Demand-Responsive Collective Transportation including Door-to-Door Services for Mobility Impaired People

Glenn Cich
Hasselt University - IMOB

July 13 2015
Overview

1. Introduction
2. Research
3. Concepts
4. Software
5. Design Ideas
6. Next Steps
1 Work in Progress
2 Main ideas and concepts
3 No implementation yet
4 In the context of SmartPT

Research partially funded by the IWT 135026 Smart-PT : Smart Adaptive Public Transport (ERA-NET Transport III Flagship Call 2013 “Future Travelling”)
Overview

1 Introduction

2 Research
   - General
   - Example

3 Concepts

4 Software

5 Design Ideas

6 Next Steps
General:

1. Modelling *thin flows*
   - Low density regions
   - Elderly and mobility impaired people
2. Modelling feeder services
   - Low density $\rightarrow$ high density
3. Research Questions
   - Are these companies viable?
   - Do these companies need subsidizing?
   - What is the influence on the different prices?
Example: Thin Flows
Example: Thin Flows
Example: Thin Flows
Example: Thin Flows
Example: Bringing/Getting Customers

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INSTITUUT VOOR MOBILITEIT
Example: Bringing/Getting Customers

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Example: Bringing/Getting Customers

User 1
Origin: link 1-2
Destination: 14-19
Departure: 09:00
Arrival: 09:15

User 2
Origin: link 12-13
Destination: 16-21
Departure: 09:25
Arrival: 09:45

User 3
Origin: link 11-12
Destination: 23-24
Departure: 09:30
Arrival: 09:50

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Example: Bringing/Getting Customers

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Example: Bringing/Getting Customers
**Example:** Bringing/Getting Customers

![Diagram of a network with various nodes and paths, each representing a user's origin, destination, departure, and arrival times.]

- **User 1:**
  - Origin: link 1-2
  - Destination: 14-19
  - Departure: 09:00
  - Arrival: 09:15

- **User 2:**
  - Origin: link 12-13
  - Destination: 16-21
  - Departure: 09:25
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INSTITUUT VOOR MOBILITEIT
Example: Bringing/Getting Customers
Overview

1. Introduction

2. Research

3. Concepts
   - Entities
   - Company
   - Customer

4. Software

5. Design Ideas

Next Steps
**Entities: Overview**

1. **Company**
2. **Customer**
3. **Interactions, e.g.**:
   - Customer books a trip at a company
   - A Company commits a trip to a customer
   - A Company books a trip at another company
   - ....
Company: Overview

Company

Transport Provider
TripsSequenceComposer

Business Manager

Sub-Companies

Labels

Connection Graph
Solver (VRP)
Company: Responsibilities

1. Represents a real-life business
2. Always provides some kind of transportation
   - Providing own transportation
   - Acting like a broker (make use of other companies to provide trips)
3. Tries to survive
   - With subsidizing
   - Without subsidizing
Company: Transport Provider

1. Entity in the company → providing transport
   - Routing of vehicles
   - Optimizing schedules
   - ...

2. Knows the area that can be served

3. TripSequenceComposer
   - Connection graph
     - Representing the sub contractors of a company
     - e.g. \( A \rightarrow B \): Company \( A \) can ask company \( B \) for help
     - Comes in handy when request of customer falls out of the served region

Solver
- VRP with labels, capacity and time windows
Company: Business Manager

1. Entity in the company → financial situation
   - Cost of a trip
   - Subsidizing
   - Profits
   - ...
**Company: Sub-Companies**

1. For practical reasons (every company/sub-company can be handled in the same way)

2. Easier to calculate the totals of a company

3. e.g. $I_{DeLijn} = I_{Limburg} + I_{Antwerpen} + I_{VlaamsBrabant} + I_{OostVlaanderen} + I_{WestVlaanderen}$
Company: Labels

1. Terms of services
   - Income category of customer
   - Able/willing to take mobility impaired people
   - ...
**Customer: Overview**

1. Represents a real-life Person
2. Labels
   - Wheelchair
   - Blindness
   - ...
3. Plans
   - What will I do today/tomorrow?
4. Memory
   - About travel times
   - About experience with different companies
   - ...

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Overview

1. Introduction
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4. Software
   - Tools
5. Design Ideas
6. Next Steps
Tools:

1. Programming language JAVA
2. MATSim
   - Multi-Agent Transport Simulation
   - TUBerlin
   - Used for the simulation of the agents in the network
3. JANUS
   - UTBM
   - Used for the communication/negotiation between customer(s)/company(ies)
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<td><strong>Introduction</strong></td>
<td><strong>Research</strong></td>
<td><strong>Concepts</strong></td>
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Connection Graph: Example

currentCompany = \{ Company 1, Company 4, Company 5 \}
Company 1 = \{ Company 2, Company 3 \}
Company 2 = \{ \}
Company 3 = \{ \}
Company 4 = \{ Company 1 \}
Company 5 = \{ \}
**Connection Graph: Example**

\[
\text{currentCompany} = \{ \text{Company 1, Company 4, Company 5} \}
\]

\[
\text{Company 1} = \{ \text{Company 2, Company 3} \}
\]

\[
\text{Company 2} = \{ \}
\]

\[
\text{Company 3} = \{ \}
\]

\[
\text{Company 4} = \{ \text{Company 1} \}
\]

\[
\text{Company 5} = \{ \}
\]
Transport Request: Overview

1. Conceptual view of a Request

2. \( \langle \text{orig}, \text{dest}, t^P_{\text{orig}}, w_{\text{orig}}, t^P_{\text{dest}}, w_{\text{dest}}, mSet, lSet, \text{scoreFunc} \rangle \)

- \( \text{orig} \) identifies the origin
- \( \text{dest} \) identifies the destination
- \( t^P_{\text{orig}} \in w_{\text{orig}} \) is the preferred departure time
- \( w_{\text{orig}} \) identifies the departure time window
- \( t^P_{\text{dest}} \in w_{\text{dest}} \) is the preferred arrival time
- \( w_{\text{dest}} \) identifies the arrival time window
- \( mSet \) is the set of transportation modes that can be used
- \( lSet \) is the set of labels identifying special requirements (e.g. facilities of support) in order to enable travel
- \( \text{scoreFunc} \) is a function to quantify the quality of proposed solutions in order to allow the responder to return the most appropriate (according to the requester’s requirements) solutions
Transport Request: Example

Customer Company
From A: <Hasselt, Genk, 14:32, [14:15-14:33], 15:01, [14:58:15:05], <Bus>, <Blind>, f(x)>
From B: <Alken, Gent, 17:07, [17:01-17:17], 19:53, [19:50-20:15], <Bus, Train>, <>, f(x)>
From C: <Bilzen, Antwerp, 13:59, [13:40-14:00], 15:01, [14:45-15:05], <Bus, Train>, <Wheelchair>, f(x)>

To D: Possible
10:02 am
To D: Possible
10:03 am
From D: Commit this trip
10:53 am
Fixed: Customer D
10:55 am

To A: Possible
11:02 am
From A: Cancel this trip
11:02 am
Served: Customer D
11:13 am
Fixed: Customer B
11:13 am

To B: Possible
11:13 am
From B: Commit this trip
11:13 am

To C: Possible
11:20 am
From C: Commit this trip
11:20 am

To E: Not Possible
11:55 am

Fixed: Customer B

Customer C
Served: Customer D
11:55 am

Fixed: Customer D
Score Function: Conceptual View
## Overview

1. **Introduction**
2. **Research**
3. **Concepts**
4. **Software**
5. **Design Ideas**
6. **Next Steps**
1. Finish this software specification
2. Start the implementation
## Questions?

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