METROPOLIS: an Applied Dynamic Discrete-Choice Transport Network Model

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METROPOLIS Users Meeting 2010 - ETHZ

Outline of Part I

1. Motivations

Outline of Part I

Outline of Part II (Fabrice Marchal)

3. Design philosophy of METROPOLIS

Outline of Part II (Fabrice Marchal)

3. Design philosophy of METROPOLIS
4. Data issues
   - Demand - static O-D matrices and parameters
   - Network parameters

Outline of Part II (Fabrice Marchal)

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5. Simulation isssues
   - Convergence properties
   - Peak and off-peak demand
6. Application of public policies
   - Road pricing
   - Peak spread measures
   - Capacity expansion
   - Varying levels of demand

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7. FAQs

Part I

Dynamic congestion models

Context and motivations

Focus

- Transp. systems
  - Public transport
  - Private modes
    - Car traffic

Context and motivations

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- Transp. systems
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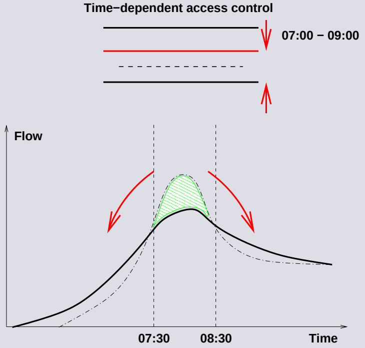
Reasons for time-dependent models

- Innovative policies

Time-dependent context



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Reasons for time-dependent models

- Innovative policies
- Technology (ITS)

Time-dependent context

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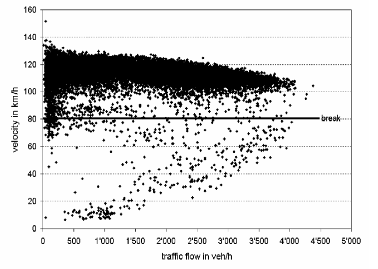
Reasons for time-dependent models

- Innovative policies
- Technology (ITS)
- Scientific analysis

Time-dependent context



Travel choices considered

- Mode choice
- Route choice
- Departure time choice

Departure time choice - Vickrey's model (1969)

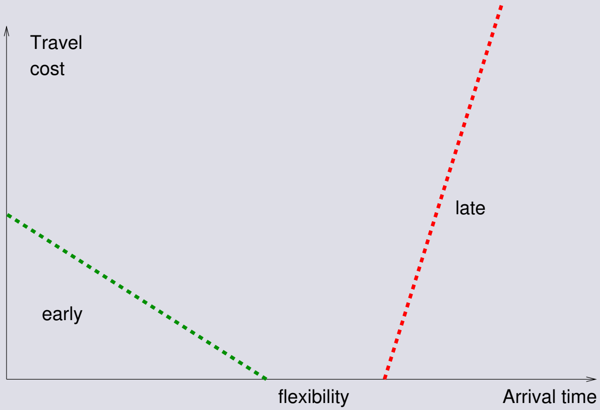
Cost specification:

$$C(t_d) = \alpha\tau(t_d) + \beta \max\{0, t^* - t_a(t_d)\} + \gamma \max\{0, t_a(t_d) - t^*\}$$

- departure time: t_d
- travel time: $\tau(t_d)$
- arrival time: $t_a(t_d) = t_d + \tau(t_d)$
- α: monetary value of time
- β, γ: penalties for early/late arrivals
- t^*: desired arrival time

Trade-off between travel time and schedule delay costs

Extension: flexible arrival period



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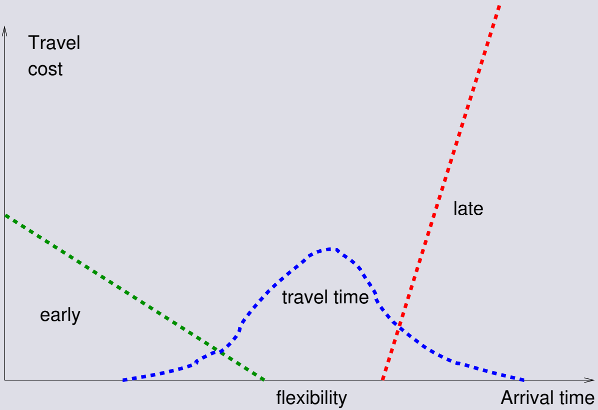
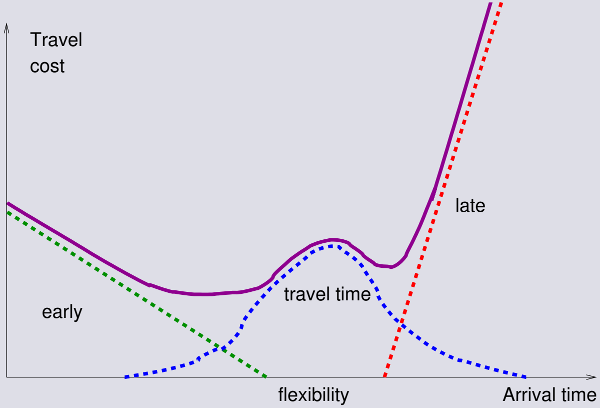


Trade-off between travel time and schedule delay costs

Extension: flexible arrival period



Typical parameter values

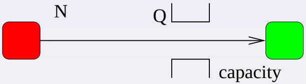
- Linear estimations

	$\beta[\$/h]$	$\gamma[\$/h]$	t^*	$\mu[\$]$
Com. (Paris/close)	6.0	7.5	N(08:30,60)	2.7
Com. (far suburbs)	8.3	17.4	N(08:24,50)	1.7
Other purposes	5.2	10.6	N(08:54,54)	2.4
			N(10:49,53)	

(value of time from external sources: $\alpha = 13\$/h$; sources: MADDIF, estimations on Paris area)

- Non-linear estimations

Linear queue for a single O-D pair



Congestion:

$$\tau(t_d) = \frac{Q(t_d)}{\kappa}$$

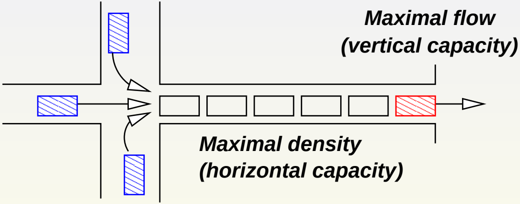
Dynamics:

$$\frac{dQ}{dt} = r(t) - \kappa \text{ if } Q > 0$$

- N: total number of users
- κ: road capacity
- $r(t)$: entry flow

Taking spill-over effects into account

Extension: space limitations and blocking back



Equilibrium - deterministic case

- Cournot-Nash equilibrium condition: $\frac{dC}{dt} = 0$
- individual cost at eq.:

$$C^{eq} = \frac{N}{\kappa} \frac{\beta\gamma}{\beta + \gamma}$$

- departure rate: $r(t) = \kappa \frac{\alpha}{\alpha - \beta}$ (early), $r(t) = \kappa \frac{\alpha}{\alpha + \gamma}$ (late)
- independent of value of time (α)
- schedule delay costs = half of travel cost
- externality = individual cost

System(social) optimum

- condition:

$$r^{so} = \arg\min_{r(t)} C_{TOTAL}$$

$$C_{TOTAL} = \int_{-\infty}^{+\infty} C(t)dt$$

- solution:

$$r^{so}(t) = \kappa \text{ if } t \in T$$

- total cost at sys. optimum:

$$C^{so}_{TOTAL} = \frac{NC^{eq}}{2}$$

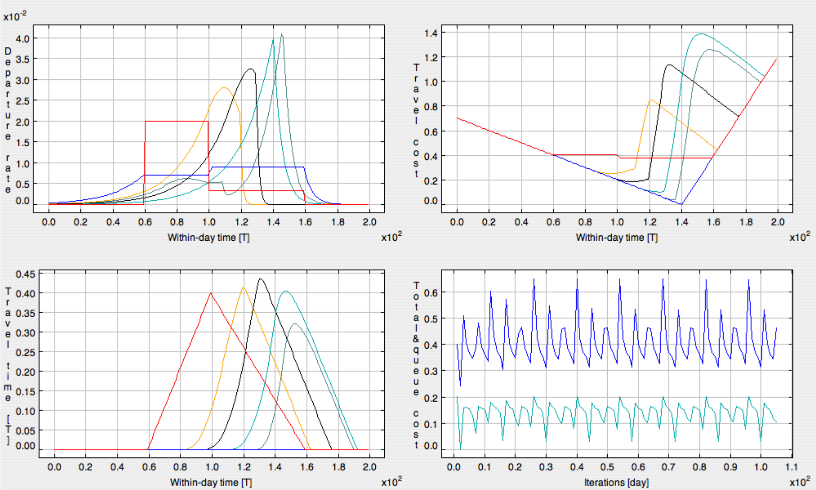
Equilibrium and sys. optimum departure rates

Day-to-day adjustment process

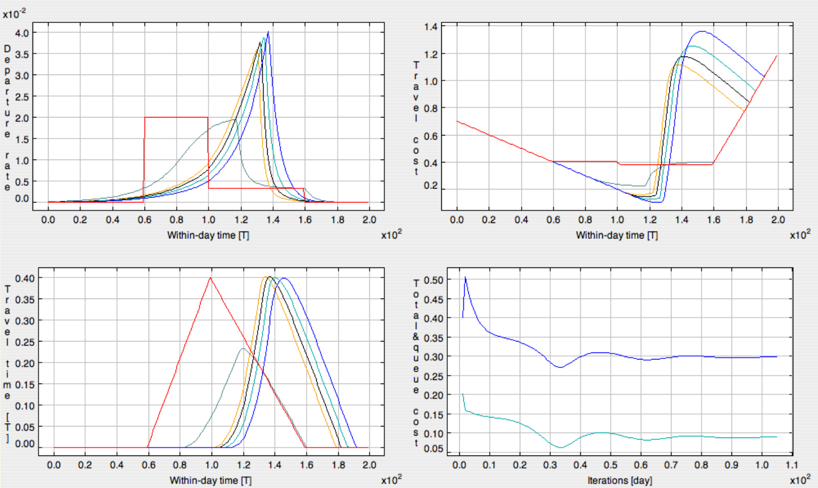
Extension: general networks , heterogenous demand

- no closed form available for the equilibrium
- heuristics procedures to adjust decisions iteratively (departure/route/mode)
- for instance, inspired by R.U.M.: $U(t_d) = -C(t_d) + \mu\epsilon_{t_d}$
  - If ϵ_{t_d} are assumed Gumbel i.i.d $\rightarrow$ logit:
    $\mathcal{P}(t < t_d \leq t + \Delta t) = \frac{\Delta t \exp\left(\frac{-C(t)}{\mu}\right)}{\int_T \exp\left(\frac{-C(u)}{\mu}\right) du}$
  - $\tau_H^{k+1}(t) = \lambda\tau_H^k(t) + (1-\lambda)\tau_S^k(t)$

Logit adjustment - instabilities - case $\lambda = 0$



Logit adjustment - instabilities - case $\lambda = 0.9$



Part II

METROPOLIS: a tutorial

Design philosophy

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Demand

Network

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Convergence

Travel purposes - peak/off-peak

Road pricing

Peak spread measures

Capacity expansion

Varying level of demand

FAQs

Questions