

**Homework 11**

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Examine Figure 1, and consider time increments in milliseconds (ms). A sender begins sending packetized audio periodically at  $t = 1$ . The first packet arrives at the receiver at  $t = 8$ .

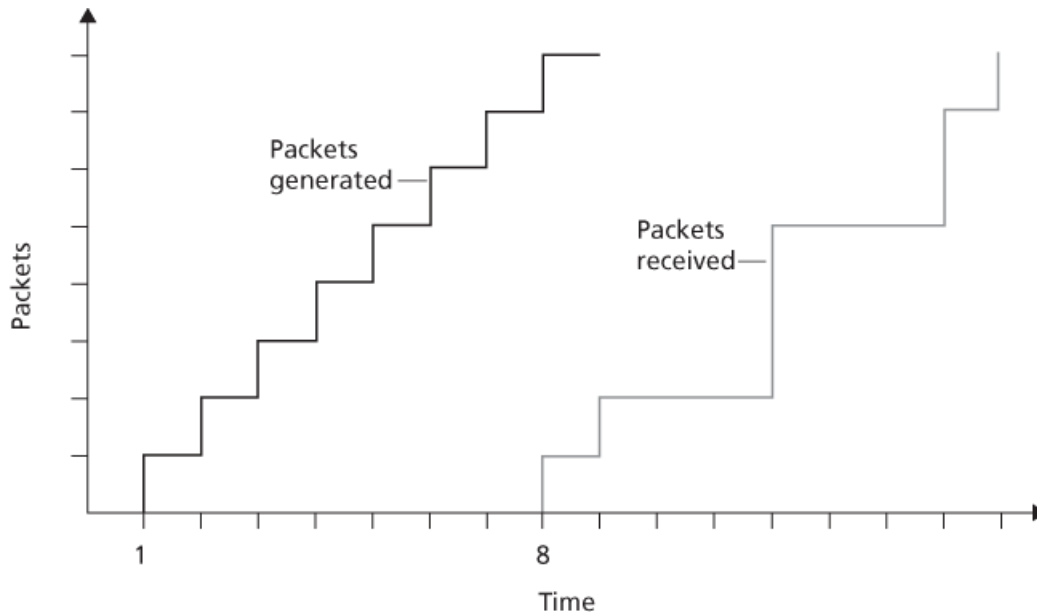


Figure 1

1. What are the delays, in ms, from sender to receiver (*ignoring any playout delays*) of packets 1 through 7? (4 points)

Packet 1:

Sent at  $t = 1 \rightarrow$  Arrives at  $t = 8 \rightarrow$  Delay =  $8 - 1 = 7$  ms.

Packet 2:

Sent at  $t = 2 \rightarrow$  Arrives at  $t = 9 \rightarrow$  Delay =  $9 - 2 = 7$  ms.

Packet 3:

Sent at  $t = 3 \rightarrow$  Arrives at  $t = 10 \rightarrow$  Delay =  $10 - 3 = 7$  ms.

Packet 4:

Sent at  $t = 4 \rightarrow$  Arrives at  $t = 11 \rightarrow$  Delay =  $11 - 4 = 7$  ms.

Packet 5:

Sent at  $t = 5 \rightarrow$  Arrives at  $t = 12 \rightarrow$  Delay =  $12 - 5 = 7$  ms.

Packet 6:

Sent at  $t = 6 \rightarrow$  Arrives at  $t = 13 \rightarrow$  Delay =  $13 - 6 = 7$  ms.

Packet 7:

Sent at  $t = 7 \rightarrow$  Arrives at  $t = 14 \rightarrow$  Delay =  $14 - 7 = 7$  ms.

All packets have a delay of 7 ms.

2. If audio playout begins as soon as the first packet arrives at the receiver at  $t = 8$ , which of the first seven packets sent **will not arrive in time for playout**? (2 points)

Packet 1:

Arrives at  $t = 8 \rightarrow$  In time for playout.

Packet 2:

Arrives at  $t = 9 \rightarrow$  Too late (misses playout window starting at  $t = 8$ ).

Packet 3:

Arrives at  $t = 10 \rightarrow$  Too late.

Packet 4-7:

Arrive at  $t = 11, 12, 13, 14 \rightarrow$  All too late.

Packets 2-7 do not arrive in time for playout.

3. If audio playout begins at  $t = 9$ , which of the first seven packets sent **will not arrive in time for playout**? (2 points)

Packet 1:

Arrives at  $t = 8 \rightarrow$  In time.

Packet 2:

Arrives at  $t = 9 \rightarrow$  In time.

Packet 3:

Arrives at  $t = 10 \rightarrow$  Too late (misses playout window starting at  $t=9$ ).

Packets 4-7:

Arrive at  $t = 11, 12, 13, 14 \rightarrow$  All too late.

Packets 3-7 do not arrive in time for playout.

4. What is the minimum playout delay (in ms) at the receiver that results in all of the first seven packets arriving in time for their playout? (2 points)

**Playout delay:**

Sent at  $t = 1$ , starts at  $t = 14$ :

$t = 14 - 1 = 13\text{ms}$ .

Minimum playout delay = 13 ms.