linking their account to multiple existing social networks account, to fill the remaining fields. Otherwise, they have to fill the fields manually and verify their identity in more classical ways. Proposes Opensocial[3] as connection interface. An own rating system is also complained. Mobile system should make use of GPS and creation of a match on the fly (real-time algorithms).

Provides some results of surveys: people are ready to spend 17% more time to pickup a friend of their social network rather than a stranger. Provides a high-level description of the system, high-level implementation details. Asks for extra research on psychological factors that increase trust and perceived safety.

2.1.10 SafeRide: Reducing Single Occupancy Vehicles

[Morris, J. (2009)]

Proposal of project in the U.S.A. Reports that there is a market-formation problem: to achieve the system that attracts passengers, there will have to be many drivers available. But the drivers will emerge only when it appears profitable or otherwise desiderable, and that depends on there being many passengers, etc.

[3] Google, MySpace et al. (Accessed Sept. 5th 2010) http://www.opensocial.org/

Someone must discover a winning formula before anyone will invest. Lists some interesting user stories, as well as algorithms and requirements.

2.1.11 Current Trends in Dynamic Ridesharing, identification of Bottleneck Problems and Propositions of Solutions

[Zimmerman, H. and Stempfel, Y. (2009)]

Reviews some papers about Dynamic Carpooling. Also reviews some applications. Identifies barriers and proposes solutions.

2.2 Systems

After the theoretical research, also the existing systems were taken into consideration. The following list contains the existing Dynamic Carpooling applications and some static, web-based systems that are either innovative or famous. All the reported websites were accessed on Accessed Sept. 5$^{\text{th}}$2010. For more information and a complete list, please see the Dycapo website[4]

2.2.1 Carriva

https://www.carriva.org/MFC/app

A proprietary solution using phone calls as communication system and a fixed price of 0,10€ / km. Has got 1118 active users.

2.2.2 Avego

http://www.avego.com

A proprietary application for Apple iPhone. It uses GPS technologies and presents a simple, intuitive useri interface. It handles costs automatically. Passengers are not required to have an iPhone. It will offer information about public transports. Relies on a proprietary service called Futurefleet. On October, 10th 2009 the service offered 5310 empty seats.

2.2.3 Carticipate

http://www.carticipate.com

A proprietary iPhone application that integrates with Facebook, defined as "a location based mobile social network for ride sharing, ride combining, and car pooling". It has a very simple interface looking like Google Maps mobile. It is available on 59 countries.

[4] Graziotin, D. (Accessed Sept. 5$^{\text{th}}$ 2010) http://dycapo.org/Research/Systems_Analyzed

2.2.4 Piggyback

http://www.piggybackmobile.com/

A proprietary Android application usint a step-by-step approach (max. one user input at each application screen) and makes use of graphics instead of text, when possible. Offers the possibility to bookmark addresses. The map screen seems also proprietary. When driver and passengers are matched, their compatibility is showed, represented with stars (0 to 5) and categorized as friendliness, reliability, driving skills and car. Trip cost is also showed. After the ride, the feedback system lets the user set the points for the aspects listed above. The application lets also plan rides using a static approach.

2.2.5 Aktalita

http://www.aktalita.com/

An under development application, supposed to be proprietary.

"Aktalita combines the Web, a geospatially enabled database, and a Java enabled cellphone to provide real-time dynamic carpooling between drivers and passengers"

2.2.6 RideGrid

http://www.highregardsoftware.com/ridegrid-dynamic-ridesharing.html

Another proprietary, not yet in production system. "RideGrid is a service that uses mobile internet and location technology to enable individuals to obtain rides to and from any location, spontaneously. [..] RideGrid works by dynamically combining routes. We evaluate the change required in a driver's route such that it passes through the desired source and destination of a compatible rider, and broker the agreement. We have proprietary means to calculate the routes, monetize the transactions, and introduce people to others they trust. "

It uses an internal credit system. The client has an outdated classical Java Micro Edition interface.

2.2.7 Project Carpool

https://launchpad.net/carpool

The only open-source project, uses PHP and Javascript. The development seems discontinued.

2.2.8 GoLoco

http://goloco.org/

A proprietary web application that also relies on Facebook. It uses a private payment system

2.2.9 Ecolane DRT

http://www.ecolane.com/

A proprietary solution, web-based, focused on security.

2.2.10 Divide The Ride

http://www.dividetheride.com/

A static, web-based solution organized around children activities. Families invite other trusted families to join their group. Groups get notifications when a ride is needed.

2.2.11 iCarpool

http://www.icarpool.com

A static, web-based system that does not require payments. Declares to use proprietary algorithms for ride matching. "High precision trip matching. helps you find the best carpool match. Find co-workers, neighbors and friends for carpool. Use for daily commute, recurring trips, long distance trips and events Plan ahead or use on-demand". Matching criteria seem to include social relationships.

2.2.12 Hover

http://www.hoverport.org/

A casual carpooling system using RFID technologies and an own credit system. Members are approved after verfication tests. Persons must meet at a location called "Hover Park" and are identified by the RFID system. On exiting the Hover Park, the system recognizes driver and passengers and distributes credit points. There are several destination points available, that register the arrival in the same way. It also offer a guaranteed back-to-home system, by using taxis.

2.2.13 Flinc

http://www.flinc.mobi/

A Dynamic Carpooling system using smartphones (Android and Apple iPhone). "Flinc connects navigation systems and mobile phones and arranges available seats within a few seconds - directly in the car and on the pavement. Flinc combines GPS and location-based capabilities with social networking to offer a dynamic and automated method of getting from one place to another. The service can be used on smartphones or on the PC or Mac, helping users create rides within a few seconds via an entirely automated process.".

2.3 Outcomes

The analysis of the state of the art brought some issues related to adopting Dynamic Carpooling systems, also recognized by [Zimmerman, H. and Stempfel, Y. (2009)].

3 Dycapo System

In this section the outcomes of this dissertation are presented. Dycapo is developed using an open, collaborative development system. The official website[5] is the start point. Every information and outcome related to the project is stored in a Wiki, freely accessible and discussable. The code is available in an open GIT repository [6]. The Wiki content and the source are available under permissive and open licenses.

3.1 Protocol

Dycapo Protocol is an open application-level protocol for enabling communication between Dynamic (and static) Carpooling servers and clients, using HTTP [7] and JSON [8]. It is inspired by OpenTrip Core[9], a former proposal of data exhange format for Carpooling and Dynamic Carpooling presented during the MIT "Real-Time" Rideshare Research workshop[10].

3.2 Entities

The entities defined by OpenTrip core (using Atom Syndication[11] format) have been extracted and represented using UML 2.1 Class diagrams. While proceding and discussing the development of the server, those entities were extended and adapted. As discussed at the beginning of the next section, the entities were first encoded using XML-RPC data format, then JSON. The entities are represented in the Protocol using descriptive tables and real world code snippets. The Dycapo Protocol draft version of September 5, 2010is included in the Appendix A.

The following are the Models of Dycapo Protocol:

- Location - represents a geographical position
- Person
- Trip
- Modality
- Preferences
- Participation
- Search

As example, the following is the definition of the Location object:

[5] http://dycapo.org
[6] http://github.com/BodomLx/dycapo
[7] http://www.ietf.org/rfc/rfc2616.txt
[8] http://www.ietf.org/rfc/rfc4627.txt
[9] http://opentrip.info/wiki/OpenTrip_Core
[10] http://ridesharechoices.scripts.mit.edu/home/workshop/
[11] http://www.ietf.org/rfc/rfc4287.txt

3.3 Operations

The parallel development of the server and the complexity of the entities involved in the protocol, lent to the decision to first use XML-RPC [12] to transport Dycapo Protocol objects in a Service-Oriented architecture. Moreover, it was easier for testing the application to both think and develop using services, therefore methods and actions. After reaching a considerable stable state of both the protocol definition and the server prototype, a switch to a complete Resource-Oriented architecture has been made, i.e. the definition of a full [Fielding, R.T. (2000)]REST application-level Protocol.

3.4 Server

[12] http://www.xmlrpc.com/spec

4 Conclusions

A Appendix: Dycapo Protocol

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