Security Issues in Web Programming (Part 3)

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Objectives

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

Quick Review

- Recall **PennyAdmin04Auth** app
  - Username cookie exists => user is authenticated

Agenda

- **Cookie forgery attacks**
- Cross-site request forgery (CSRF) 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

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

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.
$
```

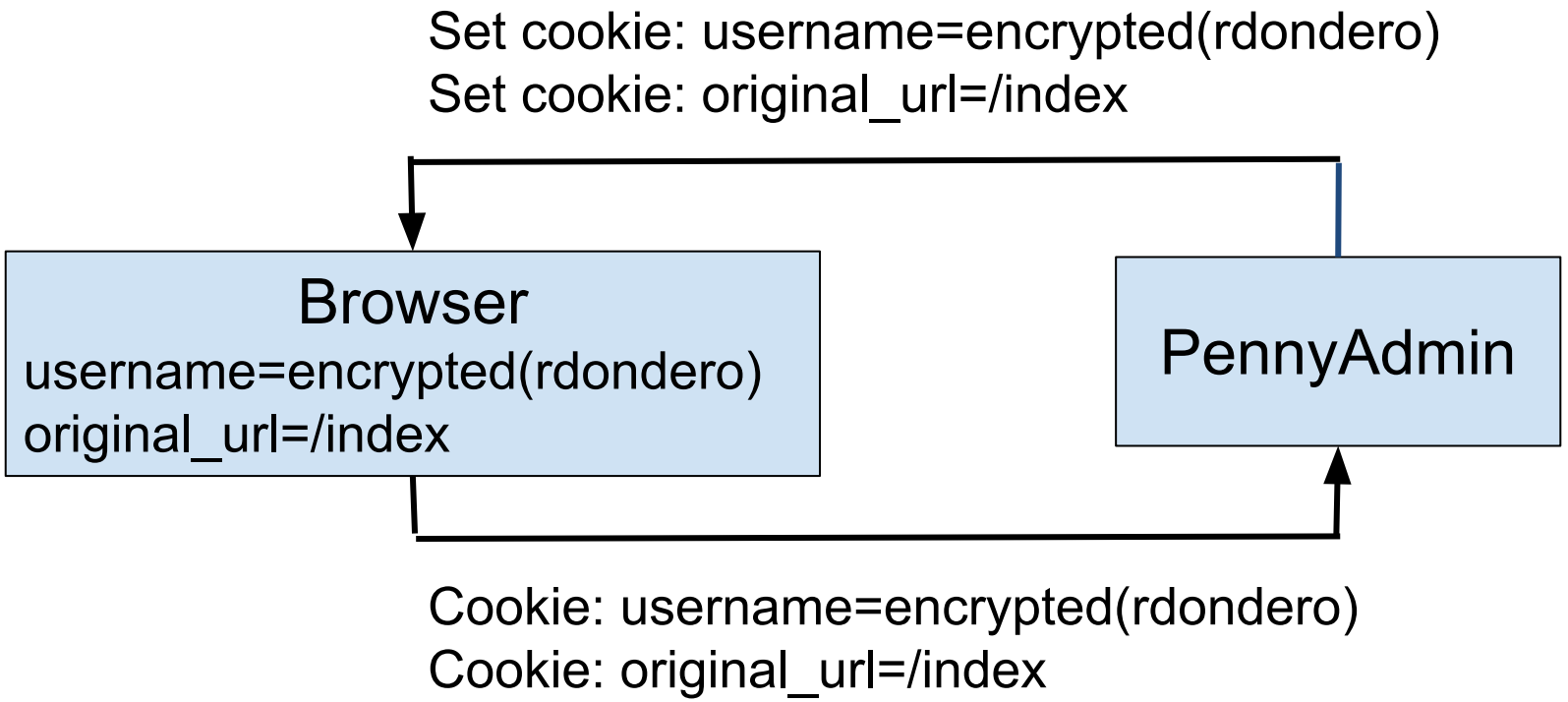
App rejects username, redirects to login page

Cookie Forgery Attacks

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

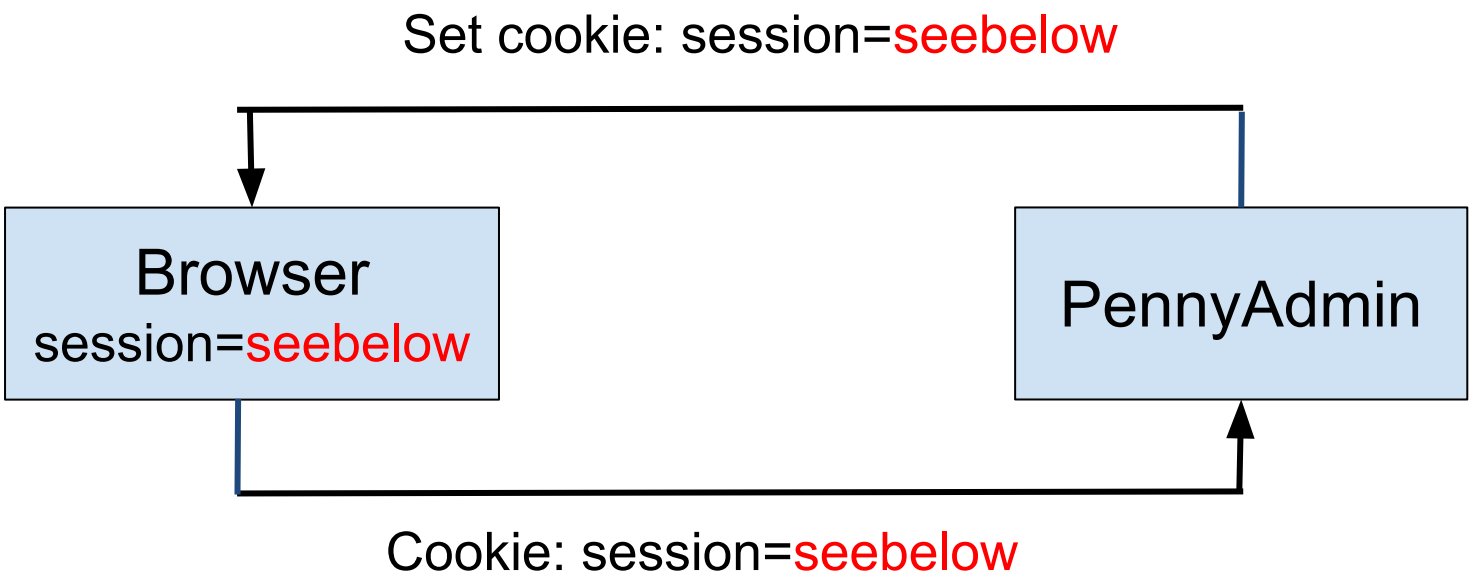
Cookie Forgery Attacks

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

Cookie Forgery Attacks

- Q: Project concern?

- A: Yes!!!
  - Iff your project app stores, in cookies, data that must not be forged

Agenda

- Cookie forgery attacks
- **Cross-site request forgery (CSRF) attacks**

CSRF Attacks

- ***Cross-Site Request Forgery (CSRF)***

Cross-Site Request Forgery (CSRF) is an attack that forces an end user to execute unwanted actions on a web application in which they're currently authenticated. With a little help of social engineering (such as sending a link via email or chat), an attacker may trick the users of a web application into executing actions of the attacker's choosing. If the victim is a normal user, a successful CSRF attack can force the user to perform state changing requests like transferring funds, changing their email address, and so forth. If the victim is an administrative account, CSRF can compromise the entire web application.
– https://owasp.org/www-community/attacks/csrf

CSRF Attacks

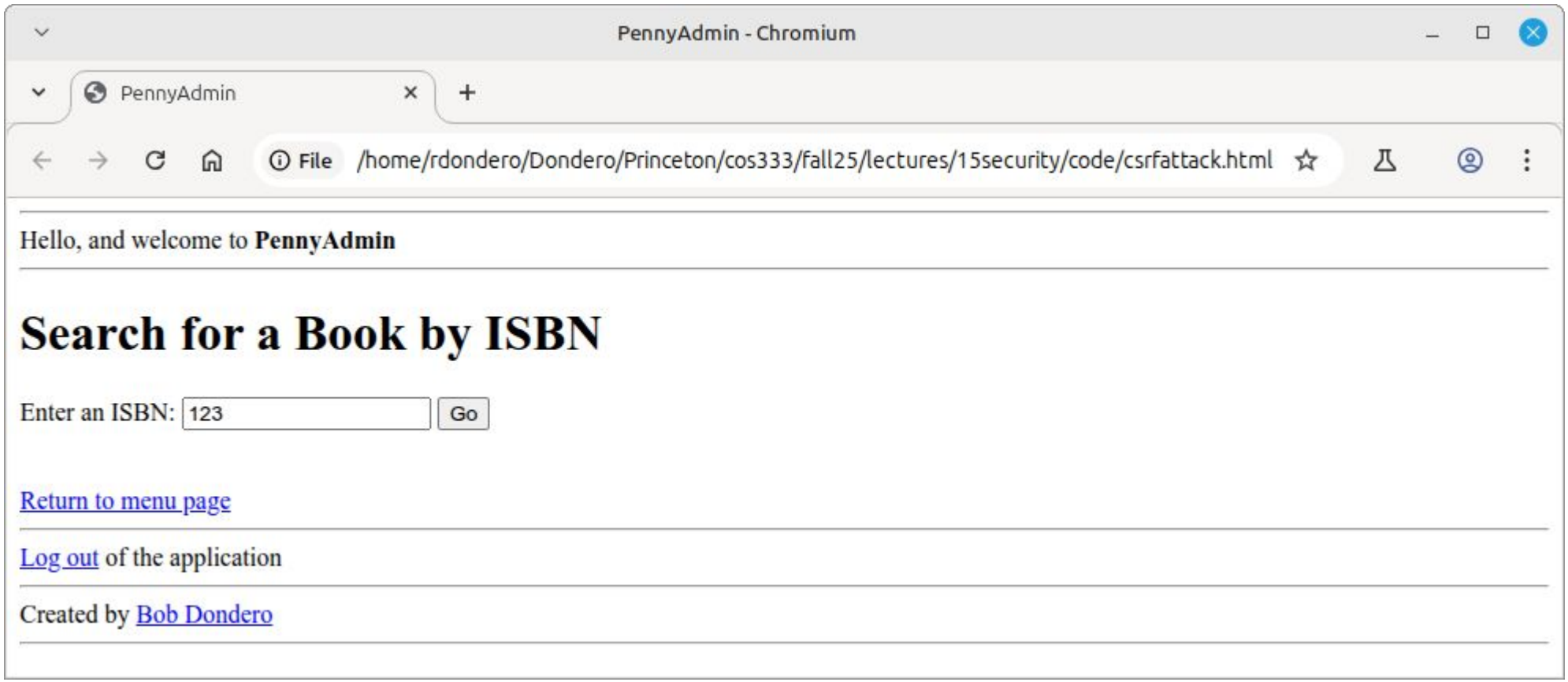
- **Problem**:
  - PennyAdmin is vulnerable to CSRF attacks

CSRF Attacks

- **Recall PennyAdmin05bSession**:
  - Example:
    - Browser user visits app and logs in; browser session is authenticated/authorized
    - Attacker tricks user into visiting **csrfattack.html**
    - User submits form on csrfattack.html

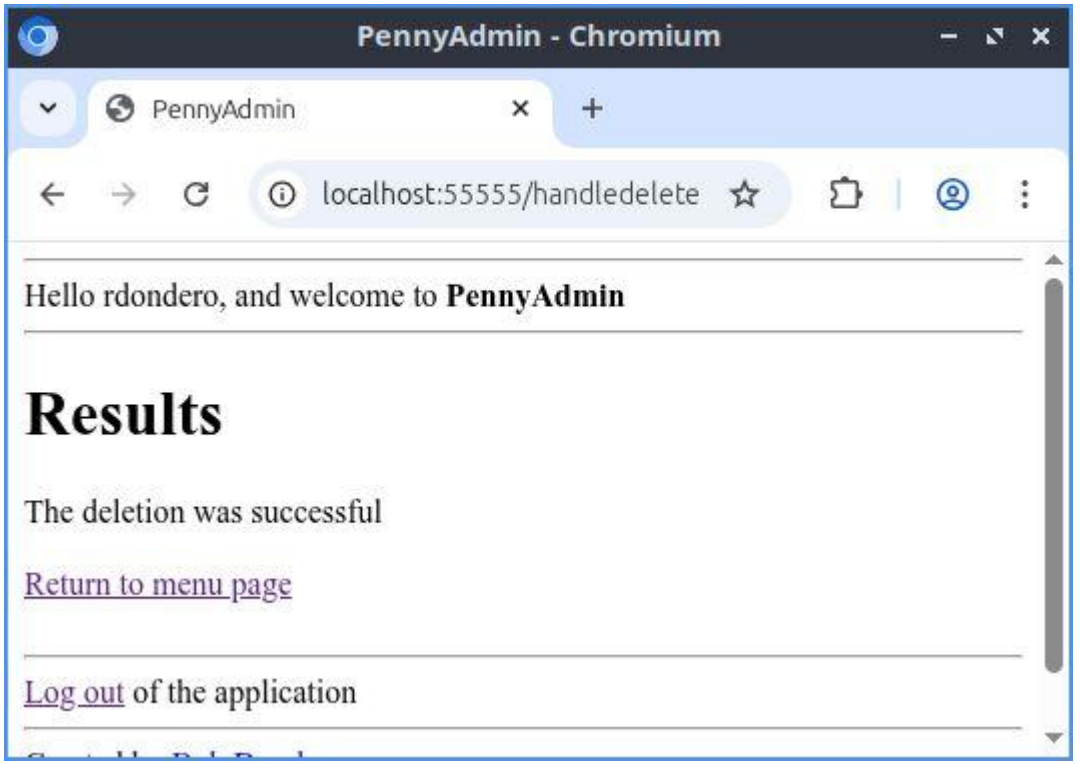
CSRF Attacks

- **Recall PennyAdmin05bSession**:
  - Example:



CSRF Attacks

- **Recall PennyAdmin05bSession**:
  - Example (cont.):



User unintentionally deletes a book!

CSRF Attacks

- **Solution (in general):**
  - **PennyAuth app** must make sure that any request that it receives was sent from a page that **PennyAuth app** created

CSRF Attacks

- **Solution 1:**
  - Use ***CSRF tokens***
    - App creates a token
    - App places token in session
    - App requires any (POST) HTTP request to contain that token
    - Upon receipt of request, app makes sure that token in request equals token in session

CSRF Attacks

- **See PennyAdmin06aCsrfToken**
  - 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**

CSRF Attacks

- **See PennyAdmin06aCsrfToken**
  - Example:
    - Browser user visits app and logs in; browser session is authenticated/authorized
    - Attacker tricks user into visiting **csrfattack.html**
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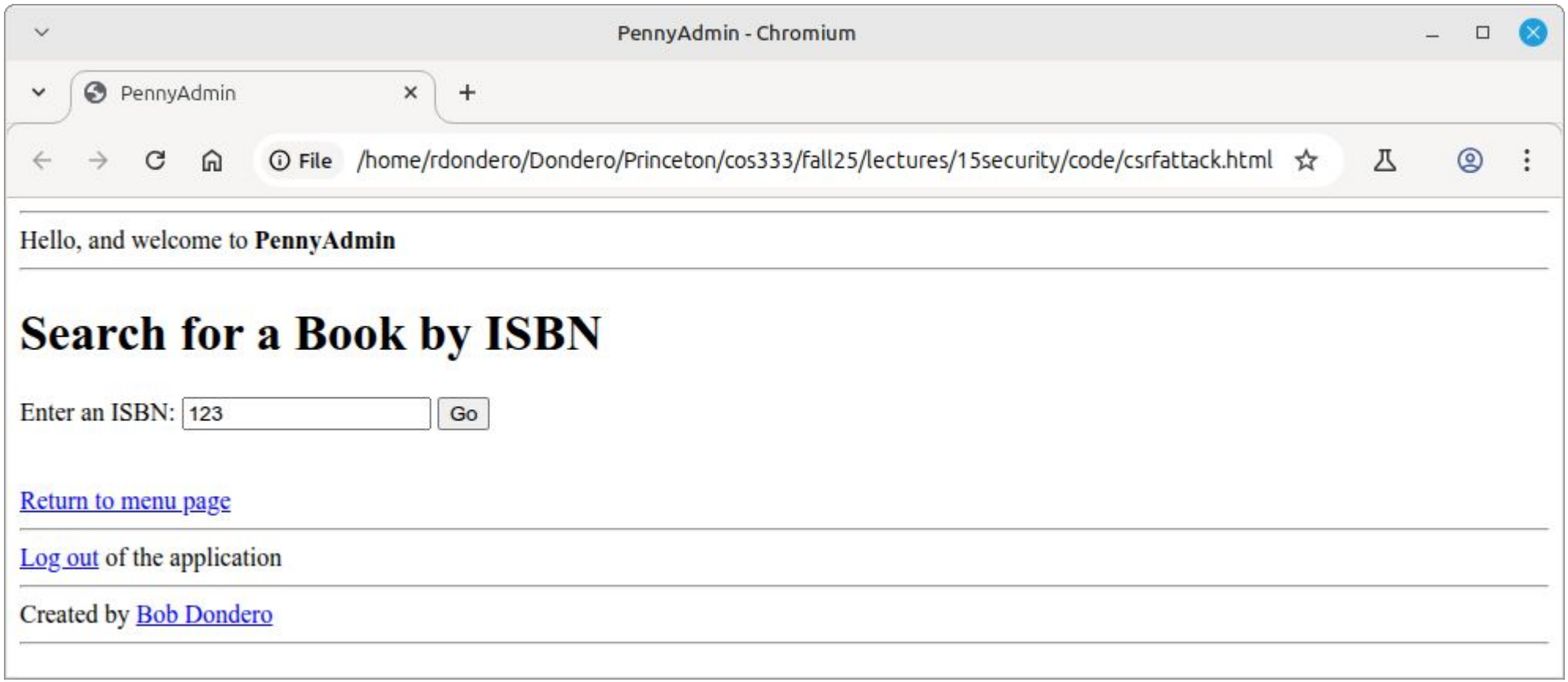
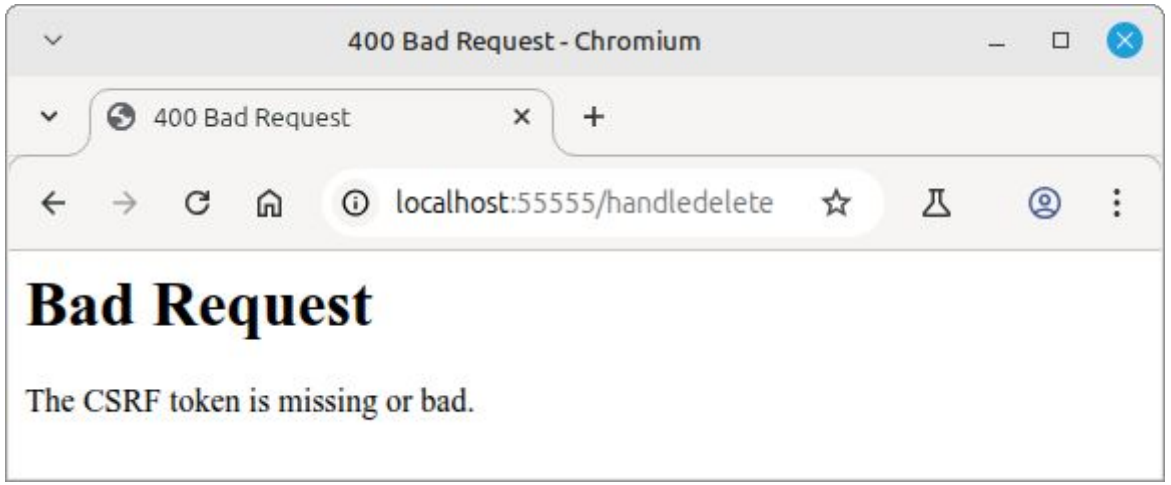
CSRF Attacks

- **See PennyAdmin06aCsrfToken**
  - Example:



CSRF Attacks

- **See PennyAdmin06aCsrfToken**
  - Example (cont.):



App rejects request

CSRF Attacks

- **Solution 2**
  - Use CSRF tokens via flask_wtf.csrf.CSRFProtect
- **flask_wtf.csrf.CSRFProtect**
  - An integration of Flask and WTForms
- **WTForms**
  - "... a flexible forms validation and rendering library for Python web development."
  - https://wtforms.readthedocs.io/en/3.2.x/

CSRF Attacks

- **See PennyAdmin06bCsrfToken**
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  - **add.html**, **delete.html**, reportresults.html
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CSRF Attacks

- **See PennyAdmin06bCsrfToken**
  - Example:
    - Browser user visits app and logs in; browser session is authenticated/authorized
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CSRF Attacks

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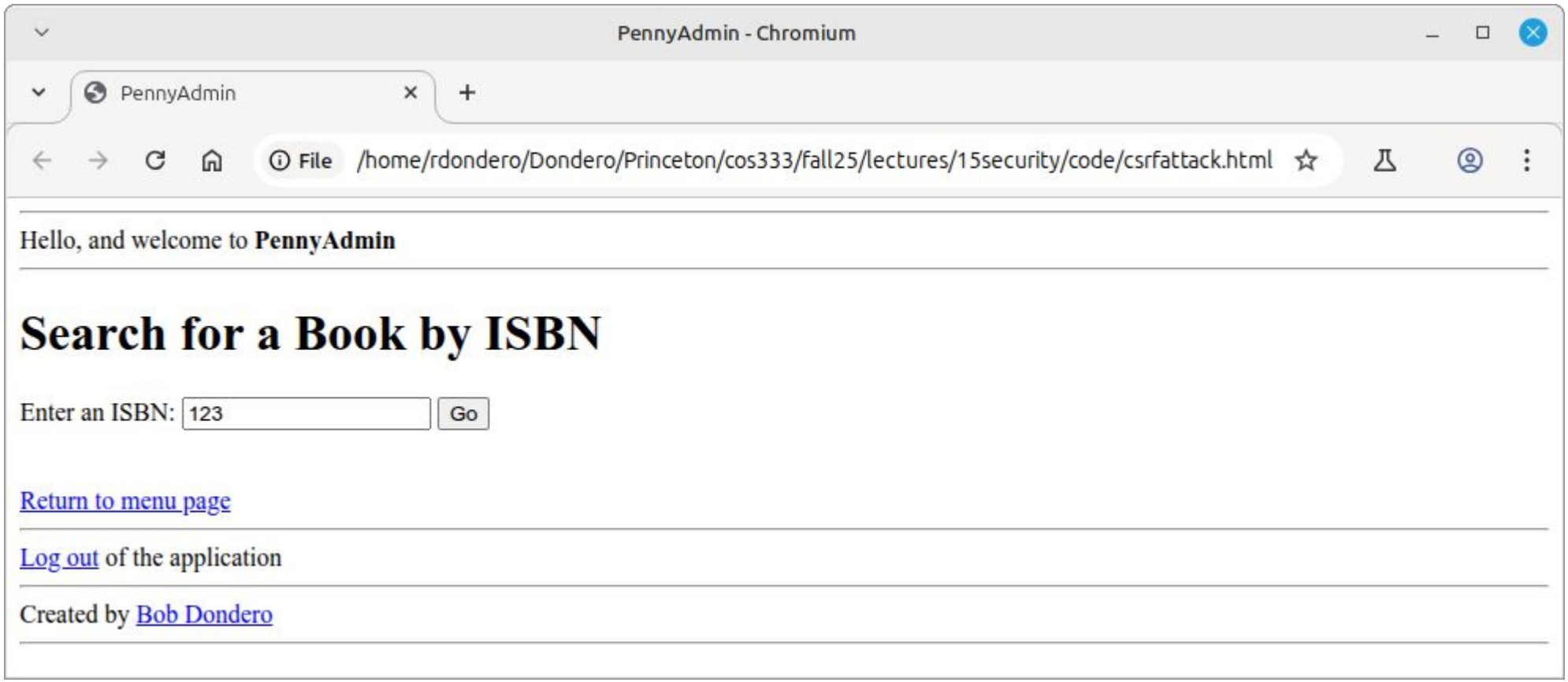
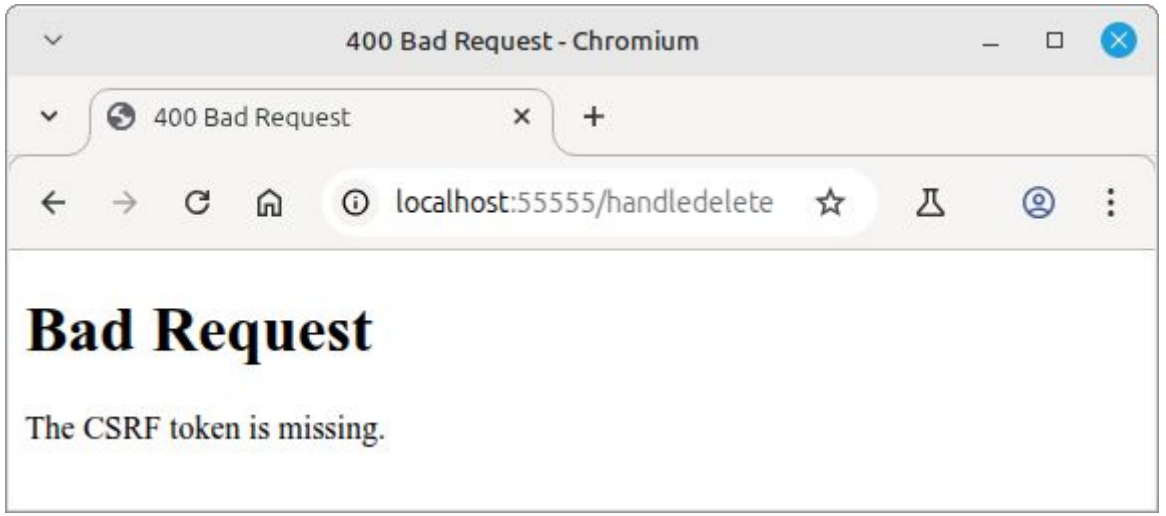
  - Example:



CSRF Attacks

- **See PennyAdmin06bCsrfToken**
  - Example:



App rejects request

CSRF Attacks

- Note:
  - Really should protect **all** POST requests with CSRF tokens
    - POST requests via forms (shown)
    - POST requests via AJAX (not shown)

CSRF Attacks

- Q: Project concern?
- A: Yes

Lecture Summary

- In this lecture we covered:
  - Cookie forgery attacks
  - Cross-site request forgery (CSRF) attacks