Overview

In project 3, you will implement an HTTP server that serves secret user data. Access to this secret data will be authenticated through one of two mechanisms: (i) user name and password, and (ii) cookies presented from successful prior authentication. We will use the HTTP protocol and build simple versions of these authentication mechanisms to render browser-readable data. You will only work with one program in this project, `server.py`.

Step 1: Let's take it for a spin!

The project archive comes with starter code for `server.py`. This file already implements an HTTP server which serves a login page. Start the server program by either typing

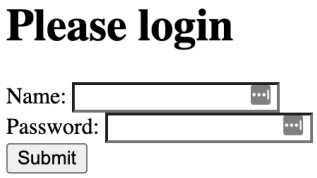
`python server.py`

which spins up the server on port 8080 (default), or you can type a port number of your choice:

`python server.py 45006`

The best part about the HTTP protocol is that you can interact with the other endpoint using your browser. Spin up the local browser and type `http://localhost:45006` (substitute `45006` by the port number you used when you started the server, which may be the default value 8080.)

You may see something that looks like this:



You can also interact with the server using a command line client like `curl`. You could type the command `curl http://localhost:45006/` to perform a transaction through the command line. You will see the HTML content of the page printed on the terminal. You can get `curl` to print more information using the `-v` flag. Here is an example of what you may see when you invoke `curl -v http://localhost:45006/`

```
*   Trying ::1...
* TCP_NODELAY set
* Connection failed
* connect to ::1 port 45006 failed: Connection refused
*   Trying 127.0.0.1...
* TCP_NODELAY set
* Connected to localhost (127.0.0.1) port 45006 (#0)
> GET / HTTP/1.1
> Host: localhost:45006
> User-Agent: curl/7.54.0
> Accept: */*
>
```

```
< HTTP/1.1 200 OK
< Content-Type: text/html
* no chunk, no close, no size. Assume close to signal end
<
<h1>Please login</h1>
   <form action = "http://localhost:45006" method = "post">
   Name: <input type = "text" name = "username">  <br/>
   Password: <input type = "text" name = "password" /> <br/>
   <input type = "submit" value = "Submit" />
   </form>
* Closing connection 0
```

You can ignore the error message at the beginning from the IPv6 connection attempt. If you go back to the terminal running the server program, it should have printed some helpful messages regarding the request it received and the responses it sent out. Example:

```
Here is the headers
"""
GET / HTTP/1.1
Host: localhost:45006
User-Agent: curl/7.54.0
Accept: */*
"""

Here is the entity body
"""

"""

Here is the response
"""
HTTP/1.1 200 OK
Content-Type: text/html

<h1>Please login</h1>
   <form action = "http://localhost:45006" method = "post">
   Name: <input type = "text" name = "username">  <br/>
   Password: <input type = "text" name = "password" /> <br/>
   <input type = "submit" value = "Submit" />
   </form>

"""

Served one request/connection!
```

Step 2: Study `server.py` carefully

In many ways, `server.py` is not that different from any of the TCP servers you implemented in project 1 or project 2. The key difference is that it receives HTTP protocol request messages and responds with HTTP protocol response messages.

It will be worthwhile understanding how `server.py` unpacks the data in the HTTP request to extract the headers and the entity body of the request. You will build on this code to extract specific headers and information from the entity body.

The `server.py` code also contains various strings that are helpful to return as entity bodies of the HTTP responses, such as `login_page, bad_creds_page,` and so on.

Pay specific attention to the places marked `TODO:`; these are the locations you will insert the main application logic for this project.

Step 3: Building the databases

The server should reads all of the username and passwords stored in the file `passwords.txt` (in plain text) provided along with this project archive. This file will contain multiple lines, one per user of the system, with their username and password (always one word) in that order, separated by a space. For example, in the sample passwords provided, one of the users of the system is named `bezos` with the password `amazon`. Your program should read in all this user data and maintain a data structure for lookup when the user attempts to authenticate.

The server should also read in the corresponding user secrets stored in plain text in the file `secrets.txt`, provided along with the project archive. This file will contain multiple lines, one per user of the system, with their username and secret data (always one word) in that order, separated by a space. For example, in the sample secrets provided, one of the users of the system is named `bezos` with the secret word `kaching`. Your program should read in all this user data and maintain a data structure to lookup for displaying after successful authentication.

Step 4: Implementing username-password authentication

The browser login form on `http://localhost:45006/` is set up to send POST requests when these details are typed into the respective fields. (Beware, the file is stored in plaintext, and any information you type in the form is sent in plain text, so please do not put any sensitive information in these!)

You can also send POST data from the command line using the `curl` tool. If you type the command

```
curl -d "username=bezos&password=amazon" http://127.0.0.1:45006/
```

it has the same effect as form data posted from a browser window. The `server.py` terminal output should show

```
Here is the entity body
"""
```

```
username=bezos&password=amazon
"""
```

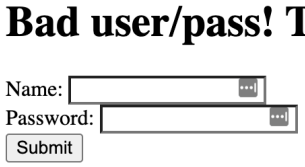
in place of the (empty) entity body from before. Specifically, the command flag `-d` makes `curl` send a POST request with the data inserted into the entity body of the HTTP request.

Parse the entity body obtained by `server.py` to recover the username and password fields of the HTTP POST request. Compare these details with the information you read from `passwords.txt` in the previous step. Not all valid HTTP requests may contain these two fields in their entity body, so you must pay careful attention to handling different kinds of requests in your code.

Case A: Username-password auth success. If the username and password fields do exist in the entity body, and they match with the username and password of a user in the passwords file, you can return the `success_page` to this user with the corresponding secret information that you read in the previous step. An example of this output on the browser looks like this, after `bezos` successfully authenticates:

To accomplish this in the code, you merely need to set the variable `html_content_to_send` to `success_page + secret`, where `secret` is the secret word of the corresponding user who just logged in.

Case B: Username-password auth failure. If exactly one among the username or password fields is absent in the entity body (i.e., exactly one field is present), or if both fields are present but the username is not in the passwords file, or the password did not match the corresponding username in the passwords file, then we ask the user to log in again. This is accomplished by setting `html_content_to_send` to `bad_creds_page`. You may see output like this:



You should be able to see HTML source code corresponding to these pages using appropriate `curl` commands as well, in case you want to test your program quickly on the terminal.

Step 5: Generate, send, and store a cookie

Now we get to the part where the server "remembers" prior successful authentications using cookies. Recall that cookies are a collaborative mechanism between the client and the server. The server assigns an opaque identifier to a successfully authenticated user, and sends it back in a `Set-Cookie` header in the HTTP response.

Step 5.1 In case A in the previous step (successful username-password authentication), generate a cookie value which is a random 64-bit value. You can accomplish this by invoking `random.getrandbits(64)` in your code. Capture this header-value pair in a string that contains the entire HTTP header line. If you assign `headers_to_send` to this string, it will be sent to the client along with the rest of the message. An example of doing this is:

```
rand_val = random.getrandbits(64)
headers_to_send = 'Set-Cookie: token=' + str(rand_val) + '\r\n'
```

(The `token=` is helpful to have `curl` record and reuse (present) cookies, as we will see later.) An example output of the full HTTP response in this case from the terminal output of `server.py` looks like this:

```
Here is the response
"""
HTTP/1.1 200 OK
Set-Cookie: token=24014456
Content-Type: text/html


   <h1>Welcome!</h1>
   <form action="http://localhost:45006" method = "post">
   <input type = "hidden" name = "action" value = "logout" />
   <input type = "submit" value = "Click here to logout" />
   </form>
   <br/><br/>
   <h1>Your secret data is here:</h1>
kaching
"""
```

Step 5.2 Store the cookie `rand_val` that you sent in step 5.2 into another data structure that can look up the cookie to obtain the corresponding pre-authenticated user name, if any.

Storing and replaying cookies using `curl`. The `curl` tool allows recording and presenting cookies through its "cookie-jar" flags, `-c` and `-b`. Type the command

```
curl -d "username=bezos&password=amazon" \
  -c cookies.txt -b cookies.txt
  http://127.0.0.1:45006/
```

and see the cookie `token` stored in the file `cookies.txt`.

Subsequent browser requests should contain the cookie. If you open a new browser tab, pointing it to `http://localhost:45006/`, you must be able to see the `Cookie:` header printed in the request headers printed on `server.py`'s output in the terminal!

Step 6: Implement cookie-based authentication

Finally, we are ready to implement cookie-based authentication for users accessing our server. Browsers, and in general any HTTP clients implementing cookies correctly (including `curl` with cookie jar), are expected to present any cookies provided by a server in subsequent HTTP requests to that server.

Your task now is to validate these cookies on the server side. From the HTTP request headers, extract the `Cookie:` header, and check if it corresponds to any user whose cookie you already recorded in step 5.2.

Case C. Cookie validated. If there is a `Cookie` header in the request, and the cookie is one of the pre-recorded cookies, this corresponds (with high likelihood) to a successfully authenticated user. (In this project, we will not consider "attacks" where cookies are stolen from a user and presented on their behalf or a malicious client checks all possible cookie values by brute force.) In this case, the output is similar to that of case A in step 4: welcome the user and show their secret content.

Case D. Cookie invalid. If there is a `Cookie` header in the request, and the cookie's value isn't one of the pre-recorded ones, you must present an error to the user similar to case B from step 4.

Case E. No cookie header. If there is no `Cookie` header in the request, you must process the request as if you're doing Step 4.

Summary of application logic. After completing this step, the flow of application logic should look like:

1. (case C) cookie header present and valid. Show the user the secret page: send back `success_page` with the secret.
2. (case D) cookie header present but invalid cookie: send back `bad_creds_page`
3. (case A from step 4) cookie header absent, username-password present in entity body, user-pass combination successfully matches correct credentials from passwords file: send back `success_page` with the secret, *don't forget to set a new cookie!*
4. (case B from step 4) cookie header absent, either one of username/password fields missing or username-password both present in entity body, but user-pass combination does not match any correct credential from the passwords file: send back `bad_creds_page`
5. (basic case, already implemented in the starter code from step 1) cookie header absent, username-password absent in entity body. Send back `login_page`