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Optimizing Traffic Flow Efficiency by Controlling Lane Changes: Collective, Group and User Optima

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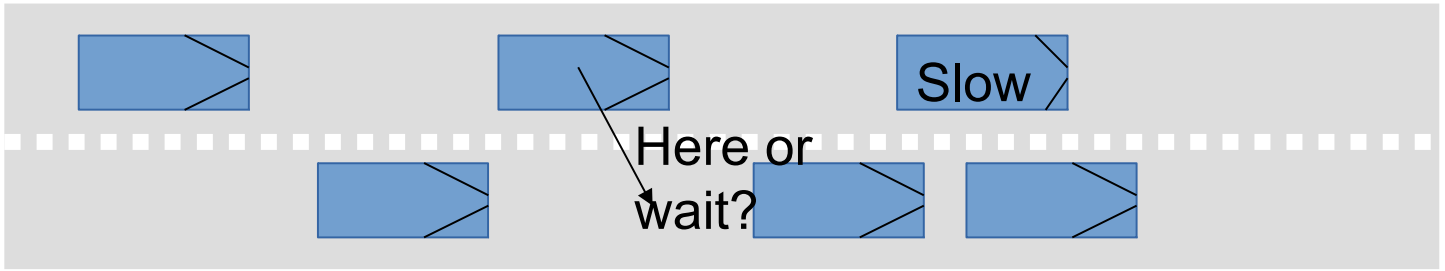
NWO Toegepaste en Technische Wetenschappen
STW Project: Taking the fast lane
Presented at TRB Annual Meeting, January 2017, Washington DC

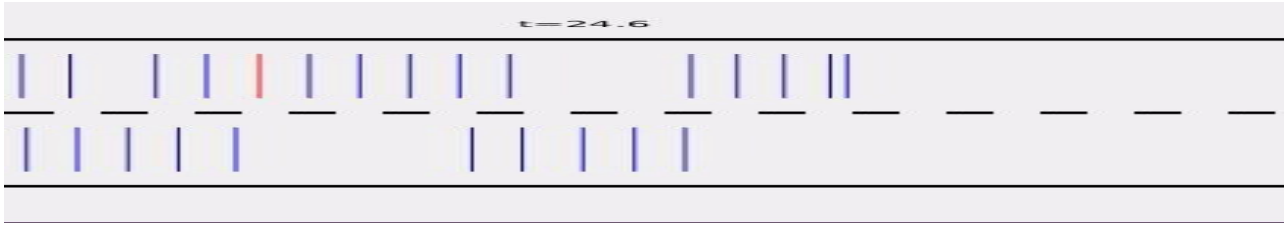
Contribution

- Connected vehicles can be sent instructions on lane change
- Optimize for best lane change instance
- User optimum, collective optimum, or group optimum:
  - Different lane change instanced
  - Different delays (and Braess-like paradoxes)



Problem description

- Two-lane simple network,
  fast lane & slow lane
- Bottleneck in the fast lane
- Controlled vehicles (5)
  change lanes to avoid congestion
- **Lane change instances optimized**



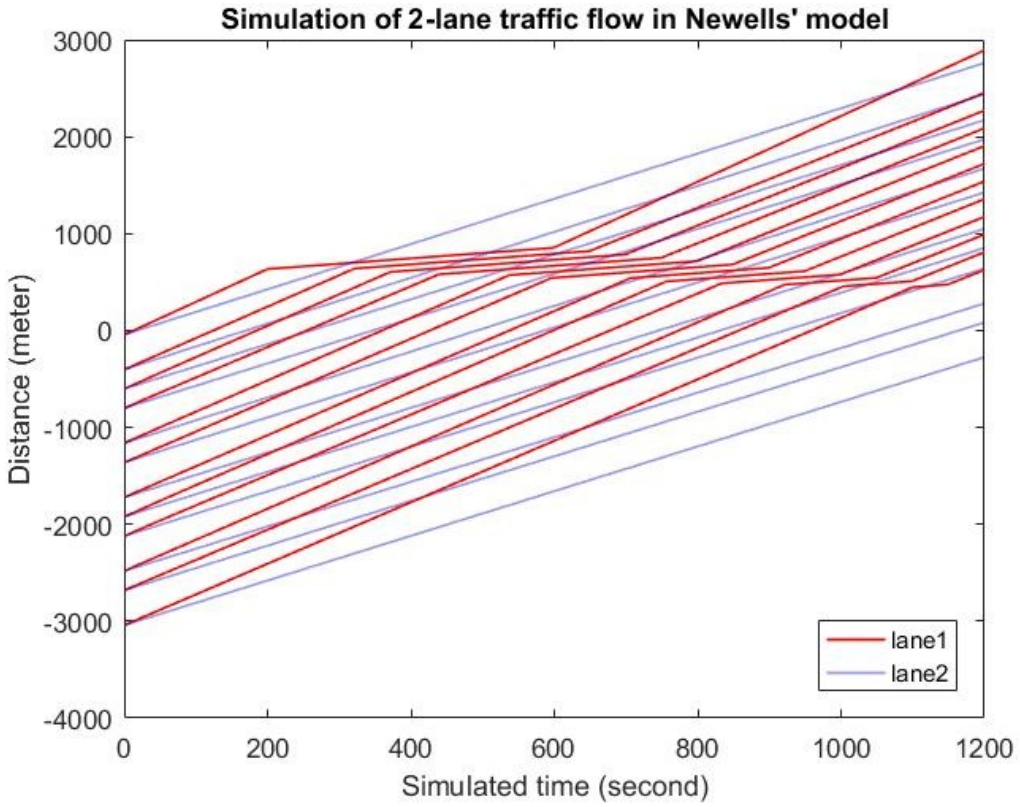
Three optima

- Minimize travel time
- Three different cases: minimize for
  - Collective travel time
  - Travel time of connected vehicles (i.e., group lane changing vehicles)
  - Individual travel time = user optimum
- Solve by genetic algorithm (Not possible in real time)
- Check properties of optimal solutions to learn from it

Simulations

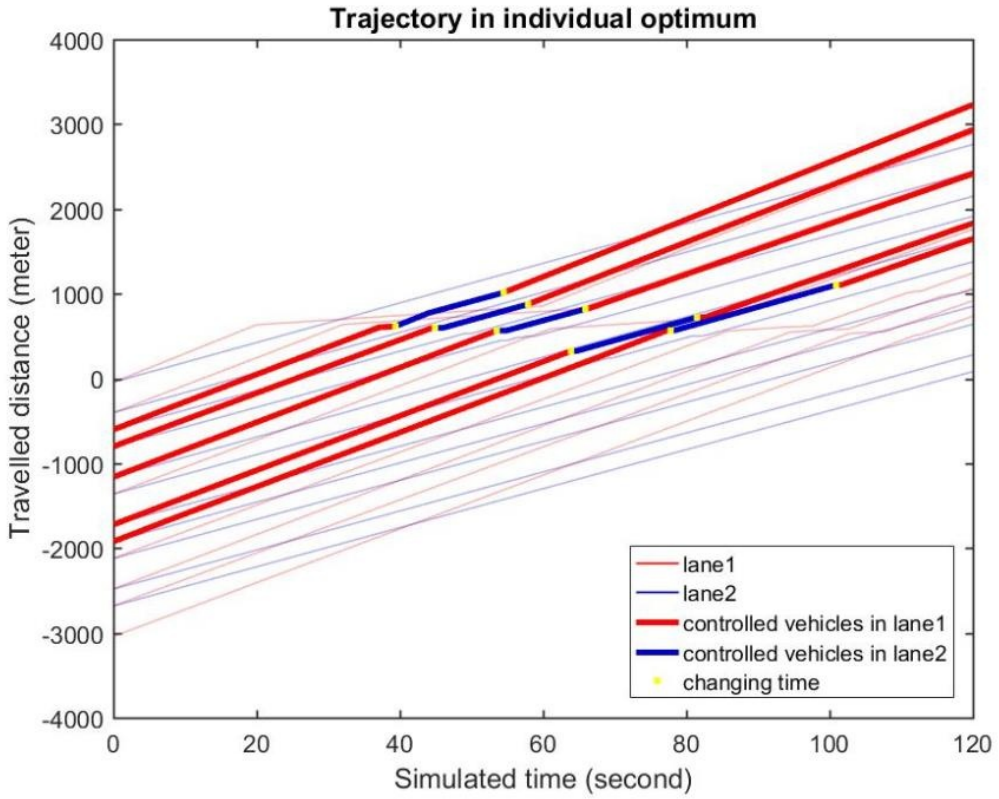
- Assumptions:
  - Point vehicles
  - Longitudinal: Newell's car following model
  - Lateral: no lane changes without instruction
- Leaving one lane = entering other lane

No control


Simulation of 2-lane traffic flow in Newells' model
Distance (meter)
Simulated time (second)
3000
2000
1000
0
-1000
-2000
-3000
-4000
0
200
400
600
800
1000
1200
lane1
lane2

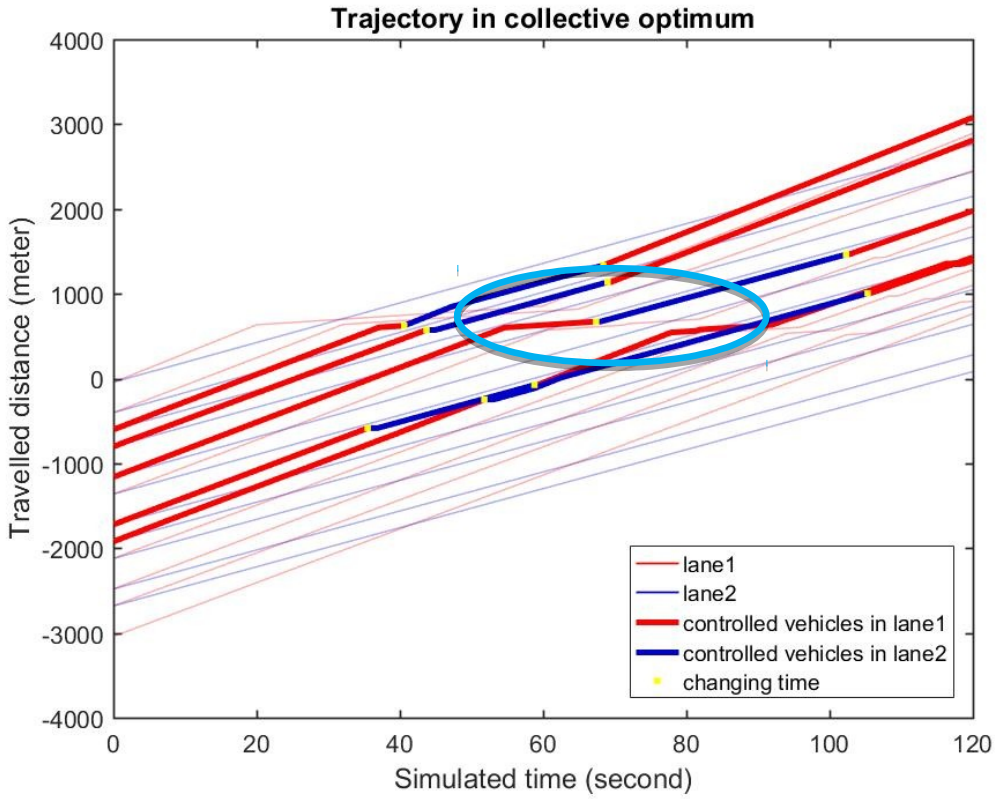
User optimum

- Drivers pass the slow moving area and change back



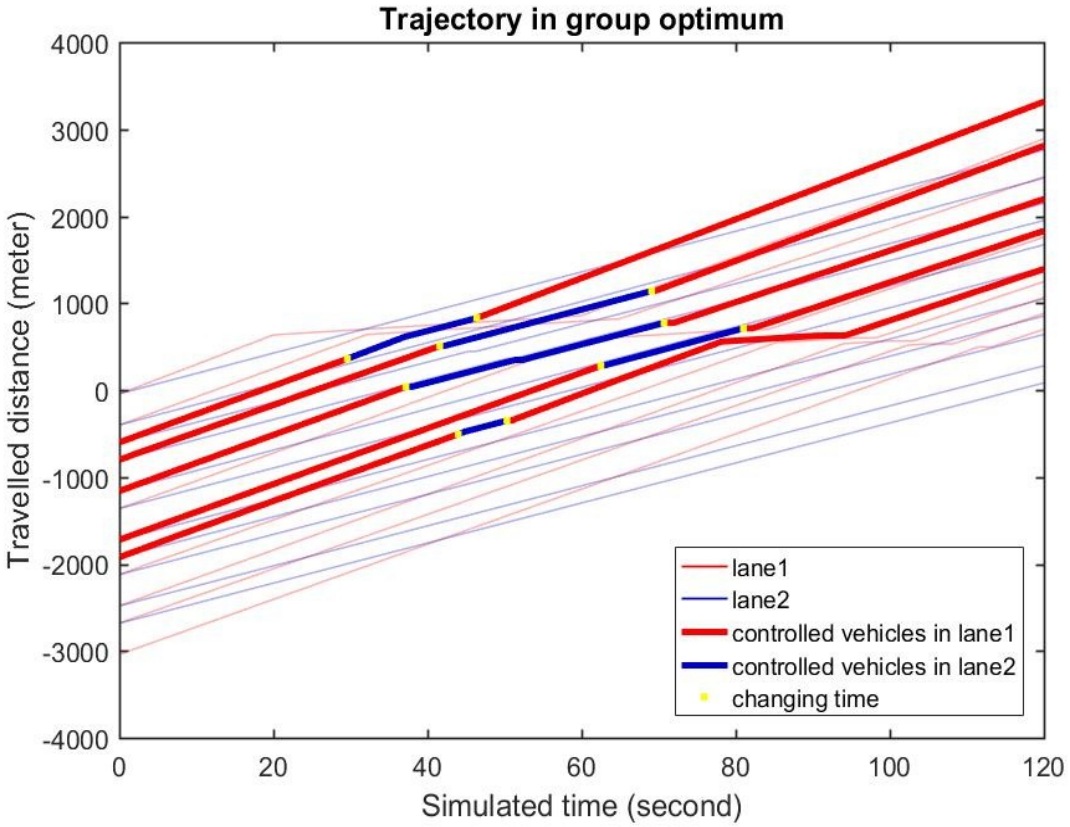
Collective optimum

- Lane changes into the voids

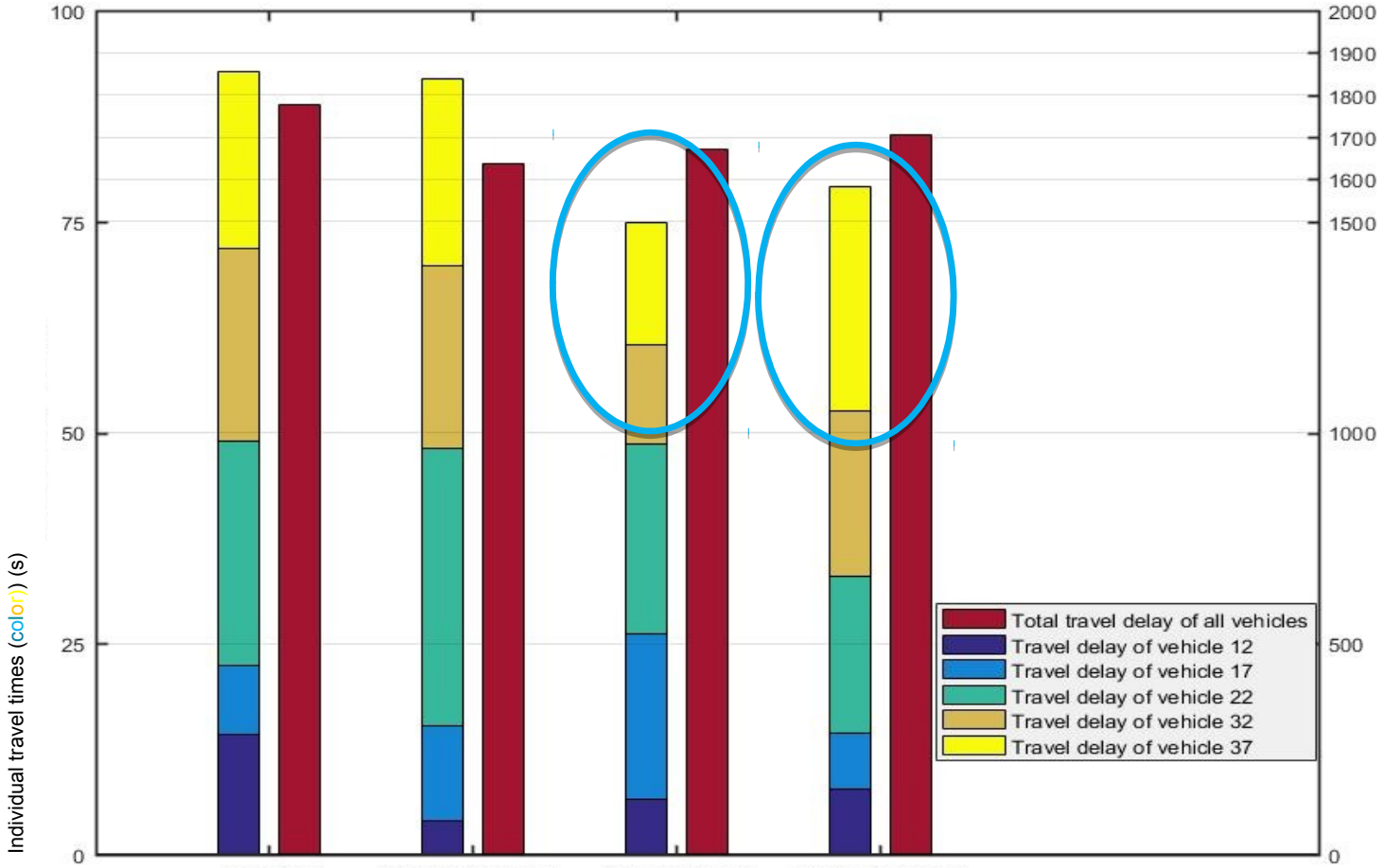


Group optimum

- Some wait for gaps, but less…

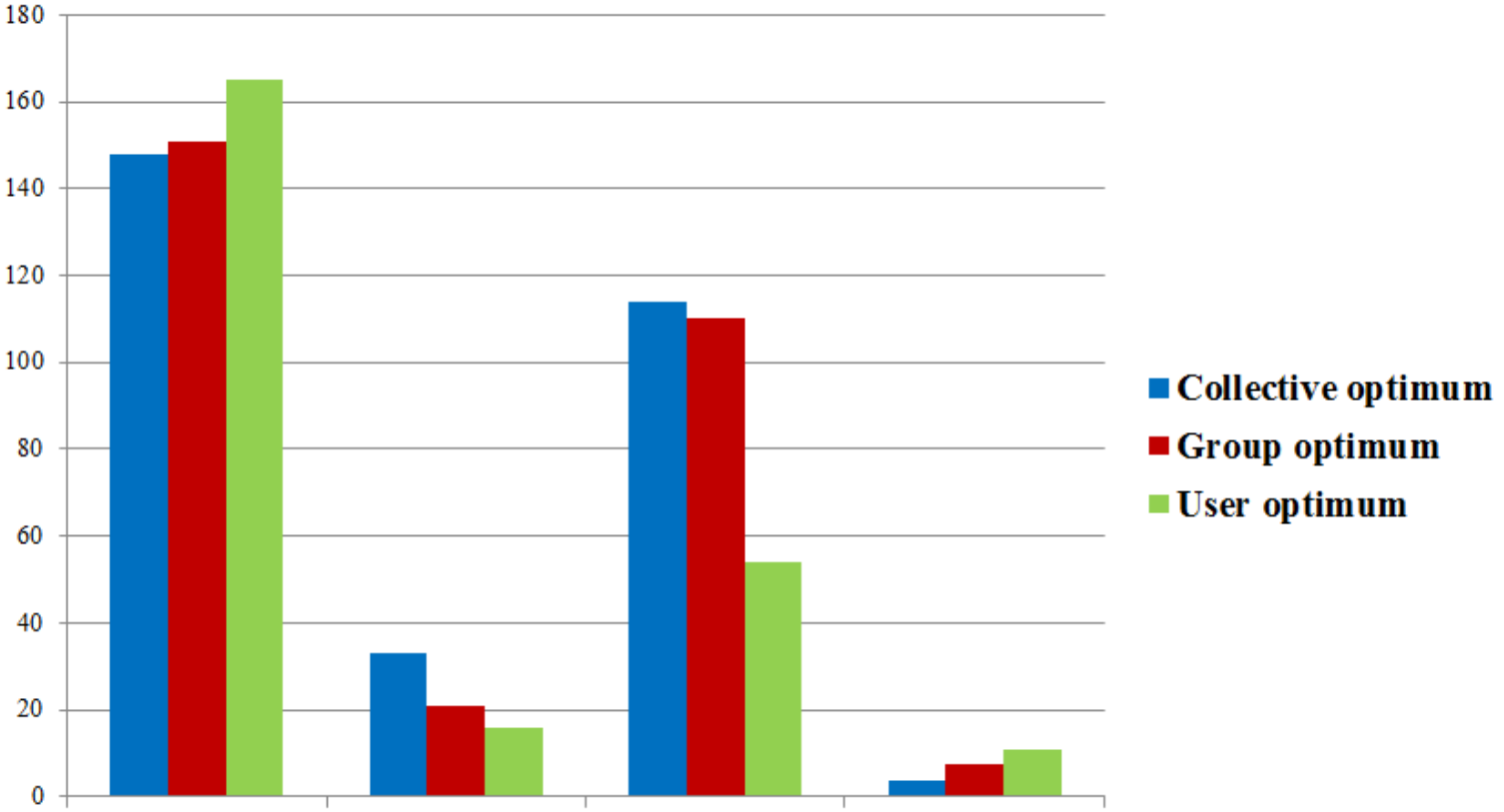


Properties: travel times



TU Delft

Properties: traffic flow



Average delay on slow lane

Average duration on lane 2

Average merging gap (m)

Average nr of vehicles overtaken

Conclusions

- Delay depends on
  - lane change instance
  - Optimization objective
- Group optimum leads to lower travel times for individual users
- All users are better of if one waits for a gap, even the driver itself, benefitting from others