Why are RED cars better than green ones?
THE twinLIN TEAM

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1. BACKGROUND
ITS: Cooperative Mobility

Thanks: networkonwheels
SOME RECENT DEVELOPMENTS

• VEHICLE AND INFRASTRUCTURE TALK TO EACH OTHER
  Smarter vehicles and infrastructure
  The cloud and real time updates

• NEW VEHICLE TYPES
  Electric vehicles and plug-in hybrid
  Hybrid vehicles and Fuel Cell

• ALGORITHMIC
  Infrastructure (lights, speed-limits)
  Vehicle mixing (routes) and vehicles

• REGULATION
REGULATION

• CONGESTION AND NETWORK EFFICIENCY
  More efficient use of road infrastructure

• ACTIVE SAFETY
  Making transport safer for road users and pedestrians

• GLOBAL WARMING (CARBON DIOXIDE)
  Reducing carbon footprint of global transportation

• POLLUTION
  Reducing pollution related deaths from road transportation
  Road noise
Average cost of congestion in 2007

Source: IBM Institute for business value
Distribution of global injury mortality by cause, 2000

- Road Transportation (25%)
- Crime (35%)
- War (6%)
- Other (34%)

Source: Peden et al., WHO, 2002 (Thx. Mikael Asplund)
REGULATION

Total Greenhouse gas emissions by sector (EU), 2009

- Road Transport (20.3%)
- Energy production (30.7%)
- Manufacturing (11.6%)
- Agriculture (10.4%)
- Waste (3%)
- Other

Source: EU Env. Agency, 2011
### REGULATION

<table>
<thead>
<tr>
<th>1. Carbon monoxide</th>
<th>3400 deaths related to vehicle safety (2008)</th>
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<tbody>
<tr>
<td>2. Nitrate Oxide</td>
<td>9400 deaths related to air pollution (2008)</td>
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<td>3. Benzene</td>
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<td>4. Ozone</td>
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<td>5. PM10 (Feinstaub)</td>
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<td>6. PM25</td>
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California Environmental Protection Agency

![Bar Chart](image)
2. RESPONSE
RESPONSE

• CLEAN VEHICLES
  EU Vehicle regulations

• ACCESS CONTROL
  Germany (Umweltzone)
  UK (congestion charging)

• BAN PETROL/DIESEL VEHICLES
  EU (2050)
  UK (2035)

Reduced carbon emissions
No explicit account for aggregate effect
Prediction of pollution peaks in cities
Sao Paulo: 1000 new cars every day

1998: BASELINE STATISTICS

Average emissions per vehicle

1998

2007
POLLUTION CONTROL

Number of vehicles

Pollution

TIME
3. twinLIN
FEEDBACK LOOPS AROUND ENTIRE CITIES

AGGREGATE EFFECT

BEST EFFORT
BEHAVIOUR AND
ELASTICITY
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- Fuel levels;
- Type of engine;
- Wishes of driver;
- Congestion charging information

POSITIONING TECHNOLOGY

ENGINE MANAGEMENT SYSTEM

CAR TO CAR/CLOUD COMMUNICATIONS

- Position;
- Topological information;
- Speed constraints;
- Environmental zones;
- Time constrained access;
- Road surface information;
- etc.
The twinLIN
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4. RED and green cars
twinLIN VEHICLES: NEW POSSIBILITIES

• WHAT CAN WE DO WITH A FLEET OF CONTEXT AWARE VEHICLES?

• Problem 1: Coordinated pollution control
• Problem 2: Fleet pollution management
• Problem 3: Distributed emissions trading
PROBLEM 1: COORDINATED POLLUTION CONTROL
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**RED** ALGORITHM FROM INTERNET CONGESTION CONTROL
PROBLEM 1: COORDINATED POLLUTION CONTROL

CONVERGENCE: LUR’E PROBLEM

CLASSICAL ENGINEERING PROBLEM
PROBLEM 1: SUMO SIMULATION

PROBLEM 1: SUMO SIMULATION

Number of cars

max

min

Time

350

UNCONTROLLED

RED

Evolution of emissions

CO emissions in grams
PROBLEM 1: COORDINATED POLLUTION CONTROL

Probability 1 for all cars (noise and pollution)
PROBLEM 2: FLEET POLLUTION CONTROL

How dirty am I?

Aggregation and response

Car to Cloud

Network adjusts local property
PROBLEM 2: FLEET POLLUTION CONTROL

• FLEET MANAGERS
  Postal and delivery services
  Car rental companies
  Logistics
  Freight

• MUNICIPAL AUTHORITIES
  Buses
  Garbage collection and services
  Universities

• COMMUNITIES OF ECO-DRIVERS
  Incentive of free parking?
PROBLEM 2: SUMO SIMULATION

Evolution of emissions

CO emission in grams

time steps (minutes)
PROBLEM 3: DISTRIBUTED EMISSIONS TRADING

AN IMPORTANT OPTIMIZATION

Maximize sum of network utility

\[ N(P_1, P_2, \ldots, P_n) = \sum U(P_i) \]

subject to constraint that

\[ \sum P_i \leq C \]

\[ P_j > C_j \quad j \in \Theta \]
PROBLEM 2: DISTRIBUTED EMISSIONS TRADING
PROBLEM 2: DISTRIBUTED EMISSIONS TRADING
5. CONCLUSIONS
COMMENTS

MANY WAYS:
- Routing
- Speed limits
- Traffic light sequencing

NEW VEHICLE TYPES
- Offer new control/optimization possibilities
- No range problems
- Non-invasive
- Elasticity
- Fairness

Battery is a filter for turning dirty energy into clean energy
CONCLUSIONS: KEY IDEAS

VEHICLES AS FILTERS

POLLUTION AS SHARED RESOURCE

AGGREGATE EFFECT

BEST EFFORT BEHAVIOUR AND ELASTICITY
CONCLUSIONS: FUTURE WORK (SUMMER 2012)

Hardware in the loop testing.
EIN DANKESCHÖN AN DAS ANDERE “LIN”

BERLIN Stadt der Ideen

Leibniz
Kronecker
Planck

Schur
Karl Marx
Einstein
Euler

Voltaire
Cantor

MARK TWAIN, 1891

“man kann alles in Berlin lernen, außer Deutsch”, 
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TWINLIN REPORT, 2012
RED CARS ARE BETTER THAN GREEN CARS?

But towers are always best when they are
PROBLEM 2: SUMO SIMULATION

Evolution of emissions

CO emission in grams

time steps (minutes)
PROBLEM 2: SUMO SIMULATION