An Activity-Based Multimodal Model Structure to assess Transportation Management Strategies for Urban Emergencies

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1993 Maas flooding – picture © Rijkswaterstaat

Introduction

Urban emergencies

Urban emergencies

Floods, hurricanes, wildfires, tsunamis, large-scale traffic accidents, airplane crashes, industrial accidents, nuclear disasters, terrorist attacks, etc.

- Observed characteristics (one or more):
  - Substantial delays for everyday traffic
  - Presence of evacuation traffic
  - Emergency services trying to reach the disaster site
- Urban transportation system is easily overloaded

Introduction

How to control

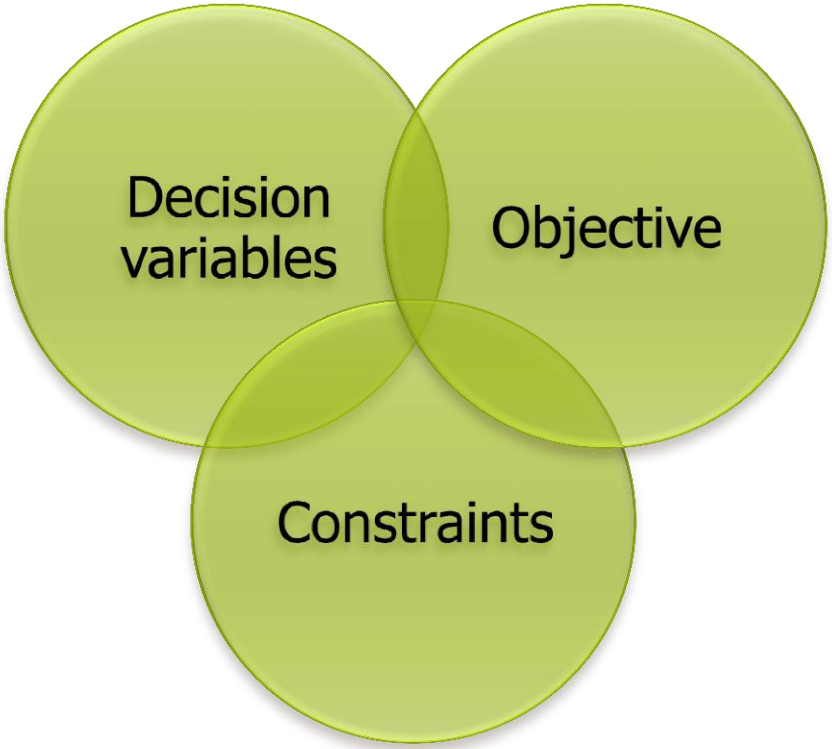
- Transportation authorities need a strategy
- Candidate strategies need assessment
- Assessment requires a simulation model
- Assessment allows for optimisation

Three issues regarding assessment:

- Interface with transportation management problem
- Travel choices of affected population
- Network performance and travel times

The management problem

Overview



The management problem

Decision variables 1/2

- Decision variables
  - Operational
    - Traffic light and ramp metering settings, dynamic speed limits, peak-hour and contraflow lanes, dynamic route information, public transport announcements, traffic regulators, emergency services, …
  - Tactical and strategic
    - Departure advice, mode advice, destination advice, route advice, roadblocks, contraflow roads, temporary road construction, public transport, public shelters, …

The management problem

Decision variables 2/2

- Adaptiveness: take uncertainty into account
  - Operational variables: frequent real-time changes
  - Tactical variables: infrequent changes
  - Strategic variables: no changes
- However, the disaster plan must be unambiguous
  - Since assessment must be possible
  - For changable variables, the decision process must be codified
    - E.g. simple decision rules, model-predictive control, …

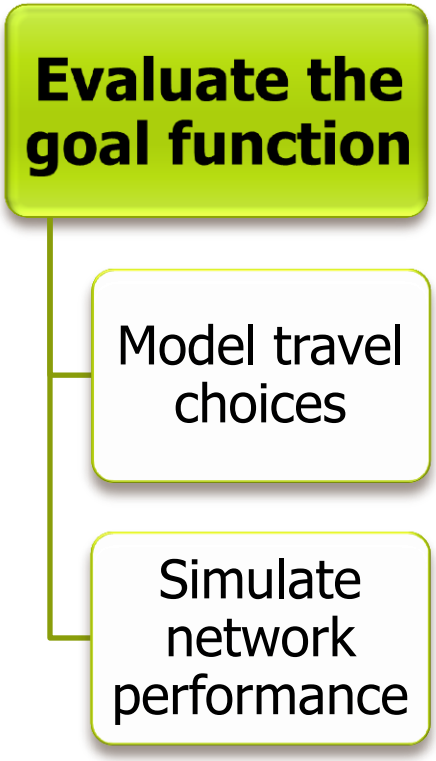
The management problem

Objective and constraints

- Objective
  - Two main categories:
    - Non-evacuations: minimise delays
    - Evacuations: maximise evacuation effectiveness
  - Robustness: evaluate goal function for multiple scenarios to account for uncertainty
    - Prevents creation of overly optimistic disaster plans
- Constraints
  - Limitations of traffic management options
  - Quality/safety of rescue operations
  - Ethics

The management problem

Simulation model components



Travel choice modelling

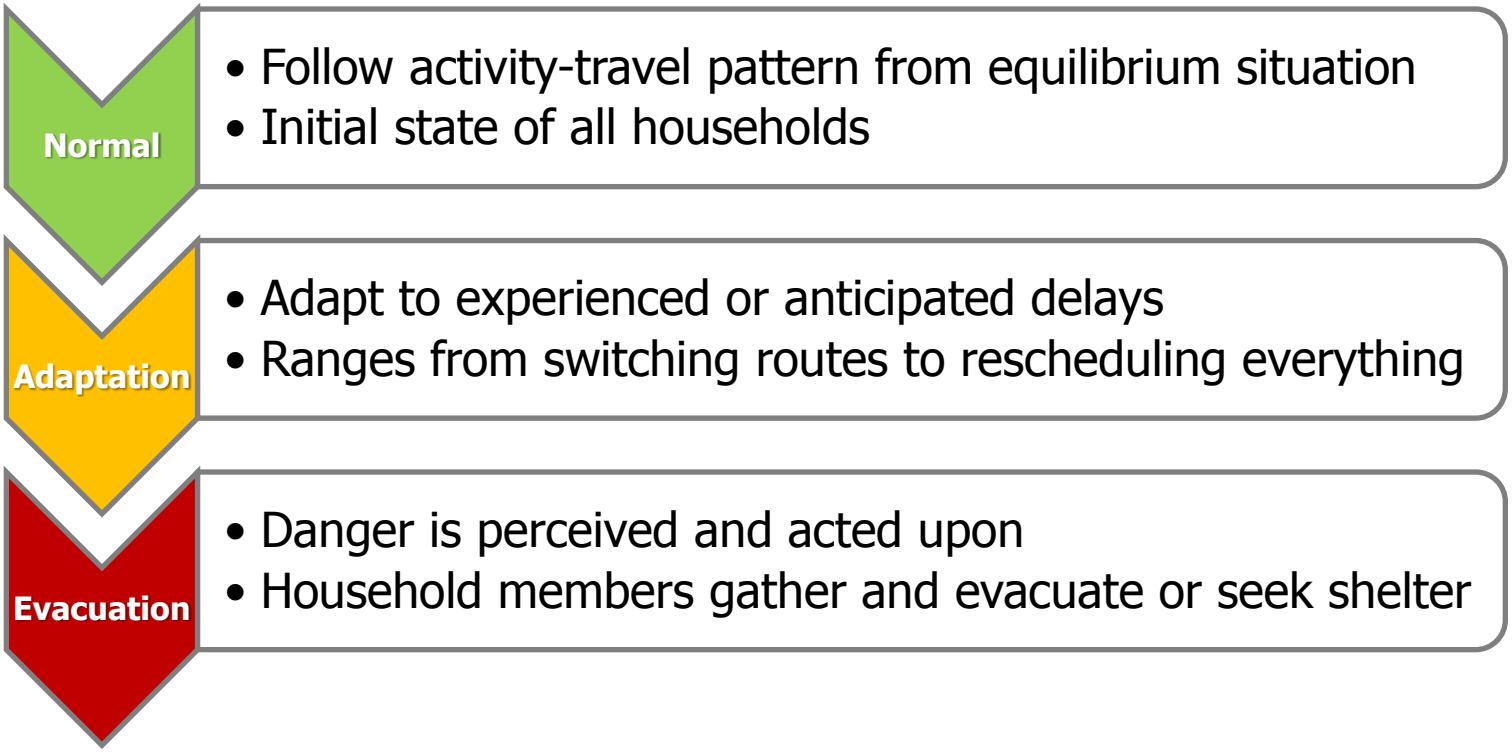
Why and how

- Used to determine expected loads on transportation system
- Used to see how authorities can influence these

- Activity-based
  - Generates a synthetic population with activity-travel schedules
  - Considers intra-household relationships
    - Important for evacuations
  - Continuously tracks location of individuals and vehicles
  - Can explicitly include relation between normal day and emergency situation
- Dynamic
  - Can study dynamic development of emergency situation
  - Can consider information availability

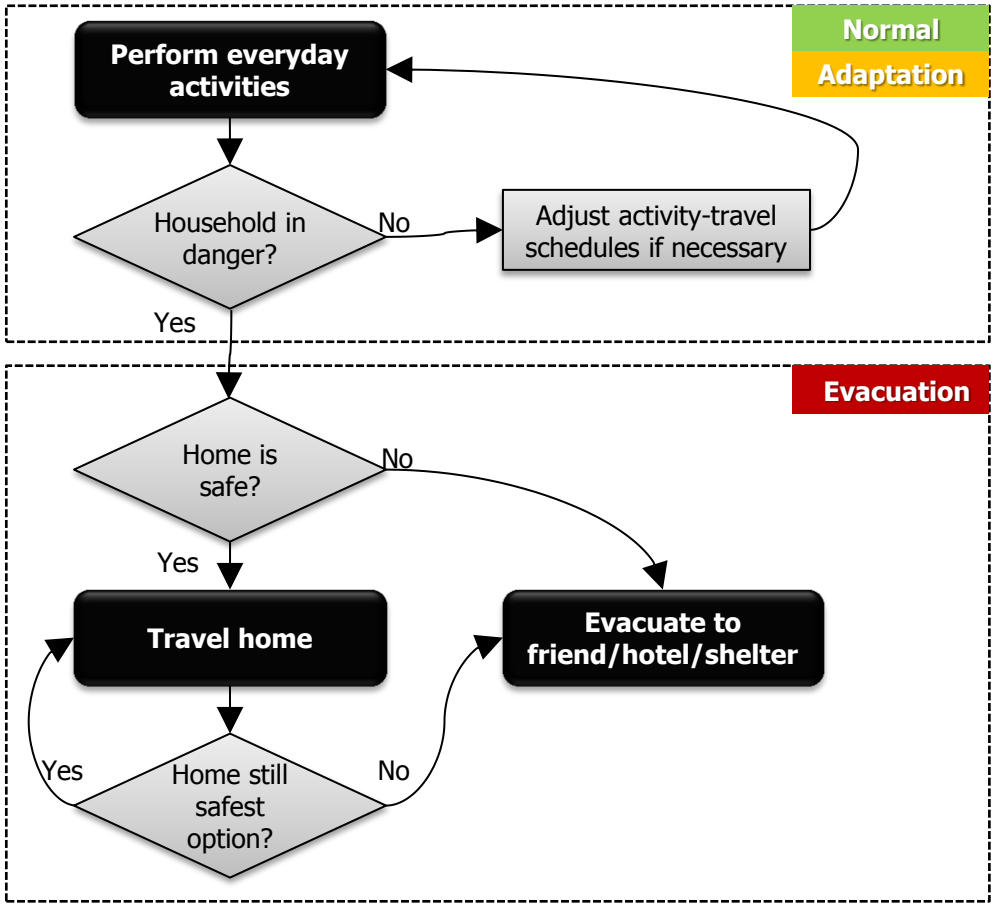
Travel choice modelling

Escalation model for household



Travel choice modelling

Example implementation



Simulating network performance

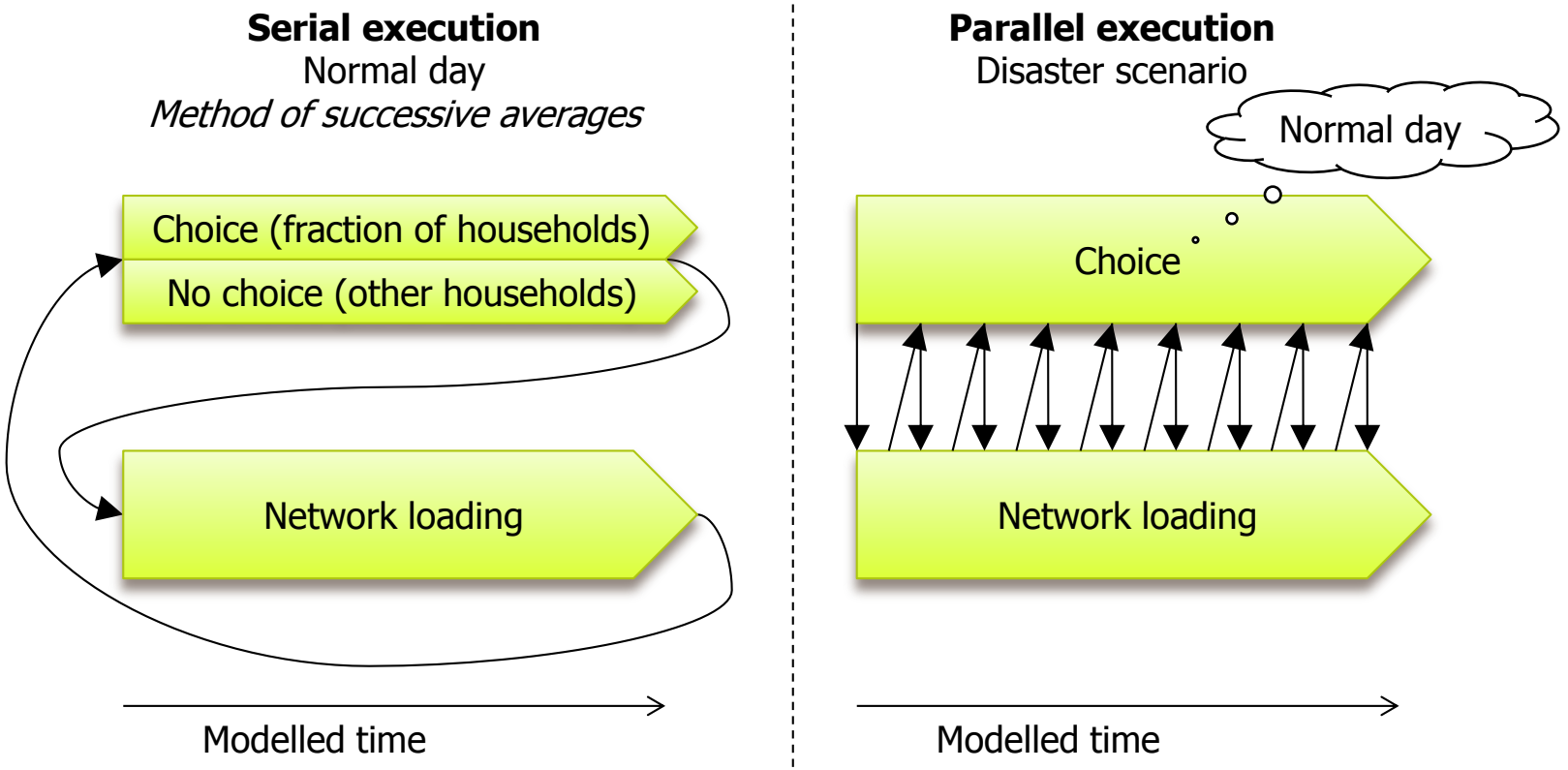
Why and how

- Used to determine congestion levels and travel times

- Dynamic
  - Can study dynamic development of emergency situation
- Multimodal
  - Should be as multimodal as urban regions
    - Public transport could be effective means of evacuation
- Macroscopic (rather than microscopic)
  - Can be more parsimonious
  - Can be calibrated on macroscopic level
  - Is computationally more efficient

Simulating network performance

Choice component interaction



Conclusion

Assess effectiveness of emergency transportation management strategy, by using a simulation model

- Allows *robust* testing of *adaptive* disaster plan
- *Activity-based* and *dynamic* choice model
- *Dynamic*, *multimodal* and *macroscopic* network performance model

What's next?

- Model implementation (already started)
- Model calibration
  - Stated preference survey for choice model
- Coupling with optimisation module