ACTIVITY
45 Left Turn Phasing

READING

Purpose

The purpose of this activity is to give you the chance to learn more about left turn phasing and the various options for serving left turn movements.

Learning Objective

- Describe the methods of left turn phasing

Deliverables

- Define the terms and variables in the Glossary
- Prepare a document that includes answers to the Critical Thinking Questions

Glossary

Provide a definition for each of the following terms or variables. Paraphrasing a formal definition (as provided by your text, instructor, or another resource) demonstrates that you understand the meaning of the term or phrase.

lagging left turns	
leading left turns	
left turn phasing	
permitted left turns	
protected left turns	

CRITICAL THINKING QUESTIONS

When you have completed the reading, prepare answers to the following questions.

1. What performance measures can you extract from the graphical representations of the three queuing models presented in the reading?

2. Why should permitted left turn phasing always be considered as a phasing plan option?

3. When should protected left turn phasing be considered?

INFORMATION

The ring barrier diagram establishes the sequence of phases to be served at an actuated signalized intersection. For a standard intersection with four approaches, the movements and the numbering scheme used to identify the movements are shown in Figure 150. For leading protected left turns, the eight phases (their sequencing and the movements that they control) are represented in the ring barrier diagram shown in Figure 151.

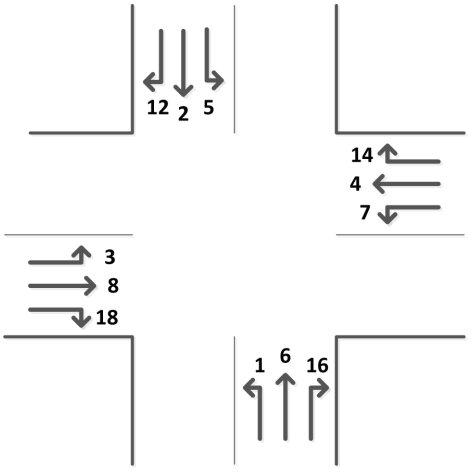

Figure 150. Movement numbers

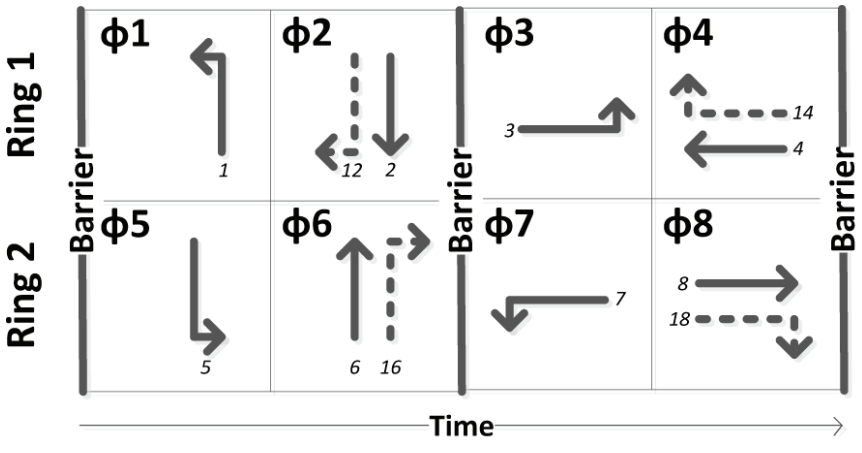

Figure 151. Ring barrier diagram for leading protected left turns

In ring 1, phase 1 (which controls the northbound left turn movement) must occur before phase 2 (which controls the opposing southbound through movement) since the left turn movement is protected: it does not have any opposing movement to contend with while phase 1 is timing. This complete time separation between the opposing left turn and through movements provides a high level of safety, especially when volumes are high.

The arrival and departure flow patterns for a protected left turn can be represented by a flow profile diagram, a cumulative vehicle diagram, and a queue accumulation polygon as originally discussed in Chapter 2. These three diagrams for a protected left turn movement are shown in Figure 152, Figure 153, and Figure 154. The left turn movement flows at the saturation flow rate during the green, without opposing flows, and the phase terminates when the flow has been served. Figure 153 and Figure 154 show the left turn queue building during red and clearing at the end of green.

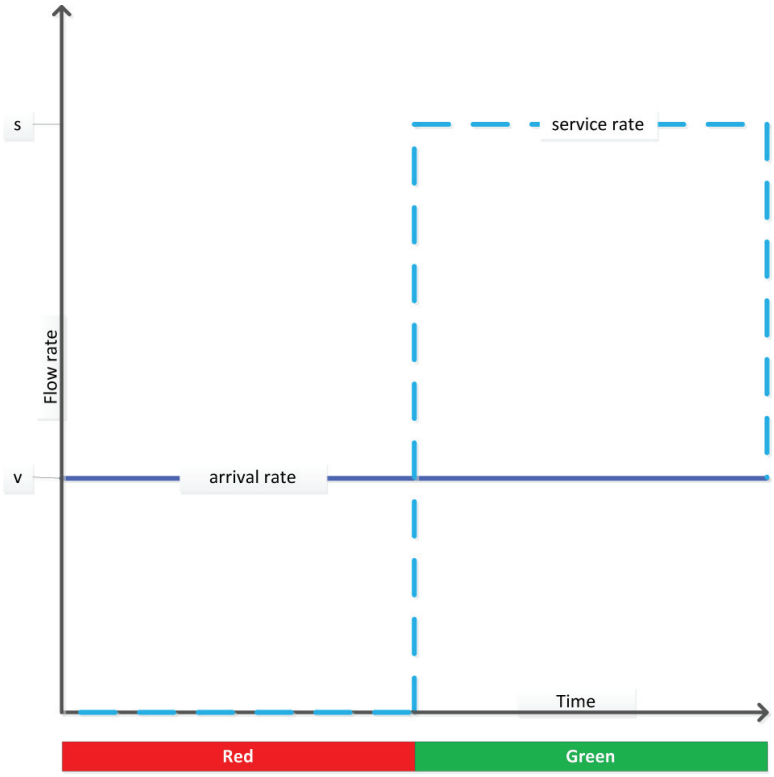

Figure 152. Flow profile diagram, protected left turn movement

But there are conditions, particularly when the left turn and/or opposing volumes are lower, where the driver can be given an option in which he or she can exercise safe judgment and accept or reject a gap in the opposing traffic stream. Examples of this gap acceptance behavior exist for other traffic facilities. Vehicles entering a

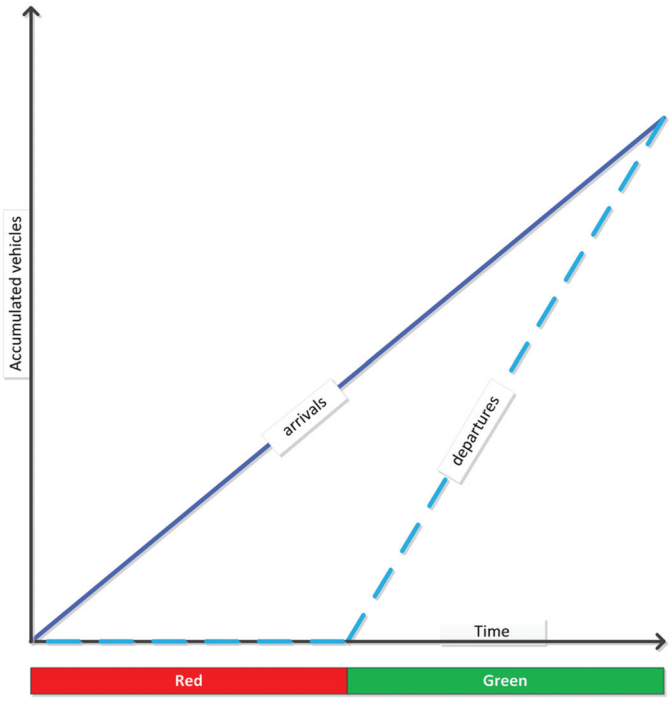

Figure 153. Cumulative vehicle diagram, protected left turn movement

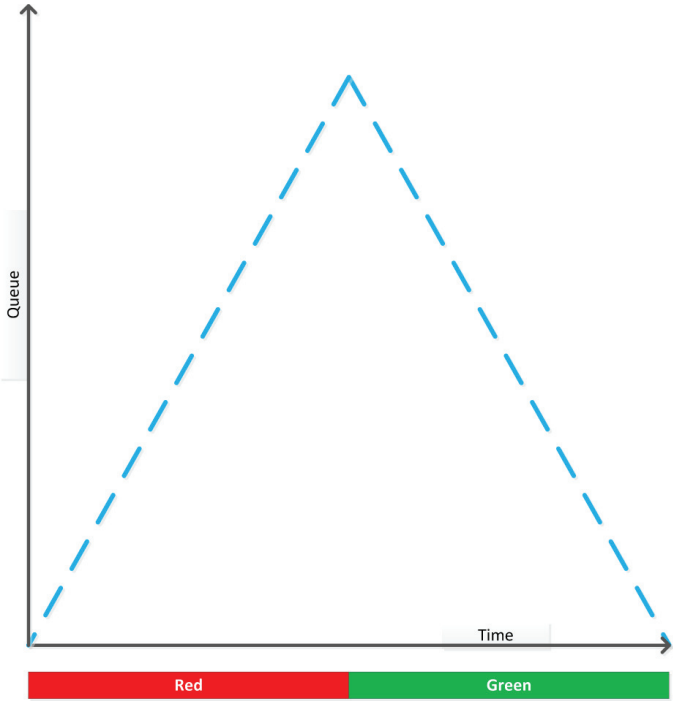

Figure 154. Queue accumulation polygon, protected left turn movement

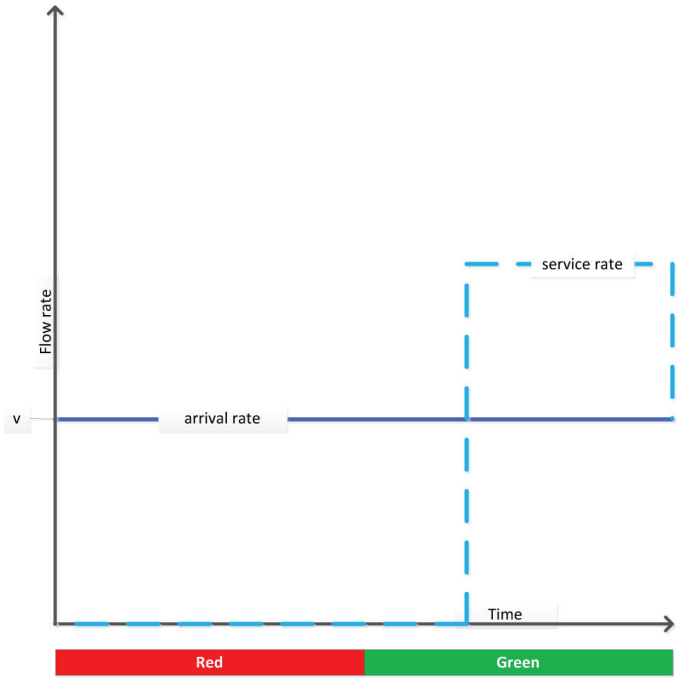

Figure 155. Flow profile diagram for permitted left turn movement

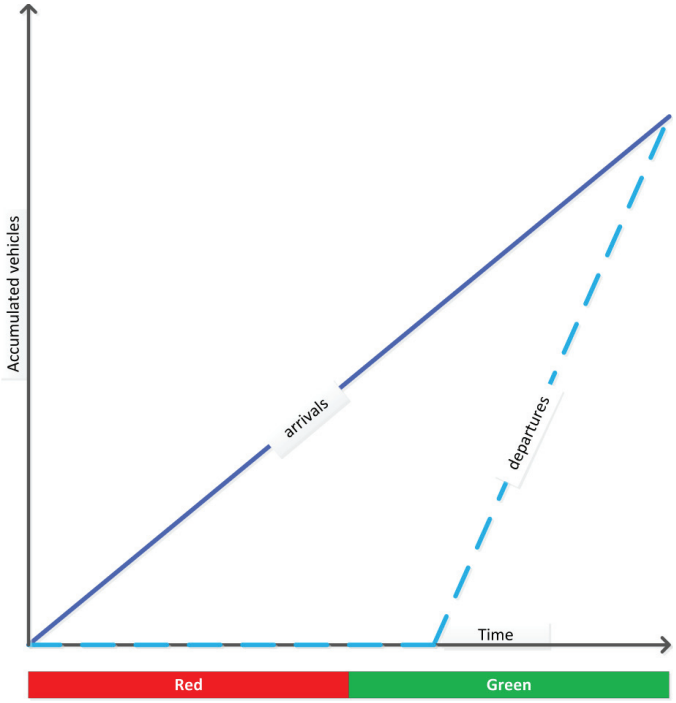

Figure 156. Cumulative vehicle diagram for permitted left turn movement

freeway have to look for a safe gap in the traffic already on the freeway before they enter the mainline. And, drivers on the minor street approach of a two-way stop-controlled intersection must find a large enough gap in the major stream before they either cross or merge into the major street. A similar option exists for permitted left turn maneuvers. The driver is shown either a solid green ball or a flashing yellow arrow, displays that indicate that a driver can proceed if, in their judgment, there is a large enough gap in the opposing traffic through which they can safely complete their turning maneuver.

Figure 155 shows the flow profile diagram for a permitted left turn movement. Here, the departure flow for the initial period of green is zero, as the opposing through movement queue is clearing. Once that opposing queue has cleared, the left turn vehicles can filter their way through the opposing gaps, when these gaps are large enough to be useful. Figure 156 and Figure 157 show the resulting cumulative vehicle diagram and queue accumulation polygon for the permitted left turn movement. As before, the total delay experienced by the left turn movement can be calculated as the area of either of these two figures.

The ring barrier diagram for permitted left turn phasing is shown in Figure 158. Only four phases are needed, since the even numbered phases control both the left turn and through movements.

In some cases, a combination, or protected plus permitted, phasing can be used. Here at least the initial

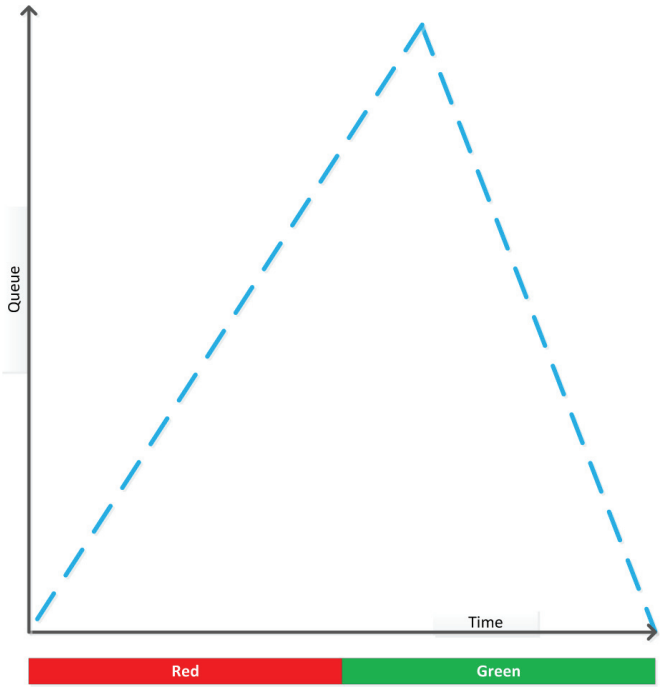

Figure 157. Queue accumulation polygon, permitted left turn movement

portion of the left turn queue is served with protected phasing while the remainder of the queue and any additional left turn vehicles that arrive can be served during the permitted phase. The queuing diagrams for this phasing option are shown in Figure 159, Figure 160, and Figure 161. Figure 159 shows that vehicles depart at the saturation flow rate during the protected phase. During the initial part of the permitted phase, the departing flow is zero when the opposing queue is clearing. Once the opposing queue has cleared, the departure rate is greater than zero but less than the saturation flow rate. Figure 160 and Figure 161 both show that the left turn queue is partially or completely served during the protected phase when vehicles are able to depart at the saturation flow rate (depending on the left turn flow rate and the amount of green time provided). During the permitted phase, the queue grows again when the left turn flow is zero during the period when the opposing through movement queue is clearing. Once this opposing queue has cleared, the queue of permitted left turn vehicles decreases to zero as left turn vehicles are able to filter through the opposing gaps. In this example, the queue clears at the end of green.

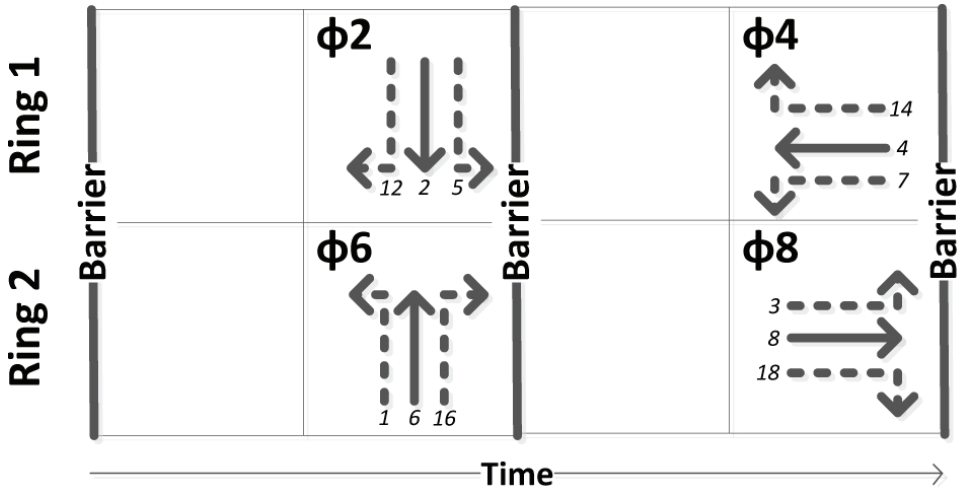

Figure 158. Ring barrier diagram, permitted left turn phasing

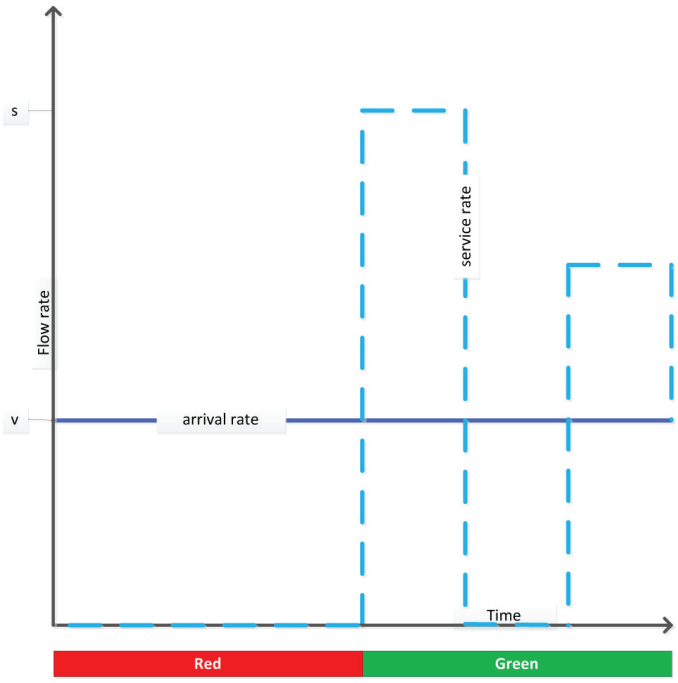

Figure 159. Flow profile diagram, protected plus permitted left turn phasing

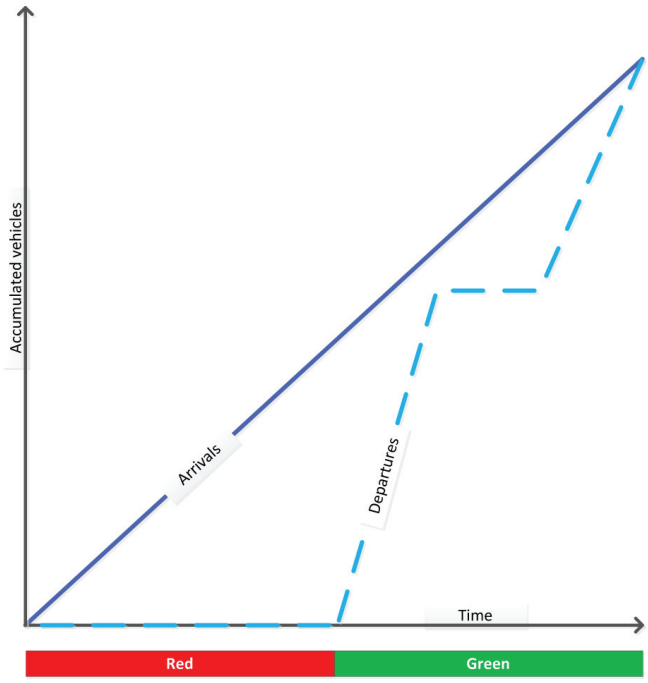

Figure 160. Cumulative vehicle diagram, protected plus permitted left turn phasing

The ring barrier diagram for protected permitted phasing is shown in Figure 162. The left turn movement is shown as a solid line during the protected phase and as a dashed line during the permitted phase.

So how do you determine which left turn phasing option is best for a particular situation? While there are a number of considerations in practice, we will consider two points that will help you in the design activity that you will complete later in this chapter. The first point is to have as few phases as possible during the cycle as this reduces the number of yellow-red clearance transitions and allows for more green time to be available to serve the traffic demand. Permitted left turn phasing means a fewer number of phases than required for protected left turn phasing. Figure 158 shows that all movements can be served with four phases requiring only two transitions per cycle. This potential efficiency means that permitted phasing should at least be considered as an option when possible.

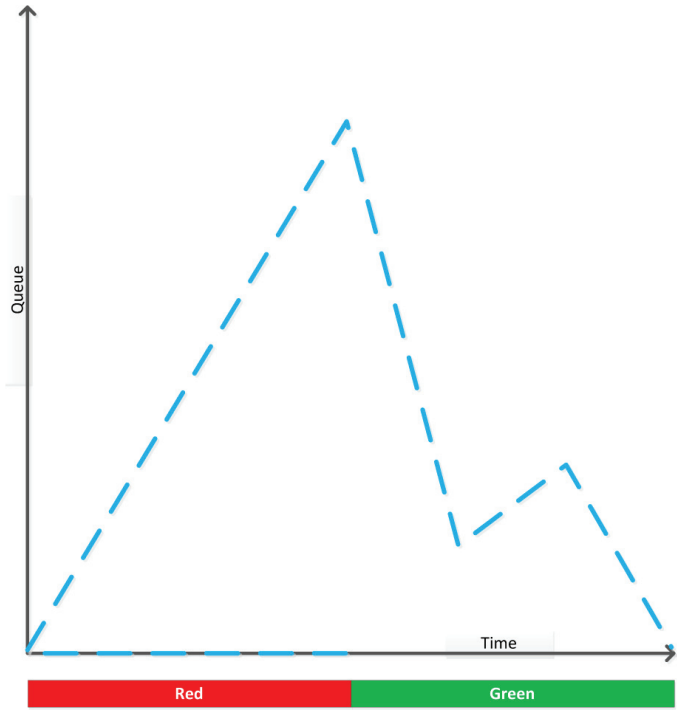

Figure 161. Queue accumulation polygon, protected plus permitted left turn phasing

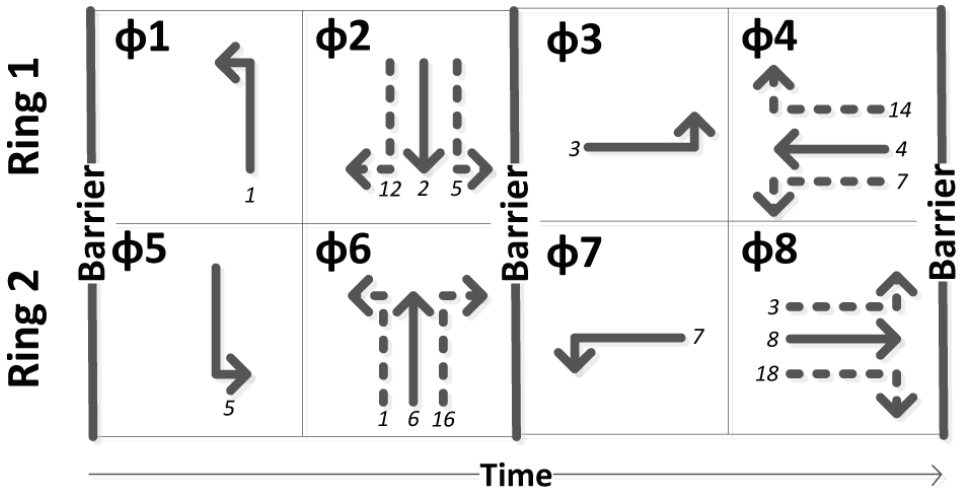

Figure 162. Ring barrier diagram, protected plus permitted left turn phasing

The second point is to make sure that there is sufficient capacity for the left turn movements. This means that if the combination of the left turn flow rate and the opposing through flow rate is high enough, there will only be sufficient left turn capacity if the phase serving the left turn movement is protected.

As you complete the activities to follow, you will see specific examples of both points when you observe the interaction of the left turn and opposing through traffic movements.

Student Notes: