Xi'an Jiaotong-Liverpool University

西交利物浦大學

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE413 DATA COMMUNICATION AND COMMUNICATIONS NETWORKS

COURSEWORK 2

Token Bucket Filter Simulation

Student Name Zhiyu.Xu

Student ID 1926905

December 2019

Contents

Task1

Result and code:

```
t=0.0000E+00 [s]: OFF->ON
t=0.0000E+00 [s]: packet generated with size=1.0000E+03 [B]
t=1.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=1.5000E-04 [s]: packet wait for time=1.5000E-04 [s]
t=2.0000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=2.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=2.0000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=1.0000E-04 [s]
t=2.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=2.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=3.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=3.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=3.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=4.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=4.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=5.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=5.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=5.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=6.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=6.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=6.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=7.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=7.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=7.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=8.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=8.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=8.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=9.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=9.5000E-04 [s]: packet wait for time=5.0000E-05 [s]
t=9.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=1.0000E-03 [s]: ON->OFF
t=2.0000E-03 [s]: OFF->ON
t=2.0000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.0500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.0500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.1000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.1500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.1500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.2000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.2500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.2500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
```

```
t=2.3000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.3500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.3500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.4000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.4500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.4500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.5000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.5500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.5500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.6000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.6500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.6500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.7000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.7500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.7500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.8000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.8500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.8500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.9000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.9500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=2.9500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=3.0000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=3.0000E-03 [s]: ON->OFF
t=3.0500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=3.0500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.0000E-03 [s]: OFF->ON
t=4.0000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.0500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.0500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.1000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.1500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.1500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.2000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.2500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.2500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.3000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.3500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.3500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.4000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.4500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.4500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.5000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.5500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.5500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.6000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.6500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.6500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.7000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.7500E-03 [s]: packet wait for time=5.0000E-05 [s]
```

```
t=4.7500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.8000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.8500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.8500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.9000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.9500E-03 [s]: packet wait for time=5.0000E-05 [s]
t=4.9500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
Average delay time = 5.1667E-05 [s]

Average waiting time = 5.3226E-05 [s]
```

Result of simulation

```
class FifoQueue(object):
    def __init__(self, env, pkt_ia_time, trace=False):
        self.trace = trace
        self.pkt_ia_time = pkt_ia_time
        self.store = simpy.Store(env)
        self.env = env
        self.out = None
        self.action = env.process(self.run())
        self.token_capacity = 5000
        self.token_current = 0
        self.wait_times=[]
    def run(self,):
        while True:
            msg = (yield self.store.get())
            # TODO: Implement packet processing here.
            now = self.env.now
            yield self.env.timeout(self.pkt_ia_time/2)
            if msg.size <= self.token_current:
                self.token_current = self.token_current -
msg.size+msg.size
                self.out.put(msg)
                self.wait_times.append(self.env.now - now)
                wait_time = self.env.now - now
                print("t={0:.4E} [s]: packet wait for time={1:.4E}
[s]".format(self.env.now, wait_time))
            else:
                temp = self.token_current + msg.size
                self.token_current = min(temp,
self.token_capacity)
                yield self.env.timeout(self.pkt_ia_time)
                self.wait_times.append(self.env.now - now)
                wait_time = self.env.now - now
                print("t={0:.4E} [s]: packet wait for time={1:.4E}
[s]".format(self.env.now, wait_time))
    def put(self, pkt):
        self.store.put(pkt)
. . . . . .
```

```
fifo = FifoQueue(env, pkt_ia_time, trace)  # TODO: implemente
FifoQueue class
• • • • • • •
print("Average waiting time = {:.4E}
[s]\n".format(np.mean(fifo.wait_times)))
```

Code 1 FifoQueue class code

Explanation：

As can be seen from the above list of results, the tokens in the bucket were 0 at the beginning. With the arrival of the first moment, the first packet (1000B) was generated. At this time, the first packet was stored because the bucket was empty In the bucket, the second packet was generated at the second moment (time interval 1ms). After being stored in the bucket, the size of the packets in the bucket is nearly larger than the size of the incoming packet at this time. Outgoing packet. Because this model is not the fluid model, it is a discrete case when the packet is transmitted to the TBF. In order to facilitate the simulation, a 0.5ms delay is set uniformly. The final average delay is 0.5ms, and the simulation results are consistent with the theory. There are two average delays in the result. Average delay time is the average delay calculated at the receiving end, while Average waiting time is the average delay settled in TBF. There is a slight gap between the two. The receiving code is given, so no changes have been made.

Task 2

Question：
What is your conclusion (i.e., the on-off traffic passing through the TBF with or without shaping)?
If packets are shaped at the TBF, explain why. Also, find TBF parameters allowing packets to pass through the TBF and show that they work (i.e., no shaping) through another simulation with the newly-designed parameters.

My conclusion is as follows:
In the simulation in Task1, the average delay is calculated to be 1ms instead of 2ms, so it can be explained that there has been traffic shaping at the TBF. Specifically, in the TBF, the amount of information in the bucket is 0 at the beginning and the first time 1000B of data, but no output, which caused a delay. After 1000B of data is stored for the second time, 1000B of data for the first time is output. The third time is the same as the second time. And so on. This causes a delay in output.

```
t=0.0000E+00 [s]: OFF->ON
t=0.0000E+00 [s]: packet generated with size=1.0000E+03 [B]
t=5.0000E-05 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=1.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=1.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=2.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=3.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=3.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=4.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=5.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=5.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=6.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=6.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=7.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=7.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=8.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=8.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=9.0000E-04 [s]: packet generated with size=1.0000E+03 [B]
t=9.5000E-04 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=1.0000E-03 [s]: ON->OFF
t=2.0000E-03 [s]: OFF->ON
t=2.0000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.0500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.1000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.1500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
```

```
t=2.2000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.2500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.3000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.3500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.4000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.4500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.5000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.5500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.6000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.6500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.7000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.7500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.8000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.8500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=2.9000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=2.9500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=3.0000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=3.0000E-03 [s]: ON->OFF
t=3.0500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.0000E-03 [s]: OFF->ON
t=4.0000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.0500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.1000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.1500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.2000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.2500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.3000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.3500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.4000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.4500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.5000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.5500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.6000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.6500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.7000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.7500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.8000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.8500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
t=4.9000E-03 [s]: packet generated with size=1.0000E+03 [B]
t=4.9500E-03 [s]: packet arrived with size=1.0000E+03 [B] delay=5.0000E-05 [s]
Average delay time = 5.0000E-05 [s]

Average waiting time = 5.0000E-05 [s]
```

Result of new simulation

As shown by the above results, the data is directly transmitted to the receiving end without delay when passing through the TBF, so no traffic shaping is caused. The parameter modified here is the preset amount of information in the bucket. At the beginning, the information in the bucket was changed from 0 to 1000B.