Security Issues in Web Programming (Part 2)

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Objectives

- We will cover:
  - Some web pgmming security attacks
  - Some ways to thwart them

Agenda

- **Authentication & authorization**
- Cookie forgery attacks

Authentication & Authorization

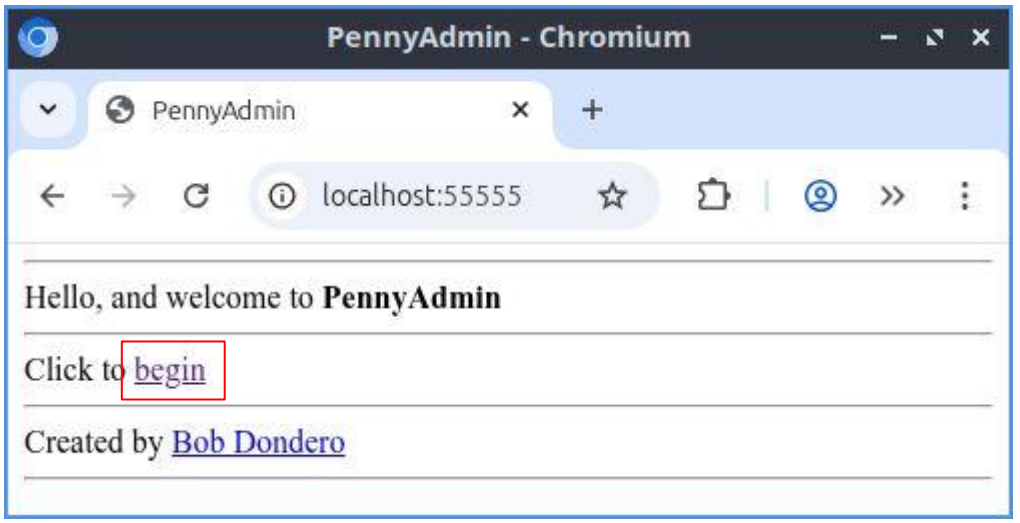
- ***Authenticate***
  - Make sure the user is *authentic*
  - Make sure the user is who he/she claims to be
- ***Authorize***
  - Having authenticated the user, make sure the user has *authority* to use the app in the way the user wants

Authentication & Authorization

- Recall: this is what we want…
  - **Show** books:
    - User must be **authenticated**
  - **Add** & **delete** books:
    - User also must be **authorized**
      - Only rdondero and bwk have authority

Authentication & Authorization

- See **PennyAdmin04Auth** app

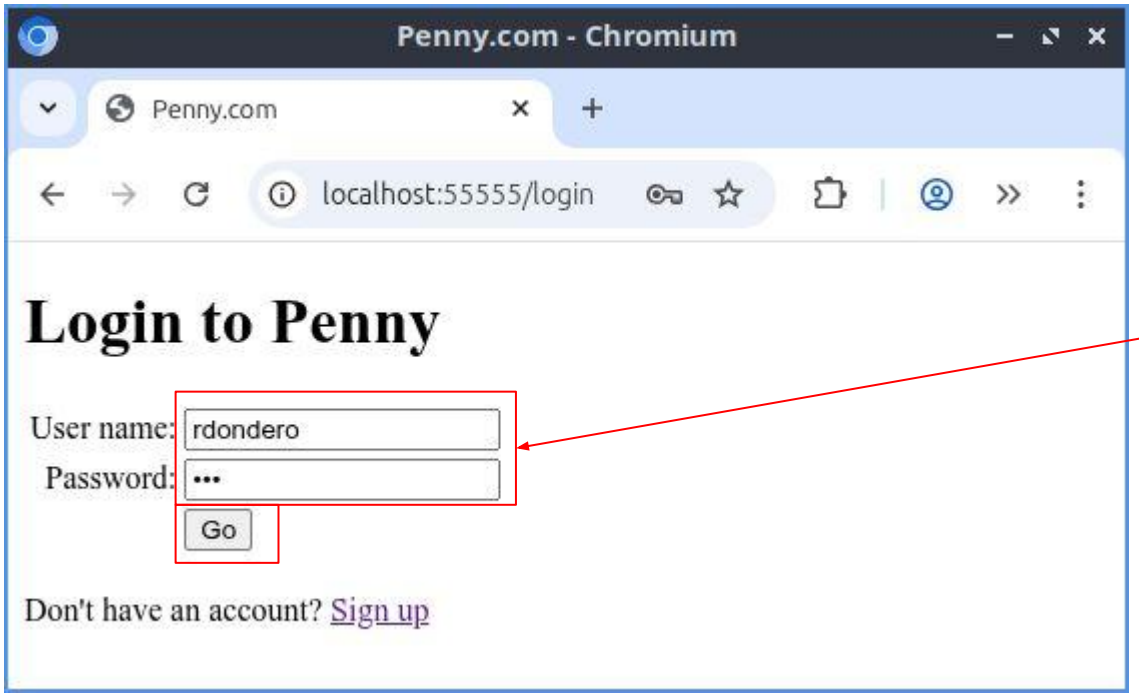


Index page

Does not require authentication

Authentication & Authorization

- See **PennyAdmin04Auth** app

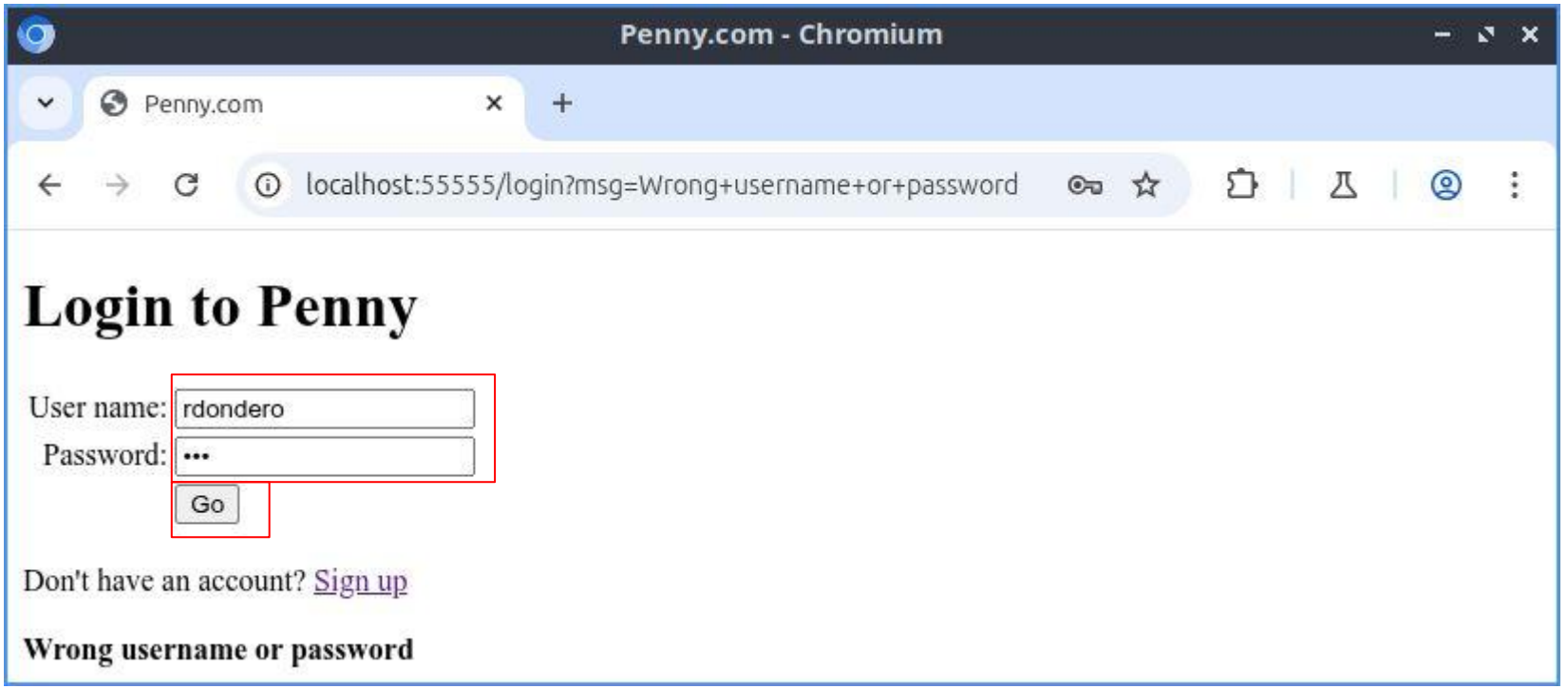


Login page

Wrong password

Authentication & Authorization

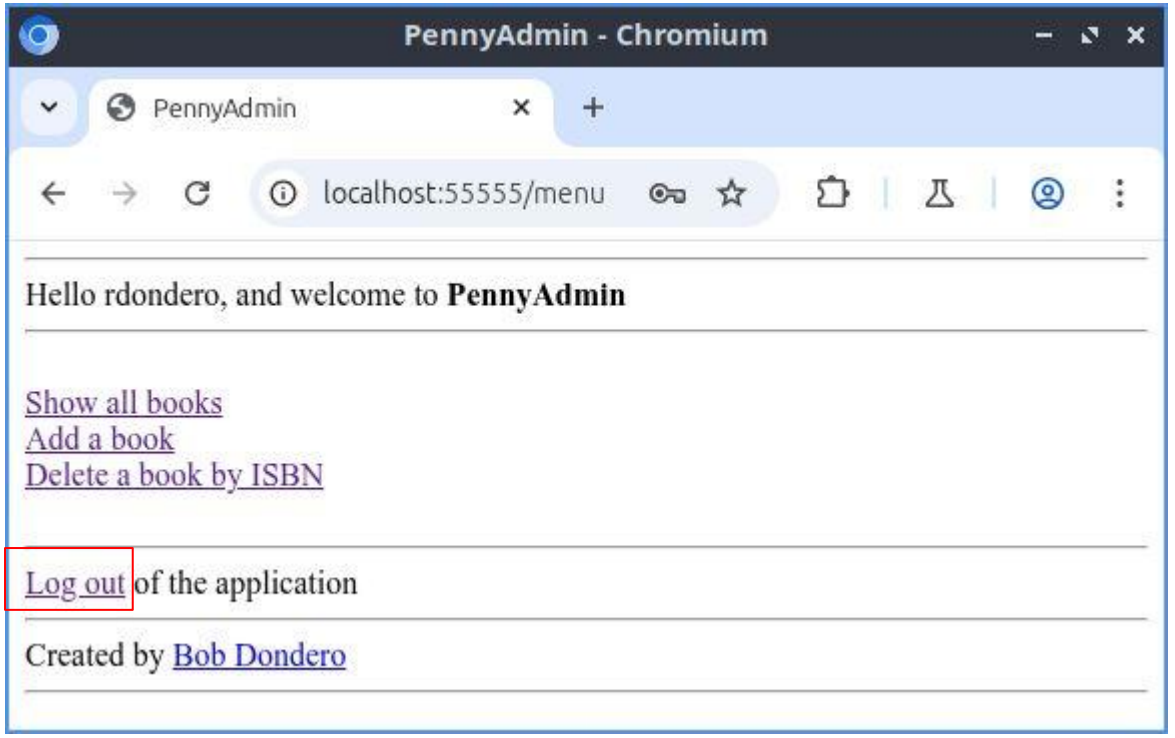
- See **PennyAdmin04Auth** app



Login page

Authentication & Authorization

- See **PennyAdmin04Auth** app



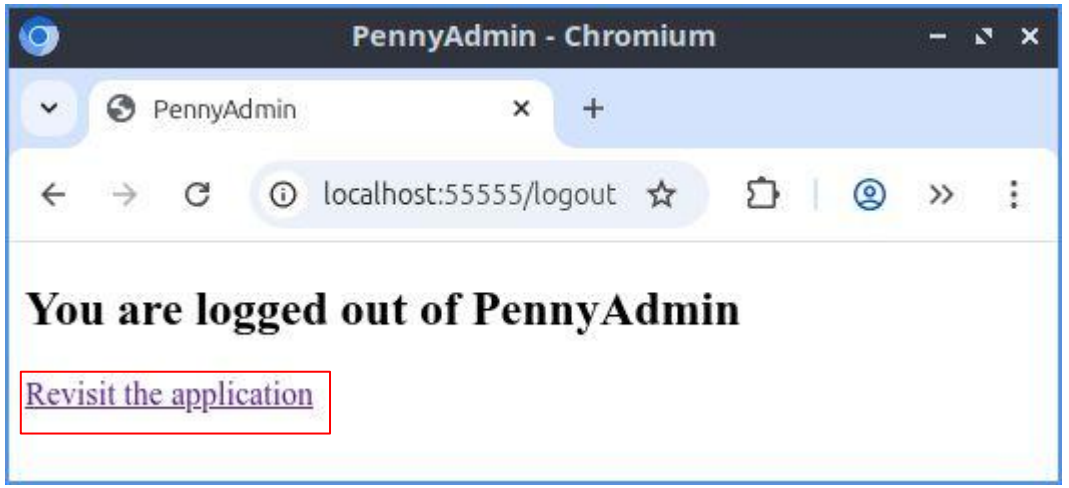
Menu page

Username in header

Log out link in footer

Authentication & Authorization

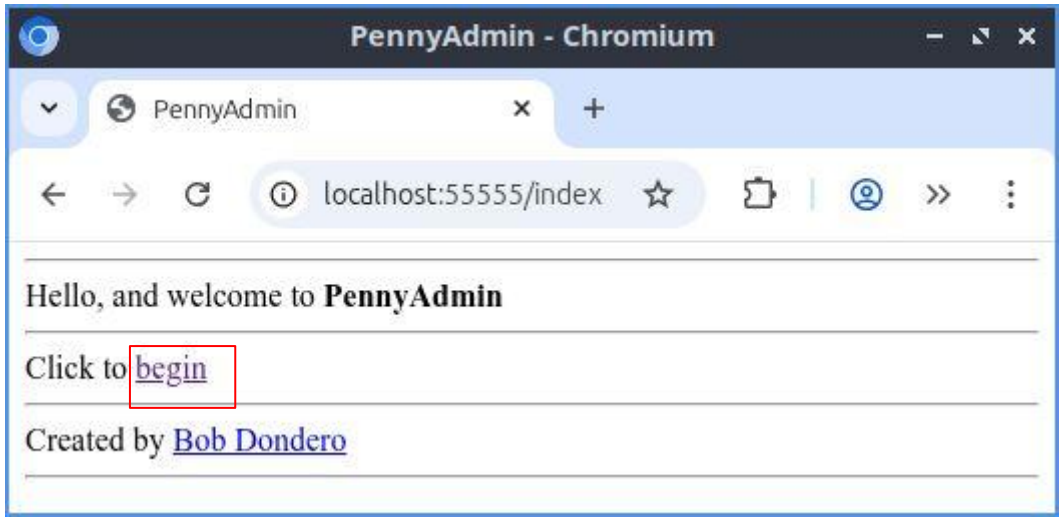
- See **PennyAdmin04Auth** app



Loggedout page

Authentication & Authorization

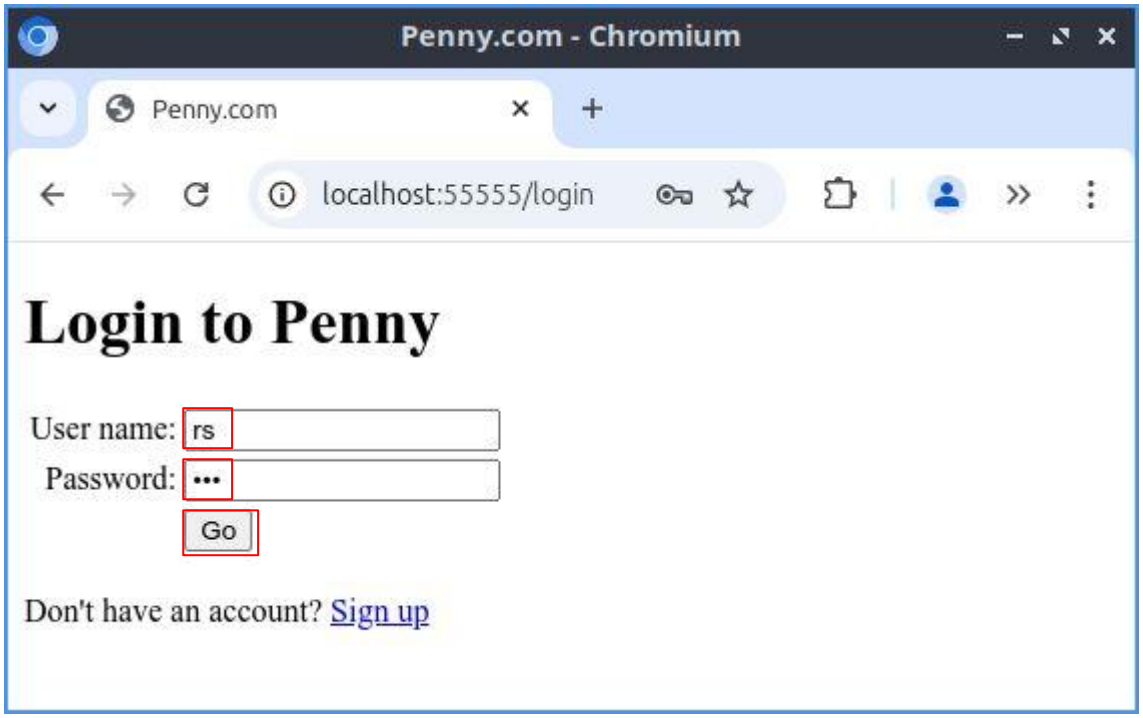
- See **PennyAdmin04Auth** app



Index page

Authentication & Authorization

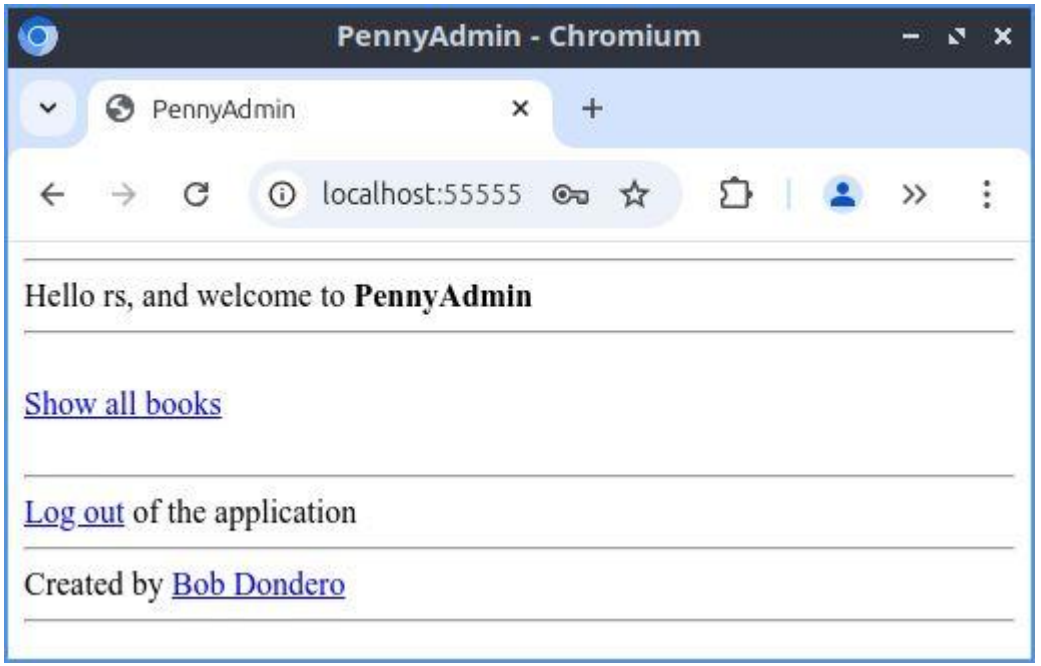
- See **PennyAdmin04Auth** app



Login page

Authentication & Authorization

- See **PennyAdmin04Auth** app

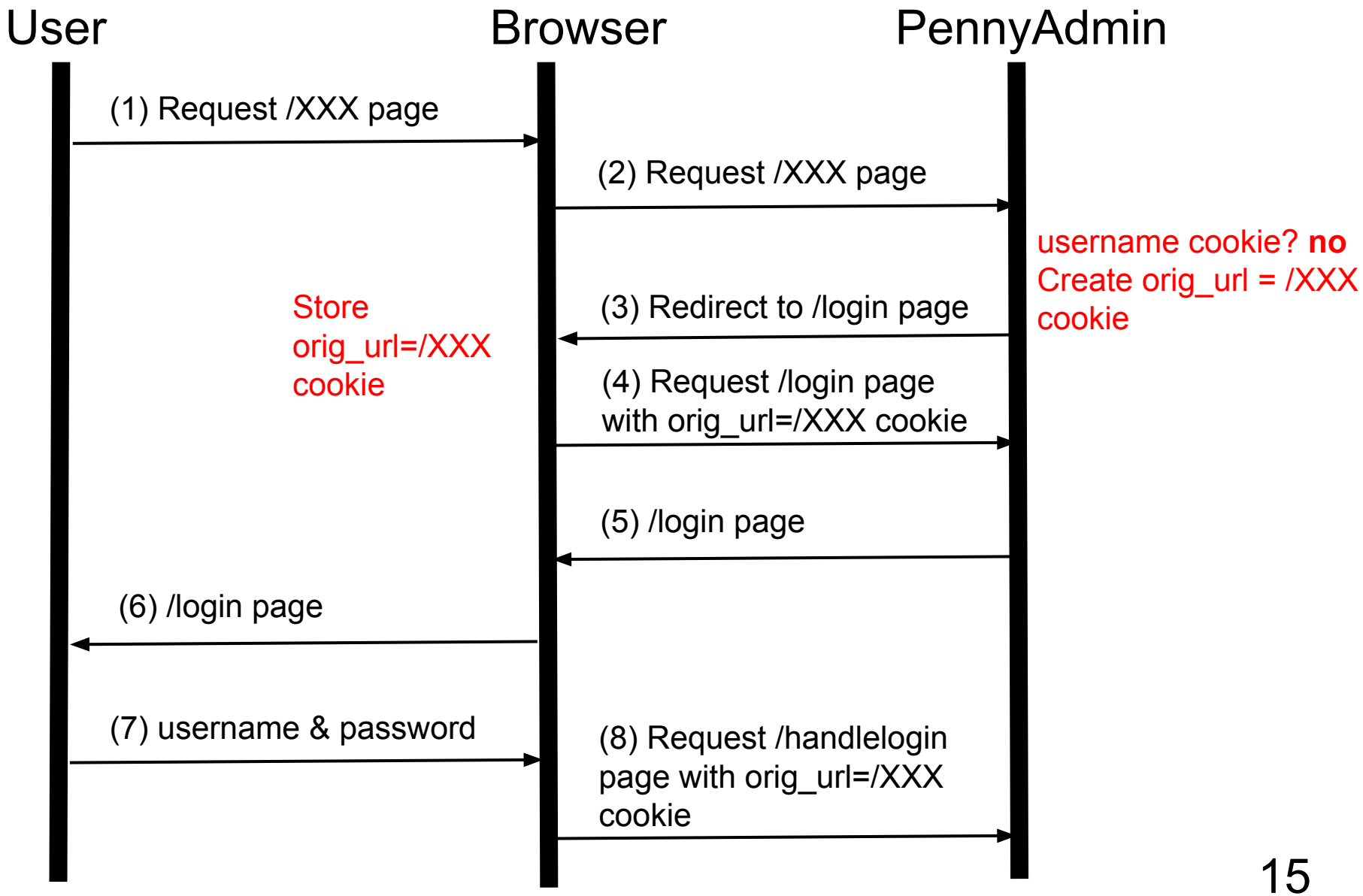


Menu page

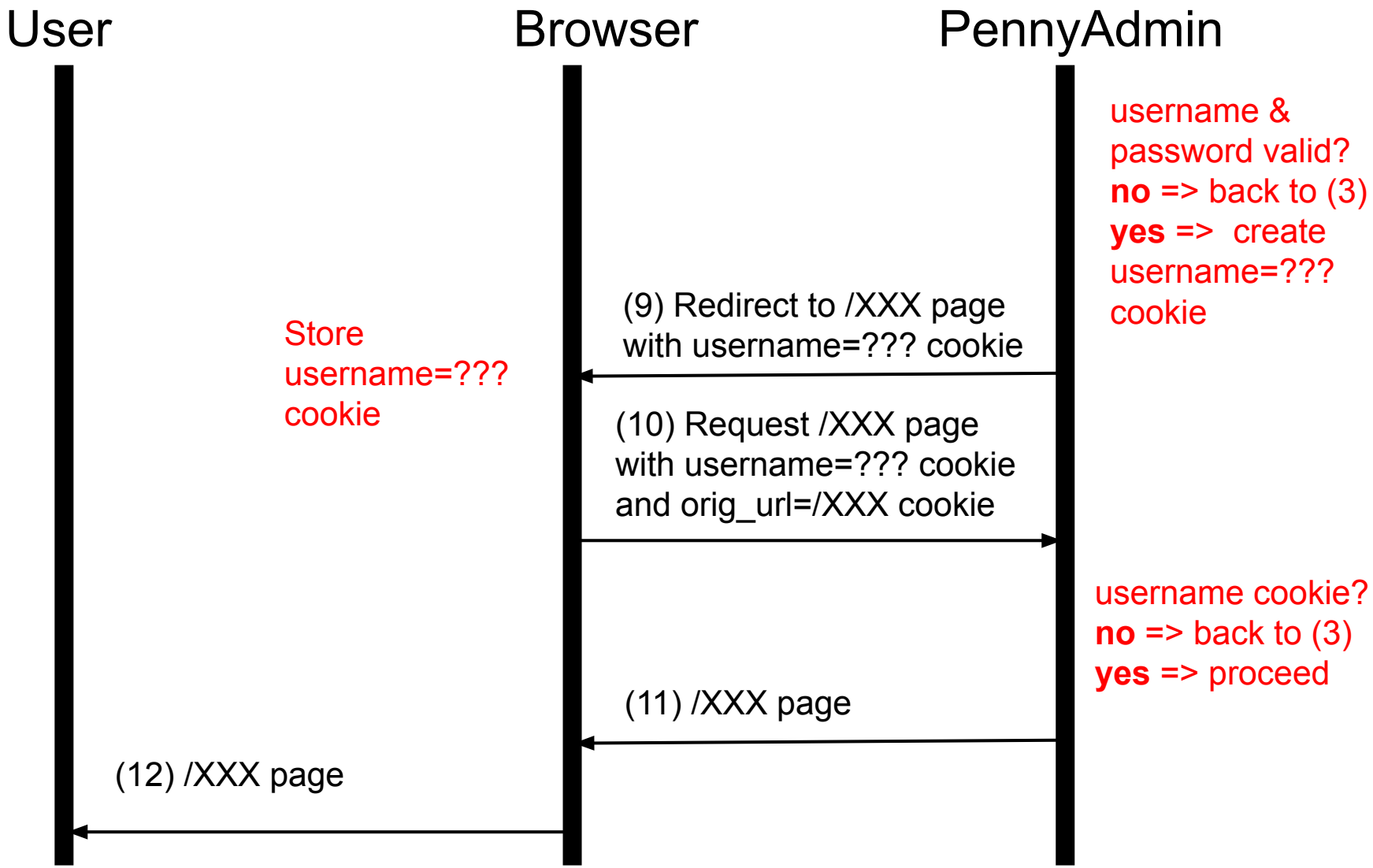
Authentication & Authorization

- See **PennyAdmin04Auth** app
  - Authentication
    - The flow…

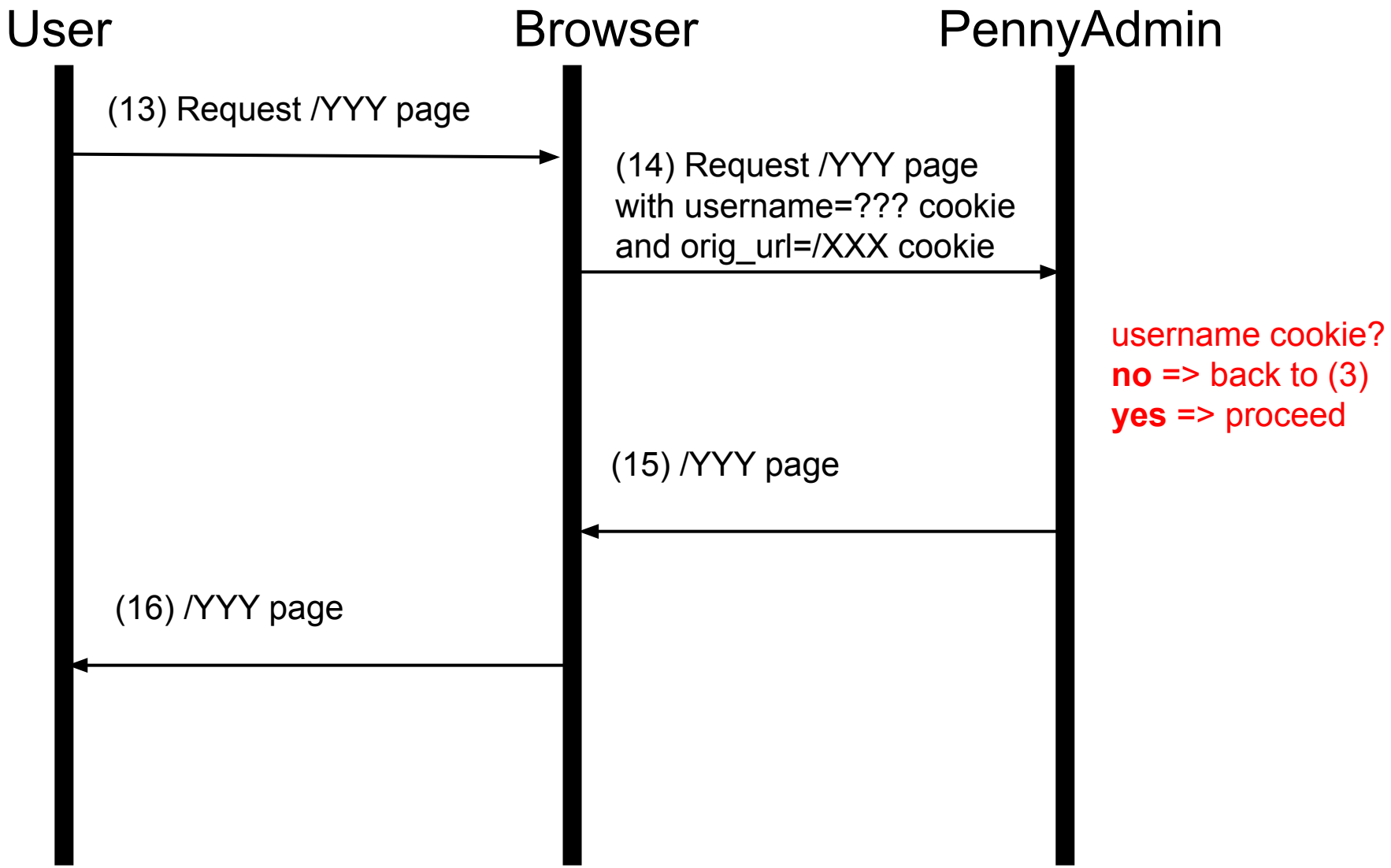
Authentication & Authorization



Authentication & Authorization



Authentication & Authorization



Authentication & Authorization

- See **PennyAdmin04Auth** app
  - Authorization
    - Handled separately from authentication
    - Straightforward…

Aside: Flask Route Mapping

Question: With Flask, how do you map URLs to routes?

Answer 1: Using decorators

```
...
@app.route('/searchform')
def search_form():
    ...
...
```

Answer 2: Using `app.add_url_rule()`

```
...
def search_form():
    ...
app.add_url_rule('/', 'searchform', search_form)
...
```

Authentication & Authorization

- See **PennyAdmin04Auth** app
  - runserver.py
  - **penny.sql**, penny.sqlite
  - **database.py**
  - **header.html**, **footer.html**
  - index.html, **menu.html**, show.html,
  - add.html, delete.html, reportresults.html
  - **login.html, signup.html, loggedout.html**
  - **penny.py, auth.py**

Authentication & Authorization

- Typical enhancements:
  - Password changing (easy)
  - Existing user un-registration (easy)
  - Email verification (hard)
  - Forgotten password recovery (hard)
  - Two-factor authentication (hard)
    - Email, phone call, text message, authenticator app

Agenda

- Authentication & authorization
- **Cookie forgery attacks**

Cookie Forgery Attacks

- **Problem**:
  - In PennyAdmin app, an attacker can forge the username cookie

Cookie Forgery Attacks

- Recall **PennyAdmin04Auth** app
  - Example:
    - Attacker runs **cookieforgeryattack.py**
      - Sends forged username cookie to PennyAdmin app

Cookie Forgery Attacks

- Recall **PennyAdmin04Auth** app
  - Example (cont.):

```
$ python cookieforgeryattack.py localhost 55555
HTTP/1.1 200 OK
Server: Werkzeug/3.0.3 Python/3.12.3
Date: Sat, 31 Aug 2024 18:56:30 GMT
Content-Type: text/html; charset=utf-8
Content-Length: 780
Connection: close

<!DOCTYPE html>
<html>
   <head>
      <title>PennyAdmin</title>
   </head>
   <body>
      <hr>Hello rdondero, and welcome to <strong>PennyAdmin</strong><hr>
      <h1>Show All Books</h1>
```

App considers user to be logged in as rdondero

Continued on next slide

Cookie Forgery Attacks

- Recall **PennyAdmin04Auth** app
  - Example (cont.):

```
            123:
            <strong>Kernighan</strong>:
            The Practice of Programming<br>

            234:
            <strong>Kernighan</strong>:
            The C Programming Language<br>

            345:
            <strong>Sedgewick</strong>:
            Algorithms in C<br>


      <br>
      <a href="/index">Return to home page</a>
      <br>
      <hr>
<a href="logout">Log out</a> of the application</br>
<hr>
Created by <a href="https://www.cs.princeton.edu/~rdondero">
Bob Dondero</a>
<hr>
   </body>
</html>
```

App considers user to be logged in as rdondero

Cookie Forgery Attacks

- **Solution 1**:
  - ***Cookie encryption***
    - Before server sends username cookie…
      - Server uses a ***secret key*** to **encrypt** the value of the username cookie
    - After server receives username cookie…
      - Server uses the same ***secret key*** to **decrypt** the value of the username cookie
      - Decryption fails => forgery

Aside: Secret Keys

- **Question**: How to generate a secret key?
- **One answer**:

```
$ python
Python 3.12.3 (main, Jul 31 2024, 17:43:48)
[GCC 13.2.0] on linux
Type "help", "copyright", "credits" or
"license" for more information.
>>> import os
>>> os.urandom(12).hex()
'[redacted]'
>>> quit()
$
```

Aside: Secret Keys

- **Question**: Where to store secret keys?
- **Possible answers**:
  - Source code files? **No**
    - Attacker might gain access to GitHub repo
  - Some other file? **Maybe**
    - But must make sure the file is not in GitHub repo
  - Environment variables? **Yes**
    - The common way

Aside: Secret Keys

To run subsequent versions of PennyAdmin:

Mac & Linux:

```
$ export APP_SECRET_KEY=yourappsecretkey
$ python runserver.py 55555
```

MS Windows:

```
$ set APP_SECRET_KEY=yourappsecretkey
$ python runserver.py 55555
```

Or use the `python_dotenv` package

```
$ cat .env
APP_SECRET_KEY=yourappsecretkey
$
```

Cookie Forgery Attacks

- See **PennyAdmin05aEncrypt** app
  - runserver.py
  - penny.sql, penny.sqlite
  - database.py
  - header.html, footer.html
  - index.html, show.html,
  - add.html, delete.html, reportresults.html
  - login.html, signup.html, loggedout.html
  - penny.py, **auth.py**

Cookie Forgery Attacks

- See **PennyAdmin05aEncrypt** app
  - Example:
    - Attacker runs **cookieforgeryattack.py**
      - Sends forged username cookie to PennyAdmin app

Cookie Forgery Attacks

- See **PennyAdmin05aEncrypt** app
  - Example (cont.):

```
$ python cookieforgeryattack.py localhost 55555
HTTP/1.1 302 FOUND
Server: Werkzeug/3.0.3 Python/3.12.3
Date: Sat, 31 Aug 2024 19:00:42 GMT
Content-Type: text/html; charset=utf-8
Content-Length: 199
Location: /login
Set-Cookie: original_url=http://localhost/show; Path=/
Connection: close

<!doctype html>
<html lang=en>
<title>Redirecting...</title>
<h1>Redirecting...</h1>
<p>You should be redirected automatically to the target URL:
<a href="/login">/login</a>. If not, click the link.
$
```

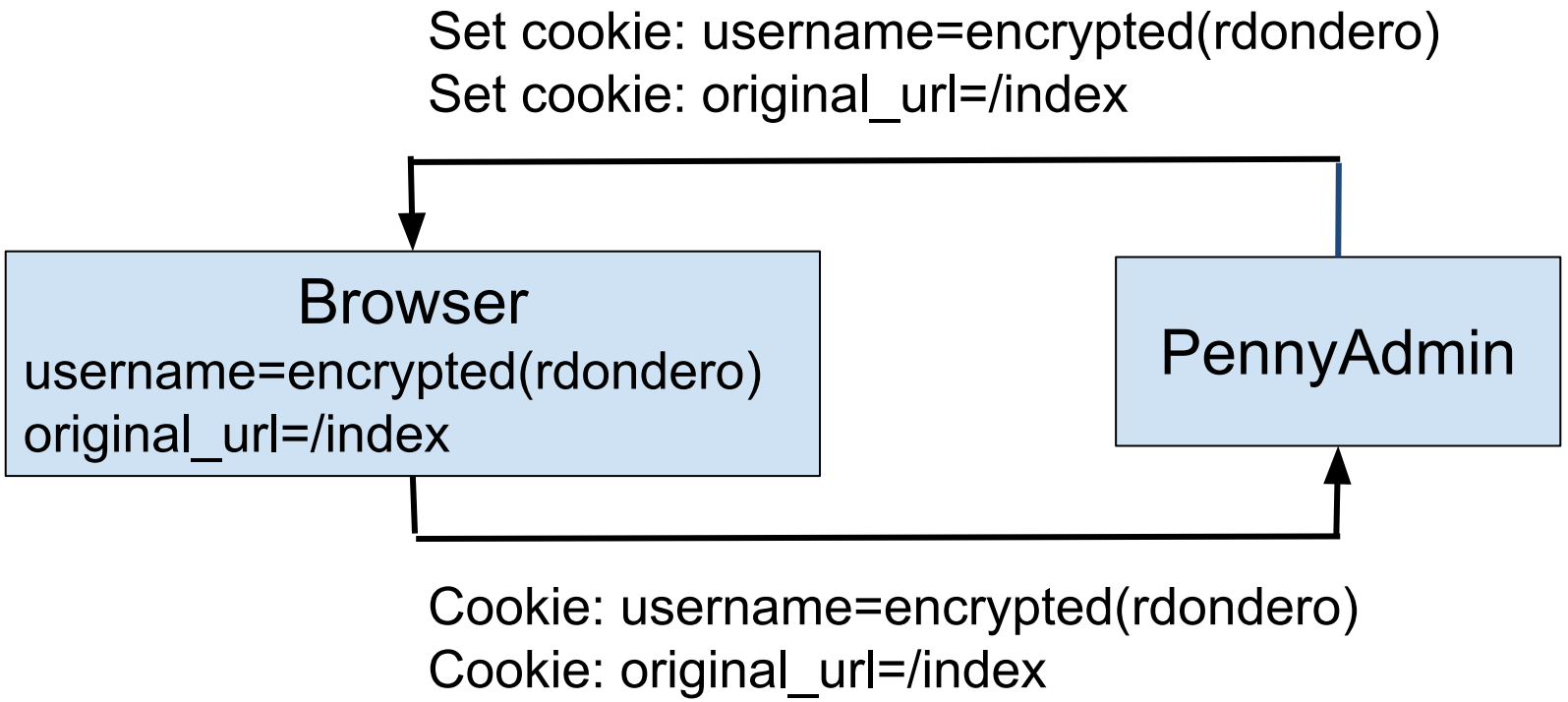
App rejects username, redirects to login page

Cookie Forgery Attacks

- **Solution 2**:
  - ***Sessions***

Cookie Forgery Attacks

Without sessions:



Cookie Forgery Attacks

With sessions:

eyJvcmlnaW5hbF91cmwiOiJodHRwOi8vbG9jYWxob3N0OjU1NTU1LyIsInVzZXJuYW1lIjoicmRvbmRlcm8ifQ.YsDrnQ.fc45qAmc0Vk6pAr32bQnogTtx1c

Using my secret key, decrypts to:

original_url=/index; username=rdondero;

Cookie Forgery Attacks

- See **PennyAdmin05bSession** app
  - runserver.py
  - penny.sql, penny.sqlite
  - database.py
  - header.html, footer.html
  - index.html, show.html,
  - add.html, delete.html, reportresults.html
  - login.html, signup.html, loggedout.html
  - **penny.py**, **auth.py**

Cookie Forgery Attacks

- See **PennyAdmin05bSession** app
  - Example:
    - Attacker runs **cookieforgeryattack.py**
      - Sends forged session cookie to PennyAdmin app

Cookie Forgery Attacks

- See **PennyAdmin05bSession** app
  - Example (cont.):

```
$ python cookieforgeryattack.py localhost 55555
HTTP/1.1 302 FOUND
Server: Werkzeug/3.0.3 Python/3.12.3
Date: Sat, 31 Aug 2024 19:03:41 GMT
Content-Type: text/html; charset=utf-8
Content-Length: 199
Location: /login
Vary: Cookie
Set-Cookie:
session=eyJvcmlnaW5hbF91cmwiOiJodHRwOi8vbG9jYWxob3N0L3Nob3cif
Q.ZtNpDQ.24_ouOA3YNt2oeAz9gEiz_sGZf0; HttpOnly; Path=/
Connection: close

<!doctype html>
<html lang=en>
<title>Redirecting...</title>
<h1>Redirecting...</h1>
<p>You should be redirected automatically to the target URL:
<a href="/login">/login</a>. If not, click the link.
```

App rejects username, redirects to login page

Lecture Summary

- In this lecture we covered:
  - Authentication & authorization
  - Secret keys
  - Cookie forgery attacks