CE 486
Urban Transportation Planning

Lec. 6
Traffic Assignment

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Trip Assignment

- is the procedure by which the planner/engineer predicts the paths the trips will take.
- For example, if a trip goes from a suburb to downtown, the model predicts the specific streets or transit routes to be used.

Inputs to assignment

- O-D matrix
- Network

Terminology

- Trip assignment: “loading the network”; volumes are assigned to links
- Free flow speed: speed under no congestion
- Free flow travel time: travel time under no congestion
- Path finding: finding the path with the minimum impedance (time)
- Path loading: loading vehicles to links comprising a path
- Level of service: a qualitative measure describing the operation conditions
- Capacity restraint: the volume loading process is constrained by the capacity of the link

Time of Day Patterns

- Trip generation usually based on 24-hour period
- LOS calculations usually based on hourly time period
- Hour, particularly peak, is often of more interest than daily

Time of Day Patterns

- Common time periods
  - Morning peak
  - Afternoon peak
  - Off-peak
- Calculation of trips by time of day
  - Use of factors (e.g., morning peak may be 11% of daily traffic)
  - Estimate trip generation by hour

Minimum Path

- Theory: users will select the *quickest* route between any origin and destination
- Several route choice models (all based on some "minimum" path)

1. **Minimum-Path Techniques (all or nothing)**
2. **Capacity Restraint.**
3. **User Equilibrium.**
4. **Incremental assignment.**

All or Nothing

- Allocates all volume between zones to minimum path based on free-flow link impedances
- Does not update as the network loads
- Becomes unreliable as volumes and travel time increases

Multi-Path

- Assumes that all traffic will not use shortest path
- Assumes that traffic will allocate itself to alternative paths between a pair of nodes based on costs
- Uses some method to allocate percentage of trips based on cost
  - Utility functions (logit)
  - Or some other relationship based on cost
- As cost increases, probability that the route will be chosen decreases

Capacity Restraint

- Once vehicles begin selecting the minimum path between a set of nodes, volume increase and so do travel times
- Original minimum paths may no longer be the minimum path
- Capacity restraint assigns traffic iteratively, updating impedance at each step

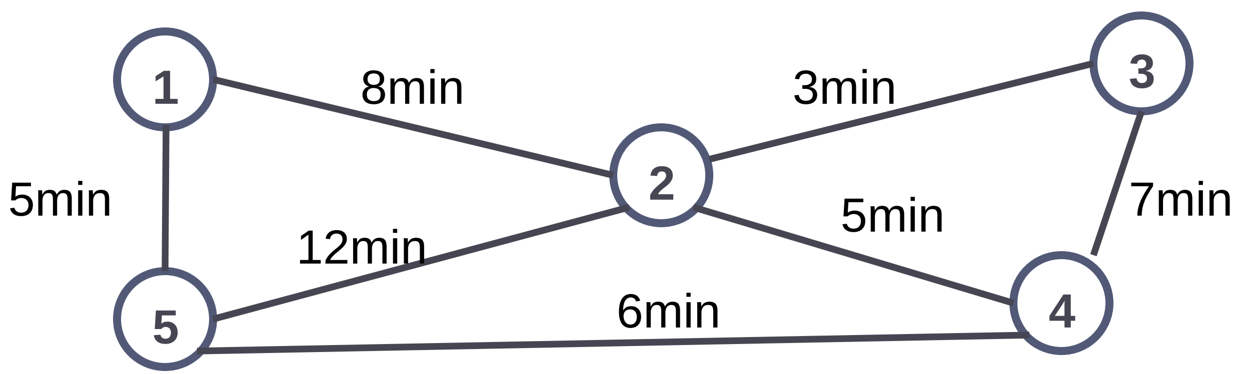
1.Minimum-Path Techniques.

- Minimum-path techniques are based on the assumption that travellers want to use the minimum impedance route between two points.
- The trip between zones are loaded onto the links making up the minimum path. This technique is sometimes referred to as “all-or-nothing” because all trips between a given origin and destination are loaded on the links comprising the minimum path and nothing is loaded on the other links.
- After all possible interchanges are considered, the result is an estimate of the volume on each link in the network.
- This method **can cause some links to be assigned more travel volume than the link has capacity at the original assumed speed**.

Example: Assign the vehicle trips shown in the O-D trip table to the network shown in Figure using the all-or-nothing assignment technique. Male a list of the links in the network and indicate the volume assigned to each. Calculate the total vehicle minutes of travel. Show the minimum path and assign traffic for each of the five nodes.

Trips Between Zones

From/To	1	2	3	4	5
1	0	100	100	200	150
2	400	0	200	100	500
3	200	100	0	100	150
4	250	150	300	0	400
5	200	100	5	350	0



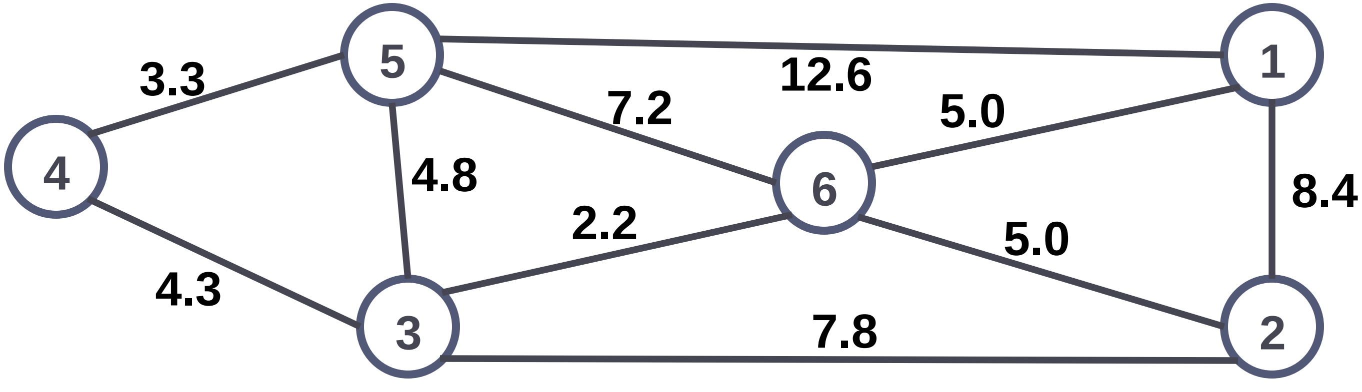
Solution:

Total Volume on Link	Time (min)
(1) —200→ (2)	8
(2) —600→ (1)	8
(1) —350→ (5)	5
(5) —450→ (1)	5
(2) —0→ (5)	12
(5) —0→ (2)	12
(2) —300→ (3)	3
(3) —300→ (2)	3
(2) —600→ (4)	5
(4) —250→ (2)	5
(3) —250→ (4)	7
(4) —350→ (3)	7
(4) —1300→ (5)	6
(5) —700→ (4)	6
	Total

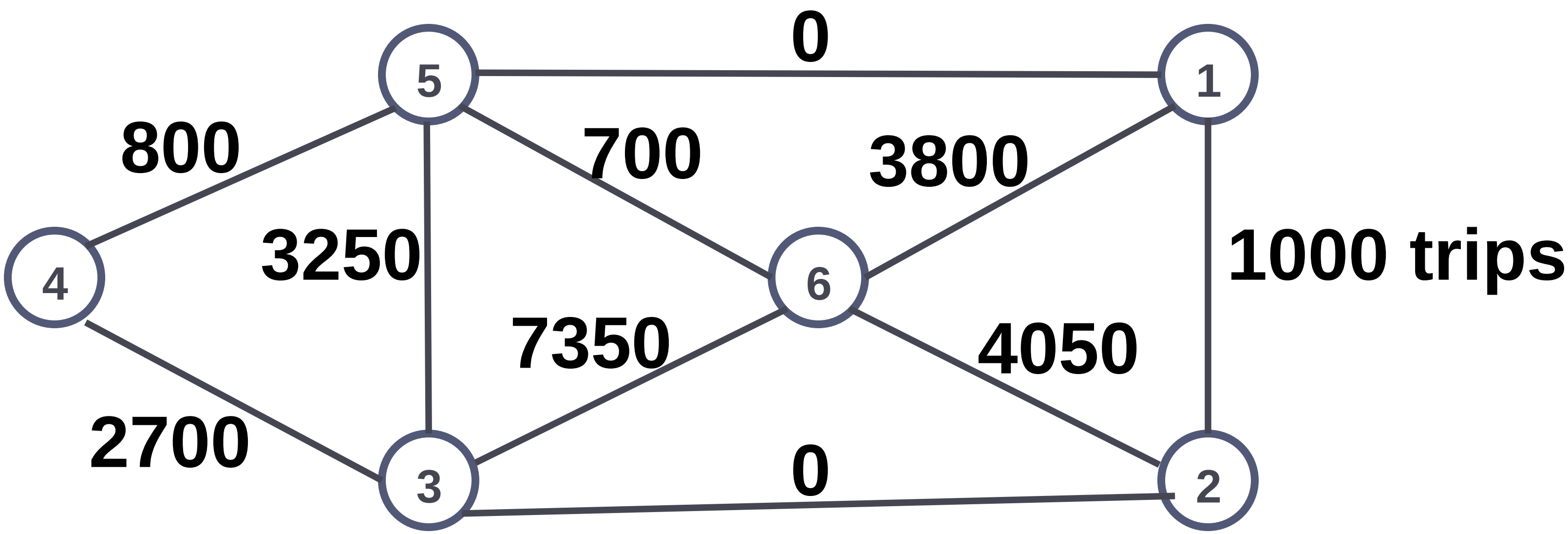
Example: The figure represents travel times on the link connecting six zonal centroids. Determine the minimum path from each zone to each other zone. Use the all-or-nothing assignment method to determine the total trips for each link after all of the trips from the following two-way trip table have been loaded onto the network.

Trips Between Zones

From/To	1	2	3	4	5	6
1	0	1000	1100	400	1000	1300
2	-	0	1050	700	1100	1200
3	-	-	0	1200	1150	1600
4	-	-	-	0	800	400
5	-	-	-	-	0	700
6	-	-	-	-	-	0



Solution:



2. Capacity Restraint

- Capacity-restraint techniques are based on the findings that as the traffic flow increases, the speed decreases.
- There is a relationship between impedance and flow for all types of highways.
- Capacity restraint attempts to balance the assigned volume, the capacity of a facility, and the related speed

Bureau of Public Roads (BPR) method

This traffic-flow-dependent travel-time relationship is represented by the general polynomial function:

$$T_Q = T_0\left[1 + \alpha\left(\frac{Q}{Q_{max}}\right)^{\beta}\right]$$

where

T_Q = travel time at traffic flow Q

T_0 = “zero-flow” travel time

= travel time at practical capacity x 0.87

Q = traffic flow (veh/hr)

Q_{max} = practical capacity = (3/4) x saturation flow

α, β = parameters

Example:

A freeway section 10 miles long has a free-flow speed of 60 mph. Q_{max} = 2000 veh/hr, Q = 1000 veh/hr, τ = 0.1, α = 0.474, and β = 4, and T_0 = 10min. Apply the (a) BPR's method to find T_Q.

(b) BPR

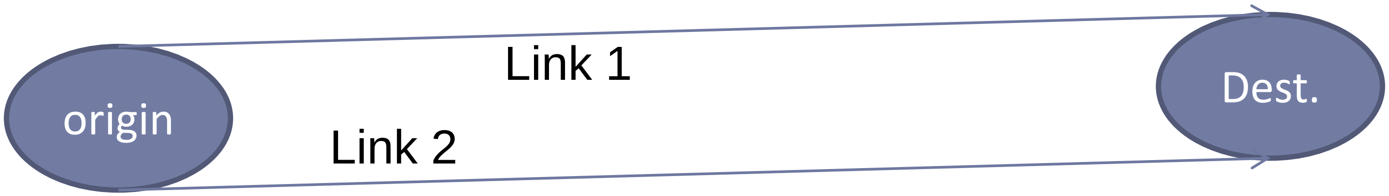
$$T_Q = T_0 \left[1 + \alpha(\frac{Q}{Q_{max}})^{\beta}\right]$$

$$T_Q = 10 \left[1 + 0.474 \left(\frac{1000}{2000}\right)^4\right]$$

$$= 10.30 \text{ min}$$

User Equilibrium

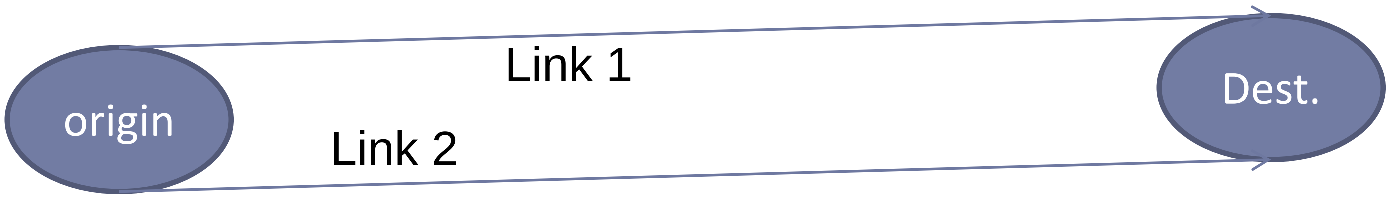
The user-equilibrium model of traffic assignment is based on the fact that humans choose a route so as to minimize his / her travel time and on the assumption that such a behaviour on the individual level creates an *equilibrium* at the system (or network) level. Flows on links (whose travel times are assumed to vary with flow) are said to be in equilibrium when no trip-maker can improve his/her travel time by unilaterally shifting to another route.



Link 1
capacity: 4000 vehicles; speed = 55 mph; distance = 7.5 miles
Free-flow travel time = 7.5/55 = 8.18 minutes

Link 2
capacity: 2000 vehicles; speed = 35 mph; distance = 5 miles
Free-flow travel time = 5/35 = 8.57 minutes

Incremental assignment



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Free-flow travel time = 5/35 = 8.57 minutes

Let us first assign 1000 vehicles to link 1 and then update link travel time, which will be:

$$t_1 = 8.18[1 + 1.15(\frac{1000}{4000})^4] = \ldots\ldots\ldots\ldots$$