Free University of Bolzano
Faculty of Computer Science

Thesis

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

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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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Part I

Introduction

Using a private car is a very convenient way of transportation system. Between year 2004 and 2009, the production of private vehicles has been of 295.216.282 units [1] and As of 2004, there were 199M registered drivers[2]. Road transport is responsible for about 16% of man-made $CO2$ emissions[3]. The availability of fuel is also highly affected by the number of cars used.

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. It also provokes a loss in terms of social capital, as people miss an opportunity to meet and talk.

One solution is carpooling, i.e. the share of a private vehicle between one or more passengers. It reduces the costs involved in car travel by dividing costs such as as fuel, tolls, and car rental. It is also an environmentally friendly and sustainable way to transport people, as reducing the number of cars used, it reduces carbon emissions, traffic on the roads, and the need for parking spaces. Last but not least, it lets people meet and talk, rising social connections and social capital.

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."[4].

There are many issues related to the implementation and the adoption of dynamic carpooling systems, discussed in the first section of this dissertation. Among them, our interest is to solve those related to technological aspects and our contribution will be presented afterwards, which is an attempt to provide the world a solid, open and collaborative base framework to start with when implementing such systems.

[1] (Accessed Sept. 9 2010) http://oica.net/
[2] http://www.fhwa.dot.gov/
[3] (Accessed Sept. 9 2010) http://oica.net/
[4] Kirshner, D. (Accessed Sept 5th 2010) - http://dynamicridesharing.org

Part II
State of the art

This section contains a summary of the state of the art regarding dynamic ridesharing. It is divided in three parts. In the first part there is a summary of the published papers - in order of publication - and their contribution in deriving and solving problems about. Then we introduce a brief analysis of the deployed systems. In the last part we present the outcomes of the analysis of the whole state of the art and how we decided to move in order to provide a significant contribute in solving the problem of adopting dynamic ridesharing services.

1 Published Papers

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.[5]

1.1 Sociotechnical support for Ride Sharing

[Resnick, P. (2003)]

This paper lists barriers and changes to be done to reduce them. It reports about High Occupancy Vehicles (HOV) lane on streets of San Francisco and Oakland and complaints that there should be no fees on bridges for HOVs. The author suggests conventions between drivers and passengers (e.g. pickup points near public transportation stops). Regarding security, the work suggests to give priority to female passengers, to not leave them alone waiting for a ride. The paper reports that there are no stories about rape, kidnapping or murder and the most common problem is bad driving.

There are suggestions on research needed:

- Need of location awareness devices, because instant ridesharing is limited to fixed pickups and dropoff locations.
- Simple user 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.

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

The paper talks about social capital impacts: there is the potential for creating new social connections and also matching drivers and passengers 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.

1.2 Pilot Tests of Dynamic Ridesharing

[Kirshner, D. (2006)]

The author presents three pilot tests done in the USA, all of them failed. The 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.

The paper adds the idea of saving money when parking. It also enforces the idea of using social networks to allow car pooling on the fly. The author imagines about using a web – and mobile service, also writing some interesting user stories.

1.3 The smart Jitney: Rapid, Realistic Transport

[Murphy, P. (2007)]

The work focuses on environmental benefits of dynamic carpooling. It asserts that dynamic car sharing would lower GHG emissions in a better way than electric/hydrogen/hybrid cars would do. It introduces the idea of Smart Jitney: an unlicensed car driving on a defined route according to a schedule.

The author suggests the installation of Auto Event Recorders on cars, enforcing security. It complaints that challenges are all focused in convincing the population to use the service, proposing a cooperative public development of the system.

1.4 Auction negotiation for mobile Rideshare service

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

The paper proposes the use of Agents and complex algorithms for person matching and auction mechanisms.

1.5 Casual Carpooling enhanced

[Kelley, L.K. (2007)]

The author thinks about areas without HOV lanes. He proposes the use of Radio Frequency IDentification chips to quickly identify passengers and drivers. Readers should be installed at common pick-up points. The paper complaints that it would cost less to pay passengers and drivers for using the service than to build a HOV lane.

1.6 Empty seats travelling

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

This paper suggests to use the phone as a mean of transport, creating a value in terms of a transport opportunity and communication. It 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.

The paper notices that people are not widely encouraged to practice carpooling by local governments. It collects obstacles and success factors in terms of human sentences, and their solution. The author says that the challenge is in the definition of a path leading from existing ride share services to a fully automated systems.

1.7 Interactive systems for real time dynamic multi hop carpooling

[Gruebele (2008)]

The author proposes a dynamic multi-hop system, by dividing a passenger route into smaller segments being part of other trips. He complaints that 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. The paper asks governments to integrate carpooling in laws and to push for its use. The author complaints that the 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.

The paper also 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. It suggests to link the application with some social networks like Facebook, MySpace and use profile information to match drivers and passengers.

As security improvement, the paper suggests: the use of finger-prints, RFID, voice signature, display the location of vehicles on a map, using user pictures, assigning random numbers to be used as passwords.

1.8 Instant Social Ride Sharing

[Gidófalvi, G. et al. (2008)]

The paper 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. It Gives some algorithms and SQL queries. The author assumes that there is already a large scale of users, and no barriers are taken into account.

1.9 Combining Ridesharing & Social Networks

[Wessels, R. (2009)]

The author 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. The paper proposes Opensocial[6] as connection interface. An own rating system is also complained.

It suggests the use of mobile systems, that should make use of GPS and creation of a match on the fly (real-time algorithms). The work 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. It also provides a high-level description of the system and implementation details.

The author asks for extra research on psychological factors that increase trust and perceived safety.

1.10 SafeRide: Reducing Single Occupancy Vehicles

[Morris, J. (2009)]

The publication is about a project in the U.S.A. It 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. The author complaints that someone must discover a winning formula before anyone will invest.

[6] Google, MySpace et al. (Accessed Sept. 5^{th} 2010) - http://www.opensocial.org/

The paper lists some interesting user stories, as well as algorithms and requirements.

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 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 well-known. All the reported websites were accessed on Sept. 5^{th}2010. Each text eclosed in double quotes is copied from the website of the application.

For more information and a complete list, please see the Dycapo website[7]

2.1 Carriva

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

It is a proprietary solution using phone calls as communication system and a fixed price of 0,10€ / km. Currently it has got 1118 active users.

2.2 Avego

http://www.avego.com

It is a proprietary application for Apple iPhone. It uses GPS technologies and presents a simple, intuitive useri interface. It handles costs automatically. The passengers are not required to have an iPhone. It will offer information about public transports. The application relies on a proprietary service called Futurefleet, on which no implementation details are given. On October, 10^{th} 2009 the service offered 5310 empty seats.

2.3 Carticipate

http://www.carticipate.com

Carticipate is a proprietary iPhone application that integrates with Facebook, defined as “a location based mobile social network for ride sharing, ride combin-

[7] Graziotin, D. - http://dycapo.org/Research/Systems_Analyzed

ing, and car pooling". It has a very simple interface looking like Google Maps mobile. According to the website, it is available on 59 countries.

2.4 Piggyback

http://www.piggybackmobile.com/

It is an Android application using a step-by-step approach (maximum one user input at each application screen) and makes wide use of graphical representations instead of text. It offers the possibility to bookmark addresses. The map screen is proprietary. When a driver and passengers are matched their compatibility is showed, represented with stars (0 to 5) and categorized as friendliness, reliability, driving skills and car. The 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 carpooling approach.

2.5 Aktalita

http://www.aktalita.com/

It is 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"

2.6 RideGrid

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

Ridegrid is 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.

2.7 Project Carpool

https://launchpad.net/carpool

Carpool was the only open-source project, using PHP and Javascript. The development was stuck at the research time. The project is now closed.

2.8 GoLoco

http://goloco.org/

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

2.9 Ecolane DRT

http://www.ecolane.com/

Ir is a proprietary solution, web-based, focused on security. It provides a customized Nokia touchscreen device. Among the features, they declare that the device is capable of real-time data communication, reports of arrivals and departures with time information, device locking mechanisms, GPS location and direction, mileage tracking, detailed trip information.

2.10 Divide The Ride

http://www.dividetheride.com/

The project is 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.

2.11 iCarpool

http://www.icarpool.com

This application is a static, web-based system that does not require payments. They declare to use advanced 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 includes social relationships, but no details are given.

2.12 Hover

http://www.hoverport.org/

It is a casual carpooling system using RFID technologies and an own credit system. The members are approved after human verfication tests. Participants 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.

2.13 Flinc

http://www.flinc.mobi/

Flinc is 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.”. The system is currently under active development.

3 Outcomes

The analysis of the state of the art brought some issues related to adopting Dynamic Carpooling systems, many of them recognized by [Zimmerman, H. and Stempfel, Y. (2009)]. We categorized the issues gathered from the state of the art and their proposals in the following categories:

- Interface Design - all issues related to graphical implementation of clients and ease of use
- Algorithms - the instructions regarding driver/passengers matching problems
- Coordination - the aspects related on how to let people meet, authenticate and coordinate.
- Trustiness - the problems related on raising user confidence to dynamic carpooling systems
- Safety - the issues regarding ensuring protection of users
- Social Aspects - all the issues related to create social connections and raising social capital in dynamic carpooling systems
- Reaching Critical Mass - the problems on reaching a sufficient amount of persons using the system that would attract more other people
- Incentives - all the political issues related to dynamic ridesharing systems
- System Suggestions - everything else that we consider relevant for building dynamic carpooling systems

Paper	Interface Design	Algorithms	Coordination
[Resnick, P. (2003)]	Give start and ending points and clear indications. Select what information to reveal		
[Kirshner, D. (2006)]	Lots of flexible settings		Entries made hours before the ride, more static than dynamic
[Murphy, P. (2007)]	Levels of services: - simple: just destination and pickup - groups preferences (only women etc.) - scheduling of rides		
[Abdel-Naby, S. et al. (2007)]			
[Kelley, L.K. (2007)]			One-time registation process RFID devices for drivers and riders
[Hartwig, S. and Buchmann, M. (2007)]			
[Gruebele (2008)]	Some suggestions about easy of use		Built around PQOS (ie: driving away from destination but to a location that increases PQOS, like a subway station)
[Gidófalvi, G. et al. (2008)]		Given, built around social connections. Social network needed.	Built around social connection between users
[Wessels, R. (2009)]	Simple registration system. In a second phase there is the link of social networks profiles, or manual fill Asks for a very simple UI		
[Morris, J. (2009)]		Both data structures and Algorithms for matching are given	
[Zimmerman, H. and Stempfel, Y. (2009)]	Must be similar simple and intuitive like Twitter. Parameters like “where are you going” are proposed to be as last time but modified easily. Car position is essential: drivers should get a message and just confirm or refuse a ride		Just suggestions about the legal pick up points

Table 2: Paper Grid Outcomes: Interface Design, Algorithms, Coordination, Trustiness

Paper	Trustiness	Safety	Social Aspects
[Resnick, P. (2003)]		Basic ideas authentication before the match: password / PIN monitor arrival at destination feedback system a la Ebay	Illusion of private space is ok, but is also ok to break it. DCP has potential for creating new social connections Announcing matching items in profiles before the ride is a good idea Asks for research in social capital aspects
[Kirshner, D. (2006)]		PIN created at registration on web page	Idea of using social networks to allow car pooling on the fly
[Murphy, P. (2007)]	Branding the idea: apply stickers on every car that participates. Limitation of drivers: age limits, extra driving tests, check on criminal records etc.	Auto Event Recorders on cars Emergency button on mobile phone, GPS Feedback system a la Ebay	
[Abdel-Naby, S. et al. (2007)]			
[Kelley, L.K. (2007)]	RFID, as carpooling activity is recorded by the system	Everything built around RFID	
[Hartwig, S. and Buchmann, M. (2007)]	Communities and governments should be involved in planning and implementation phases	Registered users only; Feedback system	Possibility to create social connections
[Gruebele (2008)]		Proposes RFID, GPS Rating system based on more than one PQOS metrics. View vehicle and driver information before entering a vehicle. Displaying participants pictures. Assignment of random numbers for passenger pickups to confirm the ride Advanced voice and video proposals.	Multi-hop system is better than single hop: in single trip with 3 hops a passenger might meet 3 to 10 persons Passengers may be socially matched Suggests to link the application to social networks and use profile information to match
[Gidófalvi, G. et al. (2008)]	The use of social networks should improve it		
[Wessels, R. (2009)]	People are ready to spend 17% more time to pickup a friend of the social network rather than a stranger	Rating system GPS Asks for extra research	
[Morris, J. (2009)]	Suggests the social	GPS Help button	

Paper	Critical Mass	Incentives	Suggestions
[Resnick, P. (2003)]			Location awareness system Use of mobile phones
[Kirshner, D. (2006)]	Mass marketing Start-up incentives	An institutional sponsor is needed. Parking spaces provided to participants	Web and mobile Ride requests submitted hours before actually needing them. A many-to-one system: all at a single destination
[Murphy, P. (2007)]		Cooperative public development of the system	Web and mobile (phone call)
[Abdel-Naby, S. et al. (2007)]			
[Kelley, L.K. (2007)]		Employers should incentive employers Regional Transportation Boards	
[Hartwig, S. and Buchmann, M. (2007)]	Incremental service, starting from a thread of backwards compatible services (bus, taxi) Service should not introduce new devices for its use	Find a way to make the service a business case Public incentives	Mobile only GPS non-obtrusive system for authentication QOS measure needed
[Gruebele (2008)]	Multi-hop system brings higher PQOS. Set of potential riders and drivers increases	Governments should be convinced and change laws to enforce carpooling	Dynamic, multi-hop, real- time mobile system Minimize waiting times, one hop at a time
[Gidófalvi, G. et al. (2008)]			Use of mobile phones and sms. Use of GPS. High-level description
[Wessels, R. (2009)]	Users should be involved in some parts of development process Asks for extra research		Mobile + web system that interacts with social networks profiles Use of Opensocial + other social network APIs High level description of the whole system
[Morris, J. (2009)]	Market-formation problem: someone must discover a new, winning formula Start with an existing service, like taxis Find large employers Serve events (ie. concerts)	Money? Incentives from governments	Very high-level Lots of Use Cases Detailed functional requirements Detailed non-functional requirements
[Zimmerman, H. and Stempfel, Y. (2009)]	Main problem is to convince the user to use the system for the first time: marketing money is probably	Provide a free taxi of public transport ride in case of no return possibility (only for the first months)	Mobile, GPS Multi-hop system

We decided to focus on technical aspects. Among them, we observed that the source code of the projects and the prototypes produced was not freely accessible by the general public. There are no information regarding the servers, that are all proprietary and obscured. Another issue seems related to a missing standardization of the protocols used. Therefore, every project started from zero, "reinventing the wheel".

Thus, the following decision was made: the introduction of:

- An open, discussable protocol for communication between dynamic (and static) carpooling systems
- An open-source server prototype implementing the protocol

Would act as a solid base for the creation of concrete projects. The openness of the research outcomes, the source-code and the protocol would more likely attract both the general and the specialized public to collaborate to the project. Therefore, the Dycapo project was born.

Part III
Dycapo

In this section first present the project born to contain the research and the implementation outcomes. Then there will be an overview of our contributions to dynamic carpooling research, that are are protocol and a server prototype.

Dycapo is the name given to a project aiming to share knowledge and outcomes on dynamic carpooling. The information are created using a fully open and collaborative system. The website[8] is the start point and the container of each project component. It is a Wiki[9], freely accessible and discussable. The Wiki content and the source code are available under permissive and open licenses. We used a blog and social networks to update in real-time about the status of the researches and the development. The website was opened on Oct. 11 2009. As of Sept. 11 2010 we had 1617 visits and many e-mail contacts, about proposals of collaboration and general interest.

The following are the components of Dycapo:

- Research - all the theoretical knowledge summarized in Section 2
- Protocol - the last draft of the protocol aiming to become a world standard
- Server - the prototype implementing dynamic carpooling functionalities and the protocol
- Client - will act as a start point for the clients implementing the protocol

Our contributions are related to the first three issues: the research, the protocol and the server. A client is under development by a university colleague and will be object of another Bachelor thesis.

For better introducing the protocol and the server prototype, we now present come user stories on system functionalities. After we illustrate a high level description of the architecture of Dycapo system.

3.1 User Stories

A simple trip Paul is in Via Roma, Bolzano, Italy. He wants to move to the cemetary. He takes out his smart-phone with GPS activated, opens his Dycapo client and gives the desired destination, therefore searching a trip. Angela is travelling with her car along Corso Libertà, Bolzano. Her destination is Laives, Italy, southern to the cimitery. She receives a notification from her Dycapo client running on her smartphone, located in a car docking station. The notification contains Paul's position and she accepts his participation request. The client displays the directions for reaching Paul, using the GPS-chip . Paul and Angela meet and share the trip, dividing the costs.

[8] http://dycapo.org
[9] MediaWiki - http://www.mediawiki.org/wiki/MediaWiki

A planned concert Anna lives in Trento, Italy. In two days she will attend a concert in Milano, Italy. She takes out her smart-phone running a Dycapo client and inputs her travel intentions. Two days after she starts her trip. Just after her start, she discovers that Mary is in Rovereto, Italy and would like to have a ride to Verona, Italy. The clients make them meet and share part of Anna trip. While driving Mary to Verona, Anna receives another ride request from John, who is in Cremona, Italy and wants to travel to Milano, too. Anna realizes that the deviation from her planned route is too much and simply refuses the request. Anna arrives to Milano and enjoys the concert.

3.2 Architecture

Dycapo system follows the client-server model, in which a server receives messages from clients (mobile phones) using a protocol, processes them and returns them using the protocol again.

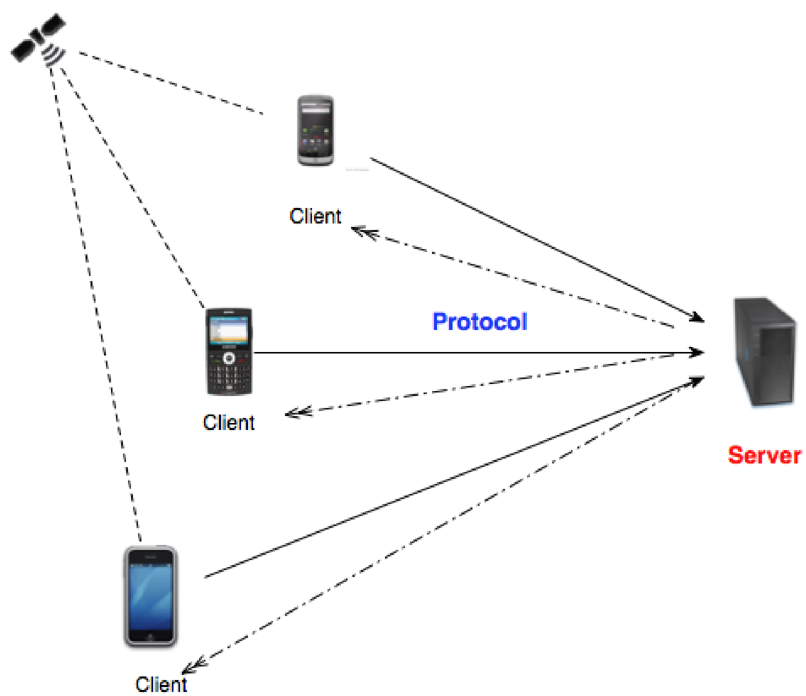

Figure 1: High level view of Dycapo components architecture

4 Protocol

Dycapo Protocol (also known as DycapoP) is an open application-level protocol for enabling communication between dynamic (and static) carpooling servers and clients, using HTTP for operations and JSON (JavaScript Object Notation) as data exchange format. The protocol models are inspired by OpenTrip Core[10], a former proposal of data exchange format for Carpooling and Dynamic Carpooling presented during the MIT "Real-Time" Rideshare Research workshop[11]. DycapoP is released under Creative Commons Attribution-ShareAlike 3.0 Unported license[12]

4.1 Entities

The entities defined by OpenTrip core (using Atom Syndication[13] format) have been extracted and represented using UML 2.1 Class diagrams. While proceeding and discussing the development of the server, those entities were extended and adapted. The entities are represented in the Protocol using descriptive tables and real world code snippets. The Dycapo Protocol draft version of September 12, 2010is included in the Appendix A.

The following are the Models of Dycapo Protocol:

Location A Location represents:

- A geographical position, using human understandable attributes (like street, town, postcode, region, subregion and country) or geolocation values such as georss_point[14]
- An interesting point from a Person's perspective, by setting attribute label to values like 'home', 'work' etc.
- A hop point in a Trip, by setting point and leaves values

[10] http://opentrip.info/wiki/OpenTrip_Core
[11] http://ridesharechoices.scripts.mit.edu/home/workshop/
[12] http://creativecommons.org/licenses/by-sa/3.0/legalcode
[13] http://www.ietf.org/rfc/rfc4287.txt
[14] http://www.georss.org/simple#Point

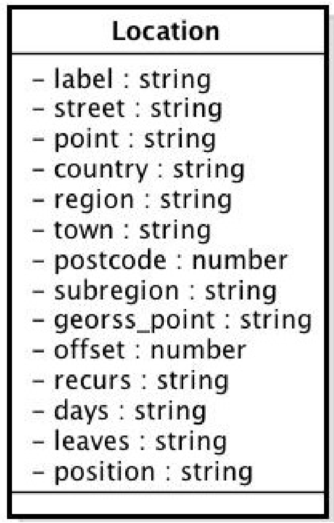

Figure 2: Location Model

Person A Person represents a user of the system and contains useful information for building social connections or search preferences.

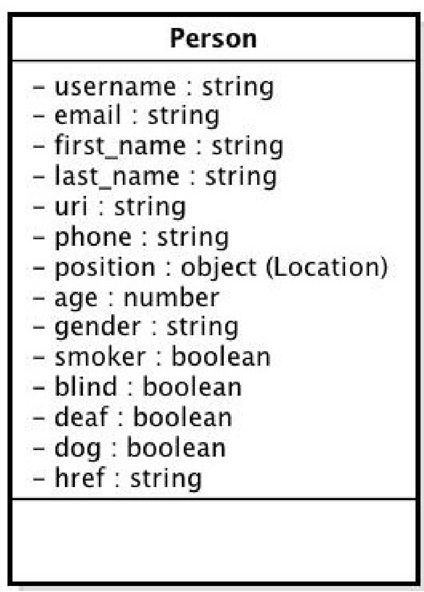

Figure 3: Person Model

Trip A Trip represents a single course of travel taken as part of one's duty, work, etc, offered by a Person. It is the most complex object of the Dycapo Protocol. It contains all the information needed for doing operations with Trips.

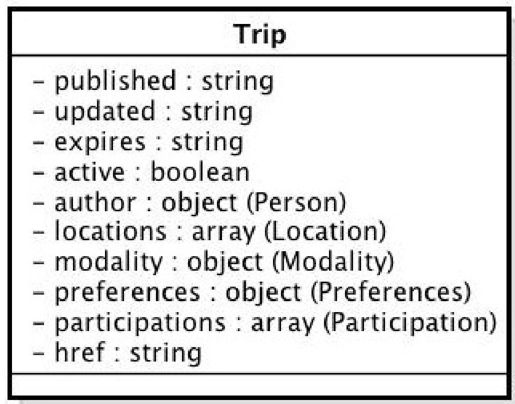

Figure 4: Trip Model

Modality A Modality object is

- A description of the mode of transportation being used by the Person offering a Trip.
- A description of the cost of the Trip

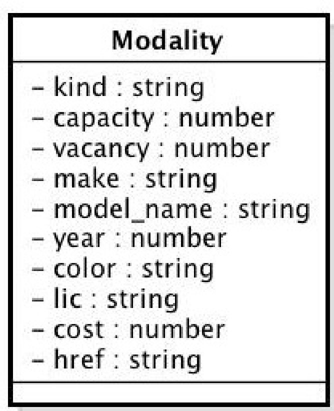

Figure 5: Modality Model

Preferences A Preferences object represents the preferences of Driver when performing a Trip, such as the age range of the Persons he will accept as passengers, whether they can smoke during the Trip, etc.

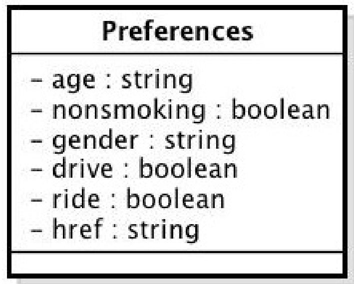

Figure 6: Preferences Model

Participation A Participation object represents the fact of taking part in a Trip. The attribute status represents the status of a Participation, being it a request, a refuse, a start etc.

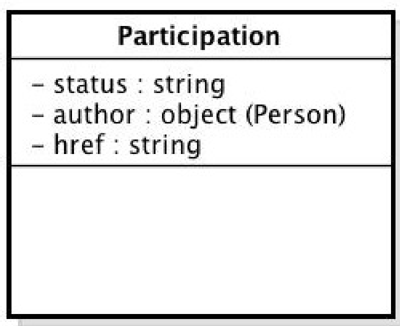

Figure 7: Participation Model

The following picture represents the possible states of a Participation, using a UML State Diagram. For each transition, we report the value of attribute status and the HTTP operation performed by the operation. We also report those transitions that only the author of the Trip (i.e. the driver) can cause.

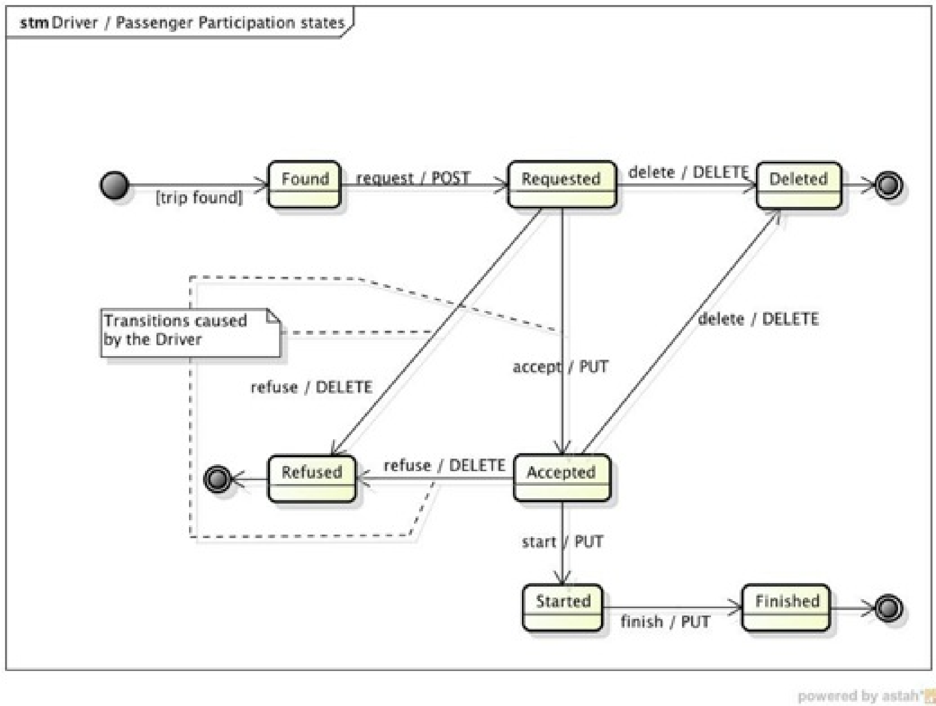

Figure 8: Participation Status

Search helper object to construct the complex queries related to the search of a Trip

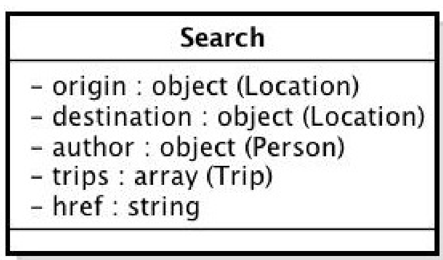

Figure 9: Search Model

4.2 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 [15] to trans-

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

port 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 REST [Fielding, R.T. (2000)] application-level protocol.

All the operations are performed using HTTP methods GET, POST, PUT, DELETE [Fielding, R.T. et al. (1999)]. They are available in Appendix A. This dissertation focuses on the implementation of the functionalities in the Server section.

The UML sequence diagram in Figure 10 summarizes a full user story - the creation of a Trip, the participation of a passenger and its end.

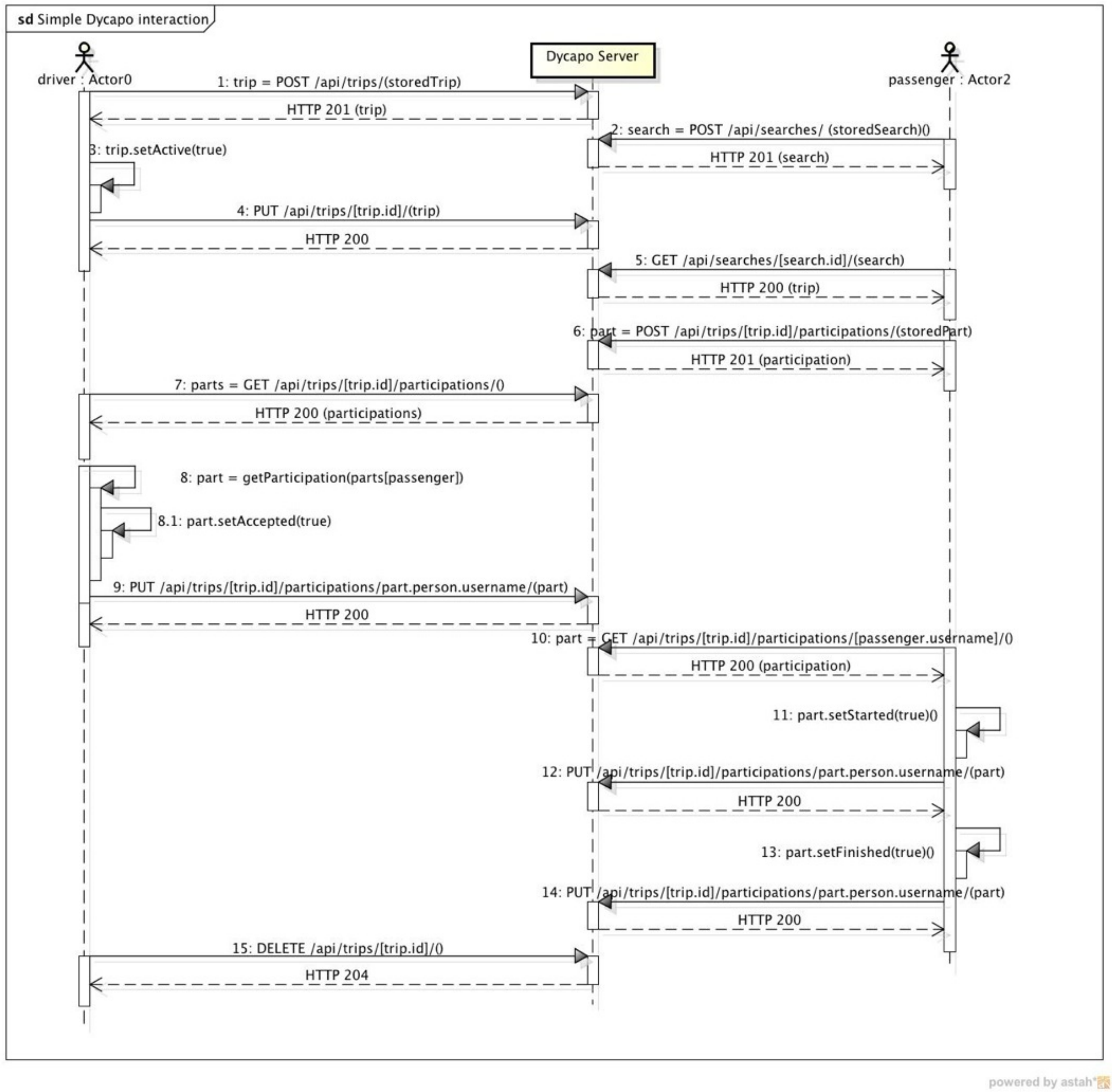

Figure 10: Interaction of two clients and Dycapo Server using Dycapo Protocol

5 Server

Dycapo Server is a software built using first throwaway then evolutionary prototyping - as defined by [Davis, A.M. (1992)] to demonstrate and support the definition of a standard protocol for dynamic carpooling.

The source-code is available in an open GIT repository [16], under the Apache License, version 2.0[17].

5.1 General Architecture View

[16]http://github.com/BodomLx/dycapo

[17]http://www.apache.org/licenses/LICENSE-2.0.html

Part IV

Conclusions

A Appendix: Dycapo Protocol

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