SYSC 4502 Assignment 3

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March 24th, 2017

1. (a) Block 1 arrives on time. Block 2 is delayed, as it arrives at a time $t > t_1 + \Delta$. Blocks 4, 5 and 6 arrive on time. Block 3 arrives after $t_1 > 2\Delta$, so it is delayed. Block 7 arrives at time $t > t_1 + 6\Delta$, so it is delayed. So, four out of the seven blocks arrive on time.

   (b) If the client begins playout at $t_1 + \Delta$, all blocks except for block 7 will have arrived on time to play. As determined in the previous question, blocks 2, 3, and 7 are delayed. Since the delay for blocks 2 and 3 is smaller than Δ, while they are late, they still arrive on time for playback. Since block 7 has a delay greater than Δ, it will be late.

   (c) At $t_1 + \Delta$ to $t_1 + 2\Delta$, block 2 is buffered, while block 1 is playing. At $t_1 + 2\Delta$ to $t_1 + 3\Delta$, block 2 is played, while block 3 and block 4 are buffered. At $t_1 + 3\Delta$ to $t_1 + 4\Delta$, block 3 is played, while block 4 and block 5 are buffered. At $t_1 + 4\Delta$ to $t_1 + 5\Delta$, block 4 is played, while block 5 and block 6 are buffered. At $t_1 + 5\Delta$ to $t_1 + 6\Delta$, block 5 is played, while block 6 is buffered. At $t_1 + 6\Delta$ to $t_1 + 7\Delta$, block 6 is played. At $t_1 + 7\Delta$ to $t_1 + 9\Delta$, nothing is played. At $t_1 + 9\Delta$ to $t_1 + 10\Delta$, block 7 is played.

   So, at most, 2 blocks are stored in the client buffer to await playout.

   (d) As per the previous question, an extra delay of 2Δ at the client's end will cover the gap from the delay in receiving block 7; i.e., the client should start playing at $t_1 + 3\Delta$ to achieve a smooth playback.

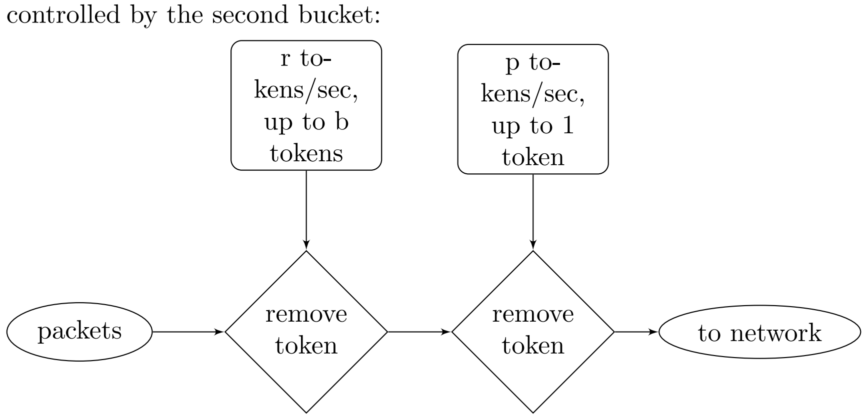
2. (a) For $x < r$, the client will consume all of the playable bits in the application buffer after $\frac{Q}{r-x}$ seconds. So, the playout period lasts $\frac{Q}{r-x}$ seconds.

   The number of bits to buffer for playing, Q, will refill at a rate of x bits per second, and will take Q/x seconds to fill. So, the freezing period is Q/x seconds.

   (b) The application will consume the first Q bits in the buffer at a rate of x. The remaining $B - Q$ bits in the buffer are consumed at a rate of $x - r$. So, the time it will take to fill the client's application buffer is given by:

$$t_f = \frac{Q}{x} + \frac{B - Q}{x - r}$$

3. The second leaky bucket generates tokens at rate $r = p$, with bucket size $b = 1$. Placing this bucket in series with the first bucket means that the peak packet rate flowing from the first bucket will be controlled by the second bucket:



4. (a) For a FIFO queue service:

Packet	Arrive	Depart	Delay
1	0	1	0
2	0	2	1
3	1	3	1
4	1	4	2
5	3	6	2
6	2	5	2
7	3	7	3
8	5	8	2
9	5	9	3
10	7	10	2
11	8	11	2
12	8	12	3

The average delay for the 12 packets is 1.9167.

(b) For a priority queue service:

Packet	Arrive	Depart	Delay
1	0	1	0
2	0	3	2
3	1	2	0
4	1	7	5
5	3	4	0
6	2	8	5
7	3	5	1
8	5	10	4
9	5	6	0
10	7	11	3
11	8	9	0
12	8	12	3

The average delay for the 12 packets is 1.9167.

(c) For a round robin service:

Packet	Arrive	Depart	Delay
1	0	1	0
2	0	3	2
3	1	5	3
4	1	2	0
5	3	4	0
6	2	7	4
7	3	6	2
8	5	8	2
9	5	10	4
10	7	12	4
11	8	9	0
12	8	11	2

The average delay for the 12 packets is 1.9167.

(d) For a weighted fair queueing service:

Packet	Arrive	Depart	Delay
1	0	1	0
2	0	3	2
3	1	2	0
4	1	6	4
5	3	4	0
6	2	8	5
7	3	5	1
8	5	10	4
9	5	7	1
10	7	11	3
11	8	9	0
12	8	12	3

The average delay for the 12 packets is 1.9167.

(e) The average delay is the same for all four cases.