Talking traffic: wireless traffic management
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The Netherlands
Population 16,730,623
GDP per inhabitant € 34,602

South Africa
Capital Pretoria
Area 41.543 km
Population 51,221,096
GDP per inhabitant € 5,160

Infrastructure of the Netherlands

<table>
<thead>
<tr>
<th>Roadway Density</th>
<th>Waterway Density</th>
<th>Railway Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium 1.29</td>
<td>Liechtenstein 0.18</td>
<td>Czech Republic, Switzerland, Germany 0.12</td>
</tr>
<tr>
<td>Netherlands 2.28</td>
<td>Netherlands 0.15</td>
<td>Belgium 0.11</td>
</tr>
<tr>
<td>Japan 1.80</td>
<td>Belgium 0.07</td>
<td>Hungary 0.09</td>
</tr>
<tr>
<td>Hungary 2.12</td>
<td>Bangladesh 0.16</td>
<td>Cuba, Austria 0.08</td>
</tr>
<tr>
<td>Senegal 2.81</td>
<td>Vietnam 0.05</td>
<td>Netherlands, Slovakia, Japan, United Kingdom 0.07</td>
</tr>
</tbody>
</table>

Mainports of the Netherlands

Port of Rotterdam
- 1st in Europe
- 10th worldwide
- Largest non-Asian port
- 3% Dutch GDP

Schiphol airport
- Quality: 1st in Europe
- 4th worldwide
- 4th passenger volume
- 4th freight volume
- 4.7% Dutch GDP (and airlines)

Traffic management in the Netherlands

- Motorway monitoring and signalling
- Ramp metering
- Dedicated lanes
- Operation and maintenance 1B€ py

Shifting from road-side to in-vehicle paradigms

Talking traffic
Can we solve or mitigate congestion using cooperative in-vehicle systems?

Typical in-vehicle systems

- ACC predecessor
- Lane, speed, headway advice
- Route navigation > 2 km

Tactical driving advice

- In-vehicle advice to the driver on speed, headway and lane use
- Comfort, safety but also efficiency
- Fusion of in-car and road side traffic data
- Perspective on large scale implementation:
  - Retrofit
  - Integrating existing technologies

Integrating geographical levels

Traffic flow improvement algorithm
CCC Implementation

Distribution

Advice principles
- Distribution: Redistribute traffic over lanes to prevent breakdown
- Acceleration: Decrease capacity drop at end of congestion
- Splitback: Prevent split back

Test drives
December 2012
1 equipped vehicle
14 subjects, 3-4 test drives per subject
12 km stretch

Lane level traffic state prediction
- Based on Adaptive Smoothing Method (ASM)
- Propagates traffic state according to typical speeds
- Can be used for short-term predictions
- 1 minute prediction to allow drivers time to act
- Used at lane level

Potential results using simulation
40-50% delay reduction at 100% penetration and compliance
Findings

- Tactical driving advice works technically and functionally
- Add-on to existing connected navigation
- Improved localization and timing needed
- Need for coordinated CCC network wide

Typical in-vehicle systems

- ACC predecessor
- Lane, speed, headway advices
- Route navigation >2 km
- Tactical driving advice
- Social navigation

Always the fastest route

Position, speed
GPRS
Travel times
Inductive loop data
Traffic data centre
Tracking of cellular phones

Is the fastest route also the best route?

User equilibrium and system optimum

Consider route choice in a network

User equilibrium: each driver has chosen a route that individually optimises own travel time

System optimum: route chosen such that total travel time in the network is optimised

Total travel time in user equilibrium 30-40% higher than in system optimum

Individual route guidance reinforces user equilibrium orientation

Selfish or social?

\[ T = \tau \left( 1 + \alpha \left( \frac{q}{C} \right) \right) \]

\[ \alpha = 0.2, \beta = 4 \text{ and } C = 1000 \]

Social navigation

\[ \text{Social cost} = \text{Personal cost} + \left( \alpha \times \text{System cost} \right) \]

Altruism factor \( x \): 1 system unit equivalent to \( x \) personal units

\( x = 0.25 \): sacrifice 1 minute personal time to reduce 4 minutes system time
Modelling framework

- Simulation with time step 1s
  - Longitudinal behaviour (Gipps, 1981)
    - $v(t+1) = \min\{v_{up}(t+1), v_{up}(t+1), v_{prev}(t+1), v_{prev}(t+1)\}$
  - Lane change behaviour (Gipps, 1986)
    - speed advantage
    - mandatory,
    - gap searching
    - gap acceptance

'S bay area' network

Effect of Altruism on Travel Time

Market Penetration

40% static, 60% dynamic/social, altruism factor 0.25

Findings

- Social navigation helps to move from UO to SO
- Up to 10% decrease in travel delay
- Effects increase with
  - market penetration
  - Altruism factor
  - Congestion level

Open issues

- Can we stimulate altruistic behaviour? To what extent?
- Empirical evidence

Outlook and challenges for Talking Traffic

- Information and communication will revolutionize transport
- Potential to complement or even replace road side systems
- User optimization may lead to sub optimization

- User is key: acceptance, compliance, altruism, ....
- Technological challenges: context awareness (data fusion, localization), cooperative strategies ....