CSE 4074 – Computer Networks Project

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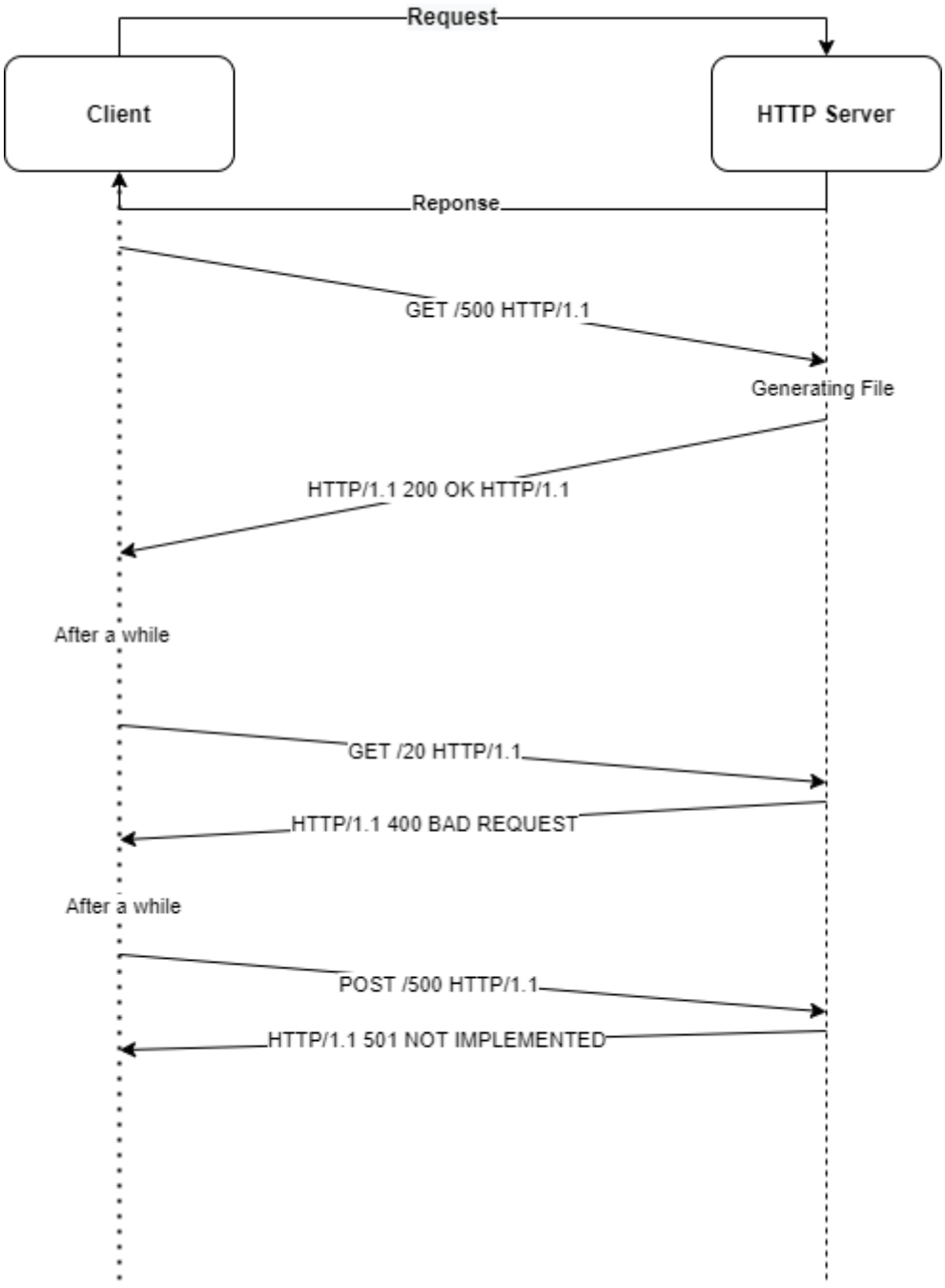
1. Http Server



Before starting coding, we have to import socket package. Which will help us to do the job. After that, we have to open a socket. To do that, we need an ip address and a port number. Our ip address will be local ip address and port number will be 5000 for now. It will be dynamic on the 1-b section.

```
import socket
SERVER = socket.gethostbyname(socket.gethostname())
ADDR = (SERVER, 5000)
FORMAT = 'utf-8'
httpserver = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
httpserver.bind(ADDR)
```

FORMAT variable is our text format for encoding responses and decoding requests.

a. First of all, we have to implement a threading functionality to our code. Because our code should give response to different clients. We used “Threading” library to do this.

```
import threading
```

we created a function, which will handle requests. Now, we should create a thread for each client (Keep alive: 1).

b. Now, we can take an argument for port number from user.

```
# python3 httpserver.py PORT_NUMBER

PORT = int(argv[1])

ADDR = (SERVER, PORT)
```

c. We can accept client and give a response them.

```
conn, addr = httpserver.accept()
thread = threading.Thread(target=handle_client, args=(conn, addr))
thread.start()
```

now, request will be handled in handle_client function. Firstly, we have to understand request message.

```
GET /favicon.ico HTTP/1.1
Host: 192.168.1.102:5000
Connection: keep-alive
Pragma: no-cache
Cache-Control: no-cache
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64)
AppleWebKit/537.36 (KHTML, like Gecko) Chrome/87.0.4280.141
Safari/537.36
Accept: image/avif,image/webp,image/apng,image/*,*/*;q=0.8
Referer: http://192.168.1.102:5000/500
Accept-Encoding: gzip, deflate
Accept-Language: en-US,en;q=0.9,tr;q=0.8
```

An example is given above. We can see first line is carrying method, file size and http version. Second line carrying host address. The other lines carrying different properties. After we decode request, we have to split first line into strings.

```
request = conn.recv(HEADER).decode(FORMAT)
headers = request.split("\n")
req_info = headers[0].split()
method = req_info[0] # GET
url = req_info[1] # /500
proto = req_info[2] # HTTP/1.1
```

In this method, we handle only GET requests. Therefore, for another request method we have to response 501 Not Implemented message. If request is GET then, we have to detect requested file size, if our file size is greater than and equal to 100 and smaller than or equal to 20000, then we should send back a response message and a file which have size of requested file size.

```
if method == "GET":
try:
            file_size = get_file_size(url)
             if url == '/favicon.ico':
                 response_status = "200 OK"
             elif 100 <= file_size <= 20000:
                 response_status = "200 OK"
                 content = create_file(file_size)
             else:
                 response_status = "400 Bad Request"
         except:
             response_status = "400 Bad Request"
else:
response_status = "501 Not Implemented"
```

In create_file function, we return a file which contains n letter where n is size of requested file given by client.

```
def create_file(size):
    content = ""
    for _ in range(size):
        lower_upper_alphabet = string.ascii_letters
        random_letter = random.choice(lower_upper_alphabet)
        content += random_letter
    content = f"<!DOCTYPE html><html><head><title>{str(size)} bytes<
/title></head><body>{content}</body></html>"
    return content
```

d.

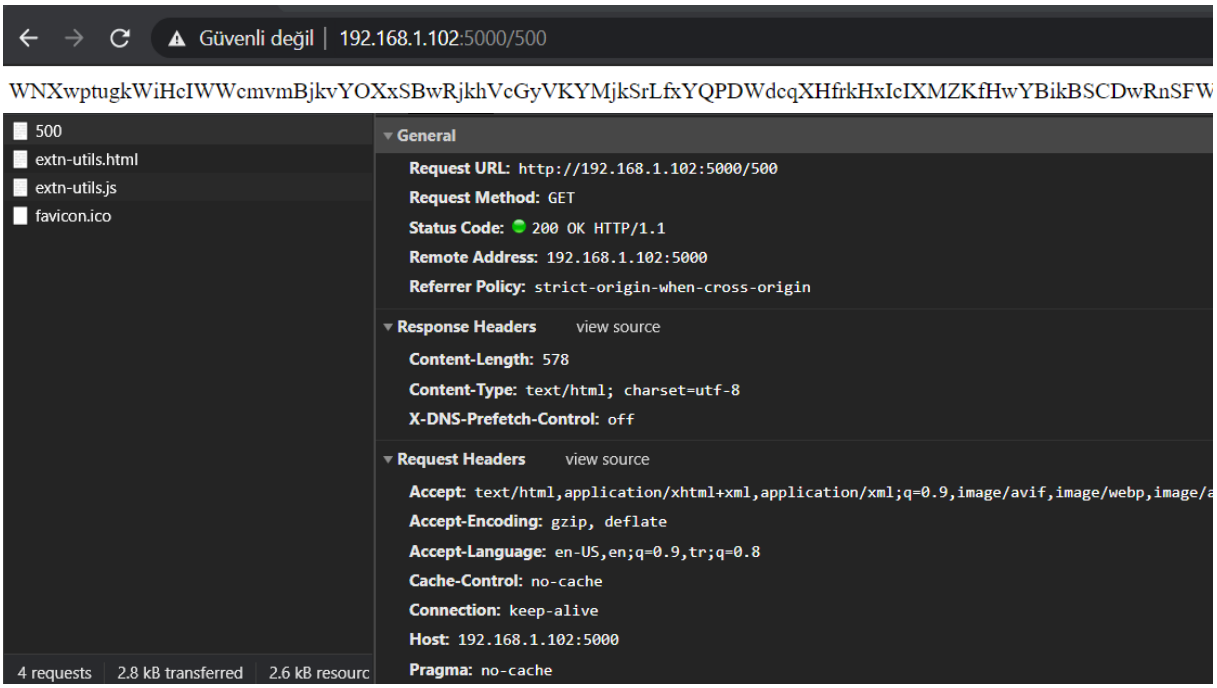
e.

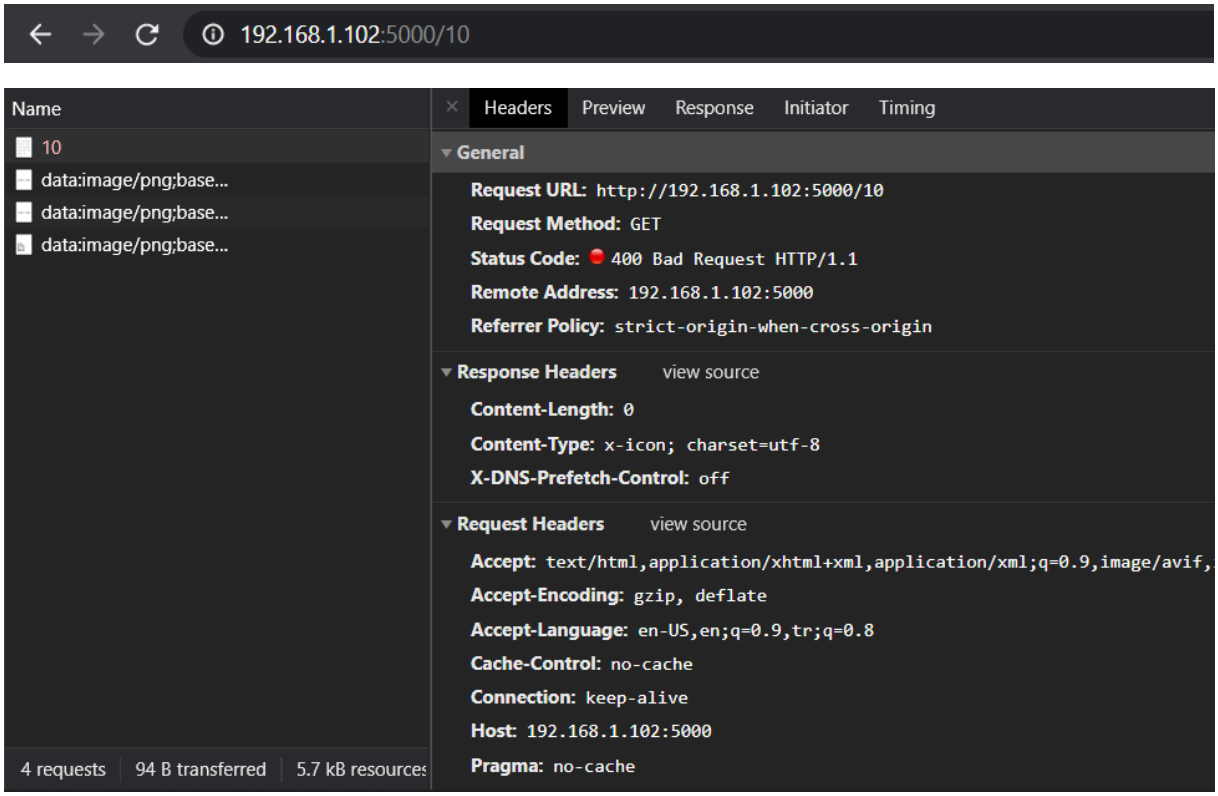
f. Then, values are passing send_response function. This function is send a response to client.

```
def send_response(connection, status, file, proto):
    response = str(
        f"{proto} {status} {proto} \r\nContent-
Length: {str(len(file))}\r\nContent-
Type: {'text/html' if file else 'x-
icon'}; charset={FORMAT}\r\n\r\n")
    print(
        f"[SERVER-RESPONSE MESSAGE]\n-----------------------------
------\n{response}")
    connection.sendall(response.encode(FORMAT))
    connection.sendall(file.encode(FORMAT))
```

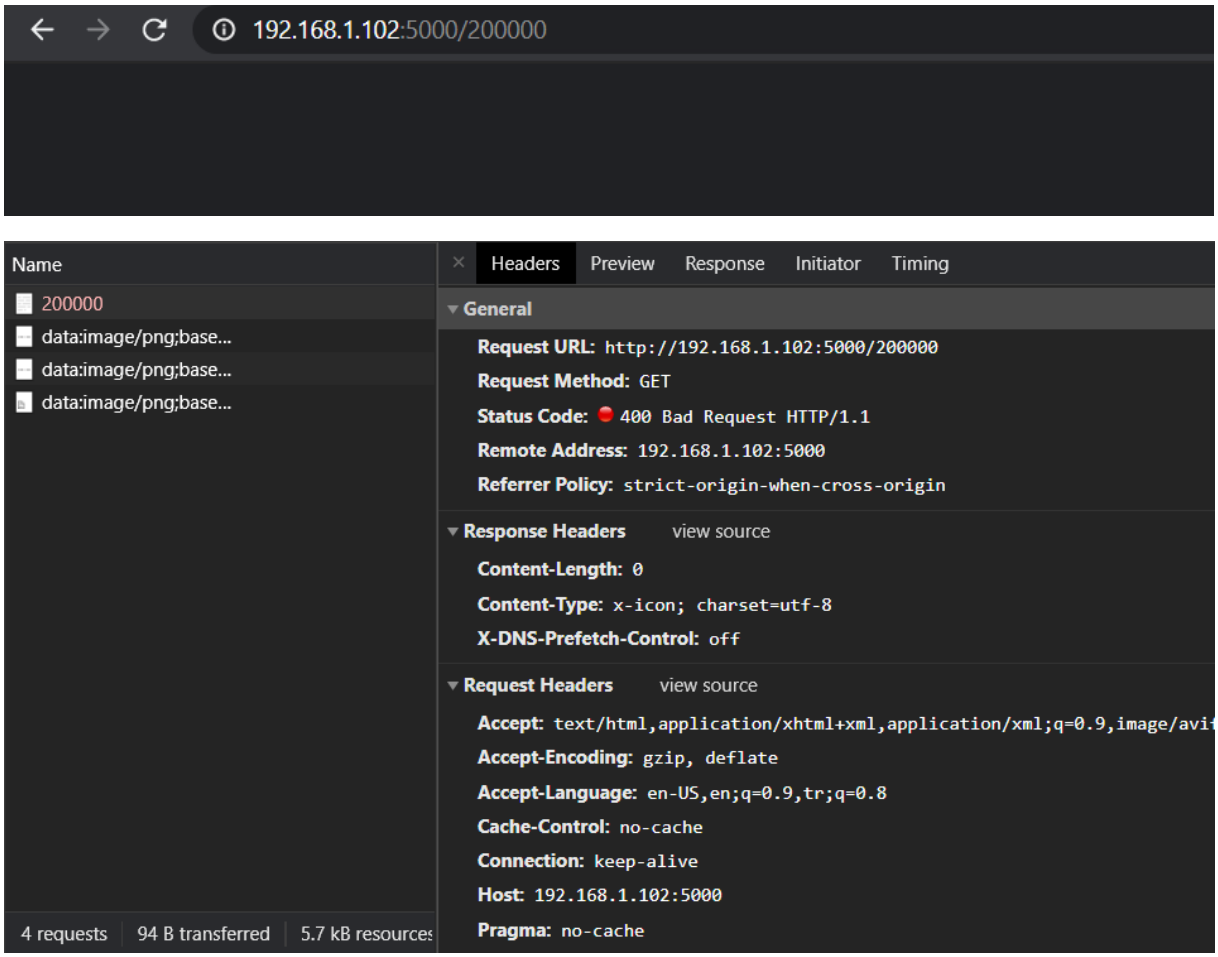
After that function, connection is closing.

g. Here are same example runs.

- 

- 

-



We will not be able to show a different method on browser. But here is a console output.

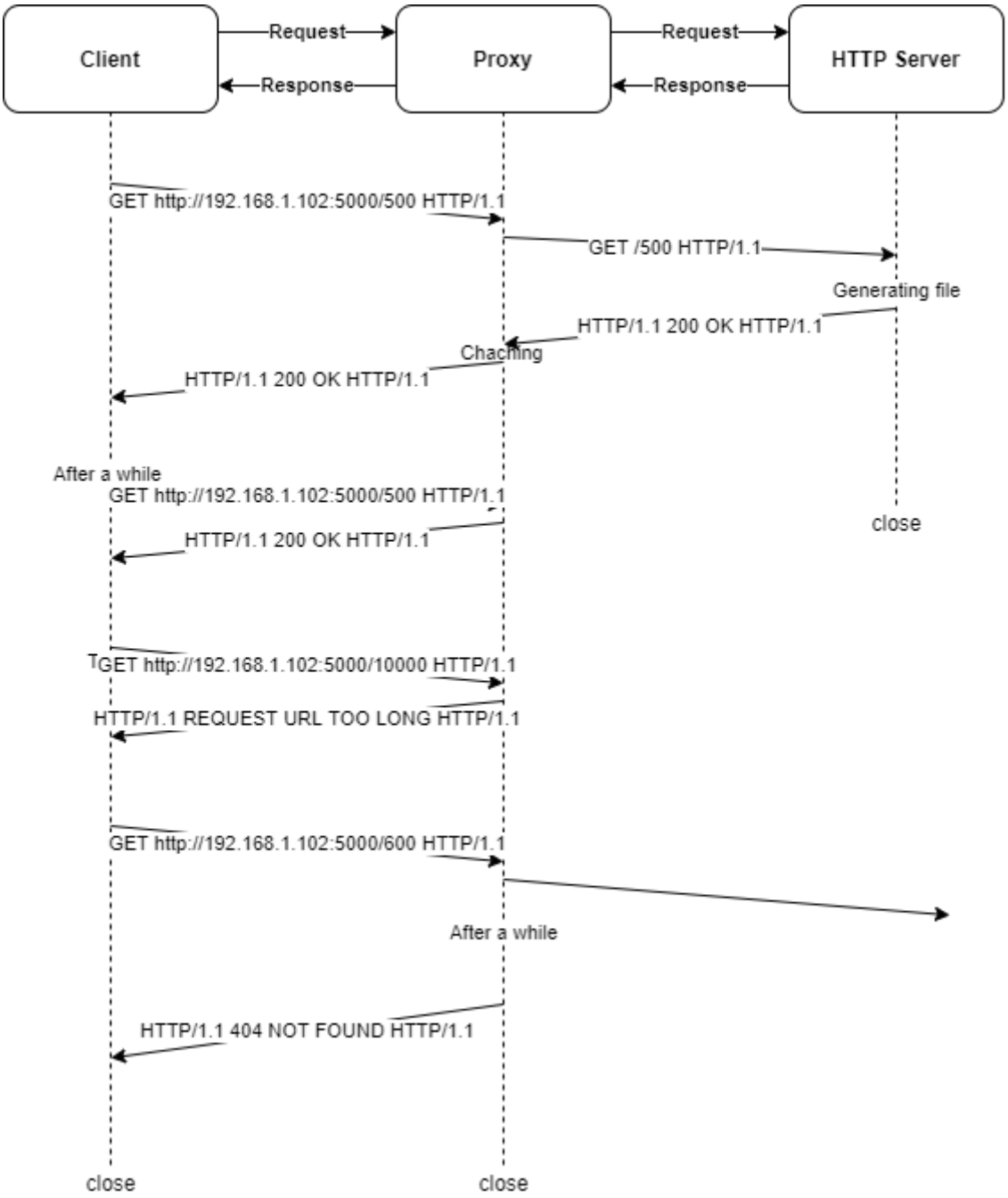
```
[SERVER-NEW CONNECTION]
------------------------------------
('192.168.1.102', 56502) is connected.

[SERVER-ACTIVE CONNECTIONS] 1
['PUT', '/2000', 'HTTP/1.0']

[SERVER-REQUEST INFORMATION]
------------------------------------
PUT /2000 HTTP/1.0

File Size= 0
[SERVER-RESPONSE MESSAGE]
------------------------------------
HTTP/1.0 501 Not Implemented HTTP/1.0
Content-Length: 0
Content-Type: x-icon; charset=utf-8
```

2. Proxy Server



a. In Proxy, Handling request is as same as in Http Server. In this part, we only redirect client's request to server then, we redirect httpserver's response to client.

```
s.send(request)          # send request to webserver
while 1:
      # receive data from web server
      data = s.recv(HEADER)
      print(f'[CONNECTION] SERVER -> PROXY')
      # print(f"[MESSAGE] {data}")

      if (len(data) > 0):
            # send to browser
```

```
            conn.send(data)
            content = data.decode(FORMAT)
            if "Content-Length" not in content:
                  save_to_cache(filename, content)
            else:
                  print(f'[CONNECTION] PROXY -> CLIENT')
      else:
            print(f'[CONNECTION] PROXY -> CLIENT')
            print(f"[MESSAGE] NULL")
```

b. If request is GET method, then request will redirect to httpserver. Otherwise, connection will be closed.

```
if webserver == SERVER and url[0] == "GET":
```

c. This if contidion checks if current request is for our httpserver and it is a GET request. We are not handling other server requests.

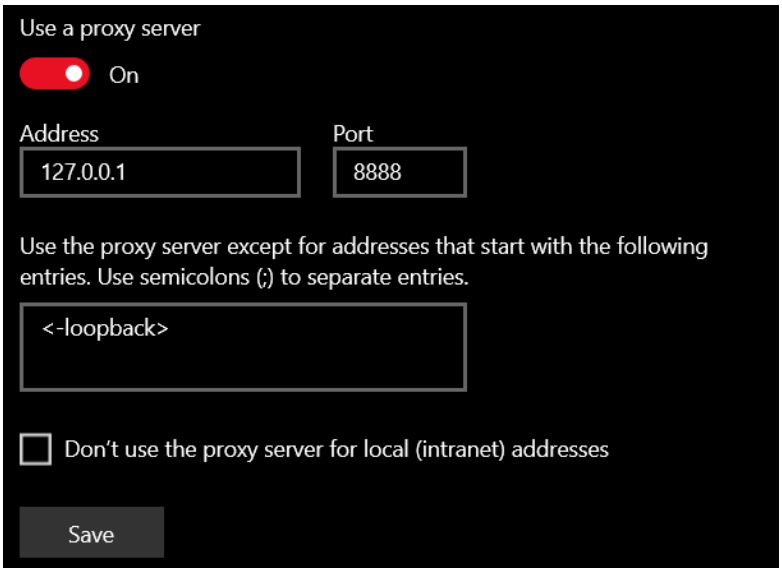
d. If requested file size is greater than or equal to 10000 bytes then, proxy send 414 REQUEST TOO LONG response.

```
if(file_size <= 9999):
      send_response(conn, "200 OK", cache_content, "HTTP/1.1")
else:
      file = read_file('/414.html')
      response = str(
            f"HTTP/1.1 414 Request-URI Too Long HTTP/1.1 \r\nContent-
Length: {str(len(file))}\r\nContent-
Type: text/html; charset={FORMAT}\r\n\r\n")
      print(f'[CONNECTION]\n{response}')
      conn.sendall(response.encode(FORMAT))
```

e. In the connect_server function, we are trying to open a socket connection to httpserver but if connection will end with an error after a timeout then, proxy send a 404 NOT FOUND response.

```
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
      try:
            s.connect((webserver, port))
            print(f'[CONNECTION] PROXY -> SERVER')
            new_message = request.decode(FORMAT).split('\n')[0]
            print(f"[MESSAGE] {new_message}")
       except:
            response = str(
             f"HTTP/1.1 404 Not Found HTTP/1.1 \r\nContent-
Length: 0\r\nContent-Type: text/html; charset={FORMAT}\r\n\r\n")
            print(f'[RESPONSE]\n404 NOT FOUND')
            conn.sendall(response.encode(FORMAT))
            s.close()
            conn.close()
```

f. Proxy setting are done in Settings>Network & Internet>Proxy.



Bonus Part

```
try:
        cached_file = open(f"cache{filename}", 'r')
        content = cached_file.read()
        cached_file.close()
        if file_size == len(content) - 79:
            return content
        else:
            return None
except IOError:
        print("AN ERROR OCCURED")
        return None
```

In this function we read the file that is stored in the cache but there is a problem. In concurrent request while a file write a content another one can try to read or write it. This cause a huge problem, to fix this we check file size of cached file and request file size. If both of them are equal than we can read it. Otherwise, we return null.

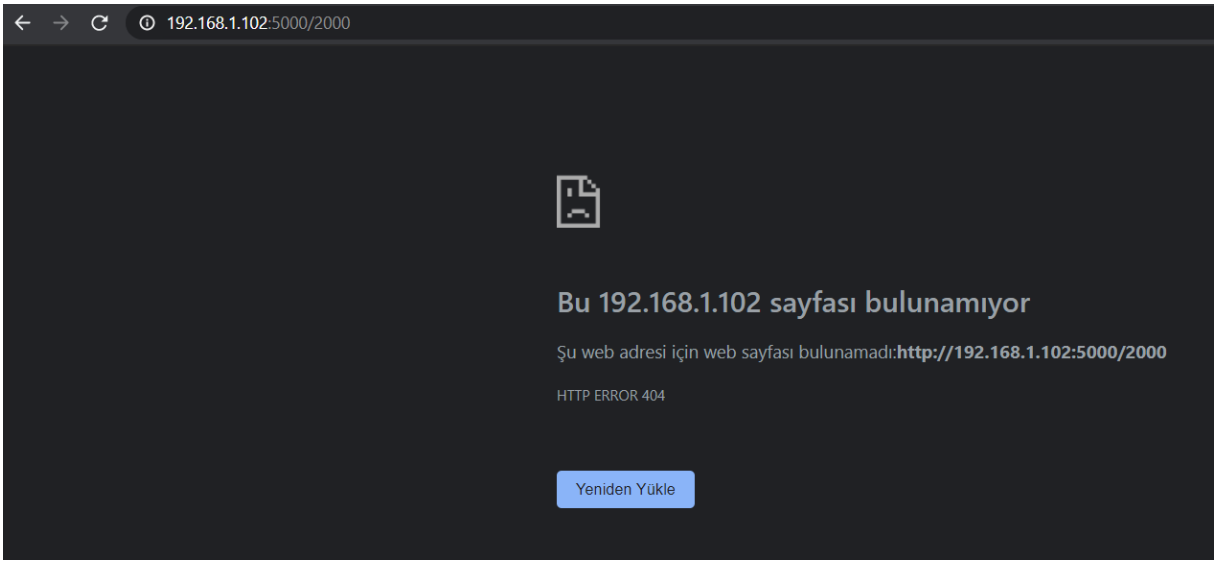
```
s.send(request)          # send request to webserver
while 1:
     # receive data from web server
     data = s.recv(HEADER)
     # print(f"[MESSAGE] {data}")
     if (len(data) > 0):
          # send to browser
          conn.send(data)
          content = data.decode(FORMAT)
          if "Content-
Length" not in content and not path.exists(f"cache{filename}"):
               save_to_cache(filename, content)
          else:
               break
```

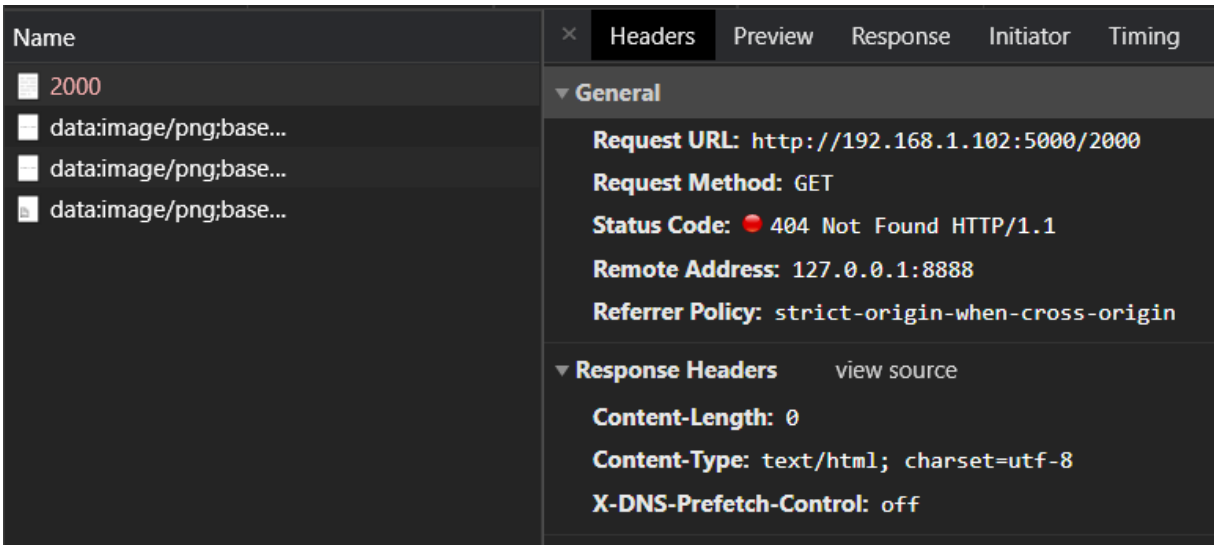
In the above code, we get content from httpserver, but there is a problem which is similar with above one. There can be more than one request that try to write on the same file. We have to set a

boundry. If a thread create a file and start to write onto it then, no thread can access it neither for writing nor for reading.

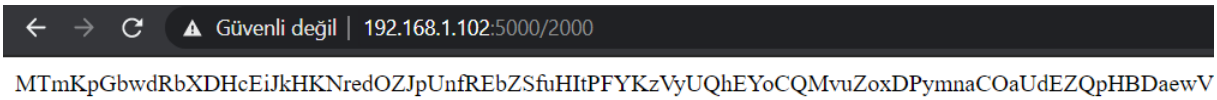
Here is sample runs:

If server is not running

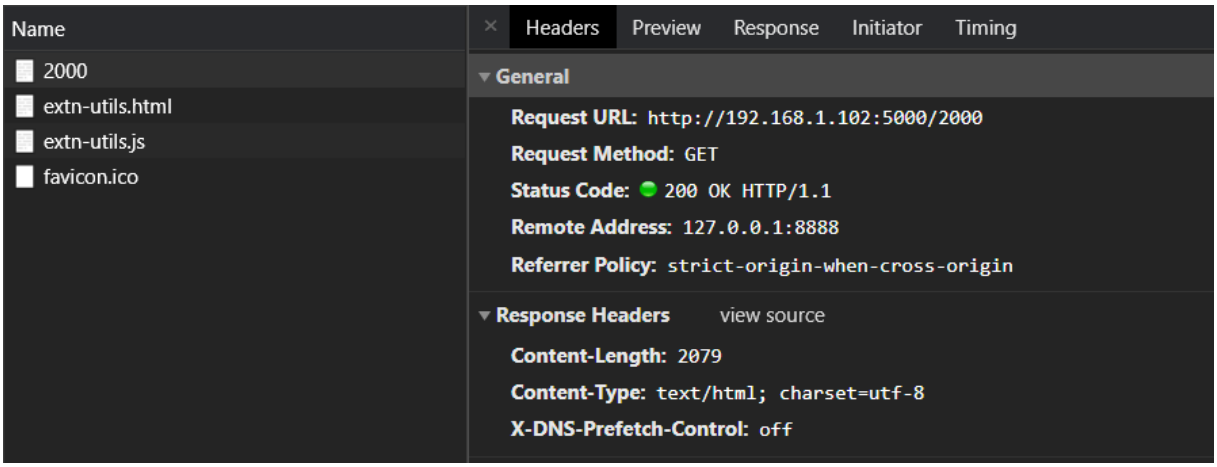




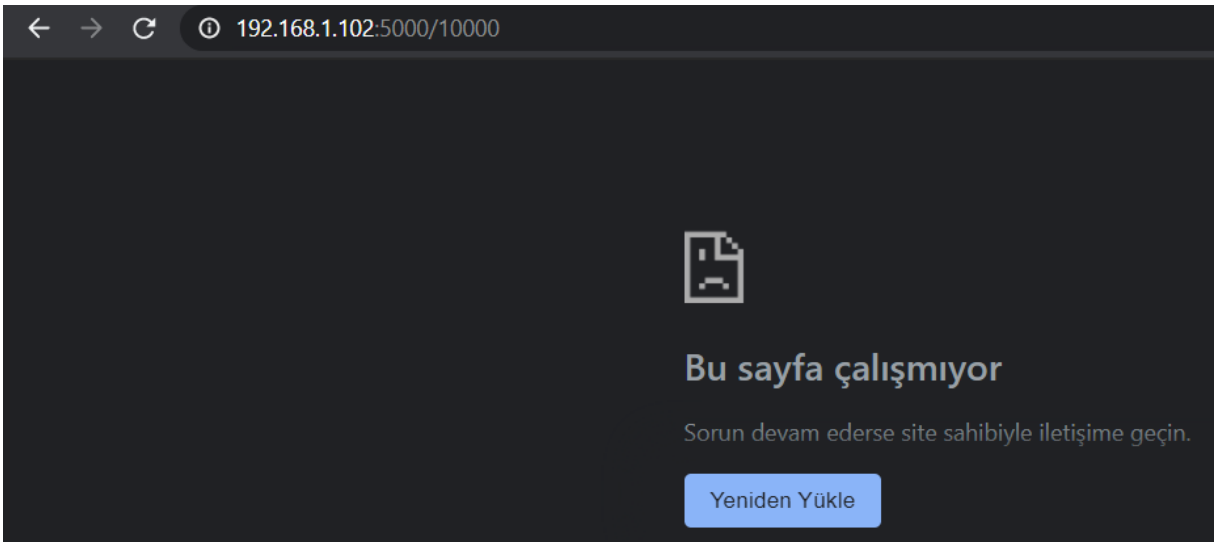
If server running and requested file size is smaller than 10000.

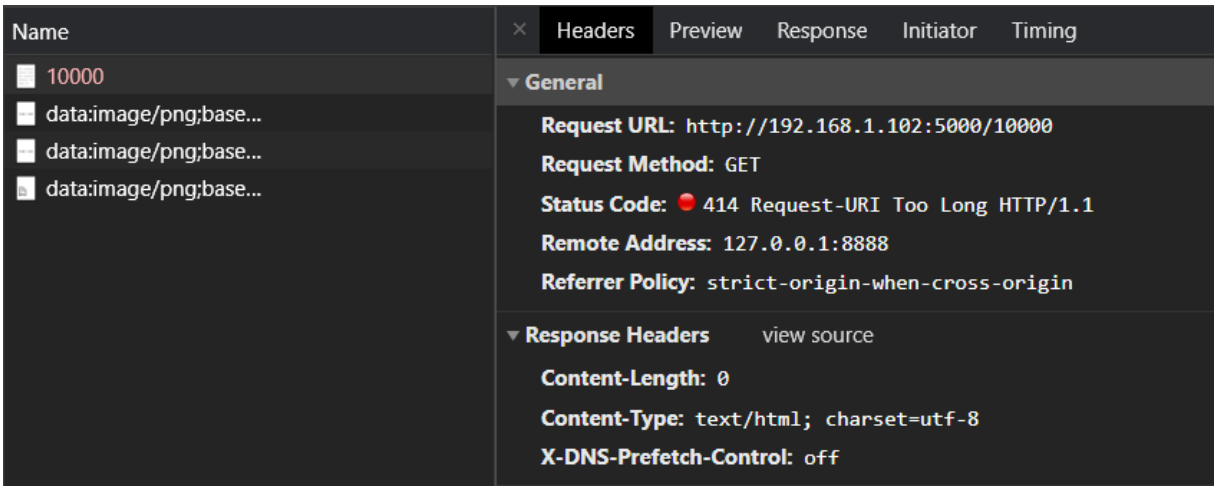


MTmKpGbwdRbXDHcEiJkHKNredOZJpUnfREbZSfuHItPFYKzVyUQhEYoCQMvuZoxDPymnaCOaUdEZQpHBDaewV



If requested file size is greater than 10000.





If same file requested twice

1.

Name	S. T. I.. Size	Time
9995	2. d. O 10.2 kB	141 ms
extn-utils.html	2. d. j.. 1.1 kB	4 ms
extn-utils.js	2. s. c. 989 B	4 ms
favicon.ico	2. t.. O 85 B	34 ms

2.

Name	S. T. I.. Size	Time
9995	2. d. O 2.0 kB	53 ms
extn-utils.html	2. d. j.. 1.1 kB	3 ms
extn-utils.js	2. s. c. 989 B	3 ms
favicon.ico	2. t.. O 85 B	22 ms

We can see time is almost 1/3 of first request.

3. Using ApacheBench (ab) program:

a.

```
ab -n 10 -c 1 http://ipv4.download.thinkbroadband.com/5MB.zip
```

```
Microsoft Windows [Version 10.0.18363.1316]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Apache24\bin>ab.exe -n 10 -c 1 http://ipv4.download.thinkbroadband.com/5MB.zi
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking ipv4.download.thinkbroadband.com (be patient).....done


Server Software:        nginx
Server Hostname:        ipv4.download.thinkbroadband.com
Server Port:            80

Document Path:          /5MB.zip
Document Length:        5242880 bytes

Concurrency Level:      1
Time taken for tests:   48.885 seconds
Complete requests:      10
Failed requests:        0
Total transferred:      52431510 bytes
HTML transferred:       52428800 bytes
Requests per second:    0.20 [#/sec] (mean)
Time per request:       4888.528 [ms] (mean)
Time per request:       4888.528 [ms] (mean, across all concurrent requests)
Transfer rate:          1047.40 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:       57  165 318.1     64    1070
Processing:  3199 4724 889.6   5210    5495
Waiting:       56   67   6.4     68      74
Total:       3263 4889 803.5   5270    5564

Percentage of the requests served within a certain time (ms)
  50%   5270
  66%   5333
  75%   5475
  80%   5530
  90%   5564
  95%   5564
  98%   5564
  99%   5564
 100%   5564 (longest request)
```

b.

```
ab -n 10 -c 5 http://ipv4.download.thinkbroadband.com/5MB.zip
```

```
C:\Apache24\bin>ab.exe -n 10 -c 5 http://ipv4.download.thinkbroadband.com/5MB.zip
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking ipv4.download.thinkbroadband.com (be patient).....done


Server Software:        nginx
Server Hostname:        ipv4.download.thinkbroadband.com
Server Port:            80

Document Path:          /5MB.zip
Document Length:        5242880 bytes

Concurrency Level:      5
Time taken for tests:   25.828 seconds
Complete requests:      10
Failed requests:        0
Total transferred:      52431510 bytes
HTML transferred:       52428800 bytes
Requests per second:    0.39 [#/sec] (mean)
Time per request:       12914.242 [ms] (mean)
Time per request:       2582.848 [ms] (mean, across all concurrent requests)
Transfer rate:          1982.41 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:       64   72   8.1     72      88
Processing:  7782 11067 3256.0  11093   16094
Waiting:       56  105  62.3     72     232
Total:       7854 11139 3258.5  11173   16174

Percentage of the requests served within a certain time (ms)
  50%  11173
  66%  14009
  75%  14135
  80%  14449
  90%  16174
  95%  16174
  98%  16174
  99%  16174
 100%  16174 (longest request)
```

c.

```
ab -n 10 -c 10 http://ipv4.download.thinkbroadband.com/5MB.zip
```

```
C:\Apache24\bin>ab.exe -n 10 -c 10 http://ipv4.download.thinkbroadband.com/5MB.zip
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking ipv4.download.thinkbroadband.com (be patient).....done


Server Software:        nginx
Server Hostname:        ipv4.download.thinkbroadband.com
Server Port:            80

Document Path:          /5MB.zip
Document Length:        5242880 bytes

Concurrency Level:      10
Time taken for tests:   21.630 seconds
Complete requests:      10
Failed requests:        0
Total transferred:      52431510 bytes
HTML transferred:       52428800 bytes
Requests per second:    0.46 [#/sec] (mean)
Time per request:       21630.472 [ms] (mean)
Time per request:       2163.047 [ms] (mean, across all concurrent requests)
Transfer rate:          2367.15 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:       54   66   9.0     69      85
Processing: 11682 16774 2985.8  16343   20896
Waiting:       63  285 162.3    270     549
Total:      11744 16840 2989.4  16413   20965

Percentage of the requests served within a certain time (ms)
  50%  16413
  66%  18599
  75%  19290
  80%  20552
  90%  20965
  95%  20965
  98%  20965
  99%  20965
 100%  20965 (longest request)
```

d.

```
C:\Apache24\bin>ab.exe -n 10 -c 1 -k http://ipv4.download.thinkbroadband.com/5MB.zip
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking ipv4.download.thinkbroadband.com (be patient).....done


Server Software:        nginx
Server Hostname:        ipv4.download.thinkbroadband.com
Server Port:            80

Document Path:          /5MB.zip
Document Length:        5242880 bytes

Concurrency Level:      1
Time taken for tests:   35.700 seconds
Complete requests:      10
Failed requests:        0
Keep-Alive requests:    10
Total transferred:      52431560 bytes
HTML transferred:       52428800 bytes
Requests per second:    0.28 [#/sec] (mean)
Time per request:       3570.020 [ms] (mean)
Time per request:       3570.020 [ms] (mean, across all concurrent requests)
Transfer rate:          1434.24 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    5  16.2      0      51
Processing:  2875 3565 766.8   3412    5418
Waiting:       48   56   5.3     56      66
Total:       2875 3570 780.6   3412    5470

Percentage of the requests served within a certain time (ms)
  50%   3412
  66%   3477
  75%   3708
  80%   4231
  90%   5470
  95%   5470
  98%   5470
  99%   5470
 100%   5470 (longest request)
```

```
C:\Apache24\bin>ab.exe -n 10 -c 5 -k http://ipv4.download.thinkbroadband.com/5MB.zip
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking ipv4.download.thinkbroadband.com (be patient).....done


Server Software:        nginx
Server Hostname:        ipv4.download.thinkbroadband.com
Server Port:            80

Document Path:          /5MB.zip
Document Length:        5242880 bytes

Concurrency Level:      5
Time taken for tests:   25.138 seconds
Complete requests:      10
Failed requests:        0
Keep-Alive requests:    10
Total transferred:      52431560 bytes
HTML transferred:       52428800 bytes
Requests per second:    0.40 [#/sec] (mean)
Time per request:       12568.871 [ms] (mean)
Time per request:       2513.774 [ms] (mean, across all concurrent requests)
Transfer rate:          2036.89 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   33  35.1     58      72
Processing:  7492 10379 2336.9   9760   15308
Waiting:       64   95  42.4     85     202
Total:       7553 10412 2356.3   9760   15375

Percentage of the requests served within a certain time (ms)
  50%   9760
  66%   9852
  75%  11690
  80%  13120
  90%  15375
  95%  15375
  98%  15375
  99%  15375
 100%  15375 (longest request)
```

```
C:\Apache24\bin>ab.exe -n 10 -c 10 -k http://ipv4.download.thinkbroadband.com/5MB.zip
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
Copyright 1996 Adam Twiss, Zeus Technology Ltd, http://www.zeustech.net/
Licensed to The Apache Software Foundation, http://www.apache.org/

Benchmarking ipv4.download.thinkbroadband.com (be patient).....done

Server Software:        nginx
Server Hostname:        ipv4.download.thinkbroadband.com
Server Port:            80

Document Path:          /5MB.zip
Document Length:        5242880 bytes

Concurrency Level:      10
Time taken for tests:   21.638 seconds
Complete requests:      10
Failed requests:        0
Keep-Alive requests:    10
Total transferred:      52431560 bytes
HTML transferred:       52428800 bytes
Requests per second:    0.46 [#/sec] (mean)
Time per request:       21638.289 [ms] (mean)
Time per request:       2163.829 [ms] (mean, across all concurrent requests)
Transfer rate:          2366.30 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:       56   64   7.0     63      77
Processing: 14297 17142 2372.2  17913   20914
Waiting:       69  266 160.0    267     520
Total:      14353 17205 2377.9  17971   20991

Percentage of the requests served within a certain time (ms)
  50%  17971
  66%  18608
  75%  18621
  80%  19923
  90%  20991
  95%  20991
  98%  20991
  99%  20991
 100%  20991 (longest request)
```

Outputs

Labels	3-a	3-b	3-c	3-d-a	3-d-b	3-d-c
Time taken for tests(seconds)	48.885	25.828	21.630	35.700	25.138	21.638
Total Transferred	52431510	52431510	52431510	52431510	52431560	52431560
HTML transferred	52428800	52428800	52428800	52428800	52428800	52428800
Time per Request	4888.528	2582.848	2163.047	3570.020	2513.774	2163.829
Requests per second	0.20	0.39	0.46	0.28	0.40	0.46
Transfer Rate	1047.40	1982.41	2367.15	1434.24	2036.89	2366.30

We send same request for 10 times with different concurrency level.

i. From first row of table, we can see time taken for tests is decreased while concurrency level is increasing. For small concurrency level, when we add -k parameter, difference between them is huge but for high concurreny level, differences are small.
ii. Size of transferred files do not change. Because we always request same file. Same for HTML transferred.
iii. Time per request has same attitude with time taken for tests. If we use low concurrency levels than we have to wait more.
iv. Same with above but reverse direction. If we increase concurrency level then, we have high requests per second.
v. When concurrency level is high, we have higher transfer rates.
vi. Connection times generally increase when concurreny level is increasing

Main reason of them, when there is a concurrence request, there will be a queue and this will cause connection times will increase. But when concurrency is high then, we use more source in a unit time so, our request will be responded in shorter time. Our number of request does not change, but our response time decreases so time per request will decrease. We have more request in a unit time, this will increase our requests per second and transfer rate.

4. Testing your server using ApacheBench

HTTP Server

```
C:\Apache24\bin>ab -n 100 -c 1 http://192.168.1.102:5000/9000
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      1
Time taken for tests:   1.692 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    59.12 [#/sec] (mean)
Time per request:       16.916 [ms] (mean)
Time per request:       16.916 [ms] (mean, across all concurrent
requests)
Transfer rate:          529.40 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   1.2      0      10
Processing:    12   16   2.2     16      29
Waiting:       12   16   2.2     16      29
Total:         12   17   2.5     16      29

Percentage of the requests served within a certain time (ms)
  50%     16
  66%     16
  75%     16
  80%     17
  90%     20
  95%     20
  98%     28
  99%     29
 100%     29 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 5 http://192.168.1.102:5000/9000
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      5
Time taken for tests:   1.750 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    57.13 [#/sec] (mean)
Time per request:       87.517 [ms] (mean)
Time per request:       17.503 [ms] (mean, across all concurrent
requests)
Transfer rate:          511.62 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   0.8      0       4
Processing:    27   85  27.8     83     160
Waiting:       27   84  27.8     82     160
Total:         27   85  27.7     83     160

Percentage of the requests served within a certain time (ms)
  50%     83
  66%     94
  75%    100
  80%    108
  90%    124
  95%    136
  98%    152
  99%    160
 100%    160 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 10 http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      10
Time taken for tests:   1.930 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    51.82 [#/sec] (mean)
Time per request:       192.965 [ms] (mean)
Time per request:       19.297 [ms] (mean, across all concurrent
requests)
Transfer rate:          464.08 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   0.9      0       4
Processing:    46  182  47.8    184     316
Waiting:       42  181  47.5    184     316
Total:         46  182  47.8    184     316

Percentage of the requests served within a certain time (ms)
  50%    184
  66%    196
  75%    212
  80%    217
  90%    236
  95%    268
  98%    284
  99%    316
 100%    316 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 50 http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      50
Time taken for tests:   4.298 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    23.27 [#/sec] (mean)
Time per request:       2148.987 [ms] (mean)
Time per request:       42.980 [ms] (mean, across all concurrent
requests)
Transfer rate:          208.36 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   41 139.0      0     527
Processing:    34 1626 757.4   2058    2583
Waiting:       28 1194 656.0   1022    2070
Total:         66 1667 759.2   2058    2585

Percentage of the requests served within a certain time (ms)
  50%   2058
  66%   2067
  75%   2074
  80%   2075
  90%   2576
  95%   2578
  98%   2583
  99%   2585
 100%   2585 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 100 http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      100
Time taken for tests:   4.324 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    23.12 [#/sec] (mean)
Time per request:       4324.337 [ms] (mean)
Time per request:       43.243 [ms] (mean, across all concurrent
requests)
Transfer rate:          207.09 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   41 138.2      0     518
Processing:    25 2090 1309.5   2063    4110
Waiting:       25 2042 1306.0   2054    4076
Total:         49 2130 1307.7   2063    4110

Percentage of the requests served within a certain time (ms)
  50%   2063
  66%   3076
  75%   3077
  80%   3581
  90%   4088
  95%   4088
  98%   4088
  99%   4110
 100%   4110 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 1 -k http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      1
Time taken for tests:   1.778 seconds
Complete requests:      100
Failed requests:        0
Keep-Alive requests:    0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    56.24 [#/sec] (mean)
Time per request:       17.781 [ms] (mean)
Time per request:       17.781 [ms] (mean, across all concurrent
requests)
Transfer rate:          503.63 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   1.0      0       4
Processing:    12   17   5.1     16      48
Waiting:       12   17   5.0     16      48
Total:         12   18   5.0     16      48

Percentage of the requests served within a certain time (ms)
  50%     16
  66%     16
  75%     16
  80%     20
  90%     20
  95%     28
  98%     40
  99%     48
 100%     48 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 5 -k http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      5
Time taken for tests:   1.986 seconds
Complete requests:      100
Failed requests:        0
Keep-Alive requests:    0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    50.35 [#/sec] (mean)
Time per request:       99.305 [ms] (mean)
Time per request:       19.861 [ms] (mean, across all concurrent
requests)
Transfer rate:          450.89 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   0.9      0       4
Processing:    32   96  32.1     93     200
Waiting:       32   96  32.1     93     200
Total:         32   97  32.1     96     200

Percentage of the requests served within a certain time (ms)
  50%     96
  66%    109
  75%    116
  80%    116
  90%    144
  95%    160
  98%    180
  99%    200
 100%    200 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 10 -k http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      10
Time taken for tests:   1.996 seconds
Complete requests:      100
Failed requests:        0
Keep-Alive requests:    0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    50.09 [#/sec] (mean)
Time per request:       199.623 [ms] (mean)
Time per request:       19.962 [ms] (mean, across all concurrent
requests)
Transfer rate:          448.60 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   0.7      0       4
Processing:    28  189  51.9    194     313
Waiting:       28  189  51.9    192     313
Total:         28  190  51.8    194     313

Percentage of the requests served within a certain time (ms)
  50%    194
  66%    212
  75%    220
  80%    229
  90%    251
  95%    280
  98%    296
  99%    313
 100%    313 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 50 -k http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      50
Time taken for tests:   4.342 seconds
Complete requests:      100
Failed requests:        0
Keep-Alive requests:    0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    23.03 [#/sec] (mean)
Time per request:       2171.245 [ms] (mean)
Time per request:       43.425 [ms] (mean, across all concurrent
requests)
Transfer rate:          206.22 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   41 139.4      0     520
Processing:    52 1640 778.5   2065    2597
Waiting:       27 1192 658.9   1046    2082
Total:         52 1681 779.9   2065    2599

Percentage of the requests served within a certain time (ms)
  50%   2065
  66%   2075
  75%   2079
  80%   2571
  90%   2583
  95%   2595
  98%   2597
  99%   2599
 100%   2599 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 100 -k http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 (be patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      100
Time taken for tests:   4.339 seconds
Complete requests:      100
Failed requests:        0
Keep-Alive requests:    0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    23.04 [#/sec] (mean)
Time per request:       4339.438 [ms] (mean)
Time per request:       43.394 [ms] (mean, across all concurrent
requests)
Transfer rate:          206.36 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   41 138.3      0     516
Processing:    77 2144 1320.5   2071    4151
Waiting:       31 2096 1316.1   2064    4104
Total:         78 2185 1317.7   2071    4151

Percentage of the requests served within a certain time (ms)
  50%   2071
  66%   3097
  75%   3607
  80%   3608
  90%   4120
  95%   4120
  98%   4120
  99%   4151
 100%   4151 (longest request)
```

Labels	-c 1	-c 5	-c 10	-c 50	-c 100
Time taken for tests(seconds)	1.692	1.750	1.930	4.298	4.324
Total Transferred	917000	917000	917000	917000	917000
HTML transferred	907900	907900	907900	907900	907900
Time per Request	16.916	17.503	19.297	42.980	43.243
Requests per second	59.12	57.13	51.82	23.27	23.12
Transfer Rate	529.40	511.62	464.08	208.36	207.09

** Our server is located on our local device. Therefore, there is no much different when we increase concurrency level by 1 so, we use 1,5,10,50,100 concurrency levels.*

We can see when concurrency level increased, our connections are getting to slower. Main reason is that we create a file which contains n bytes word where n is entered by user. This process takes some time so, when we increase concurrency levels, our transfer rate, time taken for tests and time per request are increasing and request per second is decreasing. Same for below.

Labels	-c 1 -k	-c 5 -k	-c 10 -k	-c 50 -k	-c 100 -k
Time taken for tests(seconds)	1.778	1.986	1.996	4.342	4.339
Total Transferred	917000	917000	917000	917000	917000
HTML transferred	907900	907900	907900	907900	907900
Time per Request	17.781	19.861	19.962	43.425	43.394
Requests per second	56.24	50.35	50.09	23.03	23.04
Transfer Rate	503.63	450.89	448.60	206.22	206.36

Proxy

```
C:\Apache24\bin>ab -n 100 -c 1 -X 127.0.0.1:8888
http://192.168.1.102:5000/9000
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
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Benchmarking 192.168.1.102 [through 127.0.0.1:8888] (be
patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      1
Time taken for tests:   0.734 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    136.29 [#/sec] (mean)
Time per request:       7.337 [ms] (mean)
Time per request:       7.337 [ms] (mean, across all concurrent
requests)
Transfer rate:          1220.49 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   1.0      0       4
Processing:     0    7  17.3      4     173
Waiting:        0    5   5.5      4      42
Total:          0    7  17.3      4     173

Percentage of the requests served within a certain time (ms)
  50%      4
  66%      8
  75%      8
  80%      8
  90%     12
  95%     16
  98%     19
  99%    173
 100%    173 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 5 -X 127.0.0.1:8888
http://192.168.1.102:5000/9000
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
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Benchmarking 192.168.1.102 [through 127.0.0.1:8888] (be
patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      5
Time taken for tests:   0.324 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    308.35 [#/sec] (mean)
Time per request:       16.216 [ms] (mean)
Time per request:       3.243 [ms] (mean, across all concurrent
requests)
Transfer rate:          2761.25 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   1.0      0       4
Processing:     4   15   4.3     16      28
Waiting:        4   15   4.3     16      28
Total:          4   15   4.2     16      28

Percentage of the requests served within a certain time (ms)
  50%     16
  66%     16
  75%     16
  80%     20
  90%     20
  95%     24
  98%     25
  99%     28
 100%     28 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 10 -X 127.0.0.1:8888
http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 [through 127.0.0.1:8888] (be
patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      10
Time taken for tests:   0.318 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    314.84 [#/sec] (mean)
Time per request:       31.762 [ms] (mean)
Time per request:       3.176 [ms] (mean, across all concurrent
requests)
Transfer rate:          2819.40 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0    0   0.7      0       4
Processing:    12   29   9.0     28      48
Waiting:       12   29   9.1     28      48
Total:         12   29   9.1     28      48

Percentage of the requests served within a certain time (ms)
  50%     28
  66%     32
  75%     36
  80%     36
  90%     44
  95%     48
  98%     48
  99%     48
 100%     48 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 50 -X 127.0.0.1:8888
http://192.168.1.102:5000/9000
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Benchmarking 192.168.1.102 [through 127.0.0.1:8888] (be
patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      50
Time taken for tests:   3.653 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    27.38 [#/sec] (mean)
Time per request:       1826.342 [ms] (mean)
Time per request:       36.527 [ms] (mean, across all concurrent
requests)
Transfer rate:          245.16 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   36 130.7      0     520
Processing:    22 1515 540.2   1556    2071
Waiting:       13  968 454.0   1034    1559
Total:        515 1551 529.2   1556    2075

Percentage of the requests served within a certain time (ms)
  50%   1556
  66%   2062
  75%   2063
  80%   2064
  90%   2070
  95%   2071
  98%   2071
  99%   2075
 100%   2075 (longest request)
```

```
C:\Apache24\bin>ab -n 100 -c 100 -X 127.0.0.1:8888
http://192.168.1.102:5000/9000
This is ApacheBench, Version 2.3 <$Revision: 1879490 $>
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Benchmarking 192.168.1.102 [through 127.0.0.1:8888] (be
patient).....done


Server Software:
Server Hostname:        192.168.1.102
Server Port:            5000

Document Path:          /9000
Document Length:        9079 bytes

Concurrency Level:      100
Time taken for tests:   3.663 seconds
Complete requests:      100
Failed requests:        0
Total transferred:      917000 bytes
HTML transferred:       907900 bytes
Requests per second:    27.30 [#/sec] (mean)
Time per request:       3662.762 [ms] (mean)
Time per request:       36.628 [ms] (mean, across all concurrent
requests)
Transfer rate:          244.49 [Kbytes/sec] received

Connection Times (ms)
              min  mean[+/-sd] median   max
Connect:        0   36 131.8      0     519
Processing:    17 2024 1101.8   2083    3654
Waiting:       10 1979 1104.9   2072    3632
Total:         17 2060 1094.7   2084    3654

Percentage of the requests served within a certain time (ms)
  50%   2084
  66%   2602
  75%   3121
  80%   3121
  90%   3644
  95%   3644
  98%   3644
  99%   3654
 100%   3654 (longest request)
```

Labels	-c 1	-c 5	-c 10	-c 50	-c 100
Time taken for tests(seconds)	0.734	0.324	0.318	3.653	3.663
Total Transferred	917000	917000	917000	917000	917000
HTML transferred	907900	907900	907900	907900	907900
Time per Request	7.337	3.243	3.176	36.527	36.628
Requests per second	136.29	308.35	314.84	27.38	27.30
Transfer Rate	1220.49	2761.25	2819.40	245.16	244.49

** Now, we have a cached proxy. When client send a request, proxy redirect that request to server then, store the responsed file. After that time, when a client wants same file then, it will be served from proxy not server. Therefore, server dont used in such kind of situation. Besides, we do not have to create a file, this decreases response times.*

We can see that values in the table are better than values in http server table. As we mentioned above files are served from proxy. Again, transfer rates are decresing when concurrency is too much. Reason of that, our proxy can not handle all of them in short times.