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COMP2322

COMPUTER NETWORKING

Project Report

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1. Introduction

This project aims to develop a multi-threaded Web server in Python which should be able to process HTTP requests and responses. According to client request, the server can response with specific file saved together with the header.

2. Function Design

2.1 Host and Port

The host and the port of the server are localhost (127.0.0.1) and port 8080 by default. However, if the server runs on a host that already has a Web server running on it, the server will try to run on the next port, which is 8081. If 8081 is also unable to run, the server will keep finding the available port by adding one to the current port until it is found.

```
leowong@leows-MacBook-Pro Project % python3 server.py
Server is running on host/port: 127.0.0.1/8080
```

Server running in default

```
leowong@leows-MacBook-Pro Project % python3 server.py
Server is running on host/port: 127.0.0.1/8081
```

When port 8080 is in use

```
leowong@leows-MacBook-Pro Project % python3 server.py
Server is running on host/port: 127.0.0.1/8084
Received connection from ('127.0.0.1', 60092)
```

Successful message printed once the client connects with the port

2.2 Header

After receiving a client request, a response header will be generated. The header is included with status code, date and connection type. When the status code is 200 or 304, the details of the request file included with last-modified, content-length and content-type will also be sent.

2.2.1 Response statuses

There are four statuses only on the server including 200 OK, 400 Bad Request, 404 File Not Found, 304 Not Modified. The usage of this status code will be shown in the following explanation.

2.2.2 Last-Modified and If-Modified-Since header fields

If the client request's header sends with "If-Modified-Since", the server will respond a header with status code 304 to client only if the modified date of the file is less than the request date. Otherwise, a header with status code 200, the file details and content will be sent. The "Last-Modified" time will also be included in the header for status code 304 and 200.

```
Server is running on host/port: 127.0.0.1/8081
Received connection from ('127.0.0.1', 55414)

Received request from ('127.0.0.1', 55414):
GET /index.html HTTP:/1.1
Connection: close

Connection from: ('127.0.0.1', 55414) is closed.
```

Server view:

Receive and handling request

```
Enter a request:
GET /index.html HTTP:/1.1
If-Modified-Since: Sat, 11 May 2024 23:59:59 GMT
Connection: close

Server response:
HTTP/1.1 304 Not Modified
Date: Thu, 04 Apr 2024 23:27:13 GMT
Connection: close
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 228
Content-Type: text/html
```

Client view: Only header

receives from server for error 304

2.2.2 Keep-Alive and Close header fields

The connection between the client and the server is "close" by default. However, if the client requests a "keep-alive" connection, the connection will be persistent for 15 seconds each time. If the client sends any request message successfully after connection or sending a request, the time counter will be reset to 15 seconds again. When time out, the connection will be closed. The maximum number of requests within a connection is 100.

```
Received connection from ('127.0.0.1', 64502)

Received request from ('127.0.0.1', 64502):
HEAD /index.html HTTP:/1.1
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 64502)
Timeout, connection from ('127.0.0.1', 64502) is closed.
```

Server view: Timeout for no message being send within 15 seconds

```
Connection from: ('127.0.0.1', 62751) is closed.
Received connection from ('127.0.0.1', 64496)
Timeout, connection from ('127.0.0.1', 64496) is closed.
```

Server view: Connected but not request received within 15 seconds

```
Request completed, waiting for next request from: ('127.0.0.1', 65408)

Received request from ('127.0.0.1', 65408):
HEAD /index.html HTTP:/1.1
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 65408)
Maximum 100 requests , Connection to ('127.0.0.1', 65408) is closed.
```

Server view: Maximum requests achieve

2.3 GET command

Using the GET request, the server is able to respond to the client with both header and file content if the file exists under the folder “srcFile” and the extension is either “txt”, “html”, “png”, “jpg” or “jpeg”. Normally, the status code will be 200, however, if the file does not exist under the folder “srcFile”, the status code will be 404 with no file content responded. If the file extension is not the above extension, the status code will be 400.

```
Enter a request:
GET /index.html HTTP:/1.1
Connection: close

Server response:
HTTP/1.1 200 OK
Date: Thu, 04 Apr 2024 23:24:52 GMT
Connection: close
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 228
Content-Type: text/html

Content-Type: text/html

<html>

<head>
  <link rel="icon" href="data:,">
  <title>Index</title>
</head>

<body>
  <h1>Welcome to the index.html web page.</h1>
  <p>Here's a link to <a href="helloworld.html">hello world</a>.</p>
</body>

</html>
Enter a request:
```

Client view: Header and file content receives from Server

```
Enter a request:
GET /index.py HTTP:/1.1
Connection: close

Server response:
HTTP/1.1 400 Bad Request
Date: Fri, 05 Apr 2024 00:06:27 GMT
Connection: close
```

Client view: Error 400

```
Enter a request:
GET /abc.html HTTP:/1.1
Connection: close

Server response:
HTTP/1.1 404 File Not Found
Date: Fri, 05 Apr 2024 00:09:32 GMT
Connection: close
```

Client view: Error 404

2.4 HEAD command

When using the HEAD command, only the header will be sent.

```
Enter a request:
HEAD /index.html HTTP:/1.1
Connection: keep-alive

Server response:
HTTP/1.1 200 OK
Date: Fri, 05 Apr 2024 12:36:26 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=2
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 3
Content-Type: text/html

Enter a request:
```

Client view: only header received with 200
status code

```
Enter a request:
HEAD /index.html HTTP:/1.1
If-Modified-Since: Fri, 31 Dec 2024 23:59:59 GMT
Connection: keep-alive

Server response:
HTTP/1.1 304 Not Modified
Date: Fri, 05 Apr 2024 12:58:26 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=100
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 3
Content-Type: text/html
```

Client view: only header received with 304
status code

```

Enter a request:
HEAD /photo1.py HTTP:/1.1

Server response:
HTTP/1.1 400 Bad Request
Date: Fri, 05 Apr 2024 12:45:36 GMT
Connection: close

Enter a request:

```

Client view: only header received with 400
status code

```

Enter a request:
HEAD /abc.html HTTP:/1.1

Server response:
HTTP/1.1 404 File Not Found
Date: Fri, 05 Apr 2024 12:54:49 GMT
Connection: close

```

Client view: only header received with 404
status code

2.5 Multi-threaded Web server

The server can handle requests from different client hosts and process them synchronically by using the Threading module in Python. Each request process is handled by the child process.

The parent process is responsible for handling the connection.

```

leowong@leows-MacBook-Pro Project % python3 server.py
Server is running on host/port: 127.0.0.1/8083
Received connection from ('127.0.0.1', 58274)
Received connection from ('127.0.0.1', 58275)

Received request from ('127.0.0.1', 58274):
HEAD /abc.html HTTP:/1.1

Connection to: ('127.0.0.1', 58274) is closed.
Timeout, connection to ('127.0.0.1', 58275) is closed.

```

Server view: Receive connections from two client

```

leowong@leows-MacBook-Pro Project % python3 client.py
Enter a request:
HEAD /abc.html HTTP:/1.1

Server response:
HTTP/1.1 404 File Not Found
Date: Fri, 05 Apr 2024 13:10:17 GMT
Connection: close

Enter a request:

```

Client 1 view

```

leowong@leows-MacBook-Pro Project % python3 client.py
Enter a request:

```

Client 2 view: No request made

2.6 Log file

A record will be generated when the server receives a client request and responses to the client request. This record will be saved into the log.txt file and it basically includes all the details in the header.

```
Received connection from ('127.0.0.1', 60070)
Received request from ('127.0.0.1', 60070):
HEAD /index.html HTTP:/1.1
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 60070)

Received request from ('127.0.0.1', 60070):
GET /index.py HTTP:/1.1
Connection: close

Connection to: ('127.0.0.1', 60070) is closed.
```

Server view: Receive two requests from a client

```
Enter a request:
HEAD /index.html HTTP:/1.1
Connection: keep-alive

Server response:
HTTP/1.1 200 OK
Date: Fri, 05 Apr 2024 13:33:33 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=100
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 3
Content-Type: text/html
```

```
Enter a request:
GET /index.py HTTP:/1.1
Connection: close

Server response:
HTTP/1.1 400 Bad Request
Date: Fri, 05 Apr 2024 13:33:44 GMT
Connection: close
```

Client view: 1st request

Client view: 2nd request

```
[Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: HEAD][Request file name: /index.html][Date: Fri, 05 Apr 2024 13:33:33 GMT]
[Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 200 OK][Date: Fri, 05 Apr 2024 13:33:33 GMT][Connection: keep-alive]
[Client request from (localhost, 127.0.0.1)][Connection: close][Method: GET][Request file name: /index.py][Date: Fri, 05 Apr 2024 13:33:44 GMT]
[Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 400 Bad Request][Date: Fri, 05 Apr 2024 13:33:44 GMT][Connection: close]
```

Log file: Request and response record (refer to log.txt line 1-4)

3. Full Demo

3.1 Demo using client program

Client 1 view:

```
Enter a request:
GET / HTTP/1.1
If-Modified-Since: Sat, 11 May 2024 23:59:59 GMT
Connection: keep-alive

Server response: Client 1 request 1
HTTP/1.1 304 Not Modified
Date: Fri, 05 Apr 2024 14:03:51 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=100
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 228
Content-Type: text/html

Enter a request:
HEAD / HTTP/1.1
Connection: keep-alive

Server response: Client 1 request 2
HTTP/1.1 200 OK
Date: Fri, 05 Apr 2024 14:04:04 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=100
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 3
Content-Type: text/html

Enter a request:
POST / HTTP/1.1
Connection: keep-alive

Server response: Client 1 request 3
HTTP/1.1 400 Bad Request
Date: Fri, 05 Apr 2024 14:04:15 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=100
```

Client 2 view:

```
Enter a request:
GET / HTTP/1.1
Connection: keep-alive

Server response: Client 2 request 1
HTTP/1.1 200 OK
Date: Fri, 05 Apr 2024 14:03:58 GMT
Connection: keep-alive
Keep-Alive: timeout=15, max=100
Last-Modified: Sun, 31 Mar 2024 23:17:35 GMT
Content-Length: 228
Content-Type: text/html

<html>

<head>
  <link rel="icon" href="data:,">
  <title>Index</title>
</head>

<body>
  <h1>Welcome to the index.html web page.</h1>
  <p>Here's a link to <a href="helloworld.html">hello world</a>.</p>
</body>

</html>

Enter a request:
HEAD /abc.html HTTP/1.1
Connection: close

Server response: Client 2 request 2
HTTP/1.1 404 File Not Found
Date: Fri, 05 Apr 2024 14:04:10 GMT
Connection: close
```


Server view:

```
Server is running on host/port: 127.0.0.1/8086
Received connection from ('127.0.0.1', 61910) Client 1
Received connection from ('127.0.0.1', 61913) Client 2

Received request from ('127.0.0.1', 61910): Client 1
GET / HTTP/1.1
If-Modified-Since: Sat, 11 May 2024 23:59:59 GMT
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 61910)

Received request from ('127.0.0.1', 61913): Client 2
GET / HTTP/1.1
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 61913)

Received request from ('127.0.0.1', 61910): Client 1
HEAD / HTTP/1.1
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 61910)

Received request from ('127.0.0.1', 61913): Client 2
HEAD /abc.html HTTP/1.1
Connection: close

Connection to: ('127.0.0.1', 61913) is closed.

Received request from ('127.0.0.1', 61910): Client 1
POST / HTTP/1.1
Connection: keep-alive

Request completed, waiting for next request from: ('127.0.0.1', 61910)
Timeout, connection to ('127.0.0.1', 61910) is closed.
```

Log file: (refer to log.txt line 5-14)

```
5 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: GET][Request file name: /index.html][Date: Fri
6 [Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 304 Not Modified][Date: Fri, 05 Apr 2024 14:03:51 GMT][Con
7 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: GET][Request file name: /index.html][Date: Fri
8 [Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 200 OK][Date: Fri, 05 Apr 2024 14:03:58 GMT][Connection: k
9 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: HEAD][Request file name: /index.html][Date: F
10 [Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 200 OK][Date: Fri, 05 Apr 2024 14:04:04 GMT][Connection: k
11 [Client request from (localhost, 127.0.0.1)][Connection: close][Method: HEAD][Request file name: /abc.html][Date: Fri, 05 A
12 [Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 404 File Not Found][Date: Fri, 05 Apr 2024 14:04:10 GMT][C
13 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: POST][Request file name: /index.html][Date: F
14 ⚠️ Server response to (localhost, 127.0.0.1)][StatusCode: HTTP/1.1 400 Bad Request][Date: Fri, 05 Apr 2024 14:04:15 GMT][Con
```

3.2 Demo using web browser

By using the browser to connect the server, users can input HTTP://Host/Port/filename

Browser view with request: HTTP://127.0.0.1:8080/polyuLogo.png



Server view:

```
Server is running on host/port: 127.0.0.1/8080
Received connection from ('127.0.0.1', 51435)

Received request from ('127.0.0.1', 51435):
GET /polyuLogo.png HTTP/1.1
Host: 127.0.0.1:8080
Connection: keep-alive
sec-ch-ua: "Not_A Brand";v="99", "Google Chrome";v="109", "Chromium";v="109"
sec-ch-ua-mobile: ?0
sec-ch-ua-platform: "macOS"
Upgrade-Insecure-Requests: 1
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/109.0.0.0 Safari/537.36
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9
Sec-Fetch-Site: none
Sec-Fetch-Mode: navigate
Sec-Fetch-User: ?1
Sec-Fetch-Dest: document
Accept-Encoding: gzip, deflate, br
Accept-Language: zh-CN,zh;q=0.9,zh-TW;q=0.8

Received connection from ('127.0.0.1', 51436)
Request completed, waiting for next request from: ('127.0.0.1', 51435)
```

Browser view with request: HTTP://127.0.0.1:8080/



Welcome to the index.html web page.

Here's a link to [hello world](#).

Server view:

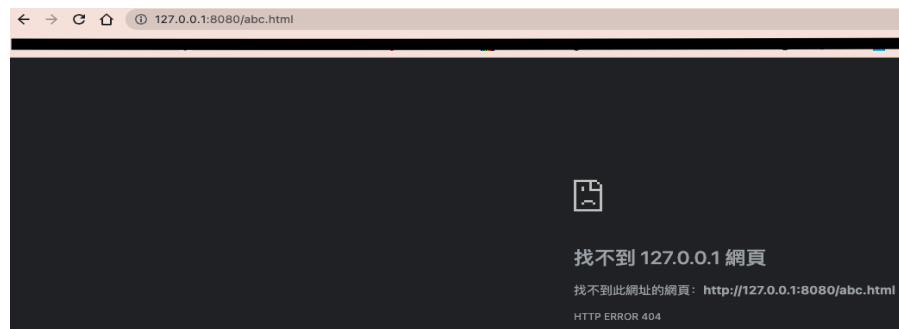
```
Received connection from ('127.0.0.1', 52233)
Received connection from ('127.0.0.1', 52234)

Received request from ('127.0.0.1', 52233):
GET / HTTP/1.1
Host: 127.0.0.1:8080
Connection: keep-alive
sec-ch-ua: "Not_A Brand";v="99", "Google Chrome";v="109", "Chromium";v="109"
sec-ch-ua-mobile: ?0
sec-ch-ua-platform: "macOS"
Upgrade-Insecure-Requests: 1
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/109.0.0.0 Safari/537.36
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9
Sec-Fetch-Site: none
Sec-Fetch-Mode: navigate
Sec-Fetch-User: ?1
Sec-Fetch-Dest: document
Accept-Encoding: gzip, deflate, br
Accept-Language: zh-CN,zh;q=0.9,zh-TW;q=0.8

Request completed, waiting for next request from: ('127.0.0.1', 52233)
```

Browser view with request: HTTP://127.0.0.1:8080/abc.html

Note: this is non-exists file



Server view:

```
Received connection from ('127.0.0.1', 52398)
Received request from ('127.0.0.1', 52398):
GET /abc.html HTTP/1.1
Host: 127.0.0.1:8080
Connection: keep-alive
sec-ch-ua: "Not_A Brand";v="99", "Google Chrome";v="109", "Chromium";v="109"
sec-ch-ua-mobile: ?0
sec-ch-ua-platform: "macOS"
Upgrade-Insecure-Requests: 1
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/109.0.0.0 Safari/537.36
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9
Sec-Fetch-Site: none
Sec-Fetch-Mode: navigate
Sec-Fetch-User: ?1
Sec-Fetch-Dest: document
Accept-Encoding: gzip, deflate, br
Accept-Language: zh-CN,zh;q=0.9,zh-TW;q=0.8

Received connection from ('127.0.0.1', 52399)
Request completed, waiting for next request from: ('127.0.0.1', 52398)
```

Log file: (refer to log.txt line 15-20)

```
15 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: GET][Request file name: /polyuLogo.png][Date: Fri, 0
16 [Server response to (localhost, 127.0.0.1)][StatesCode: HTTP/1.1 200 OK][Date: Fri, 05 Apr 2024 15:43:53 GMT][Connection: keep-al
17 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: GET][Request file name: /index.html][Date: Fri, 05 A
18 [Server response to (localhost, 127.0.0.1)][StatesCode: HTTP/1.1 200 OK][Date: Fri, 05 Apr 2024 15:49:21 GMT][Connection: keep-al
19 [Client request from (localhost, 127.0.0.1)][Connection: keep-alive][Method: GET][Request file name: /abc.html][Date: Fri, 05 Apr
20 🌟Server response to (localhost, 127.0.0.1)][StatesCode: HTTP/1.1 404 File Not Found][Date: Fri, 05 Apr 2024 15:59:58 GMT][Connect
```