Part 1

Initially, on all ports, there was a get request GET HTTP/1.1

Port 4000

On this port, I did find some faulty packets and to describe some, there were "TCP Dup ACK" i.e a gap between the packets I received from the server, "Previous segment not captured", "TCP Retransmission", "TCP DUP ACK". There was a three-way handshake in the start and also the connection ended with the standard termination sequence. There was a loss of packets and the server had to retransmit them.

Port 4001

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4000. There was a three-way handshake in the start and also the connection ended with the standard termination sequence.

Port 4002

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4001. There was a three-way handshake in the start and also the connection ended with the standard termination sequence.

Port 4003

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4002. There was a three-way handshake in the start and also the connection ended with the standard termination sequence.

Port 4004

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4003. There was a three-way handshake in the start and also the connection ended with the standard termination sequence.

Port 4005

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4004. There was a three-way handshake in the start and also the connection ended with the standard termination sequence.

Port 4006

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4005. There was a three-way handshake in the start and also the connection ended with the standard termination sequence.

Port 4007

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4006. There was a three-way handshake in the start and also the connection ended with the standard termination sequence. Connection closed without completion.

Port 4008

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4007. There was a three-way handshake in the start and also the connection ended with the standard termination sequence. Connection closed without completion.

Port 4009

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4008. There was a three-way handshake in the start and also the connection ended with the standard termination sequence. Connection closed without completion.

Port 4010

On this port, I found a lot of "TCP Dup ACK" i.e packets had to be retransmitted due to loss. There were relatively more TCP DUP ACKs than port 4009. There was a three-way handshake in the start and also the connection ended with the standard termination sequence. Connection closed without completion.

Conclusion for Part 1

From what I have analysed, the strategy that the server and client use to maintain throughput is by retransmitting packets and sending duplicate acknowledgements. This indicates that there was packet loss and that the client received packets that were out of order at times. Moreover, duplicate acks are also used to invoke fast retransmission which is why I saw a lot of retransmission as the port number increased.

Part 2

Filter: tcp.analysis.retransmission

Port 4000

Measurement	Captured	Displayed	Marked
Packets	31356	31356 (100.0%)	—
Time span, s	6.823	6.823	—
Average pps	4595.9	4595.9	—
Average packet size, B	1136	1136	—
Bytes	35625201	35625201 (100.0%)	0
Average bytes/s	5221 k	5221 k	—
Average bits/s	41 M	41 M	—

Retransmitted Packets (1/31356) * 100 = 0.003 %

Port 4001

Measurement	Captured	Displayed	Marked
Packets	51346	51346 (100.0%)	—
Time span, s	28.576	28.576	—
Average pps	1796.8	1796.8	—
Average packet size, B	730	730	—
Bytes	37473145	37473145 (100.0%)	0
Average bytes/s	1311 k	1311 k	—
Average bits/s	10 M	10 M	—

Retransmitted Packets (451/51346) * 100 = 0.88 %

Port 4002

Measurement	Captured	Displayed	Marked
Packets	51993	51993 (100.0%)	—
Time span, s	44.810	44.810	—
Average pps	1160.3	1160.3	—
Average packet size, B	722	722	—
Bytes	37564512	37564512 (100.0%)	0
Average bytes/s	838 k	838 k	—
Average bits/s	6706 k	6706 k	—

Retransmitted Packets (729/51993) * 100 = 0.01 %

Port 4003

Measurement	Captured	Displayed	Marked
Packets	52558	52558 (100.0%)	—
Time span, s	81.208	81.208	—
Average pps	647.2	647.2	—
Average packet size, B	715	715	—
Bytes	37598821	37598821 (100.0%)	0
Average bytes/s	462 k	462 k	—
Average bits/s	3703 k	3703 k	—

Retransmitted Packets (1082/52558) * 100 = 0.02 %

Port 4004

Measurement	Captured	Displayed	Marked
Packets	53141	53141 (100.0%)	—
Time span, s	172.766	172.766	—
Average pps	307.6	307.6	—
Average packet size, B	708	708	—
Bytes	37599446	37599446 (100.0%)	0
Average bytes/s	217 k	217 k	—
Average bits/s	1741 k	1741 k	—

Retransmitted Packets (989/53141) * 100 = 1.86 %

Port 4005

Measurement	Captured	Displayed	Marked
Packets	54425	54425 (100.0%)	—
Time span, s	566.827	566.827	—
Average pps	96.0	96.0	—
Average packet size, B	693	693	—
Bytes	37694647	37694647 (100.0%)	0
Average bytes/s	66 k	66 k	—
Average bits/s	532 k	532 k	—

Retransmitted Packets (1274/54425) * 100 = 2.34 %

Port 4006

Connection reset by peer and connection closed at first attempt. I gave a second attempt.

The second attempt gave me this.
64 32.0M 64 20.6M   0   0 14646   0 0:38:11 0:24:35 0:13:36 5065* transfer closed with 11943290 bytes remaining to read
 64 32.0M 64 20.6M   0   0 14648   0 0:38:10 0:24:35 0:13:35 4792
* Closing connection 0
curl: (18) transfer closed with 11943290 bytes remaining to read

Measurement	Captured	Displayed	Marked
Packets	37505	37505 (100.0%)	—
Time span, s	1722.776	1722.776	—
Average pps	21.8	21.8	—
Average packet size, B	660	660	—
Bytes	24737348	24737348 (100.0%)	0
Average bytes/s	14 k	14 k	—
Average bits/s	114 k	114 k	—

The connection timed out after almost 28 minutes. So, there was a lot of packet loss.

Retransmitted Packets (4116/37505) * 100 = 10.97 %

Port 4007

The connection was timed out and I had this response in the terminal

16 32.0M 16 5324k   0   0 12234   0 0:45:42 0:07:25 0:38:17 4523* transfer closed with 28094474 bytes remaining to read
 16 32.0M 16 5331k   0   0 12248   0 0:45:39 0:07:25 0:38:14 7448
* Closing connection 0
curl: (18) transfer closed with 28094474 bytes remaining to read

Measurement	Captured	Displayed	Marked
Packets	9941	9941 (100.0%)	—
Time span, s	511.689	511.689	—
Average pps	19.4	19.4	—
Average packet size, B	646	646	—
Bytes	6422251	6422251 (100.0%)	0
Average bytes/s	12 k	12 k	—
Average bits/s	100 k	100 k	—

Retransmitted Packets (1578/9941) * 100 = 15.87 %

Port 4008

8 32.0M   8 2703k   0   0 5630   0 1:39:19 0:08:11 1:31:08 1060* transfer closed with 30786338 bytes remaining to read
 8 32.0M   8 2703k   0   0 5630   0 1:39:19 0:08:11 1:31:08 1002
* Closing connection 0
curl: (18) transfer closed with 30786338 bytes remaining to read

Measurement	Captured	Displayed	Marked
Packets	5355	5355 (100.0%)	—
Time span, s	574.294	574.294	—
Average pps	9.3	9.3	—
Average packet size, B	612	612	—
Bytes	3276361	3276361 (100.0%)	0
Average bytes/s	5705	5705	—
Average bits/s	45 k	45 k	—

Retransmitted Packets (429/5355) * 100 = 8.01 %

Port 4009

4 32.0M   4 1448k   0   0 6361   0 1:27:55 0:03:53 1:24:02 1902* transfer closed with 32068178 bytes remaining to read
 4 32.0M   4 1451k   0   0 6362   0 1:27:54 0:03:53 1:24:01 2791
* Closing connection 0

Measurement	Captured	Displayed	Marked
Packets	2807	2807 (100.0%)	—
Time span, s	243.636	243.636	—
Average pps	11.5	11.5	—
Average packet size, B	622	622	—
Bytes	1745786	1745786 (100.0%)	0
Average bytes/s	7165	7165	—
Average bits/s	57 k	57 k	—

Retransmitted Packets (303/2807) * 100 = 10.79 %

Port 4010

0 32.0M 0 185k 0   0 1022   0 9:07:12 0:03:05 9:04:07   0* Recv failure: Connection reset by peer

 0 32.0M 0 185k 0   0 1021   0 9:07:44 0:03:05 9:04:39   0

* Closing connection 0

curl: (56) Recv failure: Connection reset by peer

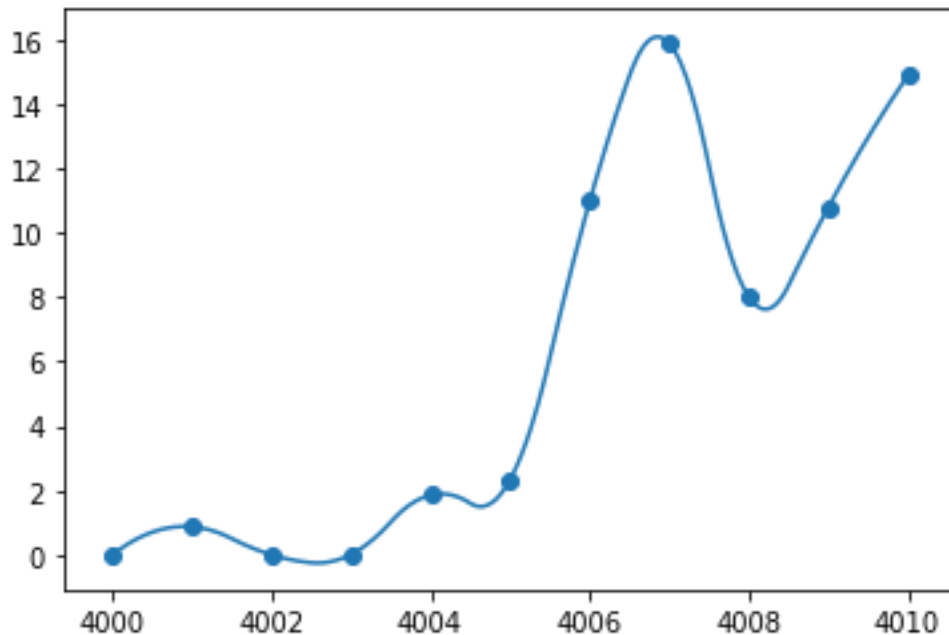| Measurement	Captured	Displayed	Marked
Packets	901	901 (100.0%)	—
Time span, s	203.699	203.699	—
Average pps	4.4	4.4	—
Average packet size, B	433	433	—
Bytes	390474	390474 (100.0%)	0
Average bytes/s	1916	1916	—
Average bits/s	15 k	15 k	—

Retransmitted Packets (134/901) * 100 = 14.87 %

Conclusion for Part 2

I mentioned that in conclusion for part 1 that there were a lot of retransmission as the port number increased. And the graph above supports that claim because the port number on the x-axis and the time on the y-axis indicates that the time taken to download the file increases as the port number increases which means which means that the packet loss got greater and greater with each port and after port 4006, the connection kept getting timed out which is why the time reduced meaning that the packet loss was very high on port 4007, 4008, 4009, 4010.

The graph below shows the time (s) on the y-axis and the port number on the x-axis.
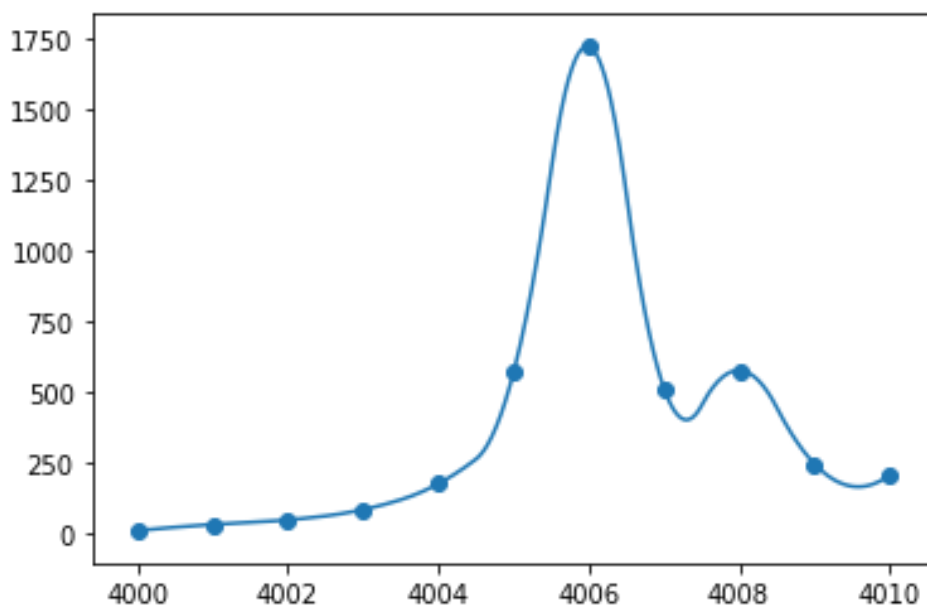
The graph below shows all the retransmission percentages (y-axis) against the port number (x-axis). This means that as the port number increases the percentage of packets that are retransmitted gets high which supports the claim of Dr Ian Batten that there is an increase in packet loss as we increase the port number of the website we are analysing.

Part 3

Port 4011

Measurement	Captured	Displayed	Marked
Packets	33534	33534 (100.0%)	—
Time span, s	6.816	6.816	—
Average pps	4919.6	4919.6	—
Average packet size, B	1068	1068	—
Bytes	35799522	35799522 (100.0%)	0
Average bytes/s	5251 k	5251 k	—
Average bits/s	42 M	42 M	—

Retransmitted Packets (2/33534) * 100 = 0.006 %

Port 4012

Measurement	Captured	Displayed	Marked
Packets	32414	32414 (100.0%)	—
Time span, s	5.440	5.440	—
Average pps	5958.6	5958.6	—
Average packet size, B	1101	1101	—
Bytes	35696577	35696577 (100.0%)	0
Average bytes/s	6562 k	6562 k	—
Average bits/s	52 M	52 M	—

Retransmitted Packets (4/32414) * 100 = 0.01 %

Port 4013

Measurement	Captured	Displayed	Marked
Packets	33351	33351 (100.0%)	—
Time span, s	5.264	5.264	—
Average pps	6336.1	6336.1	—
Average packet size, B	1072	1072	—
Bytes	35762399	35762399 (100.0%)	0
Average bytes/s	6794 k	6794 k	—
Average bits/s	54 M	54 M	—

Retransmitted Packets (1/33351) * 100 = 0.003 %

Port 4014

Measurement	Captured	Displayed	Marked
Packets	32306	32306 (100.0%)	—
Time span, s	5.524	5.524	—
Average pps	5848.1	5848.1	—
Average packet size, B	1105	1105	—
Bytes	35689456	35689456 (100.0%)	0
Average bytes/s	6460 k	6460 k	—
Average bits/s	51 M	51 M	—

Retransmitted Packets (3/32306) * 100 = 0.009 %

Port 4015

Measurement	Captured	Displayed	Marked
Packets	31936	31936 (100.0%)	—
Time span, s	6.404	6.404	—
Average pps	4986.8	4986.8	—
Average packet size, B	1117	1117	—
Bytes	35663590	35663590 (100.0%)	0
Average bytes/s	5568 k	5568 k	—
Average bits/s	44 M	44 M	—

Retransmitted Packets (4/31936) * 100 = 0.01 %

Port 4016

Measurement	Captured	Displayed	Marked
Packets	31136	31136 (100.0%)	—
Time span, s	5.764	5.764	—
Average pps	5402.0	5402.0	—
Average packet size, B	1144	1144	—
Bytes	35610718	35610718 (100.0%)	0
Average bytes/s	6178 k	6178 k	—
Average bits/s	49 M	49 M	—

Retransmitted Packets (3/31136) * 100 = 0.01 %

Port 4017

Measurement	Captured	Displayed	Marked
Packets	31187	31187 (100.0%)	—
Time span, s	5.061	5.061	—
Average pps	6162.5	6162.5	—
Average packet size, B	1142	1142	—
Bytes	35618333	35618333 (100.0%)	0
Average bytes/s	7038 k	7038 k	—
Average bits/s	56 M	56 M	—

Retransmitted Packets (10/31187) * 100 = 0.03 %

Port 4018

0 32.0M   0 14754   0   0   25   0 15d 12h 0:09:31 15d 12h   0* Recv failure:
Connection reset by peer
 0 32.0M   0 14754   0   0   25   0 15d 12h 0:09:32 15d 12h   0
* Closing connection 0
curl: (56) Recv failure: Connection reset by peer

Measurement	Captured	Displayed	Marked
Packets	99281	99281 (100.0%)	—
Time span, s	587.144	587.144	—
Average pps	169.1	169.1	—
Average packet size, B	729	729	—
Bytes	72329222	72329222 (100.0%)	0
Average bytes/s	123 k	123 k	—
Average bits/s	985 k	985 k	—

Retransmitted Packets (206/99281) * 100 = 0.21 %
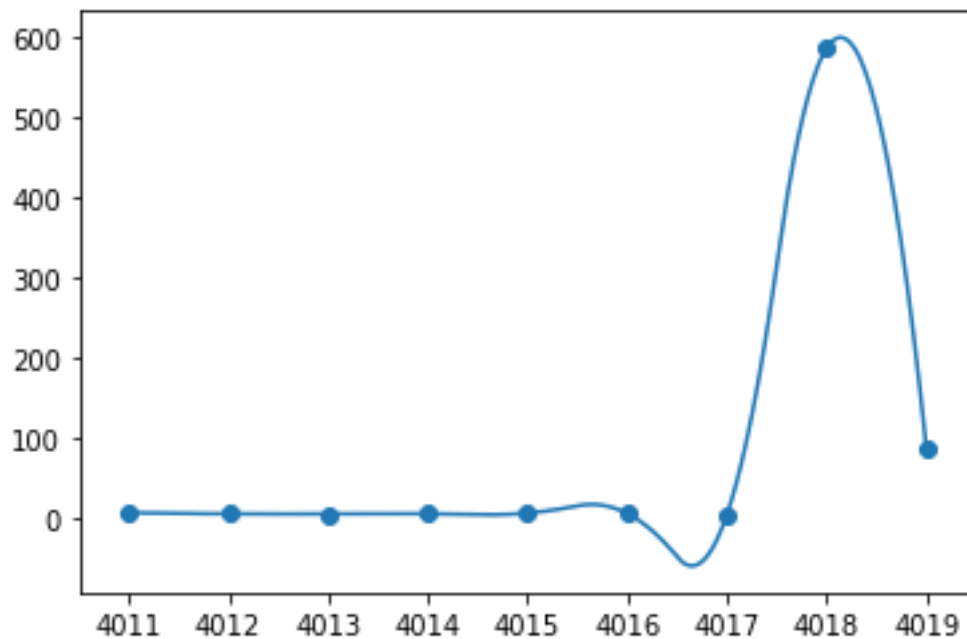
Port 4019

 0   0   0   0   0   0   0   0 --:--:-- 0:01:26 --:--:--   0* Recv failure: Connection reset
by peer
 0   0   0   0   0   0   0   0 --:--:-- 0:01:26 --:--:--   0
* Closing connection 0
curl: (56) Recv failure: Connection reset by peer

| Measurement	Captured	Displayed	Marked
Packets	732	732 (100.0%)	—
Time span, s	86.426	86.426	—
Average pps	8.5	8.5	—
Average packet size, B	430	430	—
Bytes	314640	314640 (100.0%)	0
Average bytes/s	3640	3640	—
Average bits/s	29 k	29 k	—

Retransmitted Packets (24/732) * 100 = 3.28 %

Conclusion for Part 3

Below, the time (s) is shown on the y-axis against the port number on the y-axis. The one thing to notice here is that the packet loss is not too much here because I didn't see much duplicate acknowledgements for this and the time to download the files was very small from port 4011 to port 4017. At port 4018, there was high packet loss and on port 4019, the packet loss and duplicate acknowledgements were so high that the connection was timed out or either reset by the peer. Dr Ian Batten mentioned in the assignment that the packet loss would get higher from port 4011 to 2019 but he also mentioned that this also depends on the network of the client.

Below, the retransmission percentage (y-axis) is shown against the port number (x-axis). Notice here that the percentage of the packets that are retransmitted is almost constant from

ports 4011 to port 4018 and there is a sudden intense increase in the retransmission percentage on port 4019.
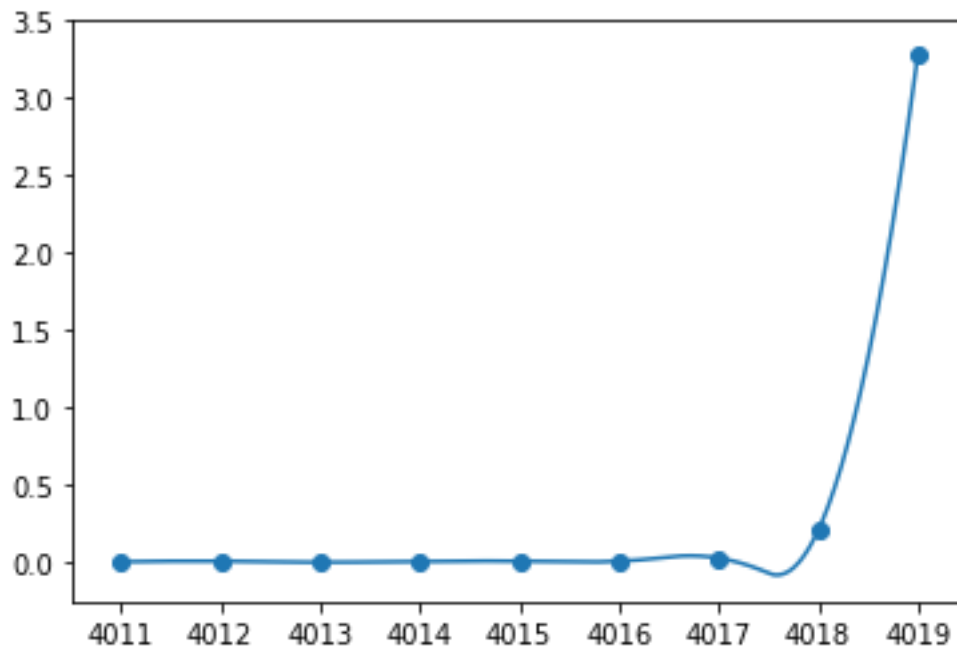
Ending Note

We can't exactly know how many packets got lost or trace them but we can find out if there is high packet loss.

Part 2 Time Against Port Number

```
In [4]: import numpy as np
        import matplotlib.pyplot as plt
        from scipy.interpolate import interp1d

        x=np.array([4000, 4001, 4002, 4003, 4004, 4005, 4006, 4007, 4008, 4009, 4010])
        y=np.array([6.823,28.576,44.810,81.208,172.766,566.827,1722.776,511.689,574.294,243.636,203.699])

        x_new = np.linspace(x.min(), x.max(),500)

        f = interp1d(x, y, kind='quadratic')
        y_smooth=f(x_new)

        plt.plot (x_new,y_smooth)
        plt.scatter (x, y)
```

Part 3 Time Against Port Number

```python
import numpy as np
import matplotlib.pyplot as plt
from scipy.interpolate import interp1d

x=np.array([4011, 4012, 4013, 4014, 4015, 4016, 4017, 4018, 4019])
y=np.array([6.816, 5.440, 5.264, 5.524, 6.404, 5.764, 5.061, 587.144, 86.426])

x_new = np.linspace(x.min(), x.max(),500)

f = interp1d(x, y, kind='quadratic')
y_smooth=f(x_new)

plt.plot (x_new,y_smooth)
plt.scatter (x, y)
```

Part 2 Retransmission Percentage Against Port Number

```python
import numpy as np
import matplotlib.pyplot as plt
from scipy.interpolate import interp1d

x=np.array([4000, 4001, 4002, 4003, 4004, 4005, 4006, 4007, 4008, 4009, 4010])
y=np.array([0.003, 0.88, 0.01, 0.02, 1.86, 2.34, 10.97, 15.87, 8.01, 10.79, 14.87])

x_new = np.linspace(x.min(), x.max(),500)

f = interp1d(x, y, kind='quadratic')
y_smooth=f(x_new)

plt.plot (x_new,y_smooth)
plt.scatter (x, y)
```

Part 3 Retransmission Percentage Against Port Number

```python
import numpy as np
import matplotlib.pyplot as plt
from scipy.interpolate import interp1d

x=np.array([4011, 4012, 4013, 4014, 4015, 4016, 4017, 4018, 4019])
y=np.array([0.006, 0.01, 0.003, 0.009, 0.01, 0.01, 0.03, 0.21, 3.28])

x_new = np.linspace(x.min(), x.max(),500)

f = interp1d(x, y, kind='quadratic')
y_smooth=f(x_new)

plt.plot (x_new,y_smooth)
plt.scatter (x, y)
```