Departure Time Choices in Traffic Congestion

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Introducing myself

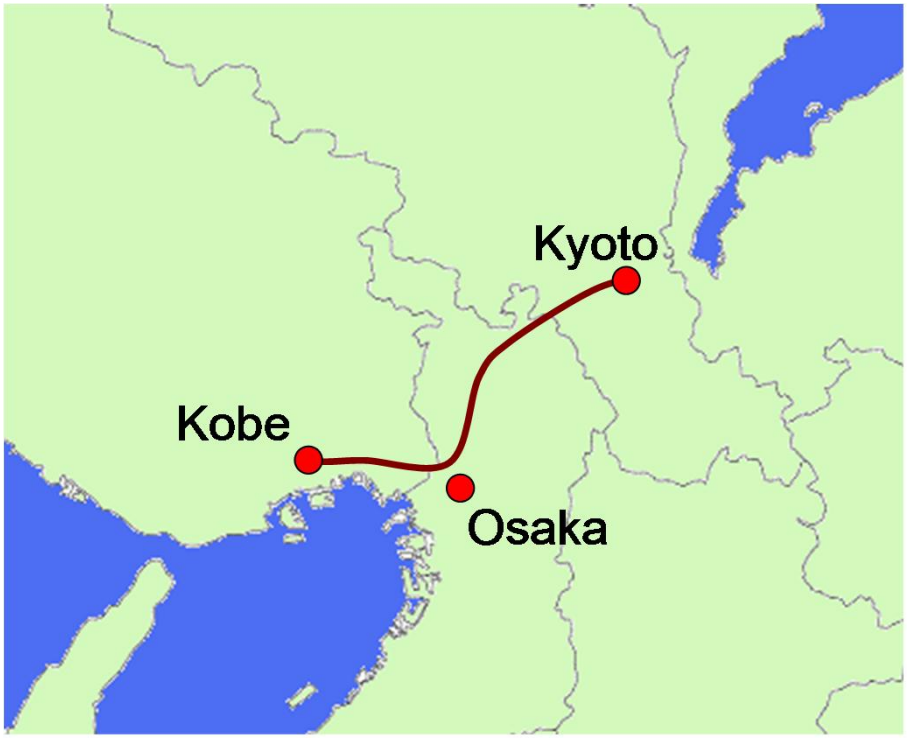
- Takamasa Iryo, Dr. Eng.
  Assistant Professor, Kobe University,
  working with Prof. Asakura.

- Studied in the University of Tokyo till 2002
  and got a degree under the supervision of
  Prof. Kuwahara.

- Main topic: Transport Network Analysis,
  esp., DTA / Pedestrians

Kitamura sensei in my study

- Kobe is near to Kyoto.
- Easy to visit Kyoto.
- I had many chances to have discussions with “Sensei” and his staffs and students.



Today's talk

- Departure Time Choices:
  in the context of the dynamic traffic assignment

- Equilibrium Approach:
  A joint work with Prof. Yoshii at Kyoto University.

- Non-equilibrium Approach

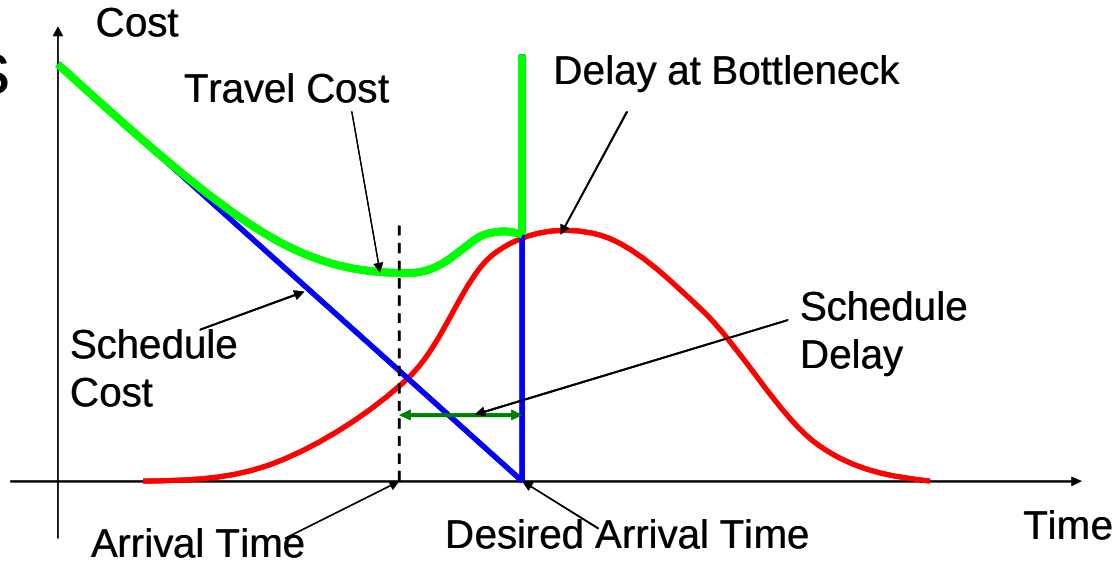
Behaviour vs. Network

- Modelling traveller's behaviour of departure time choices: Behavioural Study (e.g. Small(1982))

- Modelling traveller's interactions through departure time choices under congestion. Network Assignment Study (e.g. Vickrey(1969))

Time choice under congestion

- Define a schedule cost function. (bi-linear or non-linear)
- Define travel cost function, which is the sum of schedule cost and delay cost at a bottleneck.
- Assume travellers choose the departure time with the lowest cost in a day.



Equilibrium or Non-equilibrium?

- [Equilibrium]
  Find traveller's departure time choice pattern satisfying Wardrop's first principle within a day:
  Looking for a temporal equilibrium point

- [Non-equilibrium]
  Construct a day-to-day model and see change of traveller's behaviour over days:
  Simulating a day-to-day dynamics of travellers

Equilibrium

- Many existing studies: e.g. Smith(1984), Daganzo(1985), Newell(1985), Arnott et al. (1993 and others), Lindsey(2004).
- My contribution with Prof. Yoshii
  - There is an optimization problem that is equivalent to the equilibrium condition.
  - Total schedule cost of travellers is minimized in equilibrium.
  - The model is applicable to the more general situation; “single-bottleneck-per-route”.

Iryo, T. and Yoshii, T., Equivalent Optimization Problem for Finding Equilibrium in the Bottleneck Model with Time Choices, in *Mathematics in Transport*, B.G. Heydecker, ed., Elsevier: Oxford, p. 231-244, 2007.

Traveller's choice
(route and arrival time)

Schedule cost
(incl. detour cost)

Minimize $\sum_{\text{all } i,j} X_{(i,j)} T_{(i,j)}$

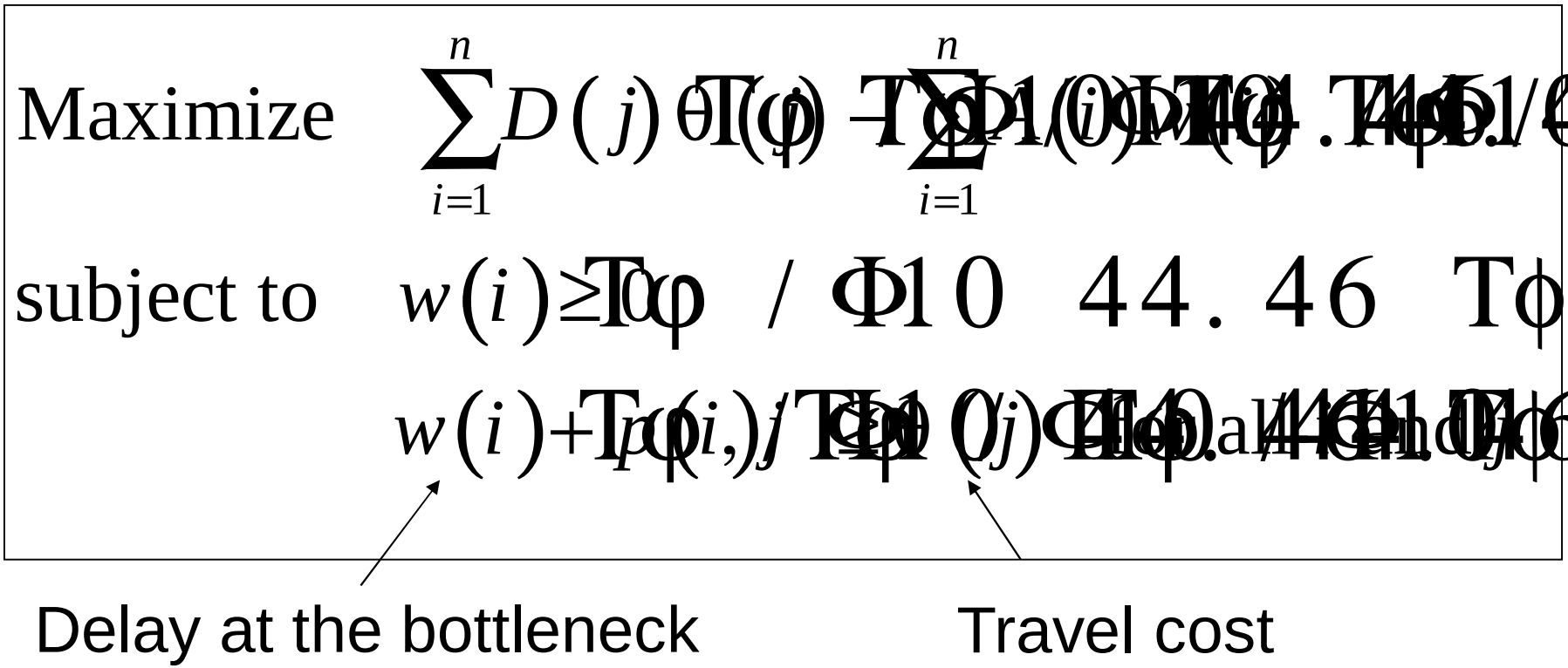
Subject to:

$\sum_{\text{all } j} X_{(i,j)} \le A_{(i)}$ Capacity Constraint

$\sum_{\text{all } i} X_{(i,j)} = D_{(j)}$ Demand Constraint

$X_{(i,j)} \ge 0$ Non-Negative Constraint

The KKT condition of the optimization problem is equivalent to the Wardrop's first principle.



The dual problem can solve delays at bottlenecks;
delays are the dual variable of the primal problem.

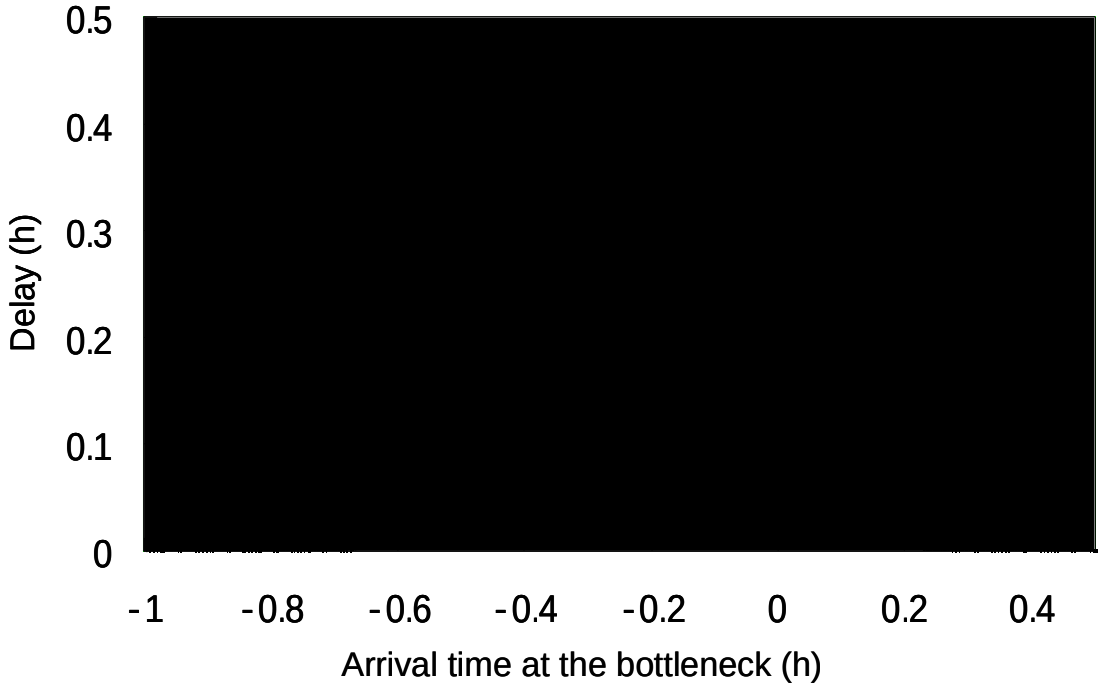
Day-to-day dynamics

- A simple day-to-day dynamics is constructed after Smith(1984) and Mounce(2006).
- Travellers move towards a choice with smaller cost gradually.
- A system converges to equilibrium if travel cost function is monotone increase against number of travellers; it is normal in traffic assignments which is not dynamic.

Day-to-day dynamics

- Monotonicity of travel cost is not guaranteed where travellers are faced to a schedule constraint, especially when they try to arrive on tine.

- Behaviour of travellers do not converge to equilibrium in some cases.



Iryo, T., An Analysis of Instability in a Departure Time Choice Problem, *Journal of Advanced Transportation*, 42(3), p. 333-356, 2008.

From system to behaviour

- Equilibrium: Simple.
  Good characteristic (equivalent to optimization)

- Equilibrium is not stable, may not be achieved??

- What is the meaning of equilibrium?
  How travellers behave under non-equilibrium situation?

- Behavioural viewpoint might be demanded to think of the meaning of equilibrium.