Real-time queue length estimation: Implementation and limitations

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CE 291

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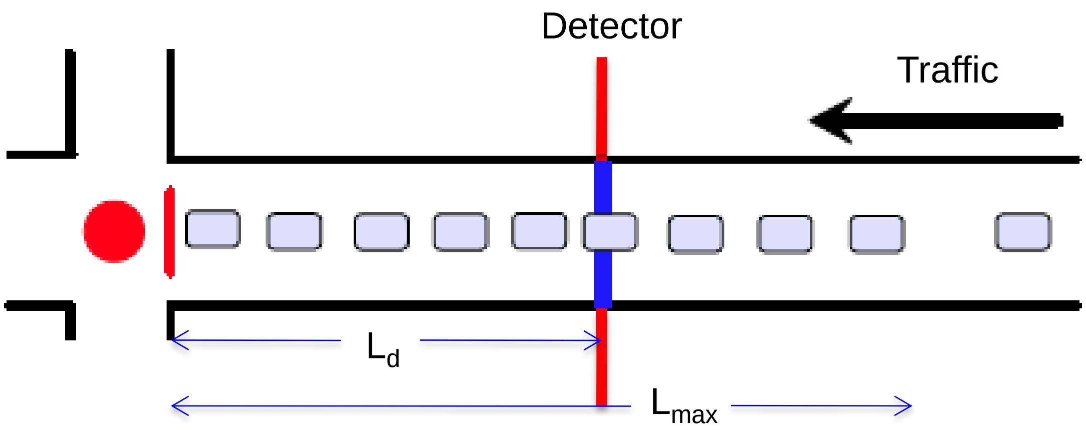
The Queue Length Problem



Existing models in literature:
- Input-output to signal link
- LWR shockwave theory based on arrival information

However, *these models do not take into account cases when queue becomes so long that it spills past the detectors.*

LWR Shockwave Theory

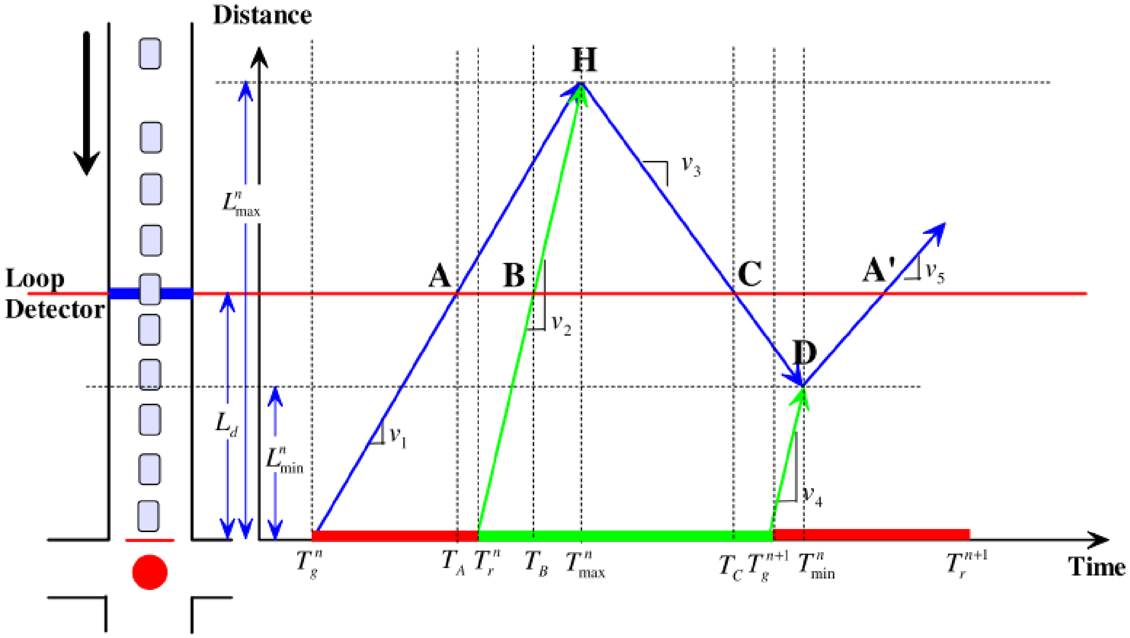


Figure 1. Break points A, B, C and traffic shockwaves at an intersection (Liu et al., 2009)

queuing wave, v_1
discharge wave, v_2
departure wave, v_3
compression wave, v_4

Queue Length Estimation

$$v_1 = \frac{0 - q_a^n}{k_j - k_a^n}$$

$$v_2 = \frac{q_m - 0}{k_m - k_j}$$

$$v_3 = \frac{q_m - q_a^n}{k_m - k_a^n}$$

$$\begin{cases} L_{\max}^n = L_d + (T_C - T_B) \Big/ \left(\frac{1}{v_2} + \frac{1}{v_3}\right) \\ T_{\max}^n = T_B + (L_{\max}^n - L_d)/v_2 \end{cases}$$

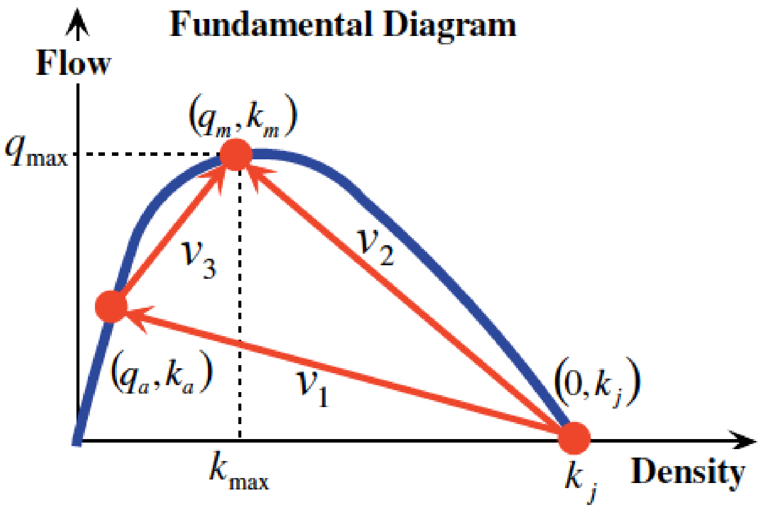
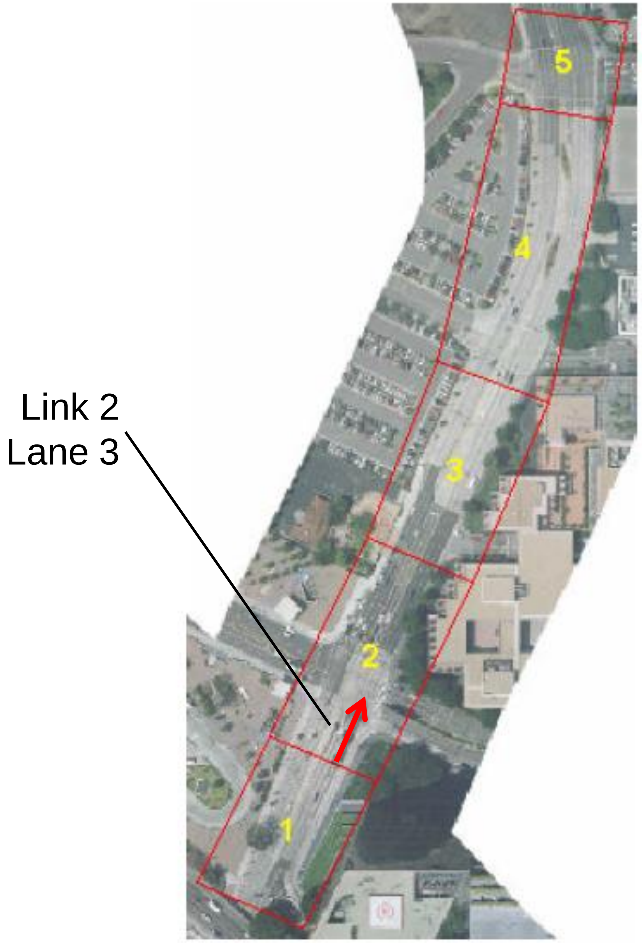
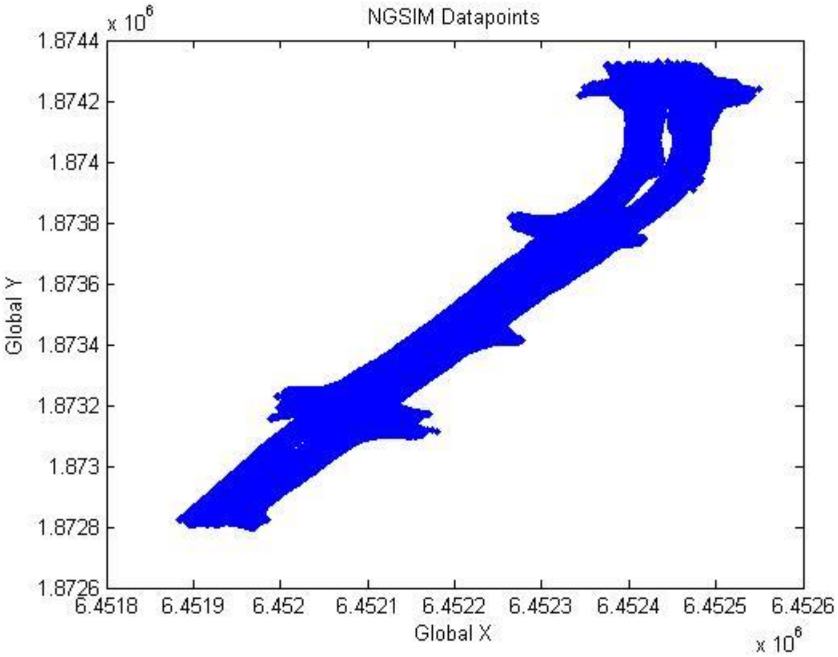


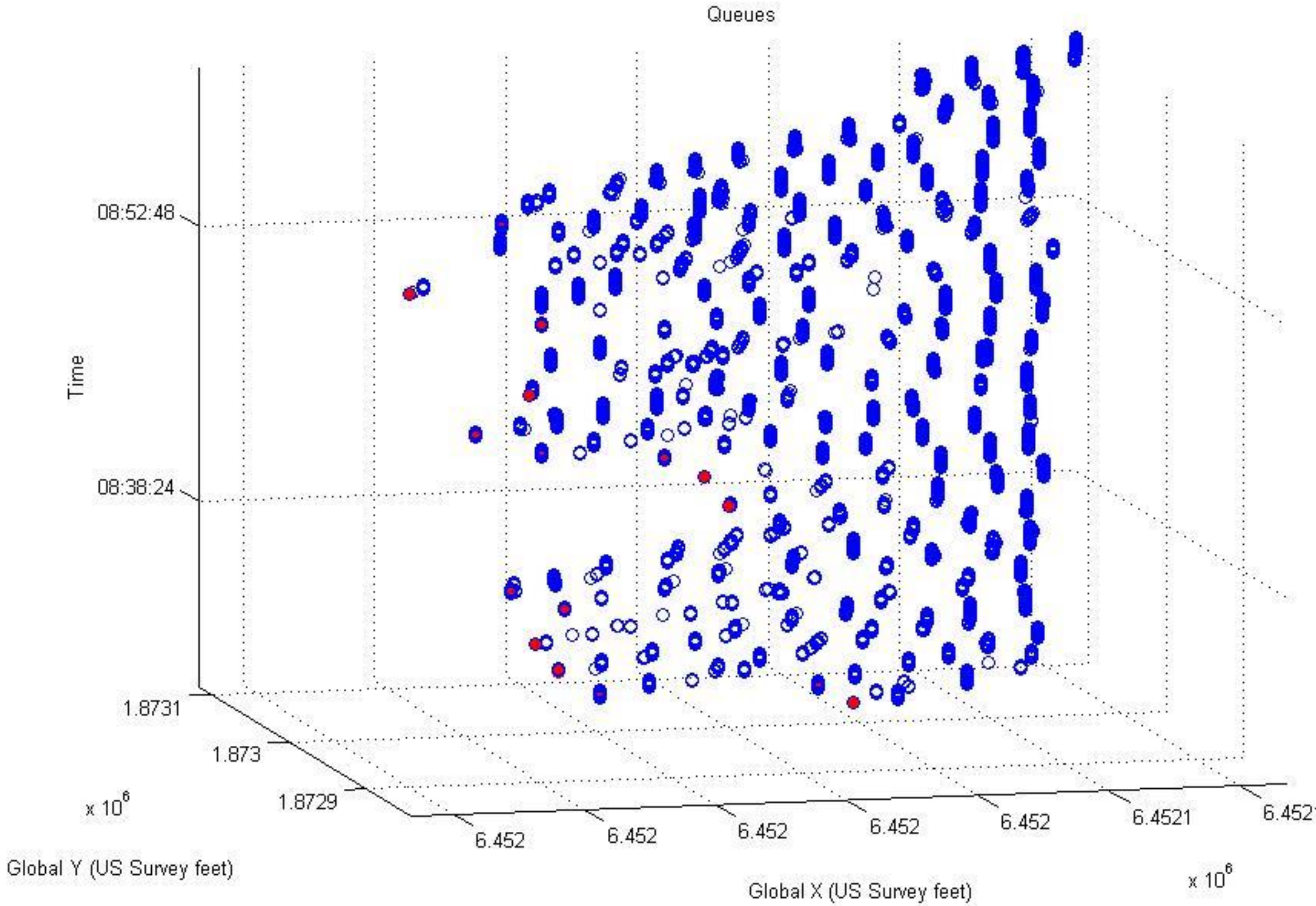
Figure 3. Greenshield's fundamental diagram (Liu et al., 2009)

NGSIM Data


Link 2
Lane 3
5
4
3
2
1


NGSIM Datapoints
x 10^6
1.8744
1.8742
1.874
1.8738
1.8736
1.8734
1.8732
1.873
1.8728
1.8726
Global Y
6.4518
6.4519
6.452
6.4521
6.4522
6.4523
6.4524
6.4525
6.4526
Global X
x 10^6

Queues


Queues
Time
08:52:48
08:38:24
1.8731
1.873
1.8729
x 10^6
Global Y (US Survey feet)
6.452
6.452
6.452
6.452
6.452
6.4521
6.4521
x 10^6
Global X (US Survey feet)

Detector Occupancy & Time Gap: Theoretical

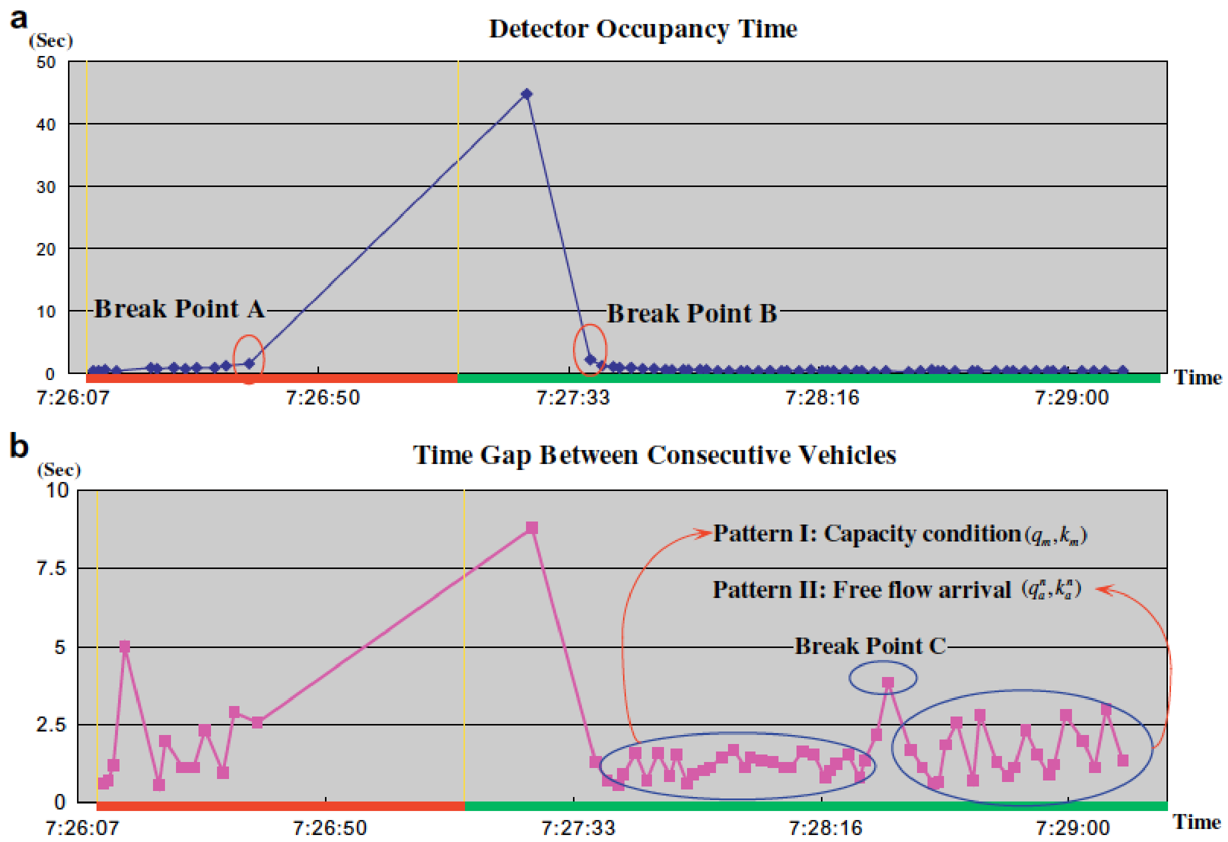
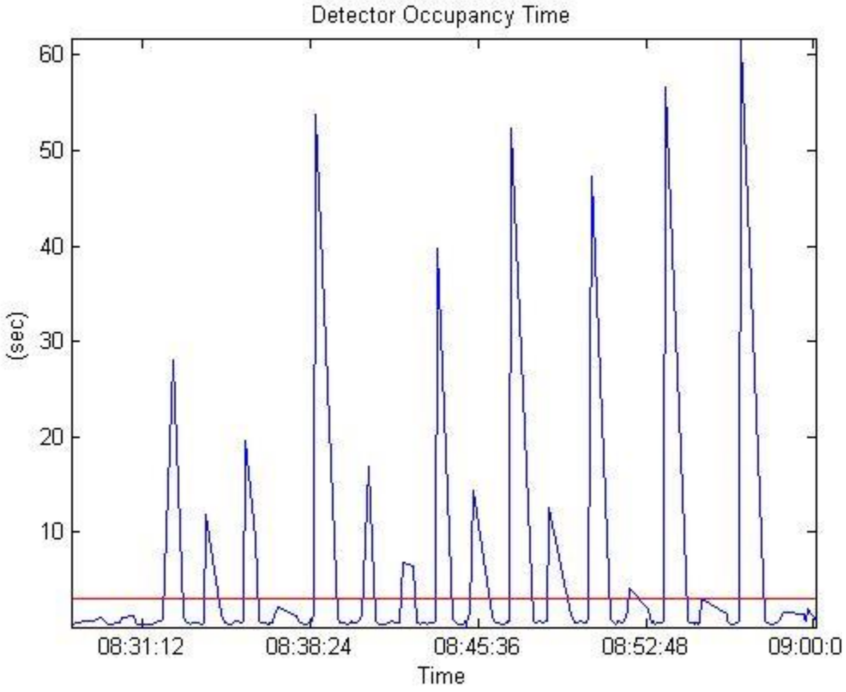
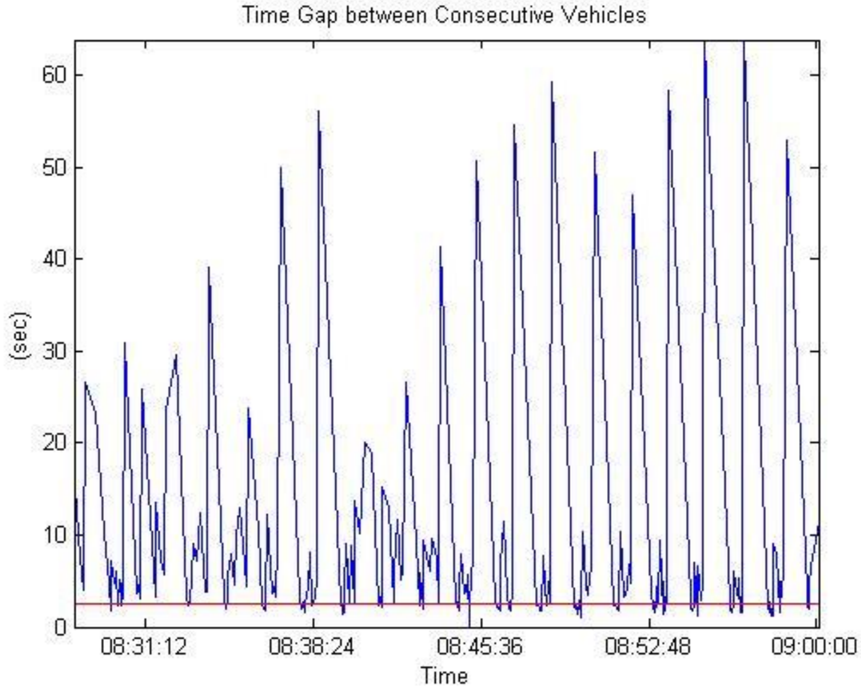


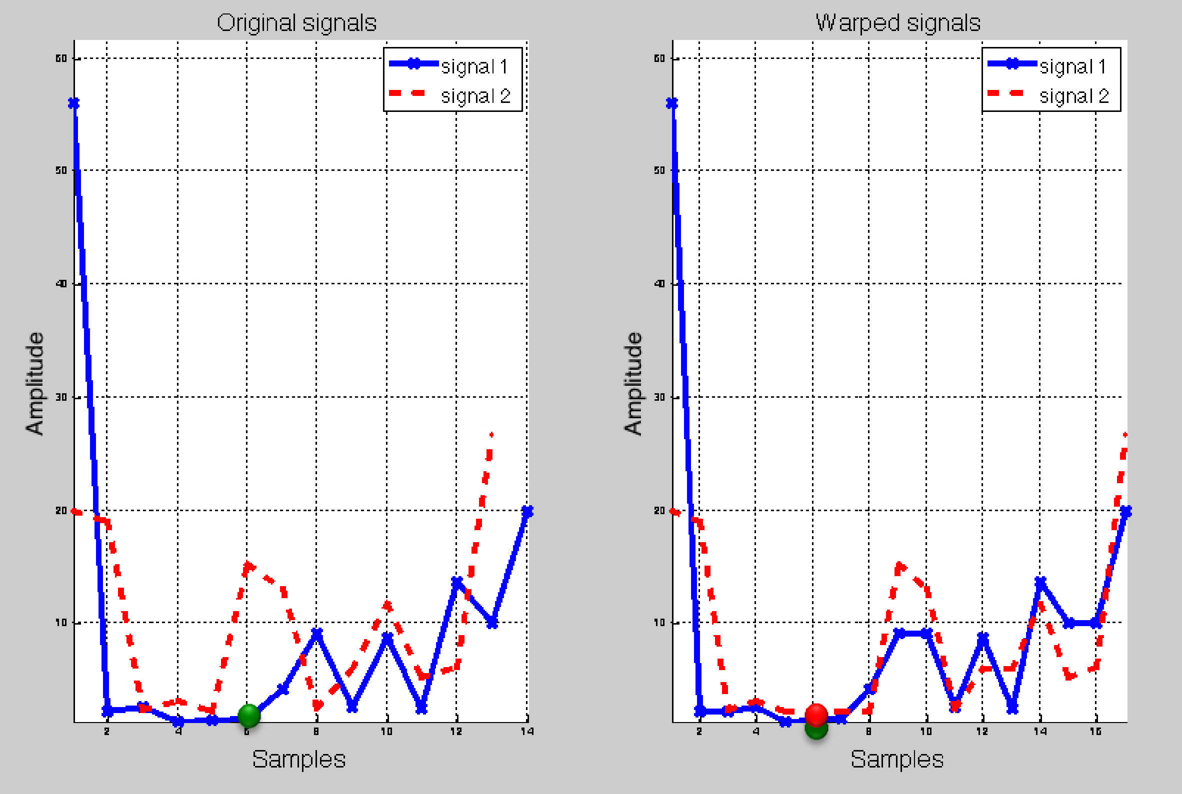
Figure 2. (a) Detector occupancy profile and (b) time gap between consecutive vehicles (Liu et al., 2009)

Detector Occupancy & Time Gap: Actual



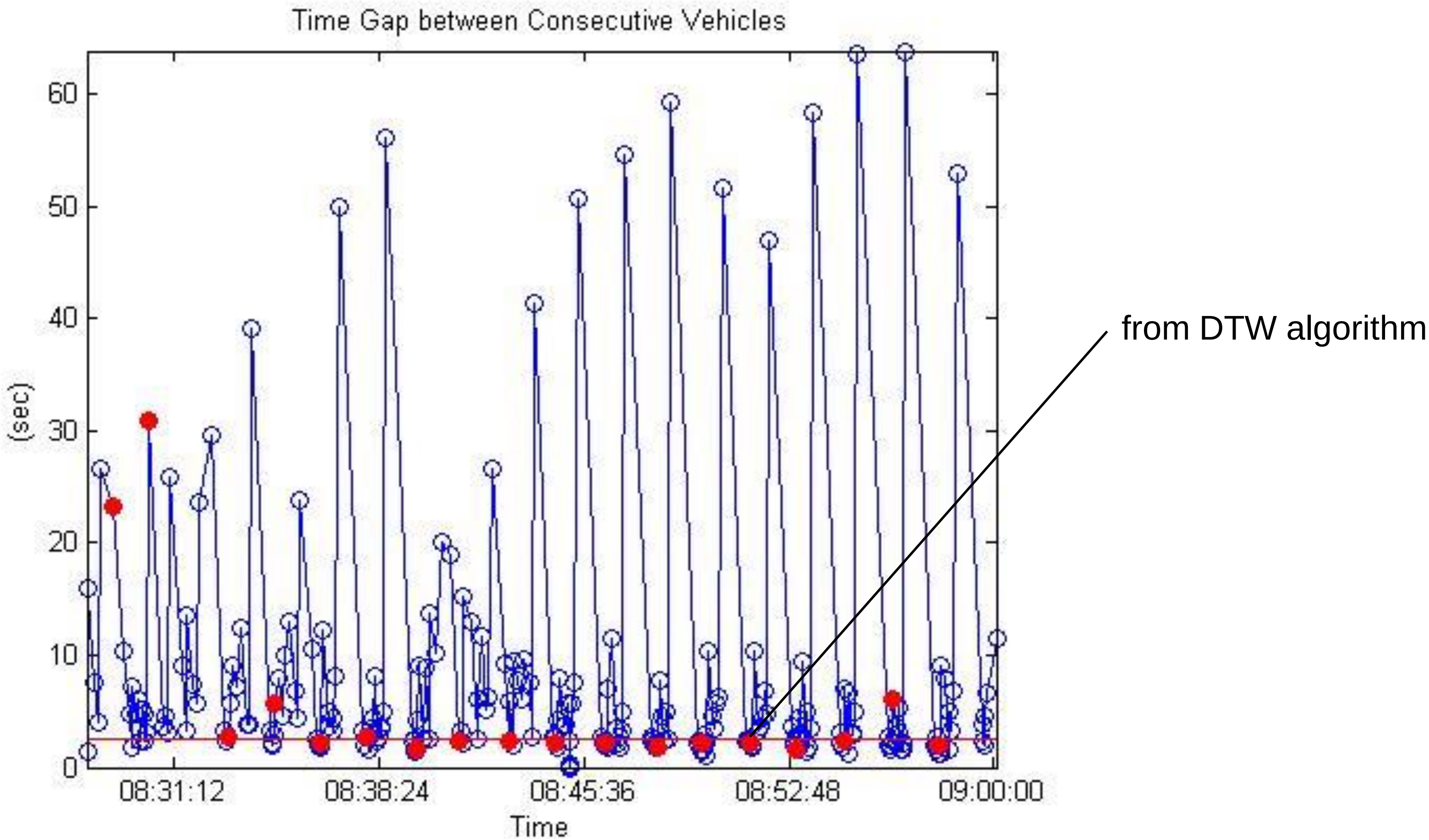


Dynamic Time Warping Algorithm

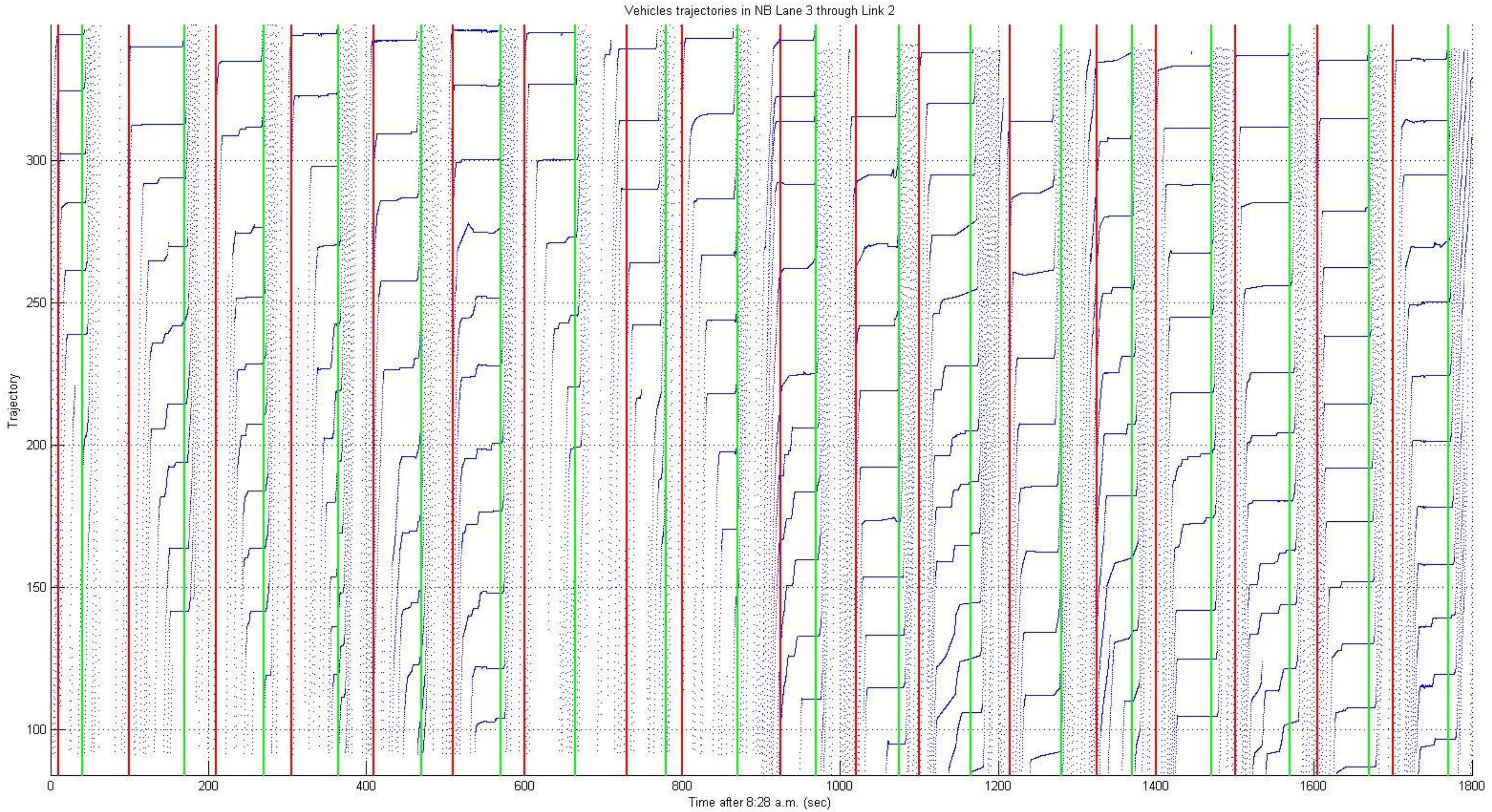


Dynamic time warping is an algorithm that detects similarity between two time-series signals. It computes the optimal match between two signals based on similarities in patterns.

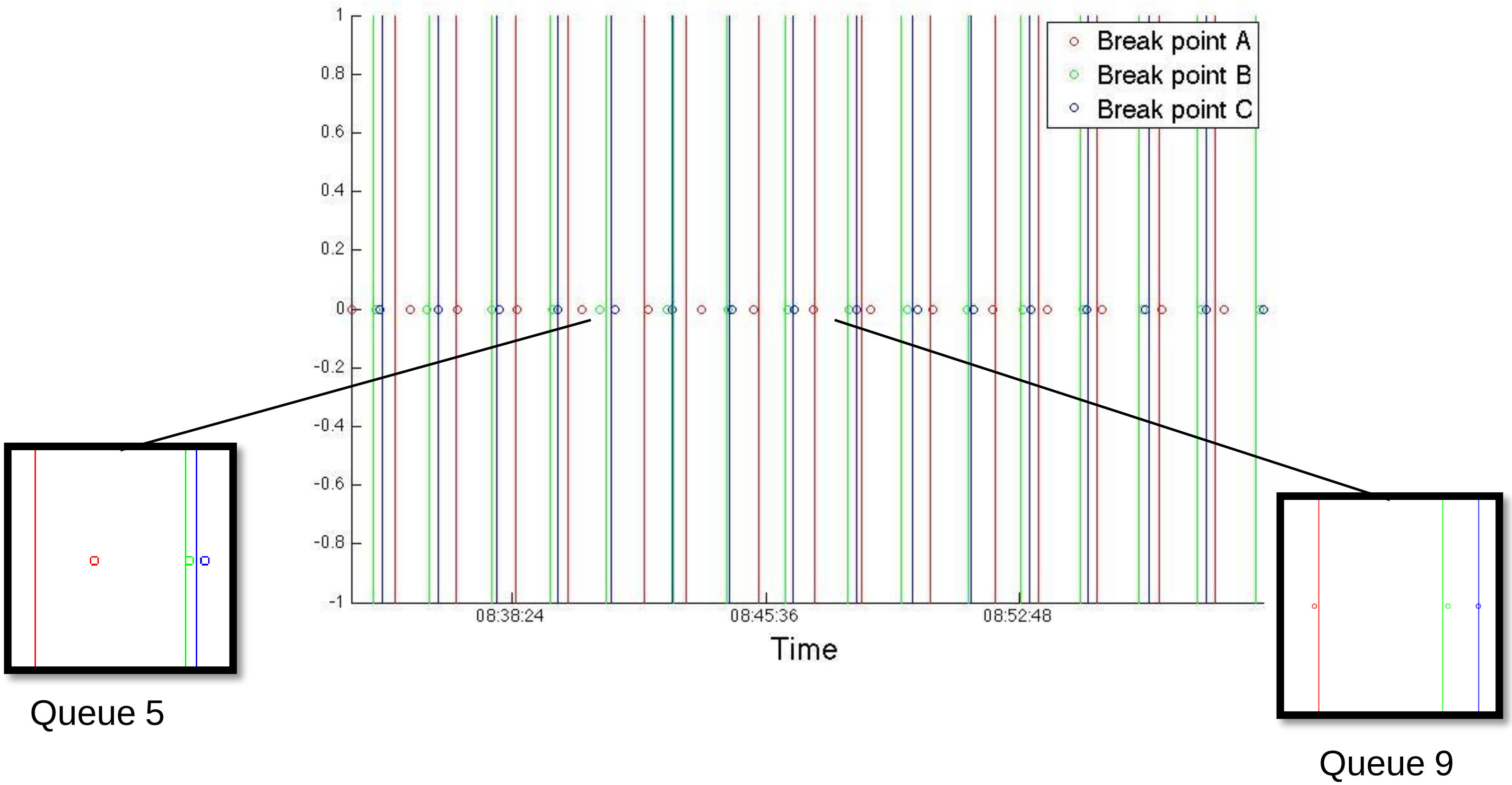
Time Gap with Break Point C



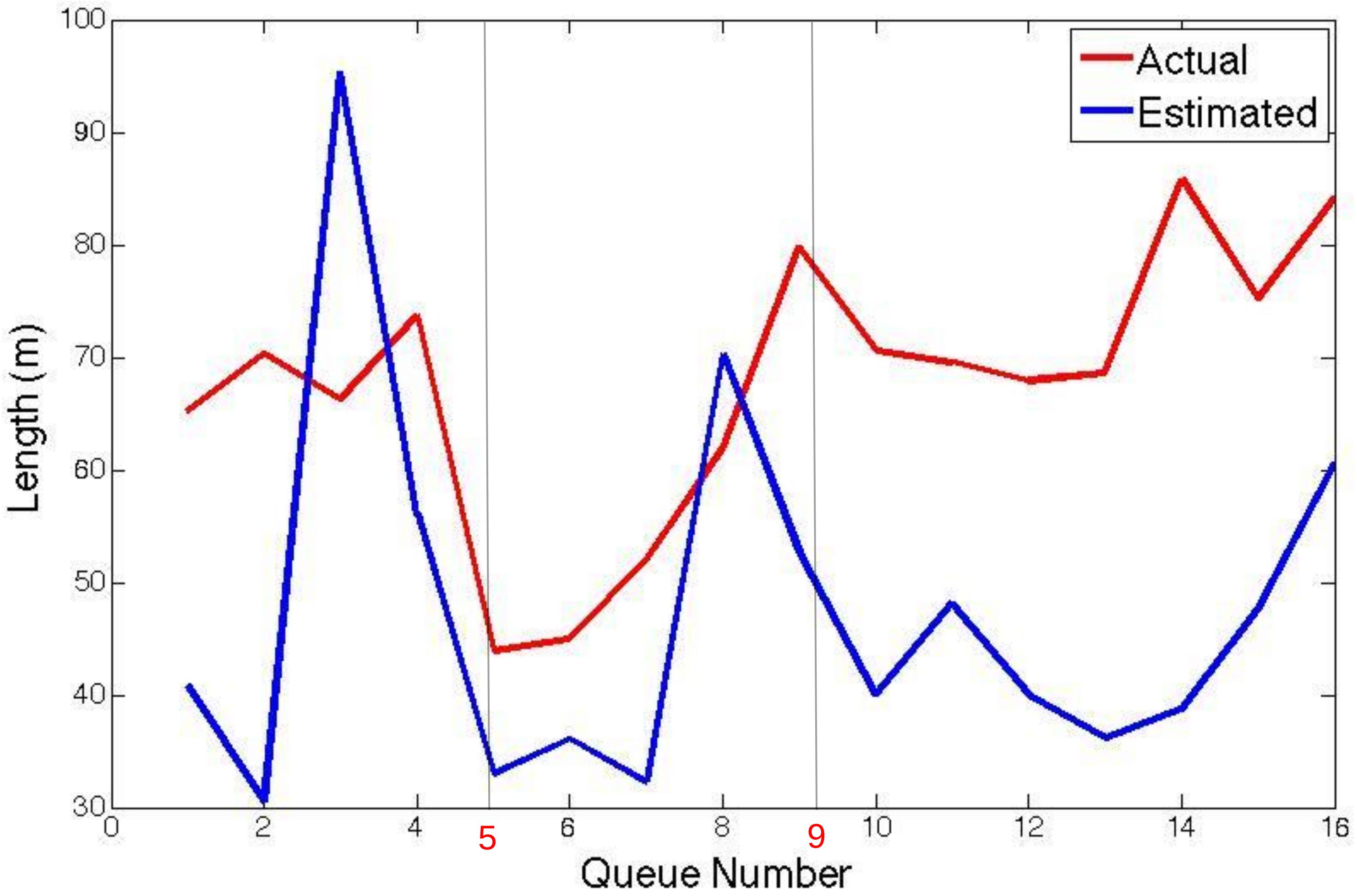
Signal Timing



Signal Timing



Theoretical vs. Actual



Limitations of the model

Errors in detector occupancy time, time gap and speed estimation.

Liu et al. explicitly mention that the proposed model works properly when break point C is correctly identified – are there better ways to do this than using the dynamic time warping algorithm?

Cases of oversaturation and downstream queue spillover.