CIE4801 Transportation and spatial modelling
Beyond the 4-step model

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Content

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  • When to use what?
  • Which components are criticised?
• Future of the 4-step model
• The 4-step model and other models
• Extending the 4-step model to other topics
1.

The 4-step model itself
4-step framework and dominant model types

- **Trip generation**
  - Regression
  - Stop & Go

- **Simultaneous distribution and modal split**
  - Gravity model
  - Choice models

- **Assignment**
  - AON/stochastic
  - DUE
  - Cheap/simple
  - Best/complex
4-step concept has more potential than just the model

- The modules are building blocks for more elaborate models as well

- You can use the distinction between the 4 steps for analysis purposes as well:
  - What’s the demand that is produced/attracted?
  - Where do they come from/go to?
  - What is the role of the various modes?
  - Why do they use this road?
Do you always need the full package?

- The order to use the modules is fixed
- However it depends on the research question which module you start with and/or which modules you skip

- If you’re only interested in car? 
  - Skip mode choice

- If you want to know the effect of a one-way street strategy?
  - Assignment only

- If you want to know the impact of changes in the PT-network
  - Mode choice and assignment
Which components are criticised?

- Trip generation
  - Ignores actual behaviour with respect to activities => activity based

- Trip distribution
  - Not really criticised? Comment on quality OD-matrices raises a question

- Mode choice
  - Not really criticised

- Time of day
  - Still a bit simple?

- Assignment
  - Clear point of debate!
What’s wrong with the assignment?

• Modelling of long distance trips, e.g. The Hague – Arnhem in a peak hour
• The (non?) modelling of congestion
• The quality of the travel times
• Delays at junctions
• Debate on static assignment (as discussed so far) versus dynamic assignment
Junction modelling

From simple to complex
• Eliminate turns
• Define travel time functions per turn
  • Fixed capacity (number of lanes per direction)
  • Capacity depends on upstream node (merge, priority)
• Capacity depends on green times
• Determine optimal green times during assignment
Static model with dynamic characteristics: Qblok

- Main idea is to check for blocking back in every iteration of the DUE, e.g.
  - Select the link having the highest V/C ratio
  - Estimate the size of the queue
  - Check whether this influences upstream links and adjust travel times of upstream links (and determine difference potential demand flow and actual flow)
  - Repeat until all links having a high V/C ratio are dealt with

- STAQ is a new algorithm for incorporating blocking back that is based on traffic flow theory
Real remedy: dynamic assignment

- Modelling the propagation of traffic through the network

- Thus
  - Model capacity as a hard constraint
  - Model the upstream shockwave of congestion and thus blocking back
  - Model the way congestion dissolves

- Consequences
  - More detailed data on networks (esp. for potential bottlenecks)
  - Data needed on departure times per zone (OD-pair)
  - More computation time
Example Pijnacker-Nootdorp

Regional model GC

Zoom

Dynamic model
2.

The future of the 4-step model?
### Evolution of LUT models

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<th>Land-use model</th>
<th>Transport model</th>
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<td>activity-based land-use model</td>
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Trends

• Dominant trend: more complexity, more detail
  • Requirement for practice
  • Models are being used for more than the purpose they were designed for (database)
  • Scientific research

• Yet, there’s a need for small agile models
• Key question then is: what can be left out? Or is it about new modelling approaches?

• In both cases: remember Einstein:

As simple as possible, but not simpler
3.

The 4-step model and other models
How does the four-step model relate to other models?
Activity based modelling

• Especially relevant when you expect changes in activity patterns

• Unit is person in a household

• Models the scheduling of activities in a chain considering both the utilities of activities and the disutilities of travelling
  • E.g. including coordination between household members

• Expertise at TU Eindhoven (Timmermans & Arentze)

• Note that choice modelling is, again, an important tool
Land use and economic models

- Output of a transport model is used in land use models and in economic models (e.g. cost benefit analysis)

- Integrated models aim to link the different ‘worlds’
  - See discussion on LUT models
  - In current projects integration with economic models is studied as well

- Ideal combination is all three
Link with other transport models

- Two main options

- Linking of models to achieve consistency
  - E.g. using a regional model to determine ingoing, outgoing and through traffic for an urban model

- Use data of a model as an input for a more detailed model
  - Usually a ‘cut out’
  - Usually requires new calibration of network and OD-matrix
Model landscape

- Space
  - National network
  - Regional network
  - Urban network
  - Links

- Time
  - Tenths of seconds
  - Seconds
  - Minutes
  - 15 min
  - Hours
  - Days
  - Years
  - Hours
  - Peak periods
  - Days
  - Years

- Modeled period

- Projection

- Models
  - MIXIC
  - FOSIM
  - FREQ
  - FLOSIM
  - METANET
  - MADAM
  - INDY
  - Saturn
  - Dynasmart
  - NRM
  - LMS
  - TIGRIS XL
  - ALBATROSS
  - ESIM
  - Waiting time model

- No route choice
- Route choice
Environmental models

• In many studies the impact on noise hindrance and air quality needs to be quantified

• For both topics elaborate models exist which try to model physical phenomena using traffic flows as an input

• For both topics there’s a dedicated data requirement
  • For noise hindrance the truck flows during the night are often critical
  • For air quality a yearly average is used with again a distinction in vehicle types
Noise: the simple method

\[ L_{Aeq} = E + C_{optrek} + C_{reflectie} - D_{afstand} - D_{lucht} - D_{bodem} - D_{meteo} \]

- \( E \): Noise emission
- \( C_{optrek} \): Correction for junctions etc.
- \( C_{reflectie} \): Correction for reflection
- \( D_{afstand} \): Correction for distance between source and receiver
- \( D_{lucht} \): Correction for air damping
- \( D_{bodem} \): Correction for impact of the ground surface
- \( D_{meteo} \): Correction for meteorological conditions

\[ E = 10 \log \left( 10^{10} + 10^{10} + 10^{10} \right) \]

\[ E_x = \alpha + \beta \log \left( \frac{v_x}{v_0} \right) + 10 \log \left( \frac{Q_x}{v_x} \right) + C_{wegdek,x} \]

- \( v_0 \): Reference speed
- \( v_x \): Actual speed for vehicle type \( x \)
- \( Q_x \): Normative flow for vehicle type \( x \)
- \( C_{wegdek,x} \): Correction for pavement type for vehicle type \( x \)
Impact of flow on noise hindrance
Air quality

- Combination of background concentration and emission due to traffic
Air quality: simple method

\[
E = \left[ (1 - F_s) \cdot \left( 1 - (F_m + F_v + F_b) \right) \cdot E_p + F_m \cdot E_m + F_v \cdot E_v + F_b \cdot E_b \right] + \left[ F_s \cdot \left( 1 - (F_m + F_v + F_b) \right) \cdot E_{p,d} + F_m \cdot E_{m,d} + F_v \cdot E_{v,d} + F_b \cdot E_{b,d} \right] \cdot \frac{1000 \cdot N}{24 \cdot 3600}
\]

- \(E\): Emission (µgr/m/s)
- \(N\): Number of vehicles per average weekday
- \(F_m\): Fraction middle weight vehicles
- \(F_v\): Fraction heavy weight vehicles
- \(F_b\): Fraction busses
- \(E_p\): Emission factor for passenger cars (gr/km)
- \(E_m\): Emission factor for middle weight trucks (gr/km)
- \(E_z\): Emission factor for heavy weight trucks (gr/km)
- \(E_b\): Emission factor for busses (gr/km)
- \(E_{p,d}\): Emission factor for vehicle type * in congested conditions (gr/km)
- \(E_{m,d}\): Emission factor for vehicle type in congested conditions (gr/km)
- \(E_{v,d}\): Emission factor for vehicle type in congested conditions (gr/km)
- \(E_{b,d}\): Emission factor for vehicle type in congested conditions (gr/km)
- \(F_S\): Fraction congested traffic
- \(E_{*d}\): Emission factor for vehicle type * in congested conditions (gr/km)

\[
C_{jm-bijdrage} = 0.62 \cdot E \cdot \Theta \cdot F_b \cdot F_{regio}
\]

- \(C_{jm-bijdrage}\): Yearly average contribution due to traffic
- \(F_b\): Correction factor for trees
- \(F_{regio}\): Regional correction factor for meteorological conditions
- \(\Theta\): Dispersion factor

H= Hoogte gebouw (m)
L= Afstand weg-as tot bebouwing (m)
Impact of traffic flow on air pollution

Particle concentrations versus Intensities

- NO2
- PM10
- SO2
- Benzeen
- BaP
- CO

Concentrations (µg/m3) vs. Intensities (veh/24h)
4. Extending the 4-step for other topics
Policy and research topics

- True multimodality
- Robustness of networks
- Reliability in transport
- Special conditions, e.g. evacuation
- Network design problems, e.g. network structure or network attributes (pricing)
Challenges

- Every topic sets requirements for the building blocks of the model
- How to combine dynamic assignment with discrete time schedules?
- How to model behaviour in case of exceptional conditions? Does the equilibrium principle still hold?
- How do all kinds of information services affect network usage? Adaptive route choice instead of pre-trip route choice
- In network design and in robustness/reliability analyses you need many network evaluations. So how can you speed up a model run?

- See CIE5802-09