Modeling the Time to Work

Part 1

We have created a simplified representation of a trip to work that we will model with either MATLAB or Python. The simplified situation we have created is illustrated in figure 3.4. We start our trip from our home on the northern area of the map. We get to the first intersection and then can follow one of two routes. The local route turns left and then follows local and major streets before getting to our work destination. The highway route turns right and then picks up the local Interstate for part of the trip.

Notice that each of the street segments are numbered. The segments are defined by interruptions in flow by a stop sign or traffic light or by a change of street or direction. Table 3.3 shows each of the street segments, the type of street and the segment length.

Table 3.3 Street Types and Lengths		
Street Segment	Type	Length (feet)
1	Local	1325
2	Major	716
3	Major	2800
4	Major	3052
5	Major	2995
6	Major	1839
7	Major	1725
8	Local	707
9	Major	2340
10	Freeway	10235
11	Major	868

The time to traverse each street segment can be derived by dividing the length, in the appropriate units, by the speed limit for that type of roadway. In addition, at each intersection, we need to add some additional time associated with the traffic control devices at that intersection. The starting assumptions we will use in the model are summarized in Table 3.4.

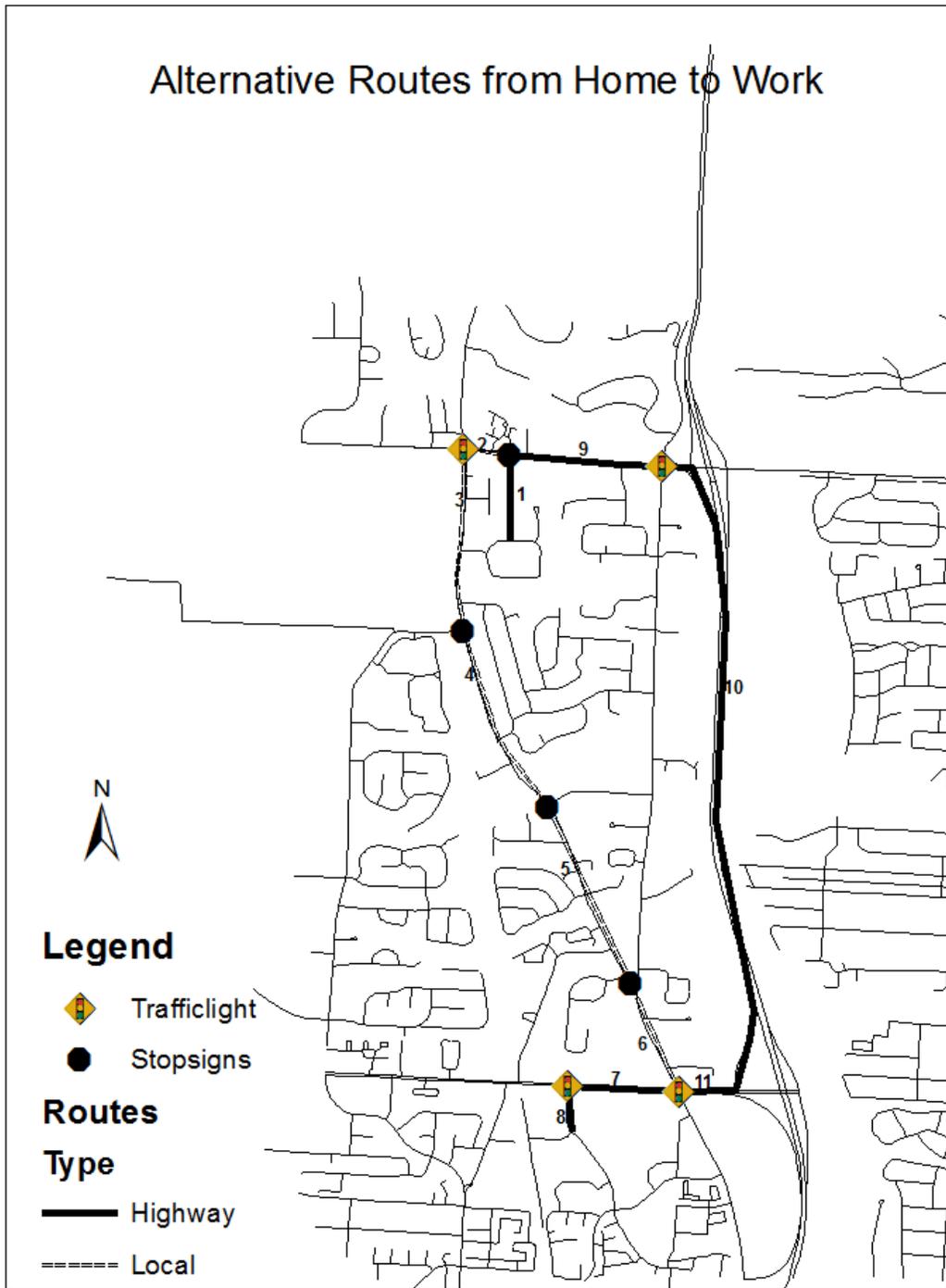| Table 3.4 Initial Model Assumptions	
Item	Assumption
Local Street Speed	25 mph
Major Street Speed	40 mph
Normal Freeway Speed	55 mph
Congested Freeway Speed	18 mph
Stop sign delay	30 seconds
Traffic light delay	2 minutes
Left onto major road delay	2.5 minutes

Figure 3.4: Representation of Two Paths to Work

The time it takes to get from our origin to our destination is a sum of the time it takes to get through each street segment and traffic control device along the way. For the "local" route we will traverse segments 1 through 8. For the "highway" route we will start with segment 1 and then use 9, 10, 11, 7, and 8. Our goal is to project the total time along each route under uncongested or "normal" conditions and also calculate how long the highway route will take when the highway is congested.

Download the starting MATLAB or Python script for this exercise (either traffic.m or traffic.py). Use the data presented here and the instructions in the code to fill in the appropriate data and syntax to complete the model. Then run the model as needed to answer all of the questions below. Be prepared to hand in a report package that includes one or more versions of your code and report which describes the model, model runs, and answers to the questions below.

Part 1 Questions

1. Is the traffic model a linear model? How do you know this? Under what circumstances would the flow of traffic be non-linear?
2. Make a list of the explicit assumptions (assumptions related to the model parameters) of this model and describe at least one circumstance where they might be violated.
3. Given the conceptual model of traffic flow you created as part of chapter 1, describe at least five things left out of this model that could impact the traffic flow. These are often called the implicit assumptions of the model.
4. Describe the outcomes of the modeling effort. How long will each route take? Would you always choose the same route?
5. If this were a model of routes in your local community, describe what data you would collect for three of the parameters to improve or validate the model.

Part 2

One of the major assumptions of the model is that one will always have a two minute wait at each traffic light. In reality, there may be times when the light is green and you need not stop at all while at other times, the wait may be longer than the two minute average because you just missed the green.

There are several ways one could investigate the impact of these chance events. One way would be to create a probabilistic representation of the green light time for each of the traffic lights along the route. To do this, we would need to know or make assumptions about the percentage of the time the light is green in the desired travel direction as traffic lights are often set to provide a larger percentage of green light time in the direction of heavier traffic.

The way we will explore these impacts is to vary the traffic light time across a range of values and model what the impacts are on the outcome of the travel time. This is called sensitivity testing. To do this, we can create a multiplier for the traffic light time and run the model multiple times to observe the impact. This multiplier will vary from 0.5 to 1.5 by increments of 0.1. A value of 0.5 can be interpreted to mean that it likely that half the time we will get a green light or approach a light with only 1 minute of wait time until it is green. A value of 1.5 would mean that we were unlucky and had to wait at red lights more than the average amount of time.

Use the example code in the file traffic_sensitive.m or traffic_sensitive.py to alter your program to simulate the impacts of changing the traffic light time across this range of values. Instead of graphing the cumulative time for each segment for the trip, we will graph the relationship between the traffic light time and the total time along each route. Implement this code and then answer the related questions.

Part 2 Questions

1. Describe the impacts of the red-light probability on the commute times.
2. Evaluate the sensitivity of the model to the change in red light probability. One way to do this is to calculate the percentage change in the commute times for each increment change in red light probability. The percentage change is:

$$\frac{(time_{new} - time_{old})}{time_{old}} x\ 100$$

This can be compared with the percentage change in the red light probability as a quantitative measure of the sensitivity of the model to the parameter change. Make these calculations and then discuss whether you think the model is sensitive to changes in the this parameter.
3. Run the model with slight changes both positive and negative in the average vehicle speed under congested freeway conditions. How do the results change and would this change which route is preferred during peak conditions?