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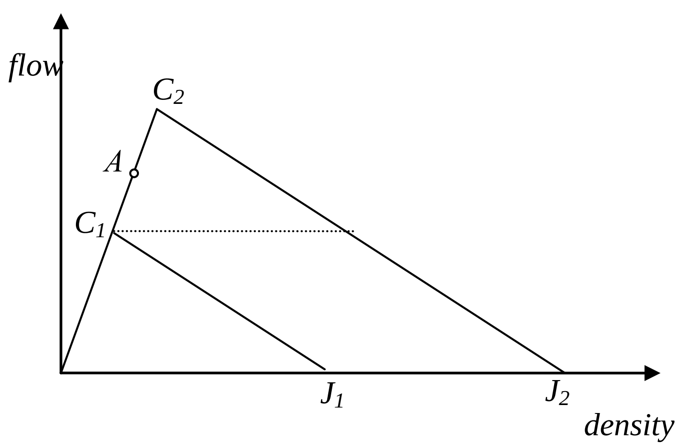
Traffic Engineering (CIV-349)

Additional notes

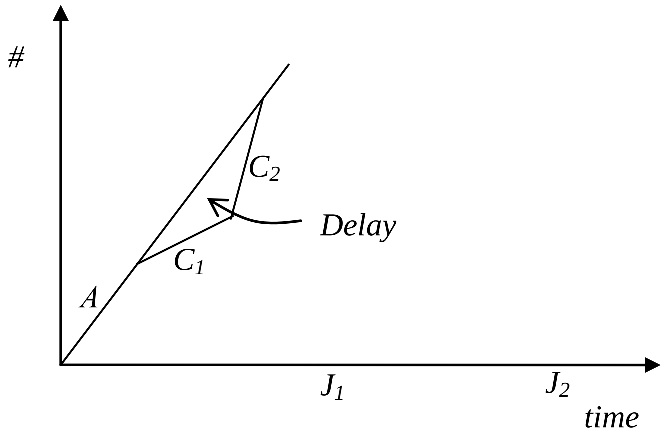
- **Input-Output Curves (An example)**
- **Back of the queue**
- **Merge dynamics**
  - o Basic rules
  - o Example

Input-Output Curves (An example)

Recall from the Kinematic Wave theory class the example with the accident at the bottleneck. [There is a two-lane freeway, where an accident occurs at 10am and blocks one lane for 30 min].



The next graph shows the virtual input and the output curves at the location of the accident. Note that the area of the triangle is the total delay (in vh-hrs) caused by the accident.



Back of the queue estimation

We might ask: what is the maximum distance covered by the queue?

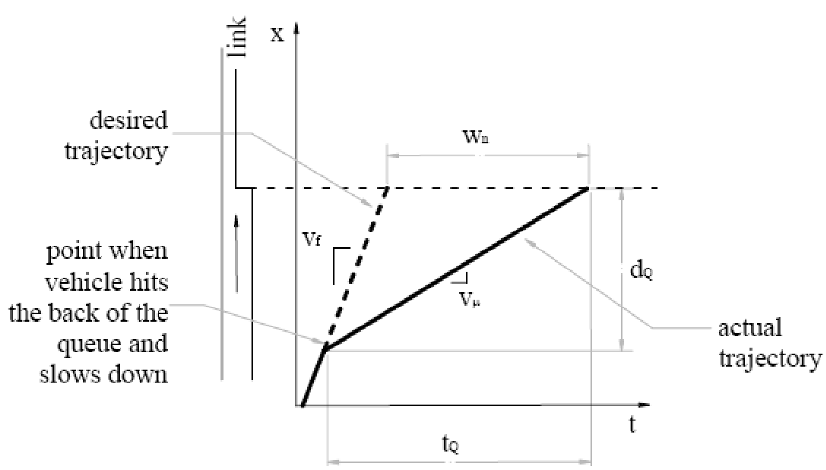
- To answer that, we are usually given
  - o A(t) → arrivals
  - o μ → capacity of bottleneck

- Recall that the slope of curve A(t) is the entry rate at every point in time λ(t) = q(t), which corresponds to a point "A" on the fundamental diagram.

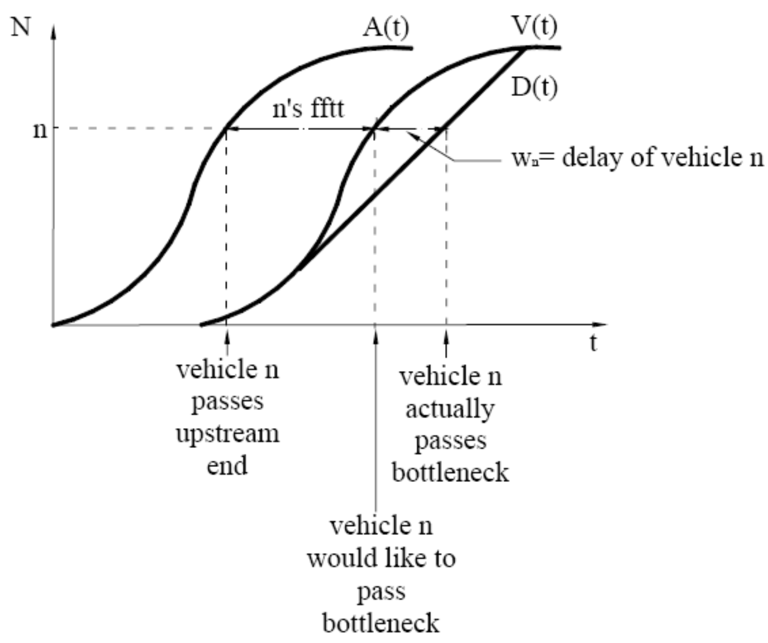
- If A(t) changes with time, the point moves and the slope of the "shockwave" also changes. The trajectory of the back of the queue is nonlinear and tedious to construct.

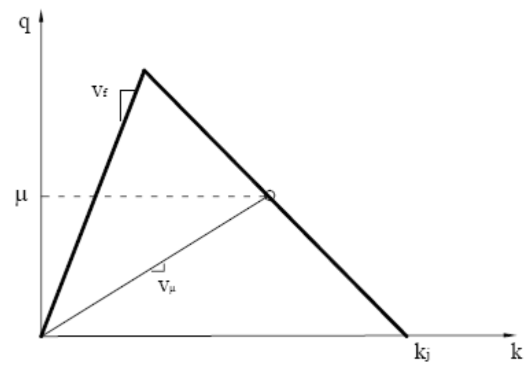
- Fortunately, even though arrival flow might change, the vehicles close to the bottleneck are in the same steady state all the time. This is exploited below.

  - o We know the delay
  - o We know the state inside the queue

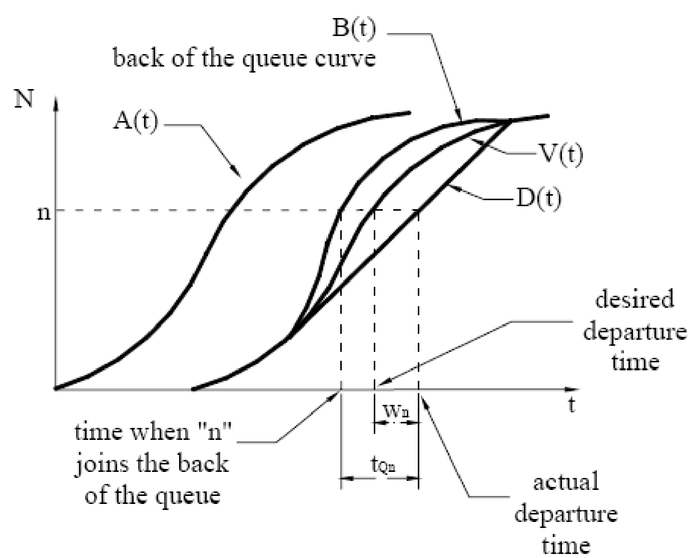


- Time spent in queue $t_Q = \frac{d_Q}{v_\mu} = \frac{d_Q}{v_f} + w$
- Distance traveled while in queue $d_Q = \frac{w}{\frac{1}{v_\mu} - \frac{1}{v_f}}$
- $t_Q = \frac{w}{1 - \frac{v_\mu}{v_f}}$
- There are some proportionality factors between w, t_Q and d_Q





Therefore, we can compute and draw the back of the queue curve B(t).



Applications

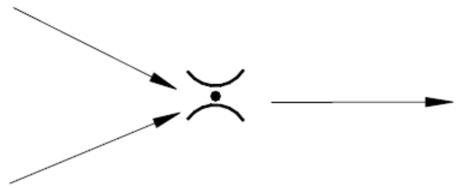
• Now we can answer different questions:

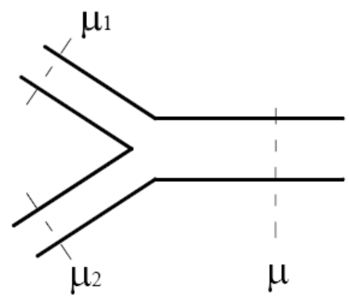
1) Where is the back of the queue at time t'?

2) When does the back of the queue pass over some location?

3) Does the back of the queue ever reach some location?

Merges dynamics





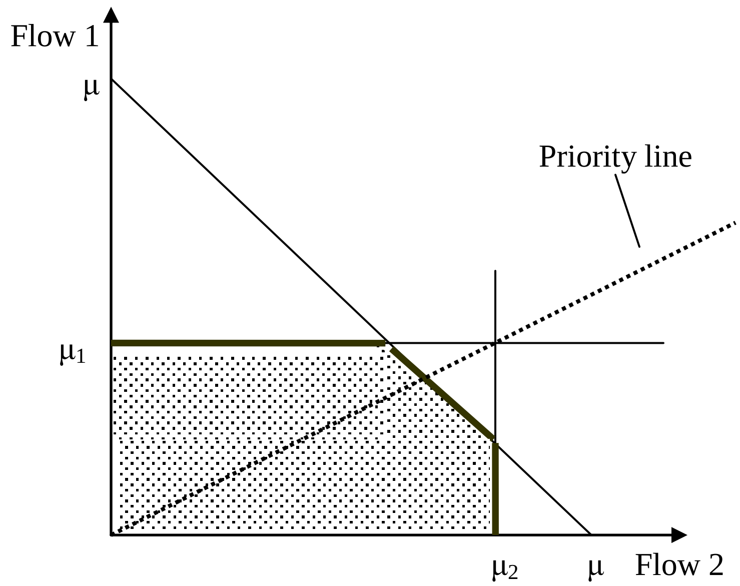
Question: Given $V_1(t)$, $V_2(t)$, and μ, μ_1, and μ_2, what are $D_1(t)$, and $D_2(t)$?

Rules:

The following diagram shows different states (discharge flows) of the merge and the capacity envelope based on the three capacity constraints:

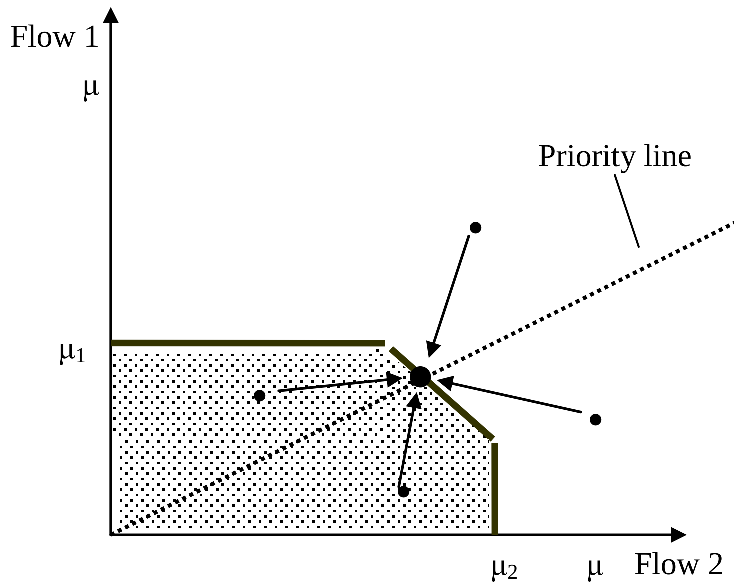
1. $D_1(t)<\mu_1$
2. $D_2(t)<\mu_2$
3. $D_1(t)+ D_2(t)<\mu$

The dotted line is the priority line which shows the relative ratio of capacities on links 1 and 2. When both link 1 and 2 are queued the observed state should belong to this line.



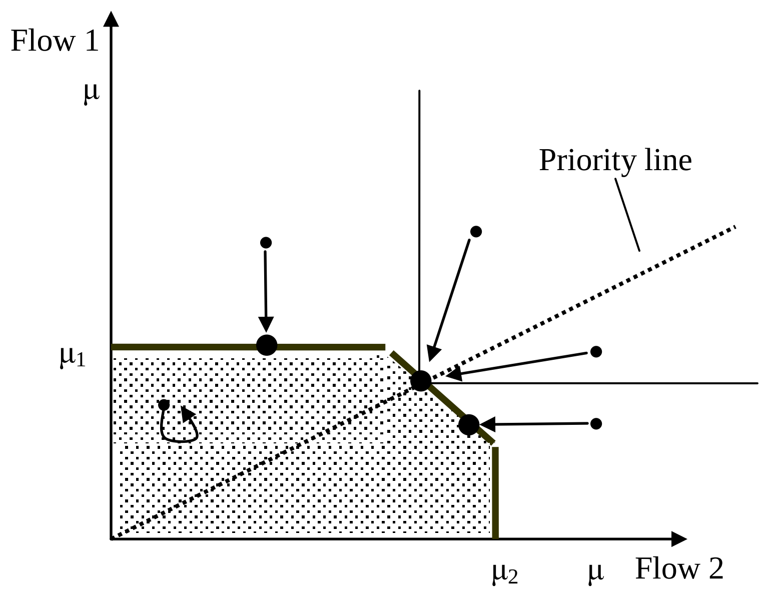
Next figures show the merge transitions based on the initial merge condition: 4 different cases are considered

(a) **QB** → Queue in both approaches

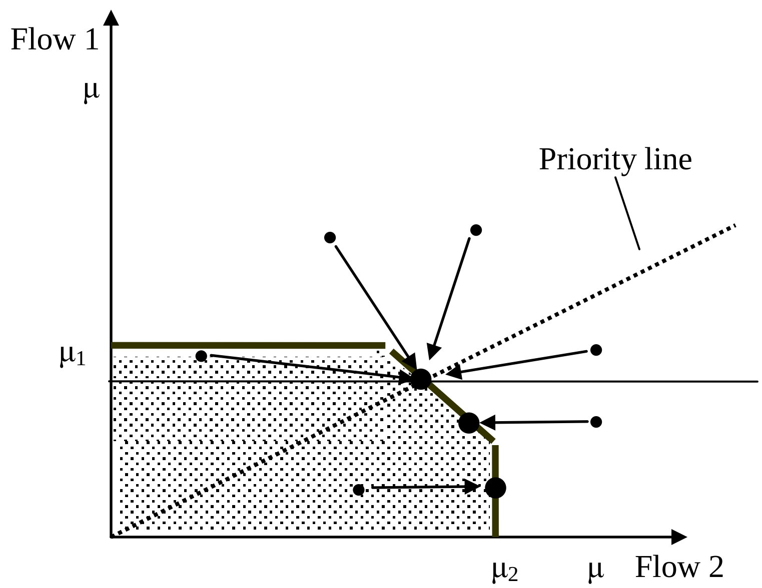


Points inside the capacity envelope, which can occur because of a decrease in demand, will lead to the point in the priority line until queue clears in one of the approaches. When queue clears in one of the approaches then we need to switch to case c and another point in the capacity envelope.

(b) **NQ** → No Queue



(c) **Q2**→ Queue in approach 2



(d) **Q1** → Queue in approach 1

Symmetric to case **Q2**