Simple model for urban traffic between two signalized intersections

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Outline

Motivation
Move from HŘSD

HŘSD $\Rightarrow$ NOMŘÍZ: Better sampling, better information about model

Current status:

- Model updated for sampling interval 5-10 s
- Waiting for the new version of micro-simulator
- Industrial partner questions the need for high sampling rate

HŘSD

Macro-level model – queue equation

Queue development

$$\xi_{i,k+1} = \delta_{i,k}\xi_{i,k} + (\delta_{i,k}S_i + (1-\delta_{i,k})I_{\text{in},i,k})z_{i,k} + I_{\text{in},i,k}$$

$\xi \ldots$ queue length, $\delta \ldots$ saturation flag, $\delta \in \{0,1\}$, $z \ldots$ relative green length

Equation assumes uniform arrivals – works well for boundary nodes, too simple for interior nodes.

Upstream intersections siginificantly influence arrival traffic flow.

NOMŘÍZ
The proposed model

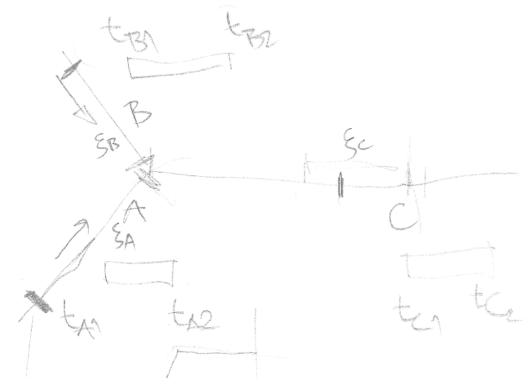
Vehicle movements in the real world are quite complex and difficult to model.

We will simplify the behaviour of vehicles to the maximum possible extent

- we will not take into account acceleration and deceleration
- we will classify the movements of vehicles into two classes:
    1. stopped vehicle, waiting in a queue, and
    2. vehicle moving with a constant speed of passage v.

Building the model

Basic building block



Building the model

Basic building block

Basic building block of the system is a simple ramp function defined by its vector of parameters $\theta = (x_1, x_2, y_1, y_2)$ as

$$\rho(x, \theta) = \rho(x, x_1, x_2, y_1, y_2) =$$

$$= \begin{cases} y_1 & \text{if } x \leq x_1 \\ y_1 + (x - x_1)\frac{y_2 - y_1}{x_2 - x_1} & \text{if } x_1 < x < x_2 \\ y_2 & \text{if } x \geq x_2 \end{cases}$$

Building the model

Computing capacity

Given a signal plan timing, capacity $c_{i,l}$ of a lane l at intersection i can be then computed as

$$c_{i,l}(t) = \rho(t, t_{\mathrm{on},i,l}, t_{\mathrm{off},i,l}, 0, \frac{S_{i,l}}{3600})$$

where $t_{\mathrm{on},i,l}$ and $t_{\mathrm{off},i,l}$ denote beginning and end time of the green signal in the signal plan cycle in seconds, and $S_{i,l}$ stands for the saturation flow of the lane in vehicles per hour.

Building the model

Demand function at the boundary

The cumulative demand volume $d_{i,l}(t)$ may be described in a similar manner for all incoming lanes of an intersection that is situated on the boundary:

$$d_{i,l}(t) = \rho(t, 0, T_{\mathrm{c}}, 0, D_{i,l}).$$

Here, T_{c} is the signal plan cycle length and $D_{i,l}$ is the count of vehicles arriving during that cycle from the outside.

Building the model

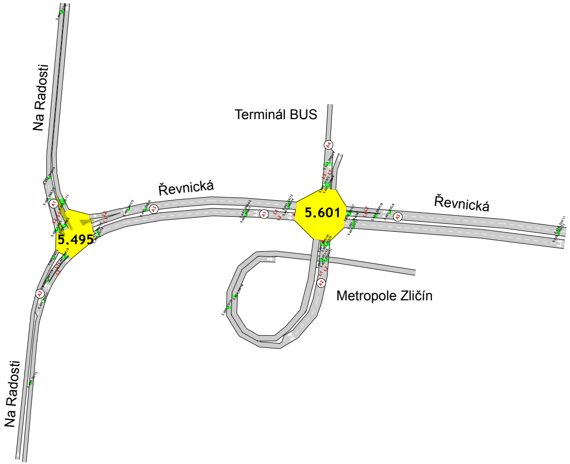
Demand function at the boundary

For all downstream intersections, the demand volume is given as a sum of several ramp functions which define partial volumes arriving from all possible lanes of their upstream intersections $\mathcal{U}_{i,l}$:

$$d_{i,l}(t) = \sum_{j,n \in \mathcal{U}_{i,l}} v_{j,n}(t).$$

$$c = \sum_{i \in L} \rho(t_{\mathrm{on},i}, t_{\mathrm{off},i}, S_i)$$

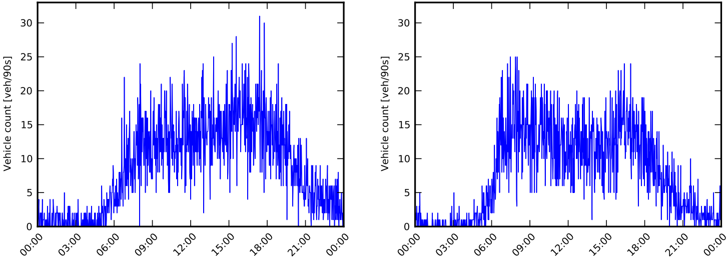
Experiment
One lane on Zličín



Experiment

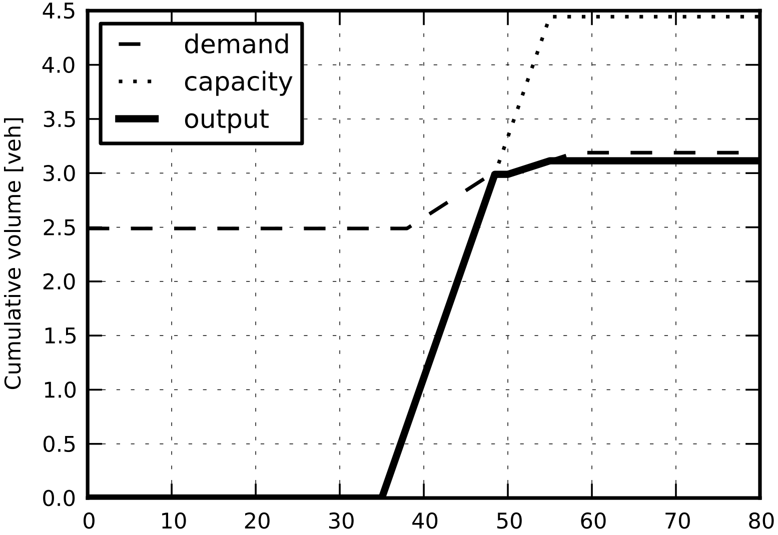
One lane on Zličín

Input flows (2007 data)

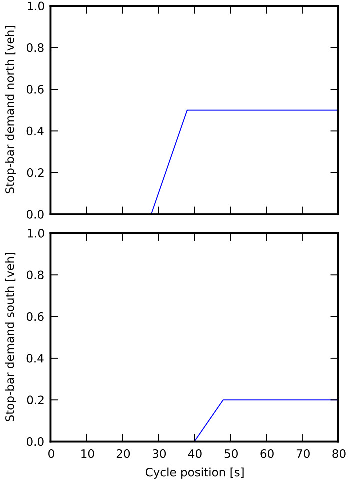


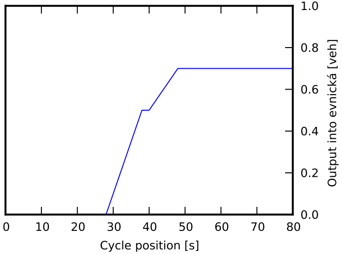
Experiment

Composition of the queue at C

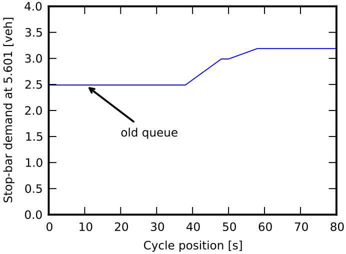


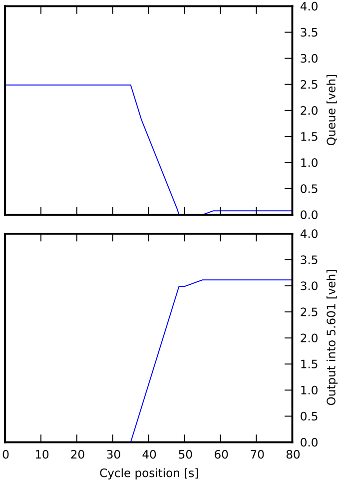
Experiment
Inputs





Experiment
Outputs





Further work

Thorough simulation

Better arrival models

Cycle reaching over T_c, i.e. $t_1 > t_2$

Quantisation of vehicle output – only integers allowed (russian roulette?)

Extension to multi-lane approach

Filtration based on measurements

Control synthesis