Rijkswaterstaat
Ministerie van Verkeer en Waterstaat

Integrated Anticipatory Control of Road Networks

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Congestion in The Netherlands

Congestion in 1955

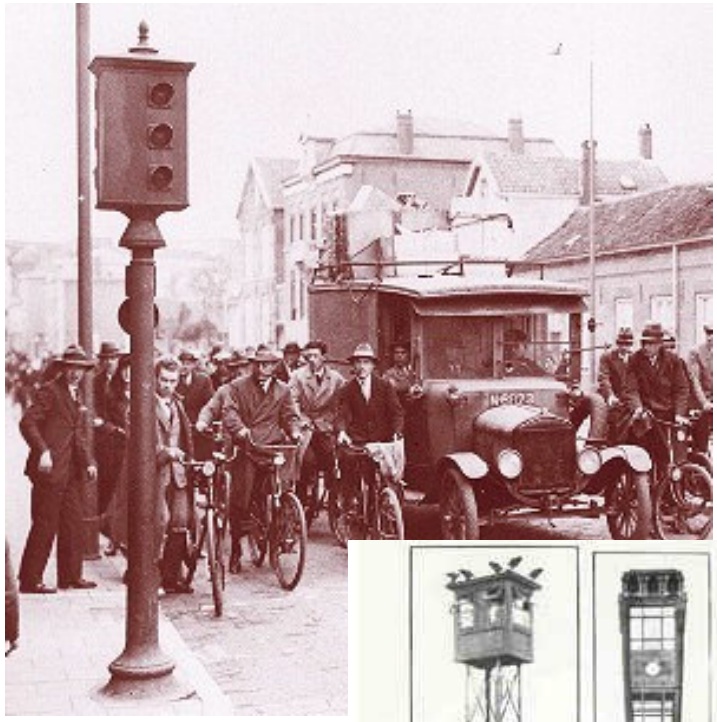
Traffic and Transport Policy

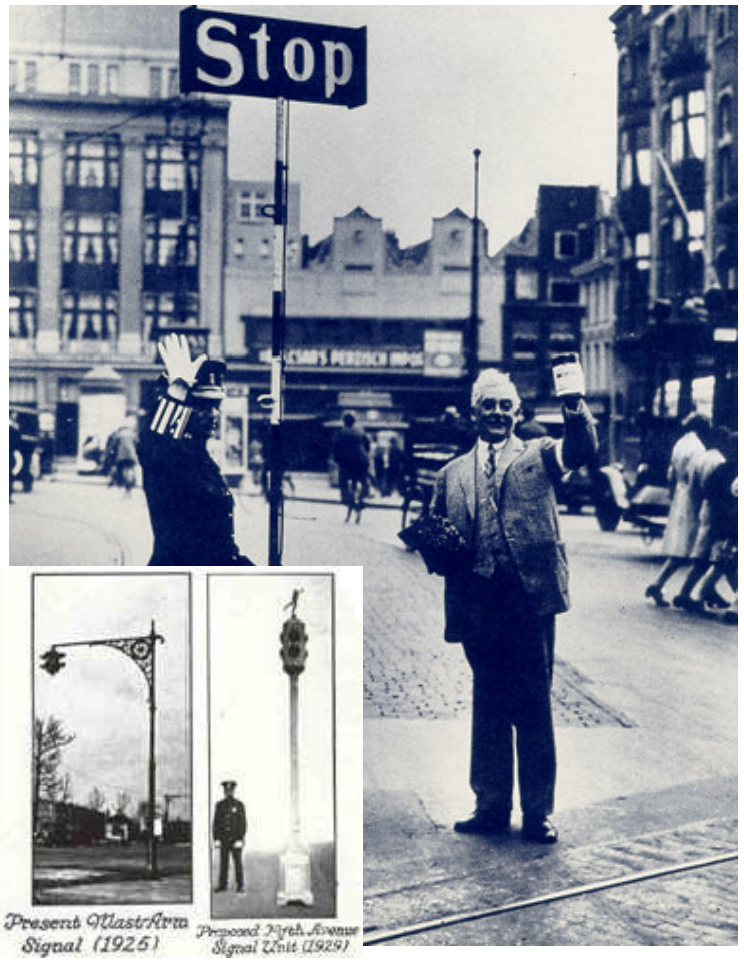
Building: *"very effective, expensive, long"*

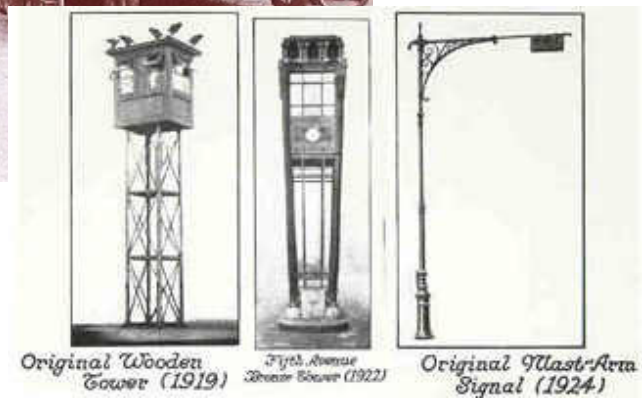
Pricing: "*politically difficult"*

Traffic Management: *"effective, less expensive and quick"*

Traffic Management Long Ago

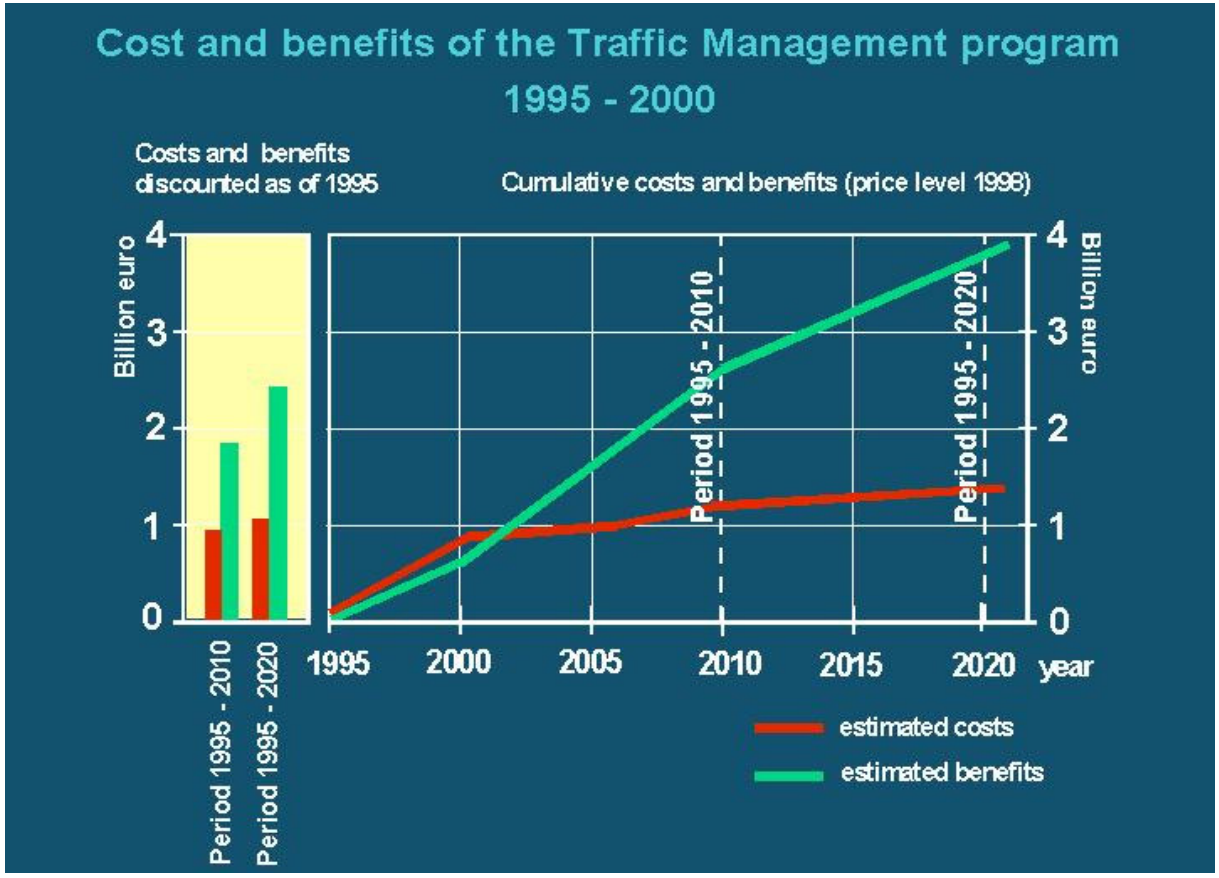




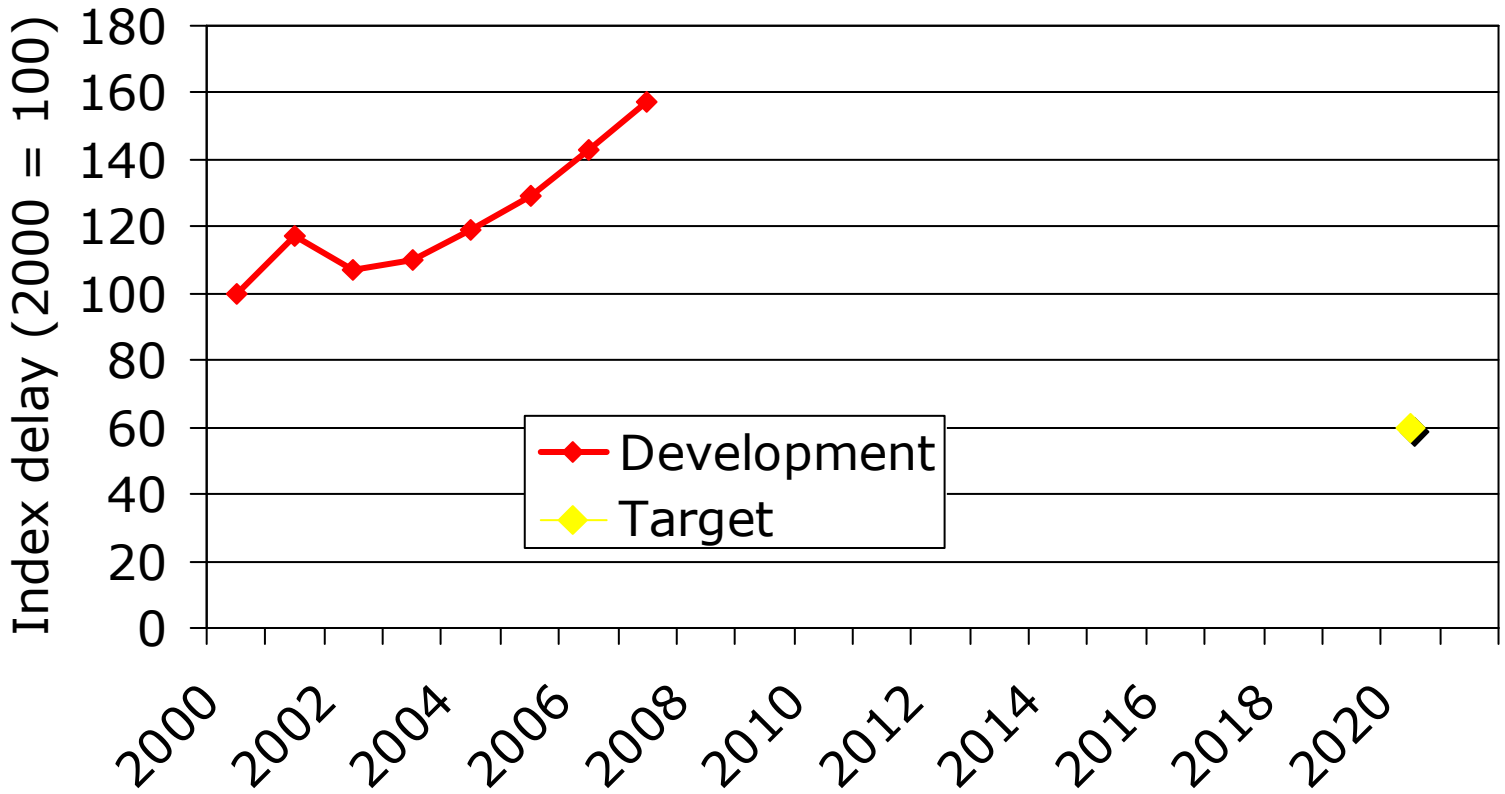


Tra… 21st …

Investment and Effects of ITS

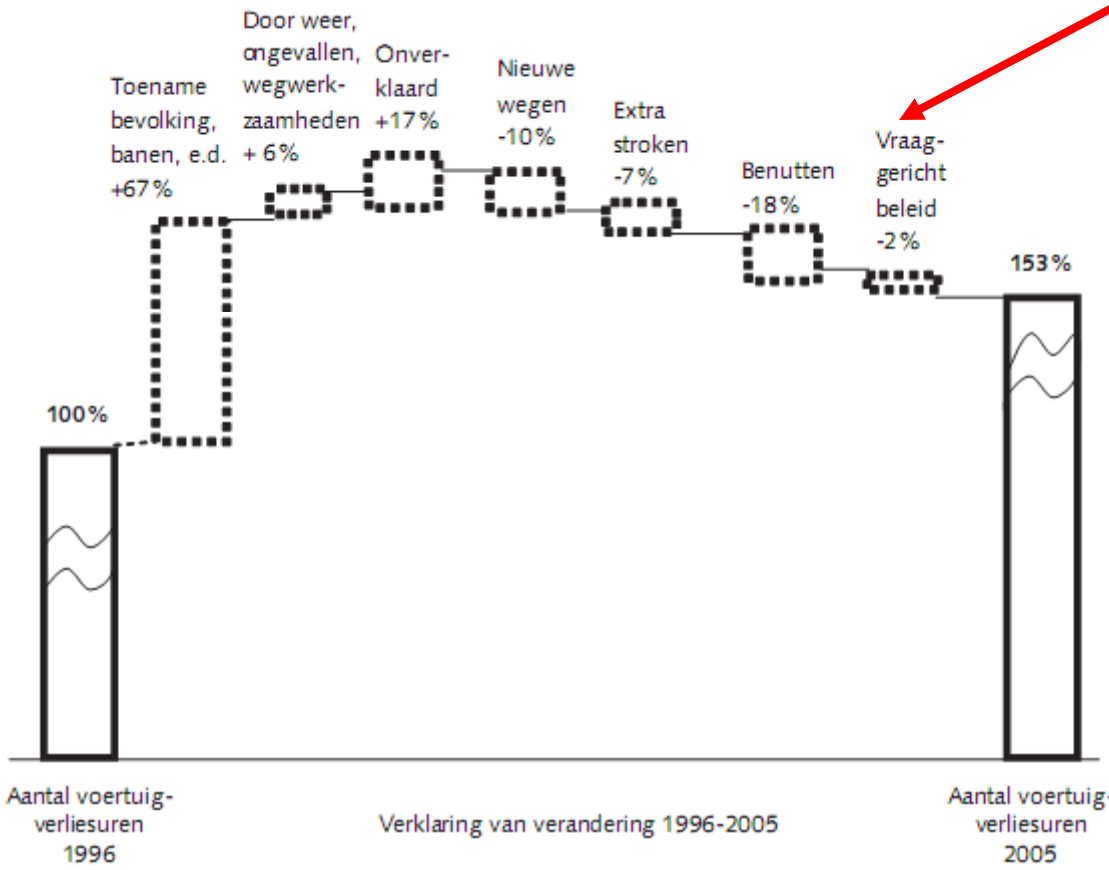


Enough?


Index delay (2000 = 100)
180
160
140
120
100
80
60
40
20
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Development
Target

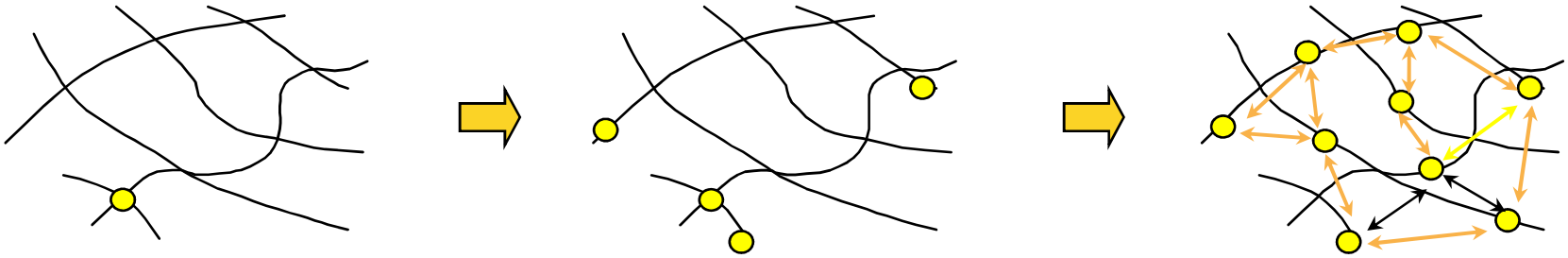
Explanation Increase Congestion

Traffic management



Next Steps

- More investments and better ITS not the fundamental solution
- From technique to result oriented approach



Technical development

First measures are explored

Application

Measures are applied at multiple locations

Result

Measures are coordinated throughout the network

Traffic Signal Control

- First traffic light: London, 1868
- Electronic traffic control equipment: USA, 1914
- Large scale implementation in cities: USA, twenties and thirties of 20th century
- First traffic lights in The Netherlands: thirties

Collectie SA. Foto: A. van Beurden, 1930

Traffic Control Strategies

- Fixed-time
- Fixed-time but changing during the day (peak periods)
- Variable green times
- In The Netherlands more local control
  - Bicycles
  - Public transport priority
- Control strategies reactive
  - Presence of vehicles
  - Upstream traffic
- Network control strategies: rest of the world

Traffic Management Measures

- Traffic signal control
- Ramp metering
- Dynamic speed limits
- Tolling
- Information

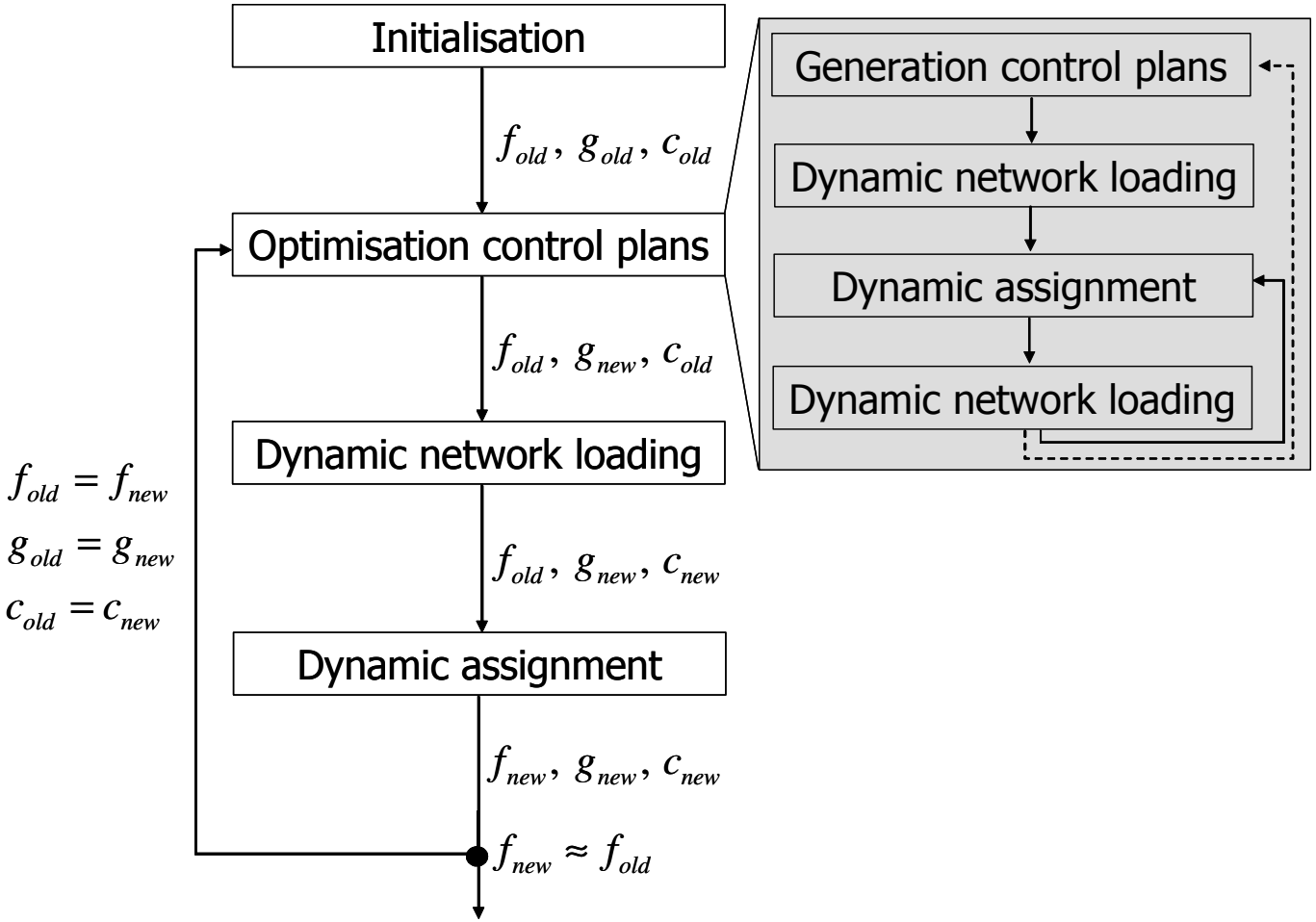
Anticipatory Control

- Interaction between road authorities and road users
- Road authorities and road users do not have the same goals
- Manage traffic such that choices of road users are taken into account (in this case: route choice)
- Manage traffic such that different goals of different road authorities are taken into account
- Network approach needed

Integrated Control

- Different road authorities
  - Can have different goals
  - Is cooperation beneficial?
- Coordination of traffic management measures
  - Currently local measures
  - Is coordination of measures better?
- Game theory
  - Interaction between players with their own decisions
  - Gain depends on own decisions, but also on decisions of the other players
- Strategies
  - React on decision of other players (Nash game)
  - Anticipate on decisions of other players (Stackelberg game)

Framework


Initialisation
$f_{old}, g_{old}, c_{old}$
Optimisation control plans
$f_{old}, g_{new}, c_{old}$
Dynamic network loading
$f_{old}, g_{new}, c_{new}$
Dynamic assignment
$f_{new}, g_{new}, c_{new}$
$f_{new} \approx f_{old}$
Generation control plans
Dynamic network loading
Dynamic assignment
Dynamic network loading
$f_{old} = f_{new}$
$g_{old} = g_{new}$
$c_{old} = c_{new}$

Dynamic network loading

- Network of links and nodes with attributes
- Other input:
  - General parameters
  - Origins and destinations + OD table
  - Routes
- Traffic flows dependent on capacity of links and nodes (blocking back)
- Akçelik and HCM 2000 functions for travel time
- Separate travel time functions for controlled intersections, roundabouts and priority junctions

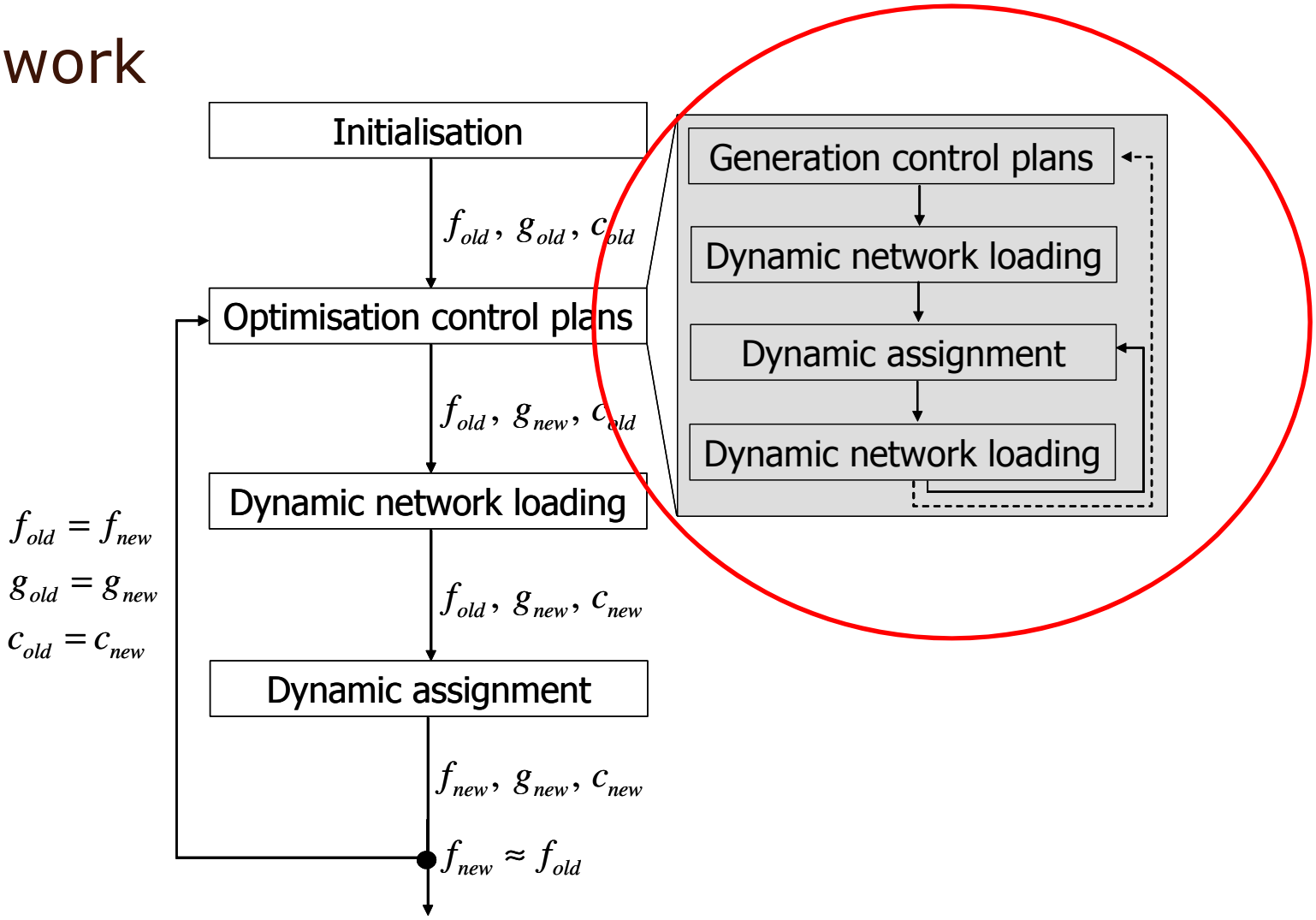
Dynamic traffic assignment

- Assign traffic in a network for every OD pair to the available routes for every time period
- Deterministic
  - For every OD pair and time period the travel costs (time) on every used route is equal and smaller than on the unused routes
- Stochastic
  - For every OD pair and time period the travel costs (time) on every used route is more or less equal and smaller than on the unused routes
  - C-logit assignment algorithm
  - Overlap in routes

Routes

- Route-based assignment
- Route are either:
  - User specified
  - Generated based on Dijkstra's algorithm:
- Dijkstra
  - Randomise free flow travel times, including control delay
  - Search shortest route
  - If shorter add to k-shortest route list
- Exclude unwanted or similar routes
- Determine route equality value
- Do not allow certain turning movements

Framework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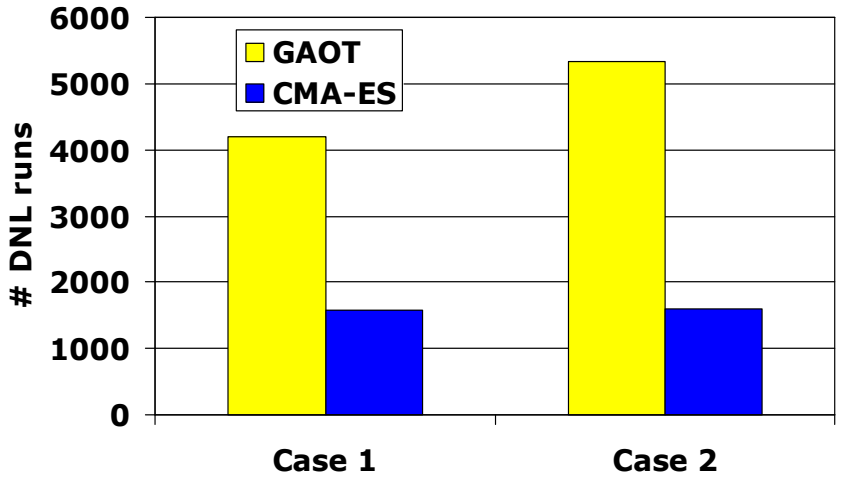
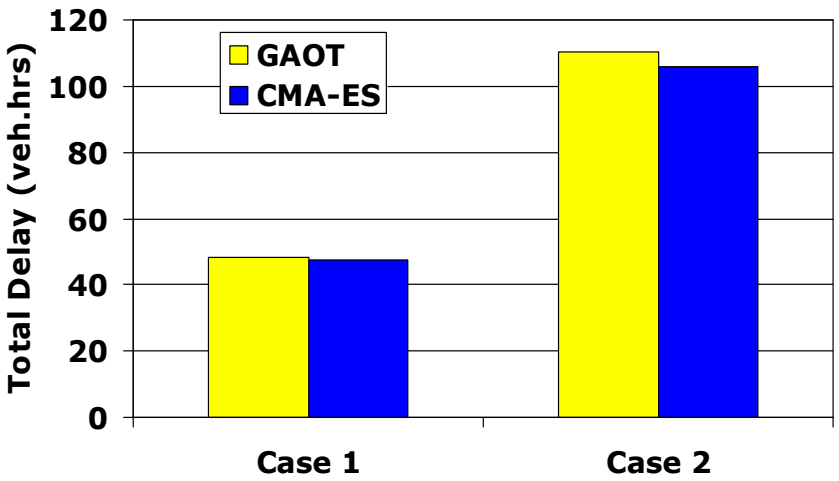
Optimisation Method

- Optimisation problem involves at least 2 DNL runs and 1 DTA
- Global and costly optimisation
- Deterministic methods
  - DIRECT
  - MCS (Multilevel Coordinate Search)
- Heuristic methods
  - Simulated annealing
  - Differential evolution
  - Advanced genetic algorithm (GAOT)
  - CMA-ES (Covariance Matrix Adaptation Evolution Strategy)

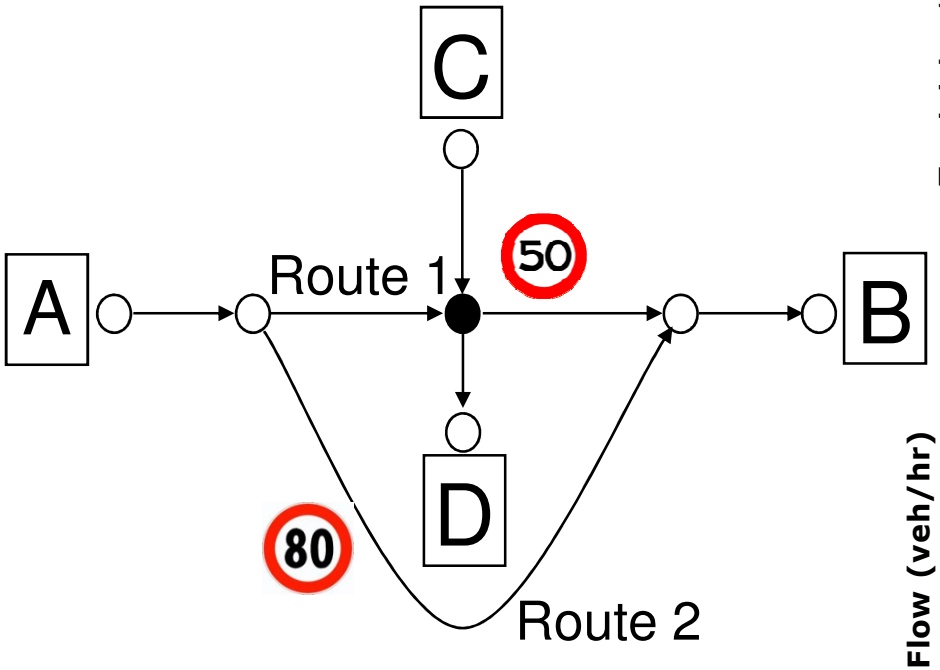
Optimisation Method Comparison

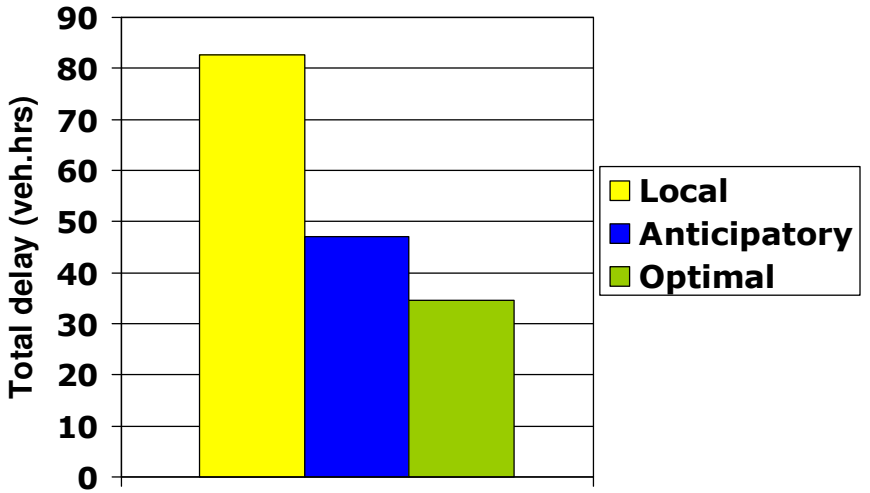
- 2 small cases: 10 variables and 20 variables to optimise
- 10 runs per optimisation method
- Graphs shows average

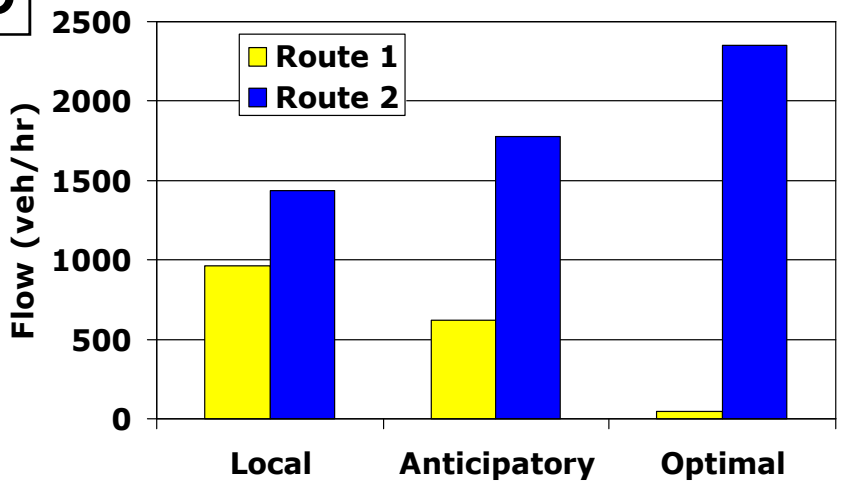




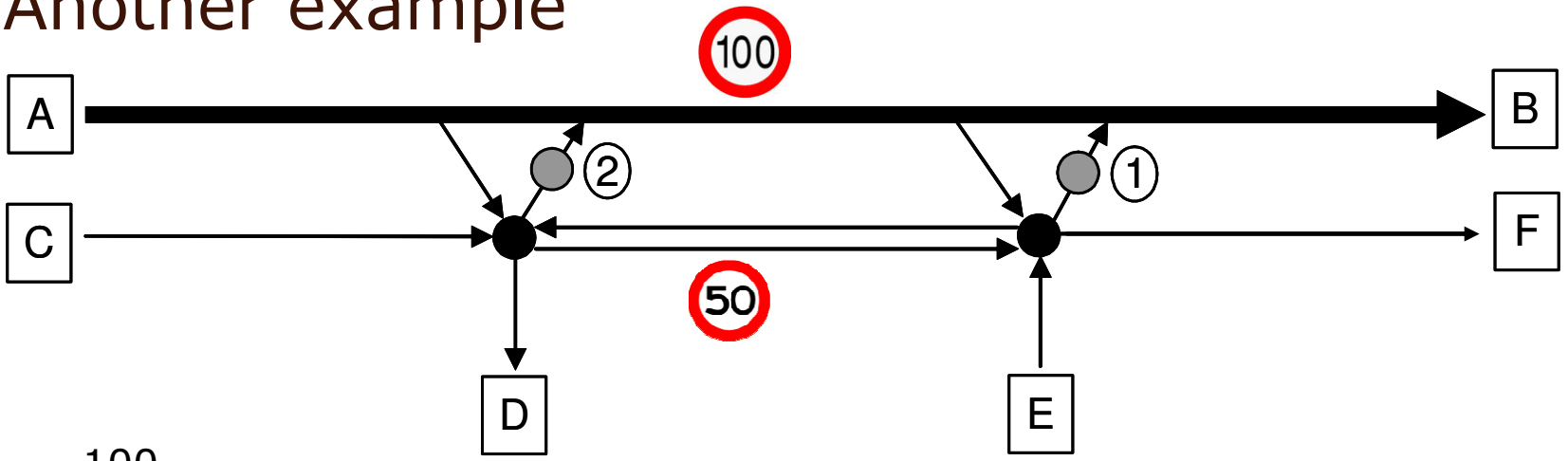
Simple example

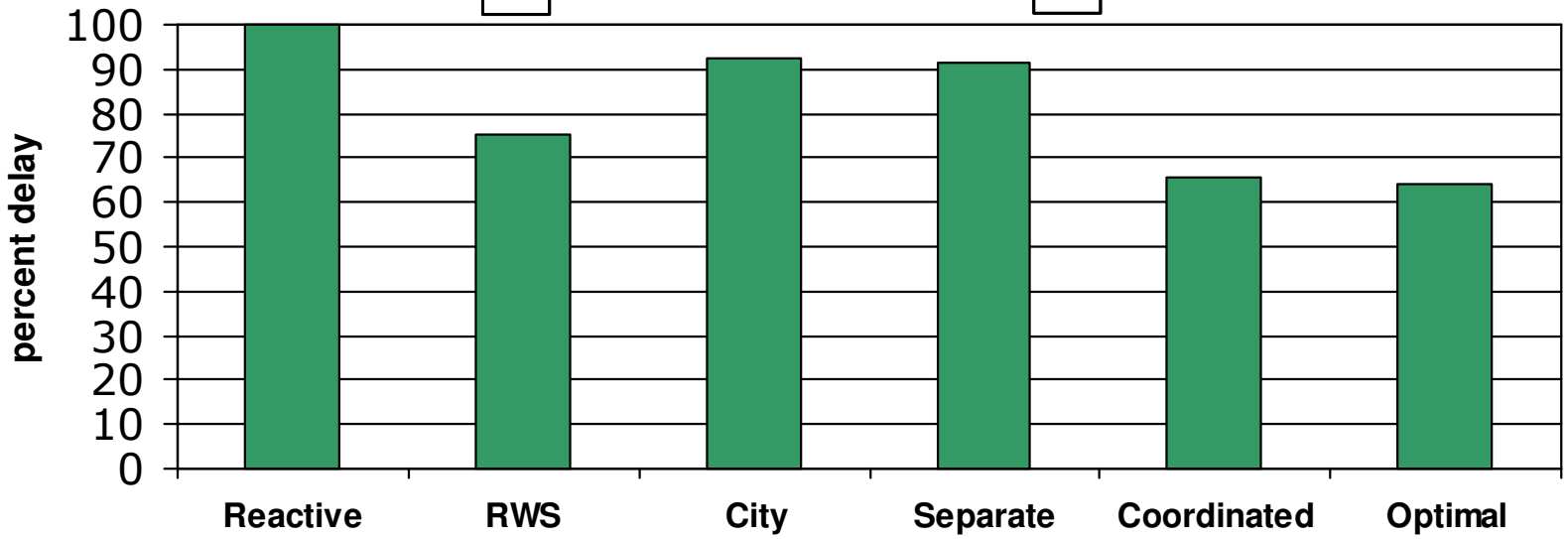






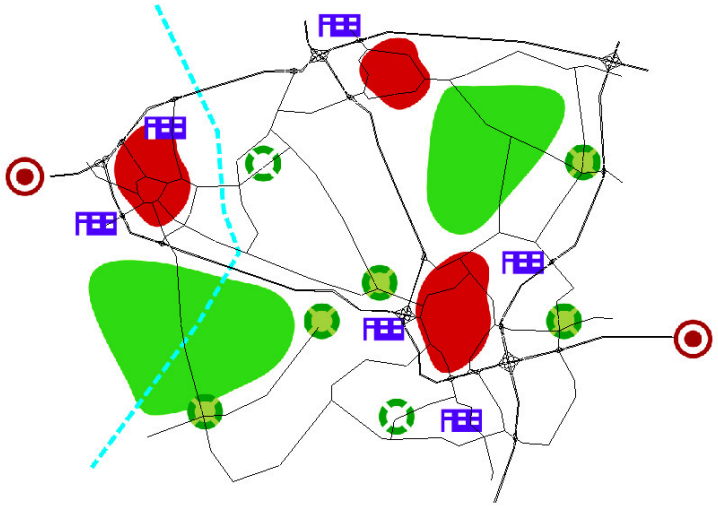
Another example





Conclusions

- Anticipatory control gives less congestion
- Integrated anticipatory control can be profitable for all players
- Concept only shown for small networks
- Application for larger networks needs an improvement of the optimisation method



Colophon

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Pictures: Rijkswaterstaat