In-Vehicle Application for Multimodal Route Planning and Analysis

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Problem – Application level

- How to encourage drivers to use public transportation?
- How to plan multimodal routes?
  - Multimodal = car + public transportation
- How to bring the relevant data to drivers easily?
Problem – Technical Level

• How to integrate cloud services with vehicles?

Powered by

Google
Maps

GENIVI

Android
Cars are becoming open development platforms

- “Car maker Ford has just released OpenXC an open-source hardware and software toolkit that will let the hacker community play around with the computer systems that run modern cars.”
- And many other steps to the same direction

**brake_pedal_status**
Boolean (True == pedal pressed)
**Ford frequency:** Sent only if value changes

**engine_speed**
0 to 16382 RPM
**Ford frequency:** 4Hz (max 60Hz)

...
Demo Video

- Application gets the target from phone calendar
- The systems searches for park-and-ride options
- Display on car console shows
  - Routes combining driving and public transport
  - Estimated CO2 emissions, driving times, and costs
  - Regular navigation instructions through chosen route
- The system dynamically looks for better options
  - because initial estimates for riding time and public transport schedules may change
- After parking travel continues with smart phone guidance

https://www.youtube.com/watch?v=1ezf-fEwxhA
Two Schools of Thought

Intelligence in car
• Different lifetimes
  – Car 15 years, mobile ICT 3 years
• What kind of mobile subscription for your car?
• Works also for empty cars

Intelligence in driver’s phone
• Familiar platform for mobile developers & ecosystem & users
• Bluetooth communication with
  – OBD2 (for car data)
  – Displays and control
Phone Centric Architecture

- Google API
- Public transport route planner API

Traffic information
- Static maps
- Public transport info

Suggested transfers

Mobile application

SmartDeviceLink

Vehicle data (consumption, odometer, GPS, etc.)

Vehicle infotainment system
Searching for Multimodal Routes

• Searching limited to park-and-ride parking lots
  – In our case 43 lots
• Google Directions API to estimate the driving times
• Reittiopas API for Helsinki region public transport information
• Fixed time (5 min) to park and move to bus stop
  – Clearly a point for improvement
• Estimated values criteria: time, distance, cost, CO2
• Driving to destination directly used as a baseline
• Routes ranked according to a weighted sum of the delta in each criteria
  – E.g. 0.9 * delta_time + 0.1 delta_CO2
  – Personal preferences
• Driver browses the routes and chooses his favorite
Dynamic Route Search

• Initial estimates of driving times and public transport schedules can be inaccurate
  – E.g. effect of traffic jams

• The system periodically looks for better routes
  – Every 1 km or every 60 s

• When better routes are found driver is alerted

• This requires a lot of communication
  – We heuristically limited the search to only 5 closest transfer points (too trivial?)
Alternative Approach: Mobile centric -> Cloud centric

- A new cloud service for route search
  - Cloud has much more power to search for better routes
  - And alert the phone only when a new one is found
- Mobile communication reduced but not eliminated
  - Requires updating mobile location to cloud service
- Would users feel being monitored more?
Environment for Experiments

- Google API
- Reittiopas API
- Mobile App
- Vehicle data
- Button events
- HMI commands
- Test result interface
- SmartDeviceLink Emulator
- Vehicle data simulator

Jukka K. Nurminen
# Impact on journey when optimizing for different factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Time %</th>
<th>Cost %</th>
<th>Emissions %</th>
<th>Distance %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions</td>
<td>301.70</td>
<td>31.70</td>
<td>46.74</td>
<td>152.64</td>
</tr>
<tr>
<td>Time</td>
<td>204.05</td>
<td>40.82</td>
<td>60.56</td>
<td>118.30</td>
</tr>
</tbody>
</table>

Minimizing low emissions
- Decreases emissions by more than half
- Increases trip time almost 3 times

Minimizing trip time
- Still 2x longer with part&ride
  - can be too pessimistic as parking time in destination not counted
- Emissions down by 40%

Cost is directly related to fuel consumption.
In both cases the driver pays less than half price to reach a destination.
Static and dynamic routing comparison

<table>
<thead>
<tr>
<th>Trip length (km)</th>
<th>Optimising for time</th>
<th>Optimising for emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>10 - 25</td>
<td>0.7</td>
<td>1</td>
</tr>
<tr>
<td>25 - 35</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>&gt; 35</td>
<td>0.4</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Ratio = number of (S == D) / total number of trips
S – transfer point chosen by the static routing strategy
D – best transfer point chosen by the dynamic routing strategy

- Strongly dependent on the optimization criteria
  - Depending on optimization goal the frequency of dynamic search could be adapted.
- The longer the trip the more visible the uncertainty in initial estimates
Summary

• Seamless integration of vehicle car display and controls, mobile app, and cloud services with REST APIs
• Static and dynamic route search for multimodal travel
  – Adapts to current vehicle
  – Always looking for the best transfer
• One example of mobile cloud computing for smart traffic
Thank You! Questions?