

1. Recall the simple model for HTTP streaming shown as follows.  $B$  denotes the size of the client's application buffer, and  $Q$  denotes the number of bits that must be buffered before the client application begins playout. Suppose the buffer size is infinite but the server sends bits at variable rate  $x(t)$ . Specifically, suppose  $x(t)$  has the following saw-tooth shape. The rate is initially zero at time  $t = 0$  and linearly climbs to  $H$  at time  $t = T$ . It then repeats this pattern again and again, as shown in the figure below.

(1). What is the server's average send rate?  $H/2$

(2). Now suppose  $Q > 0$ .  $Q < HT/2$ . Determine as a function of  $Q$ ,  $H$ , and  $T$  the time at which playback first begins.  
 $\sqrt{2QT/H}$

(3). Suppose  $H > 2r$  and  $Q = HT/2$ . Prove there will be no freezing after the initial playout delay.  
 Start to play at  $T$ .

In  $[T, T+t]$ ,  $t < T$ , the data volume at buffer is  $Q - rt + \frac{Ht^2}{2T}$ , which is always positive.

In  $[2T, 2T+t]$ ,  $t < T$ , the data volume is  $Q + (\frac{H}{2} - r)T - rt + \frac{Ht^2}{2T}$ , which is always positive.

In  $[3T, 3T+t]$ ,  $t < T$ , the data volume is  $Q + 2(\frac{H}{2} - r)T - rt + \frac{Ht^2}{2T}$ , which is always positive.

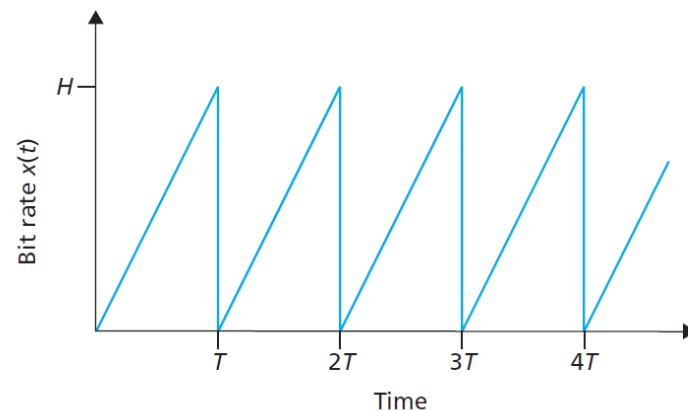
...

Similarly, in any  $[kT, kT+t]$ , there is no freezing.

## Assignment Project Exam Help

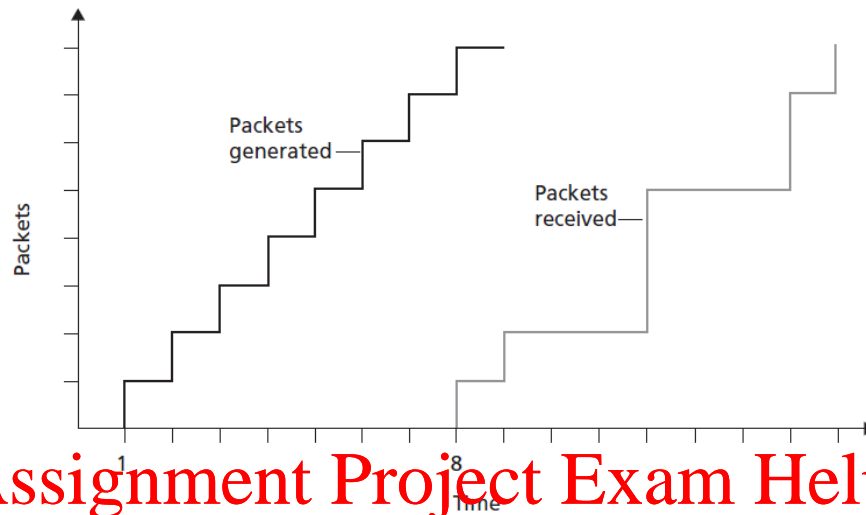
<https://eduassistpro.github.io/>

Add WeChat edu\_assist\_pro



2. Consider the figure below. A sender begins sending packetized audio periodically at  $t = 1$ . The first packet arrives at the receiver at  $t = 8$ .

- (1). What are the delays (from sender to receiver, ignoring any playout delays) of packets 2 through 8?
- (2). If audio playout begins as soon as the first packet arrives at the receiver at  $t = 8$ , which of the first eight packets sent will *not* arrive in time for playout?
- (3). If audio playout begins at  $t = 9$ , which of the first eight packets sent will not arrive in time for playout?
- (4). What is the minimum playout delay at the receiver that results in all of the first eight packets arriving in time for their playout?



## Assignment Project Exam Help

1) 7 7 9 8 7 9 8 8

2) Packets 3, 4, 6, 7, a

3) Packets 3 and 6 wil

4) No packets will arr

<https://eduassistpro.github.io/>  
=10

Add WeChat edu\_assist\_pro