



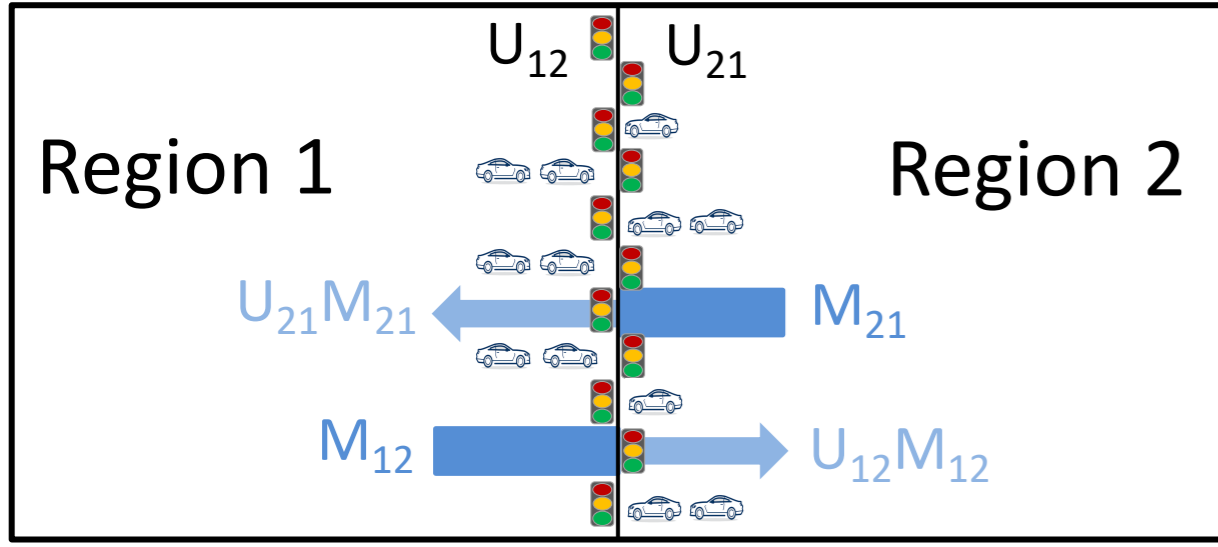
# Integrating the Dynamics of Boundary Queues in Perimeter Flow Control

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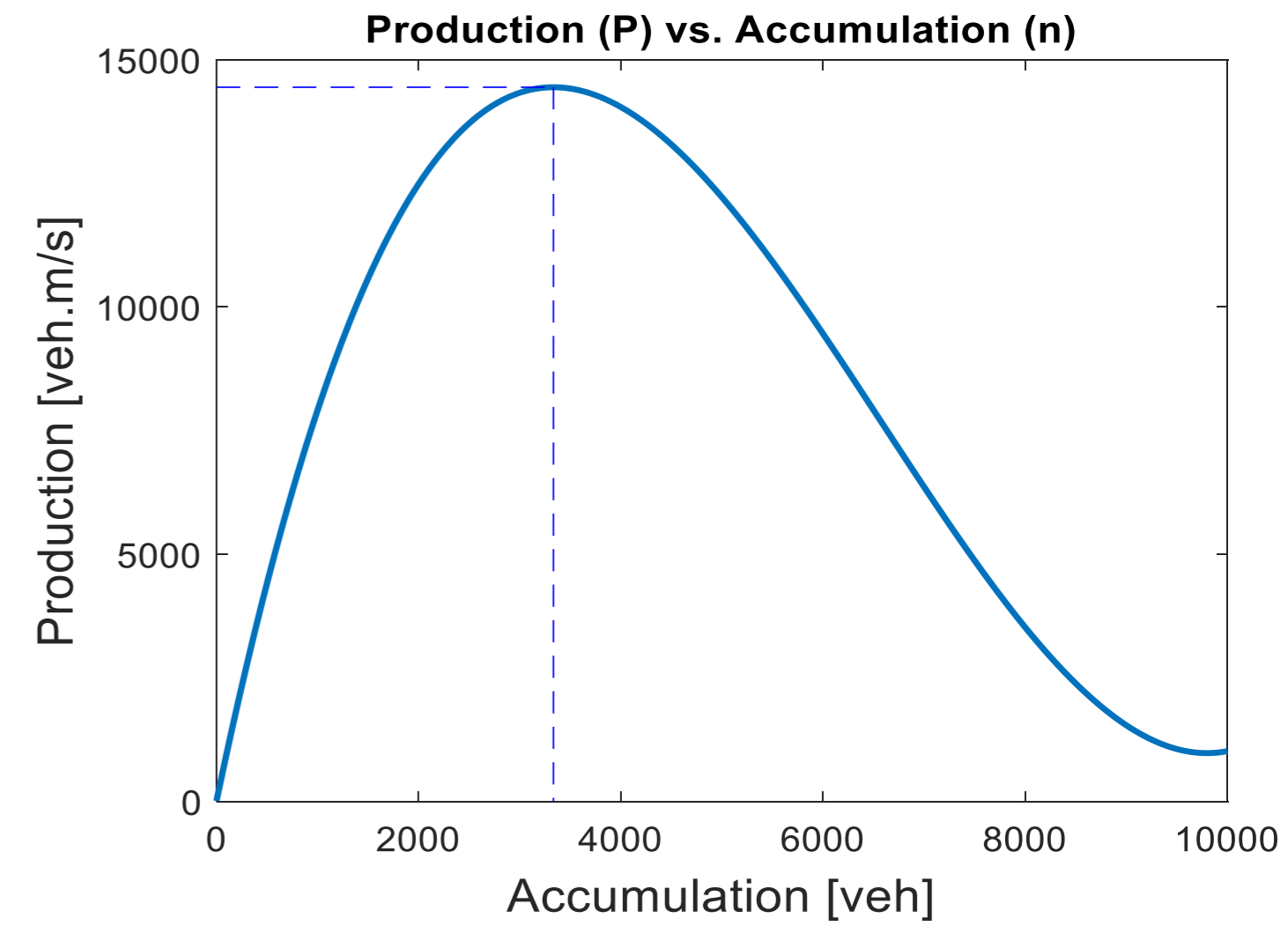
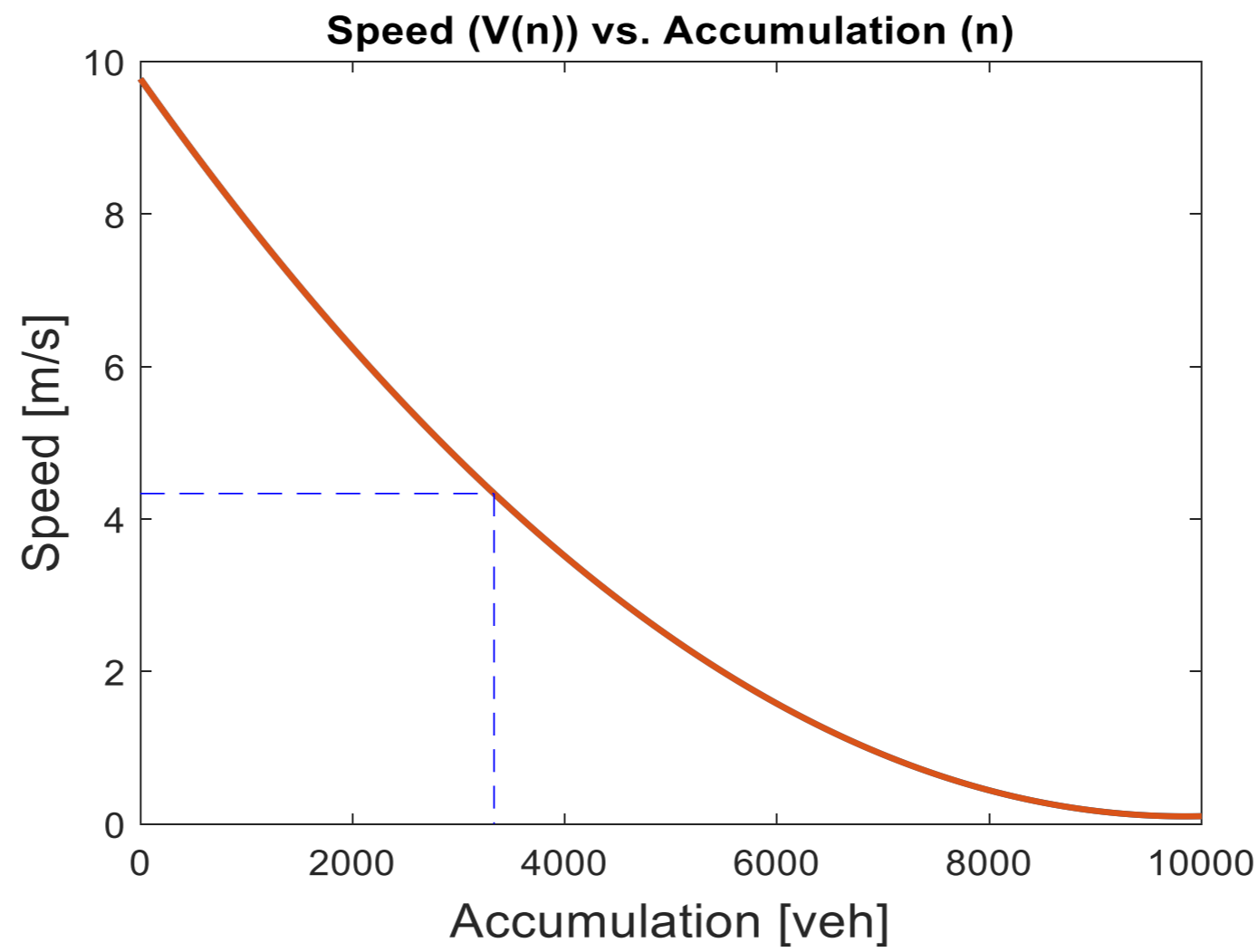
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## INTRODUCTION



### Perimeter Flow Control:

Monitors vehicle density in a protected region and manipulates the traffic inflow to the protected region to regulate vehicle accumulation under a certain value.



## METHODOLOGY

### Pseudo-code of Trip-based MFD Model

```

Initialize information of each vehicle i, [Origin, Destination,
current status, L, t_dep, t_Q, t_LQ, t_arr]
current_speed_I = V(N_I), current_speed_J = V(N_J)
for all vehicles (i), do
    event_list ← t_dep, assigned departure time
    event_list ← t_Q
    event_list ← t_LQ
    event_list ← t_arr
end for
Sort event_list
while there are events in the event list do
    current_time ← the 1st event occurs time
    for All current traveling vehicles do
        % vehicles travel inside a region
        L_II ← L_II - V(N_II)(current_time - previous_time)
        % vehicles travel between regions
        L_IJ ← L_IJ - V(N_IJ)(current_time - previous_time)
        L_JJ ← L_JJ - V(N_JJ)(current_time - previous_time)
    end for
    if The 1st event is vehicle departure or arrival then
        N_T ← N_T + 1 % vehicle departure
        N_T ← N_T - 1 % vehicle arrival
    else The 1st event is vehicle join or leave queue
        N_Q ← N_Q + 1 % join queue
        N_Q ← N_Q - 1 % leave queue
    end if
    Re-scale MFD
    Update current_speed_I and current_speed_J
    for current traveling vehicles do
        Update the time of join queue, leave queue,
        and arrival based on new speed
    end for
    remove the 1st event in the event_list
    save the current states for next iteration
end while

```

### Trip-based MFD Model

$$l_{11}^i = \int_{t_{dep}^i}^{t_{arr}^i} V_1(N_1^T(t), N_1^Q(t)) dt$$

$$l_{12}^i = \int_{t_{dep}^i}^{t_{Q1}^i} V_1(N_1^T(t), N_1^Q(t)) dt, \quad l_{22}^i = \int_{t_{LQ1}^i}^{t_{arr}^i} V_2(N_2^T(t), N_2^Q(t)) dt$$

$$l_{21}^i = \int_{t_{dep}^i}^{t_{Q2}^i} V_2(N_2^T(t), N_2^Q(t)) dt, \quad l_{11}^i = \int_{t_{LQ2}^i}^{t_{arr}^i} V_1(N_1^T(t), N_1^Q(t)) dt$$

$$l_{22}^i = \int_{t_{dep}^i}^{t_{arr}^i} V_2(N_2^T(t), N_2^Q(t)) dt$$

### Accumulation-based MFD Model

$$\frac{dN_{11}(t)}{dt} = Q_{11}(t) - \frac{\gamma_1(t)P_1(N_1(t))}{L_{11}}\theta_1(t) + U_{21}(t)(1 - \theta_2(t))\frac{\gamma_2(t)P_2(N_2(t))}{L_{21}}$$

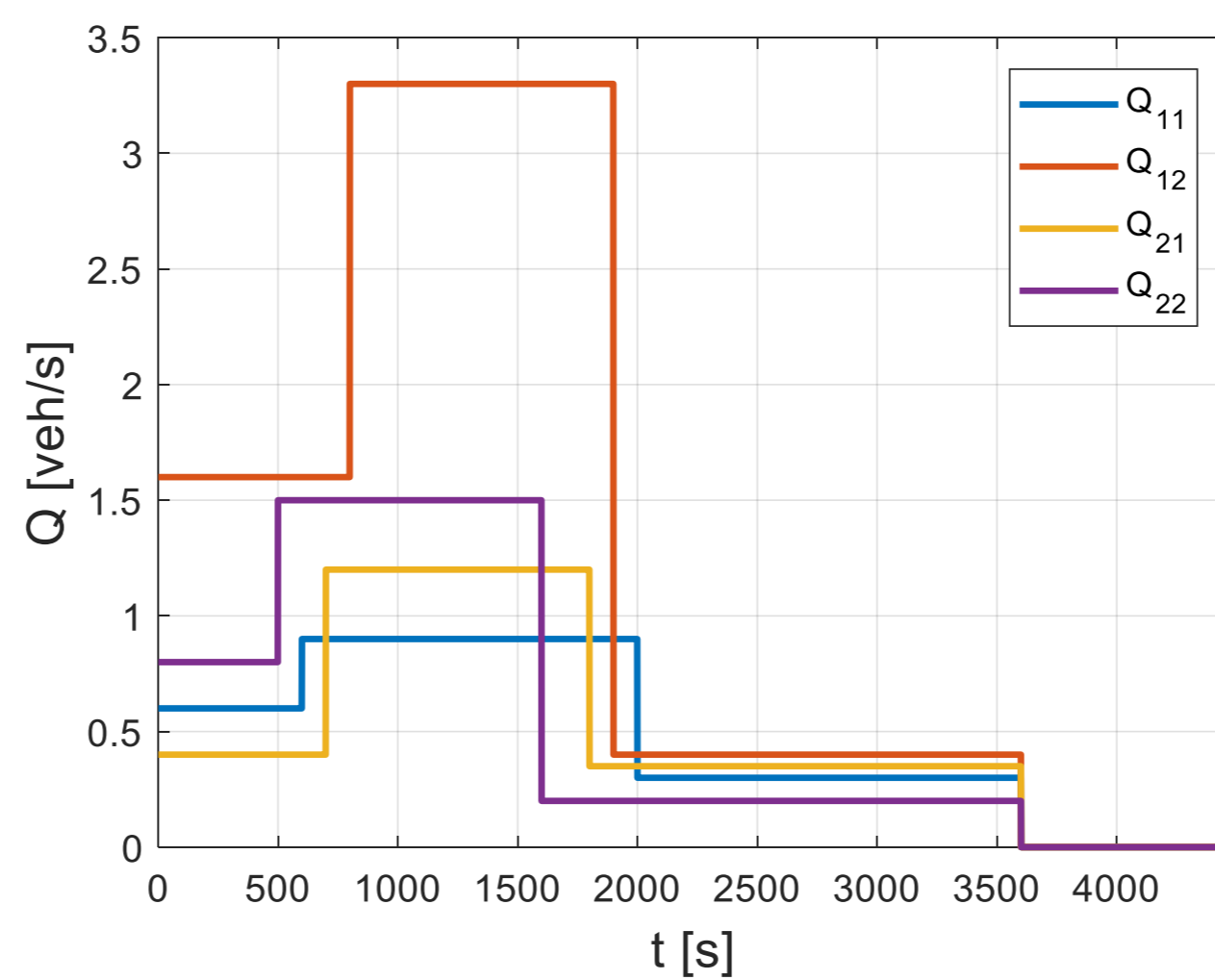
$$\frac{dN_{12}(t)}{dt} = Q_{12}(t) - \frac{\gamma_1(t)P_1(N_1(t))}{L_{12}}(1 - \theta_1(t))U_{12}(t)$$

$$\frac{dN_{21}(t)}{dt} = Q_{21}(t) - \frac{\gamma_2(t)P_2(N_2(t))}{L_{21}}(1 - \theta_2(t))U_{21}(t)$$

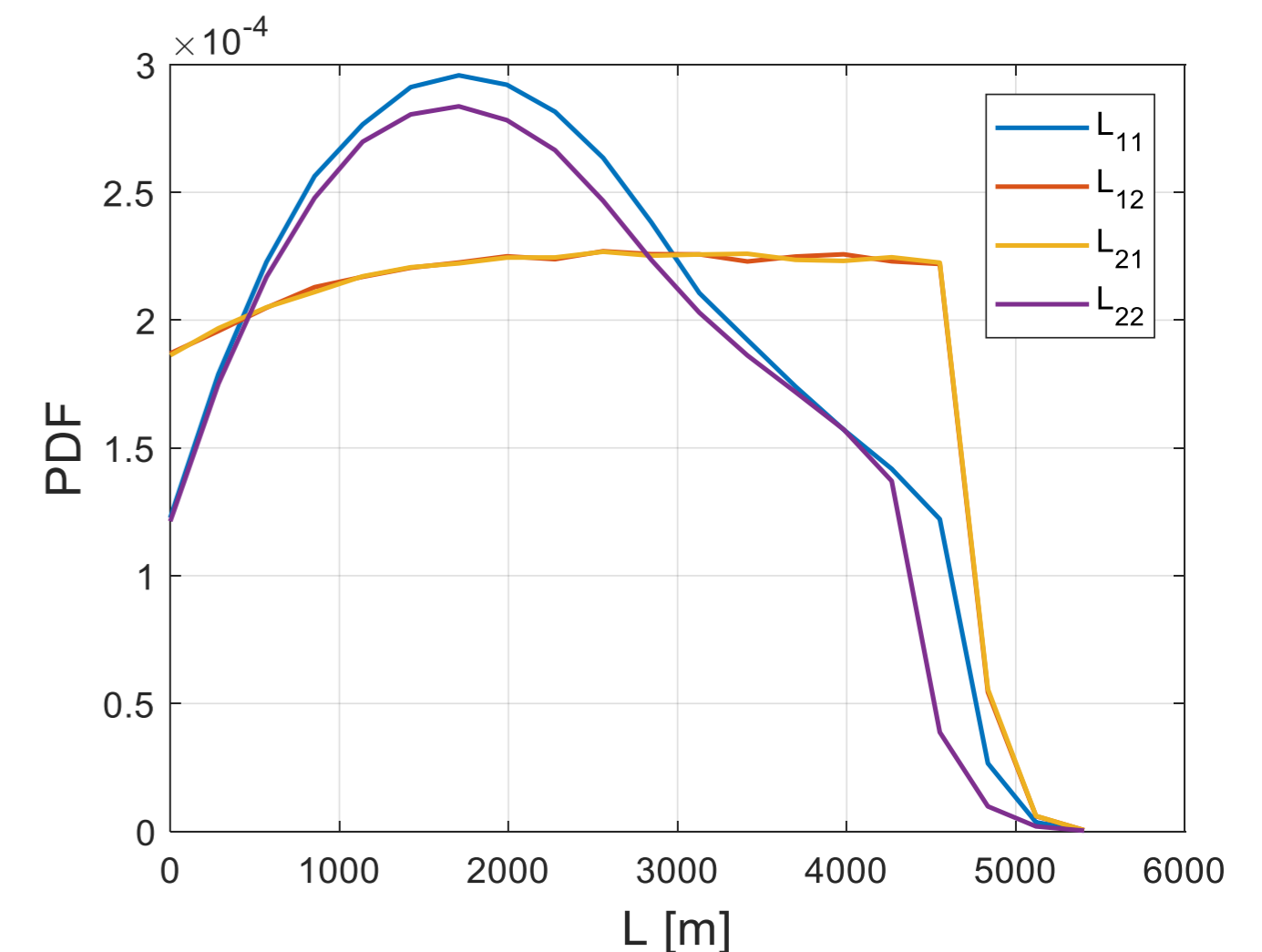
$$\frac{dN_{22}(t)}{dt} = Q_{22}(t) - \frac{\gamma_2(t)P_2(N_2(t))}{L_{22}}\theta_2(t) + U_{12}(t)(1 - \theta_1(t))\frac{\gamma_1(t)P_1(N_1(t))}{L_{12}}$$

## CASE STUDY

### Simulation Inputs

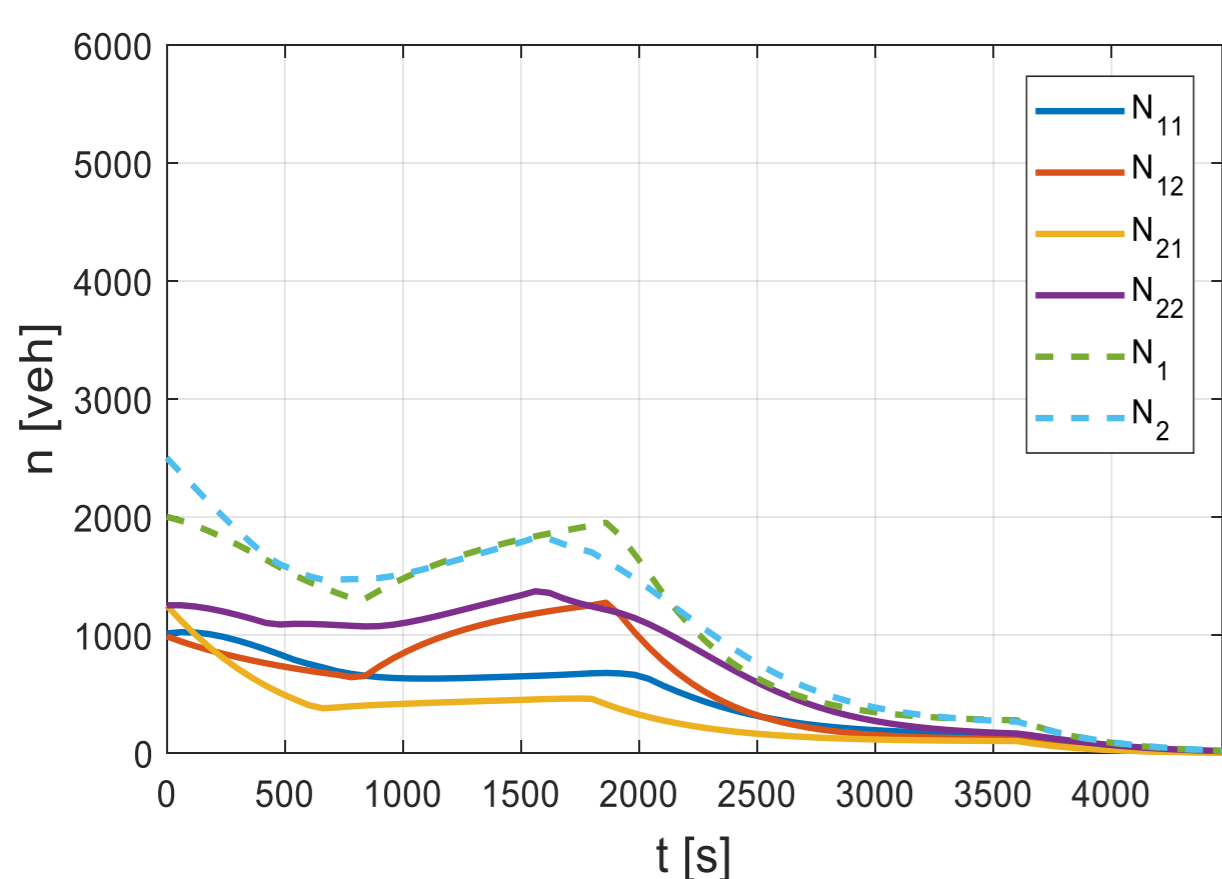


(a) Demands

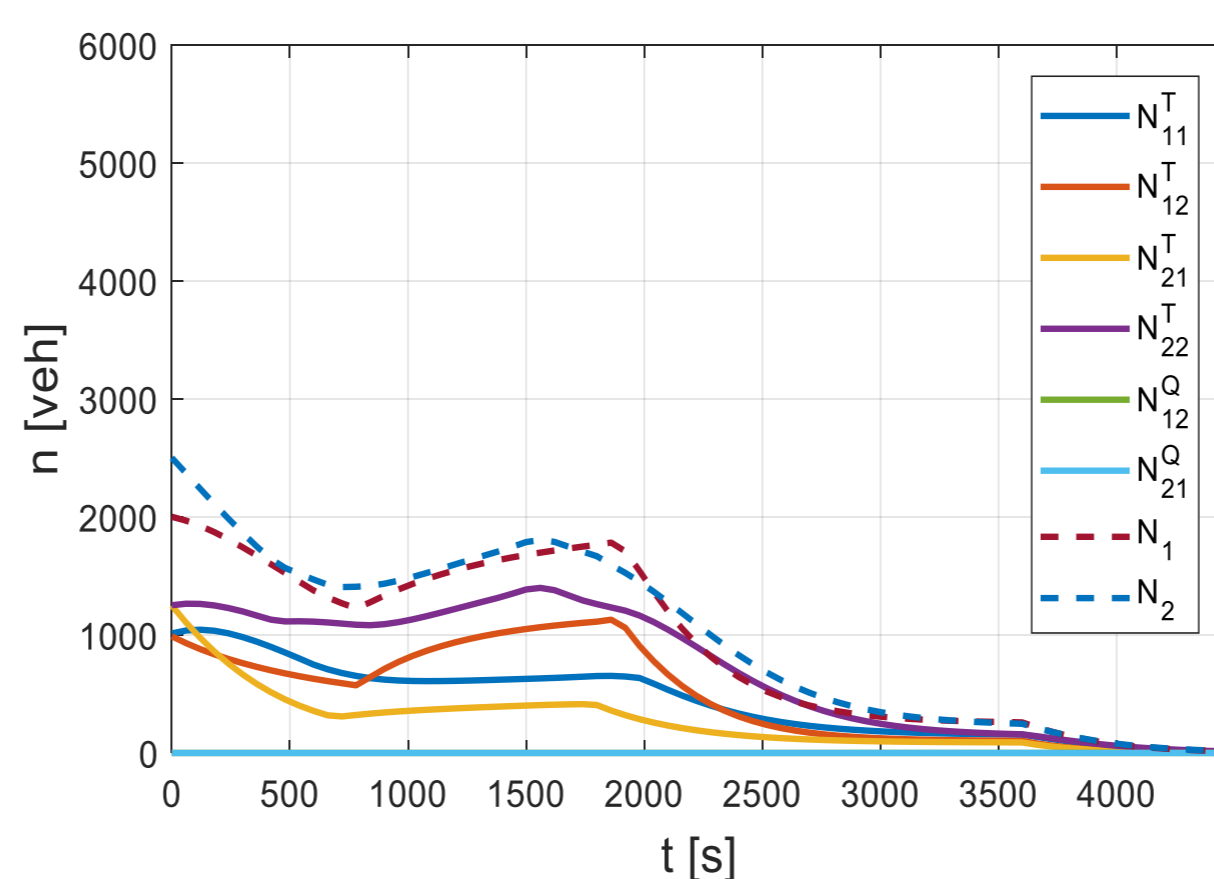


(b) Trip Length Distribution

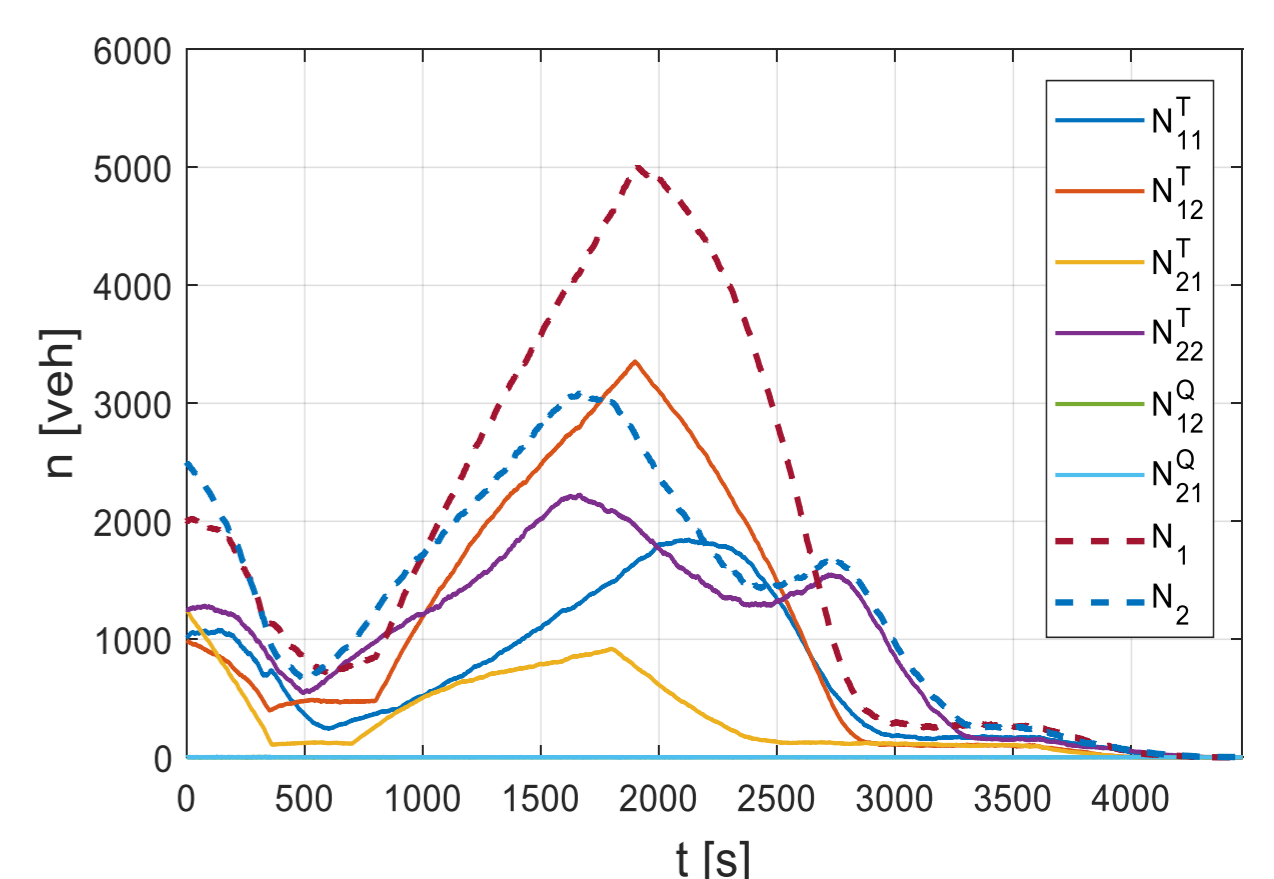
### Accumulation Evolution



(c) Accumulation-based Model without Queue



(d) Accumulation-based Model with Queue



(e) Trip-based Model