Server-Side Web Programming: CGI (Part 3)

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Objectives

- We will cover:
  - A fundamental example
  - Stateful web programming

Agenda

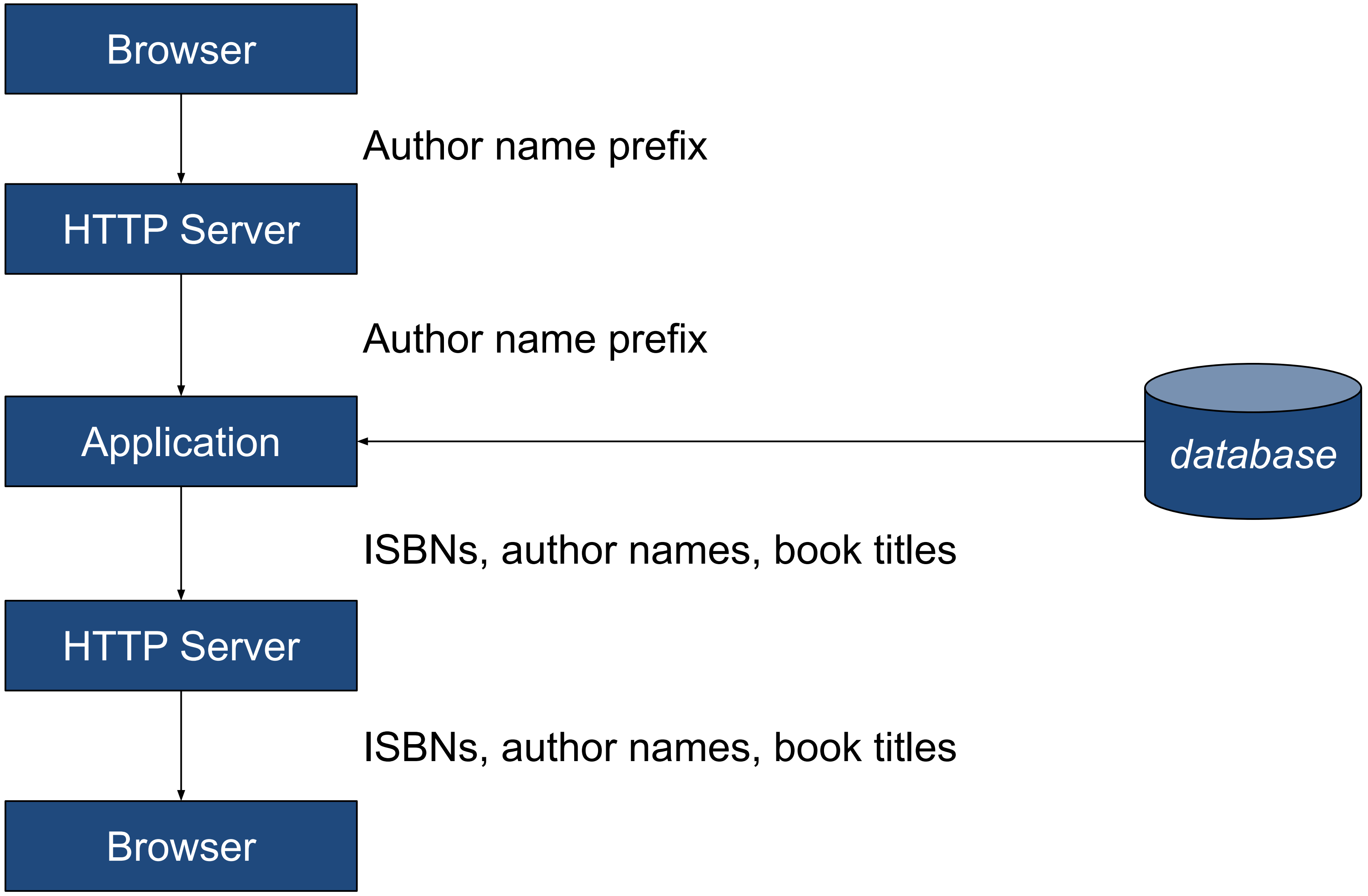
- **Fundamental example**
- Stateful web programming
- Stateful web programming with cookies

Fundamental Example

- **Penny app**
  - Website for a very small bookstore
  - We’ll see *many* versions

Fundamental Example

Penny app



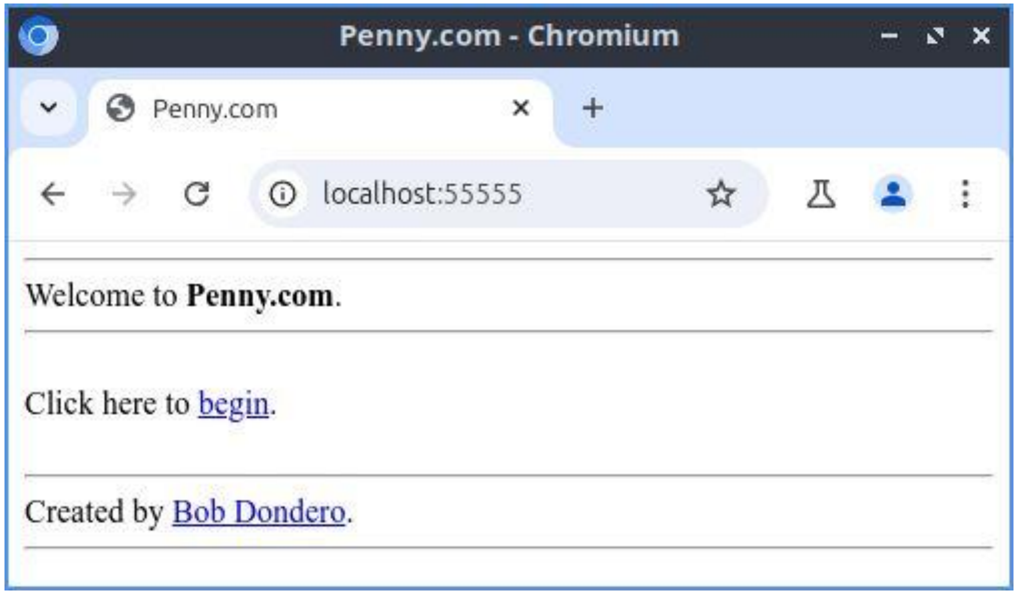
Fundamental Example

- See **PennyCgi** app

```
$ python runserver.py 55555
Serving HTTP on 0.0.0.0 port 55555
(http://0.0.0.0:55555/) ...
```

Fundamental Example

- See **PennyCgi** app (cont.)



Welcome to **Penny.com**.

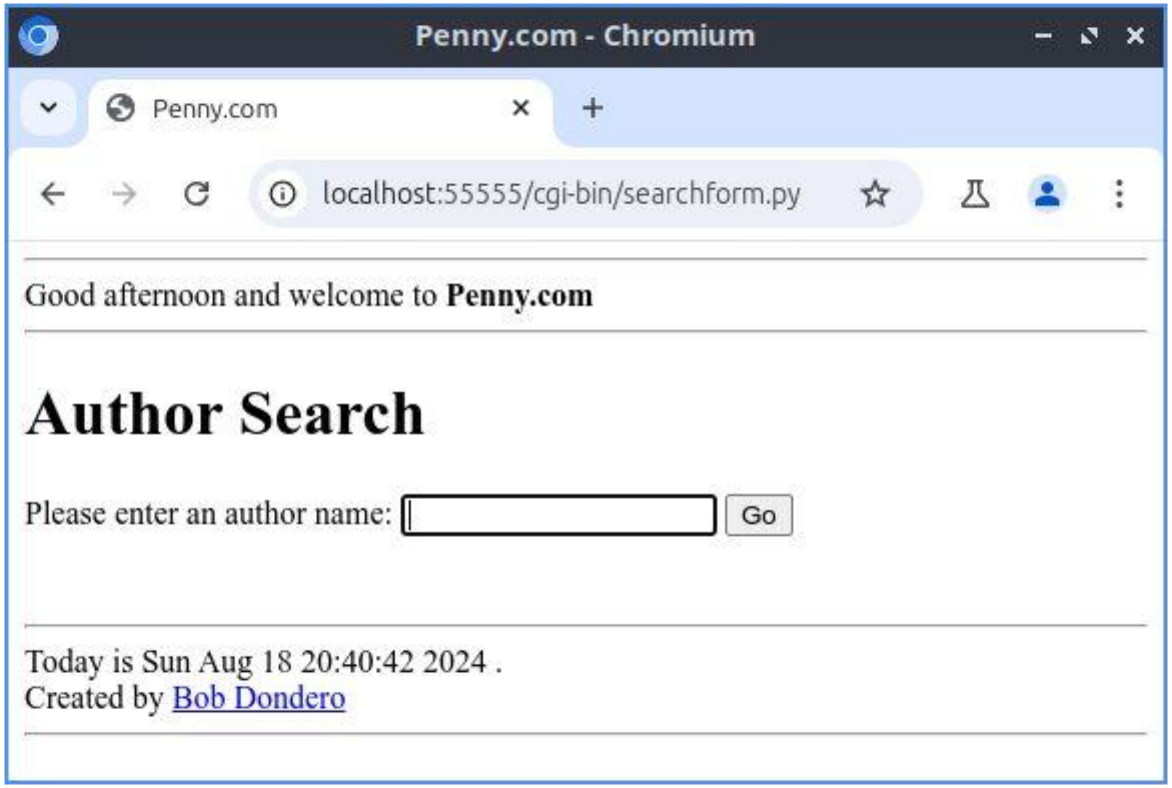
Click here to begin.

Created by Bob Dondero.

The index page

Fundamental Example

- See **PennyCgi** app (cont.)



Good afternoon and welcome to **Penny.com**

Author Search

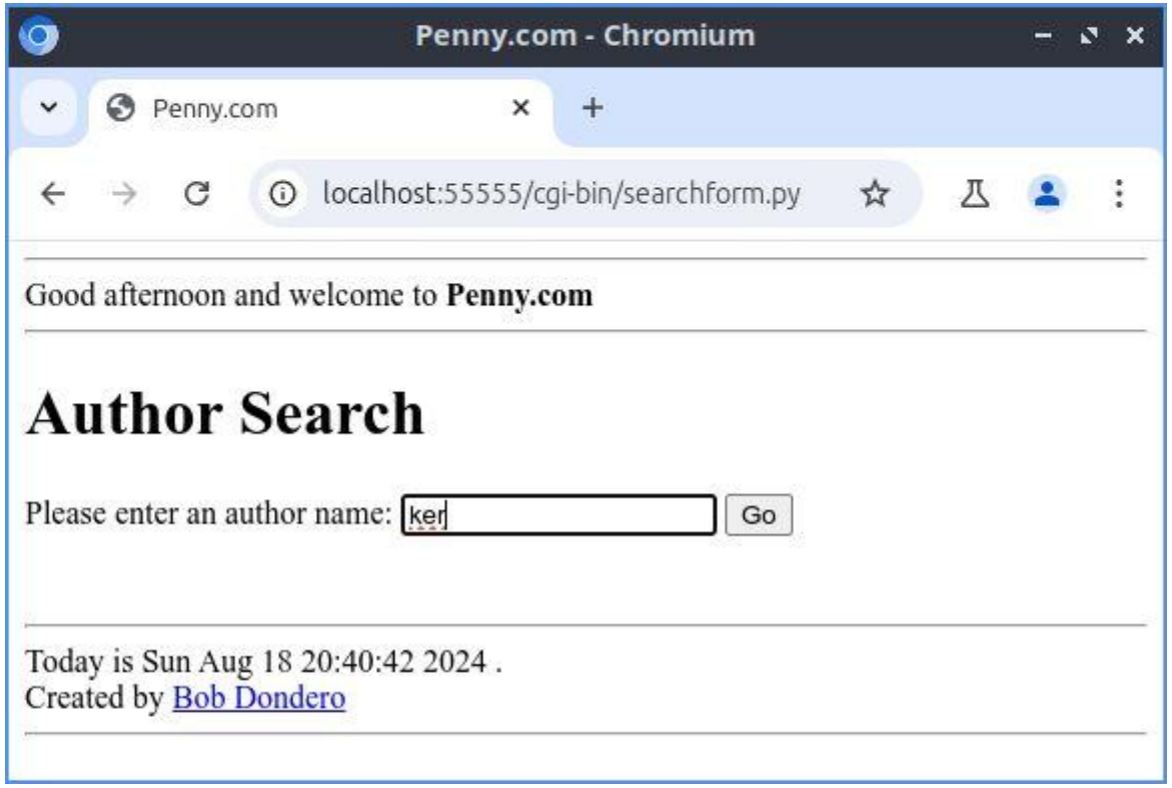
Please enter an author name: Go

Today is Sun Aug 18 20:40:42 2024 .
Created by Bob Dondero

The searchform page

Fundamental Example

- See **PennyCgi** app (cont.)



Good afternoon and welcome to **Penny.com**

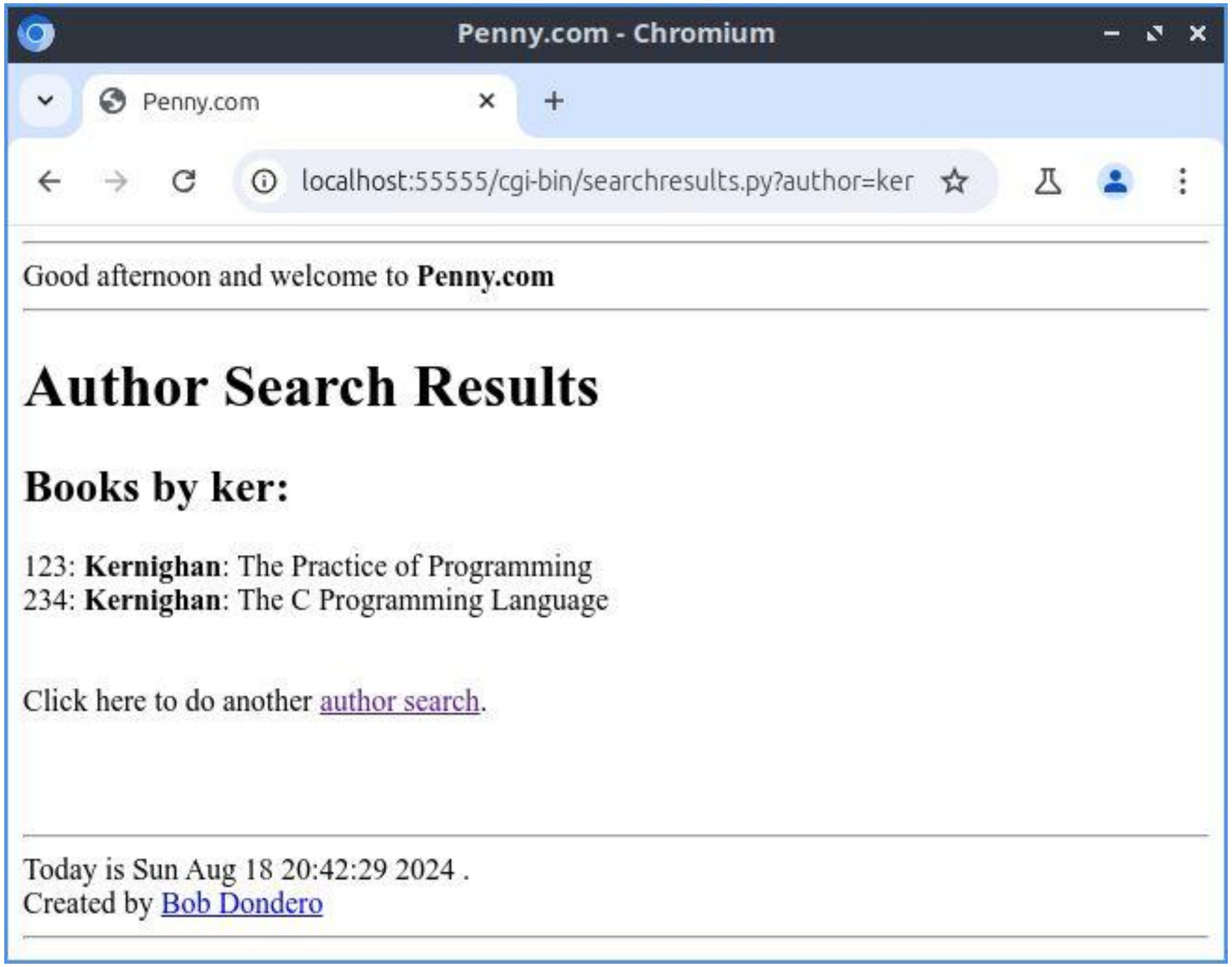
Author Search

Please enter an author name: ker Go

Today is Sun Aug 18 20:40:42 2024 .
Created by Bob Dondero

Fundamental Example

- See **PennyCgi** app (cont.)



Good afternoon and welcome to **Penny.com**

Author Search Results

Books by ker:

123: **Kernighan**: The Practice of Programming
234: **Kernighan**: The C Programming Language

Click here to do another author search.

Today is Sun Aug 18 20:42:29 2024 .
Created by Bob Dondero

The searchresults page

Fundamental Example

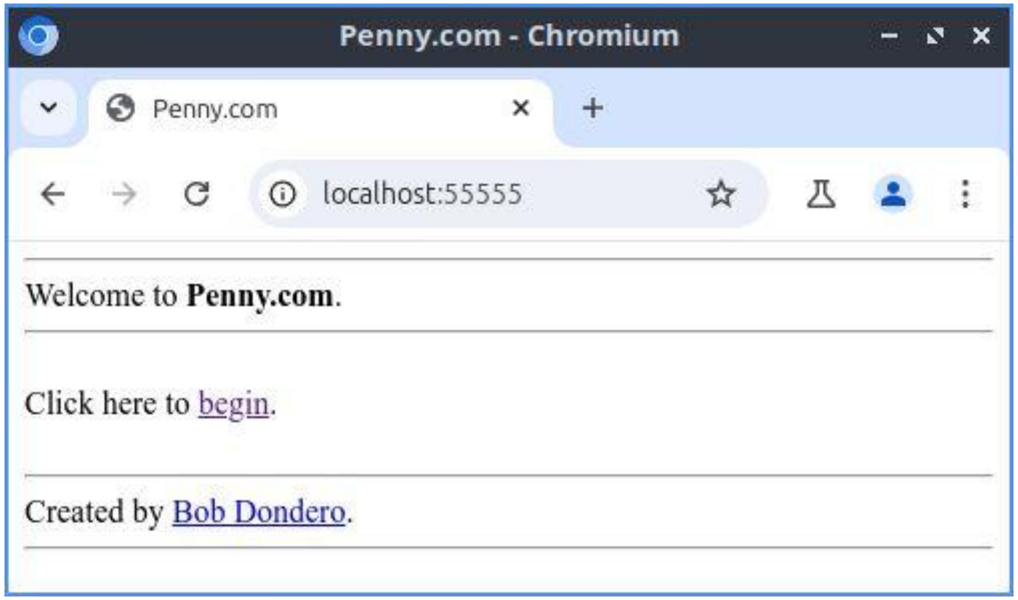
- See **PennyCgi** app (cont.)
  - runserver.py
  - **penny.sql**
  - penny.sqlite
  - **index.html**
  - **cgi-bin/database.py**
  - **cgi-bin/common.py**
  - cgi-bin/parseargs.py
  - **cgi-bin/searchform.py**
  - **cgi-bin/searchresults.py**

Agenda

- Fundamental example
- **Stateful web programming**
- Stateful web programming with cookies

Stateful Web Programming

- See **PennyCgiState** app



Welcome to **Penny.com**.

Click here to begin.

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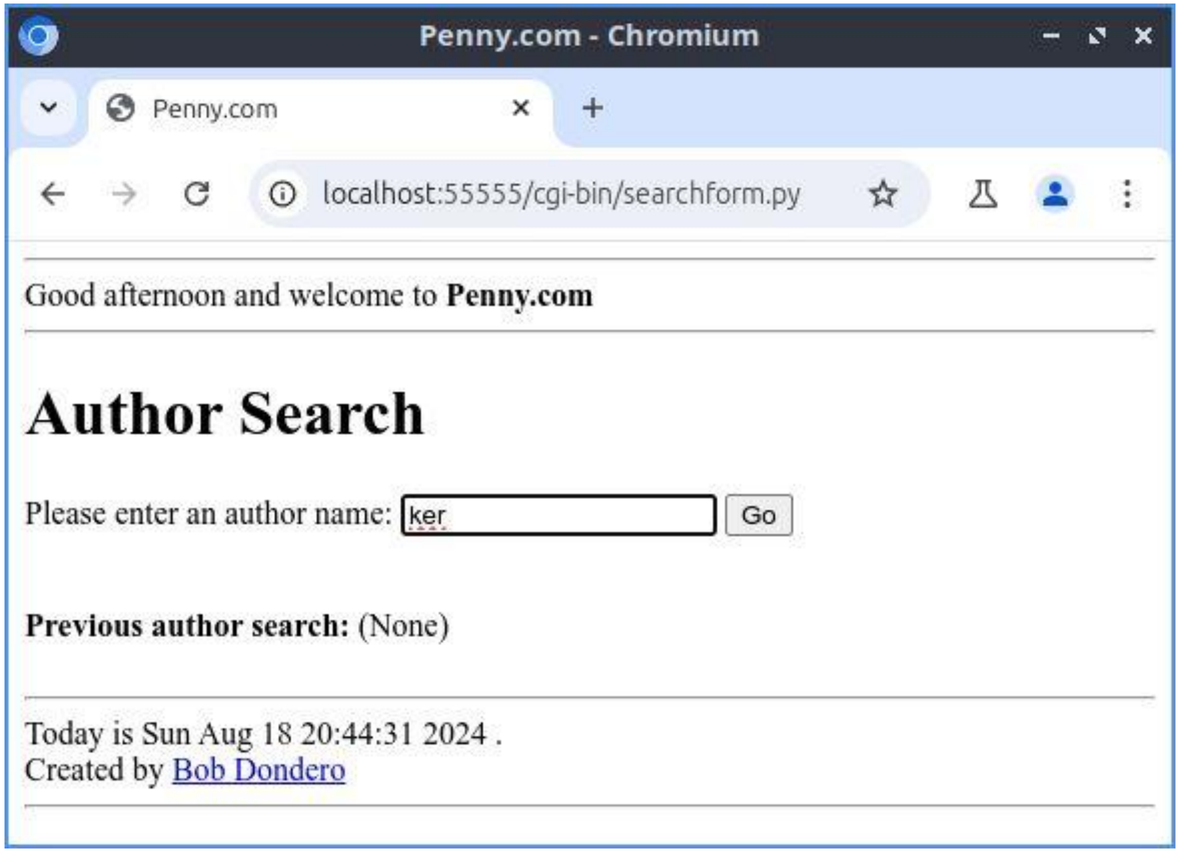
Stateful Web Programming

- See **PennyCgiState** app (cont.)



Good afternoon and welcome to **Penny.com**

Author Search

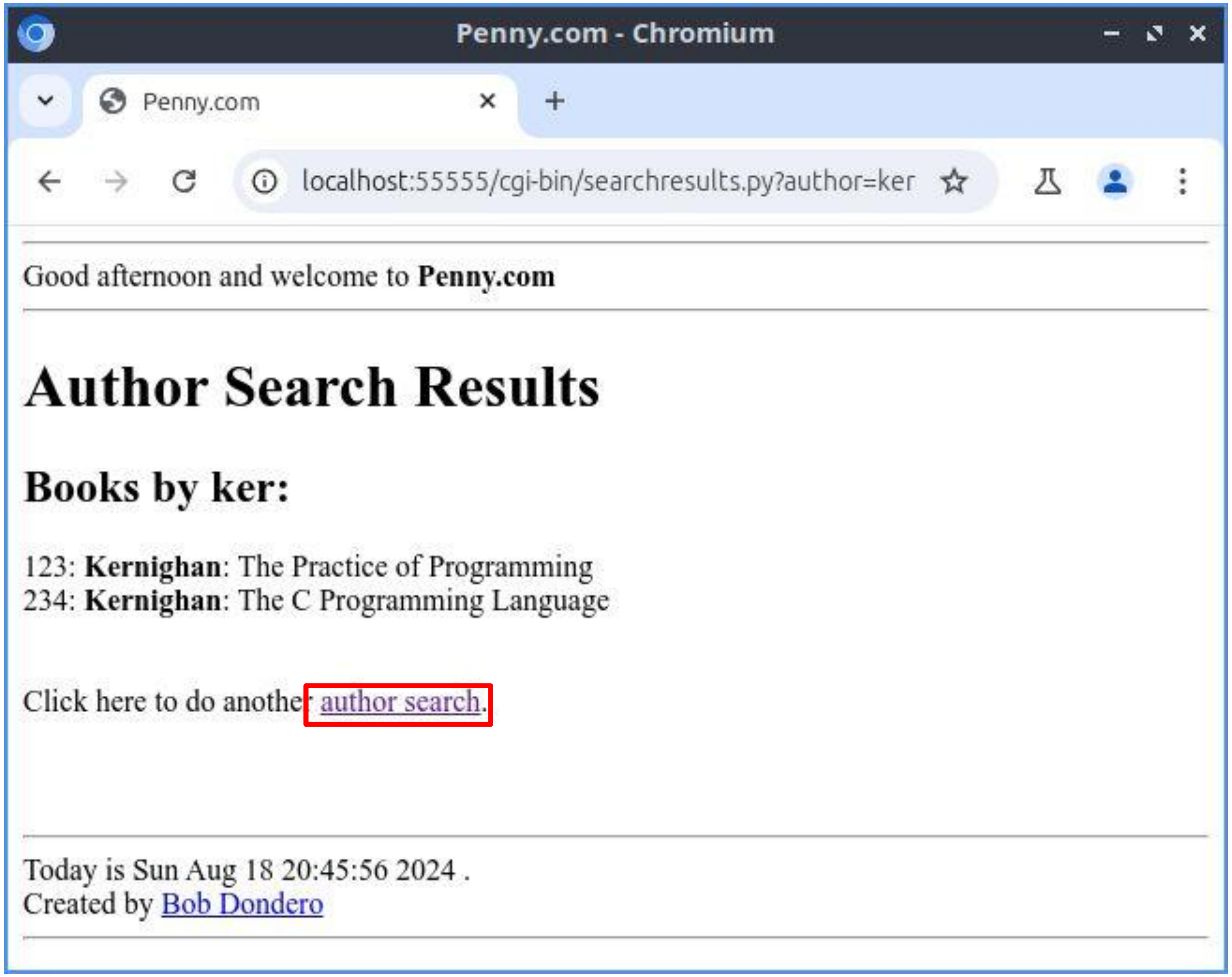
Please enter an author name: ker Go

Previous author search: (None)

Today is Sun Aug 18 20:44:31 2024 .
Created by Bob Dondero

Stateful Web Programming

- See **PennyCgiState** app (cont.)



Good afternoon and welcome to **Penny.com**

Author Search Results

Books by ker:

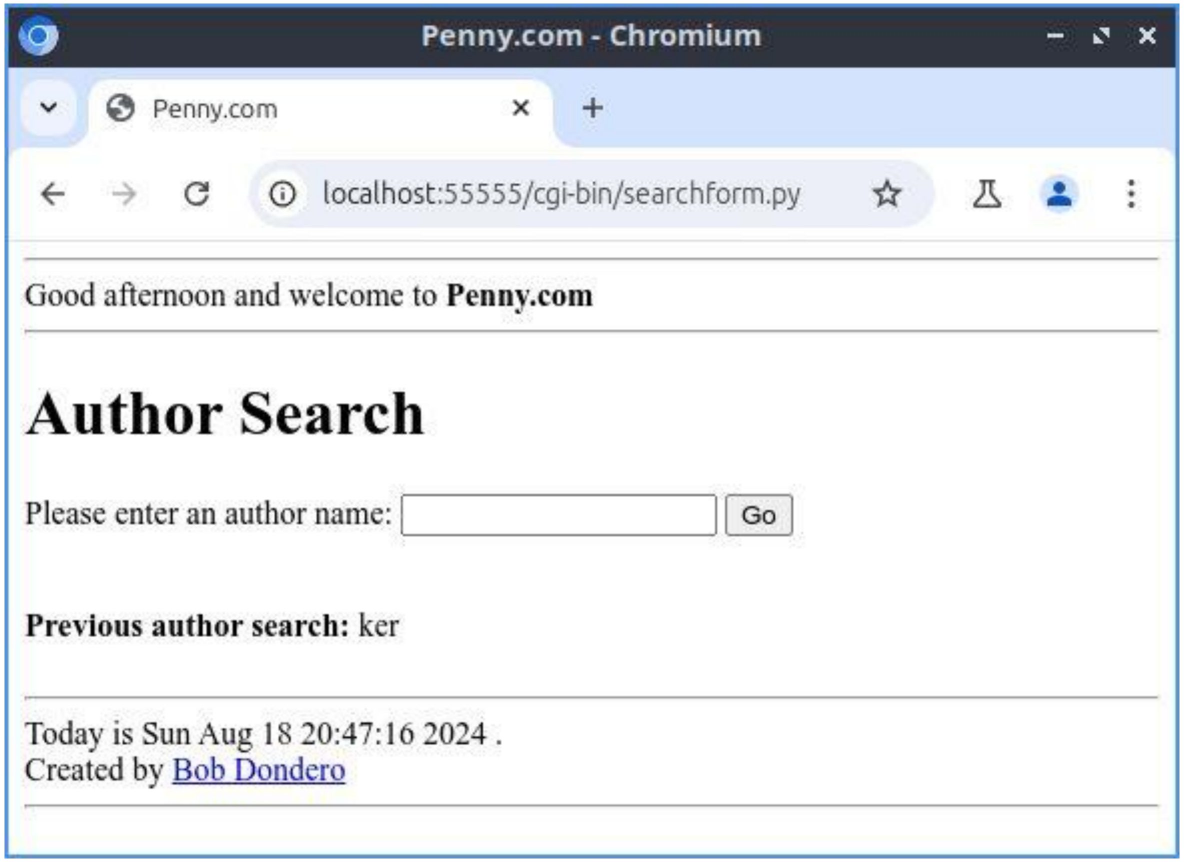
123: **Kernighan**: The Practice of Programming
234: **Kernighan**: The C Programming Language

Click here to do another author search.

Today is Sun Aug 18 20:45:56 2024 .
Created by Bob Dondero

Stateful Web Programming

- See **PennyCgiState** app (cont.)



Good afternoon and welcome to **Penny.com**

Author Search

Please enter an author name: [ ] Go

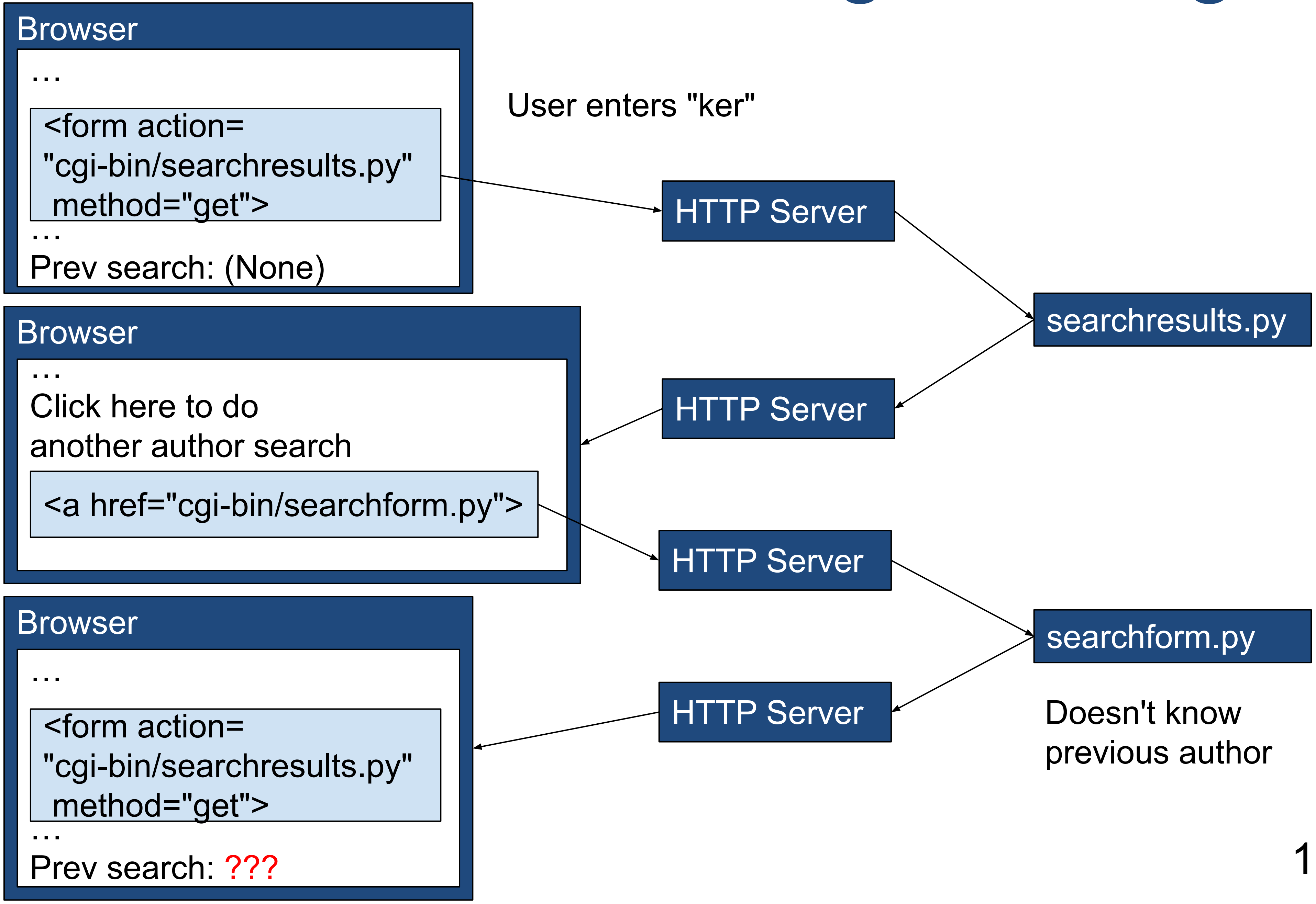
Previous author search: ker

Today is Sun Aug 18 20:47:16 2024 .
Created by Bob Dondero

Stateful Web Programming

- See **PennyCgiState** app (cont.)
  - Displays name of previously-searched-for author in searchform page
  - But how???

Stateful Web Programming


Browser
…
<form action= "cgi-bin/searchresults.py" method="get">
…
Prev search: (None)
User enters "ker"
HTTP Server
searchresults.py
HTTP Server
Browser
…
Click here to do another author search
<a href="cgi-bin/searchform.py">
HTTP Server
searchform.py
HTTP Server
Doesn't know previous author
Browser
…
<form action= "cgi-bin/searchresults.py" method="get">
…
Prev search: ???

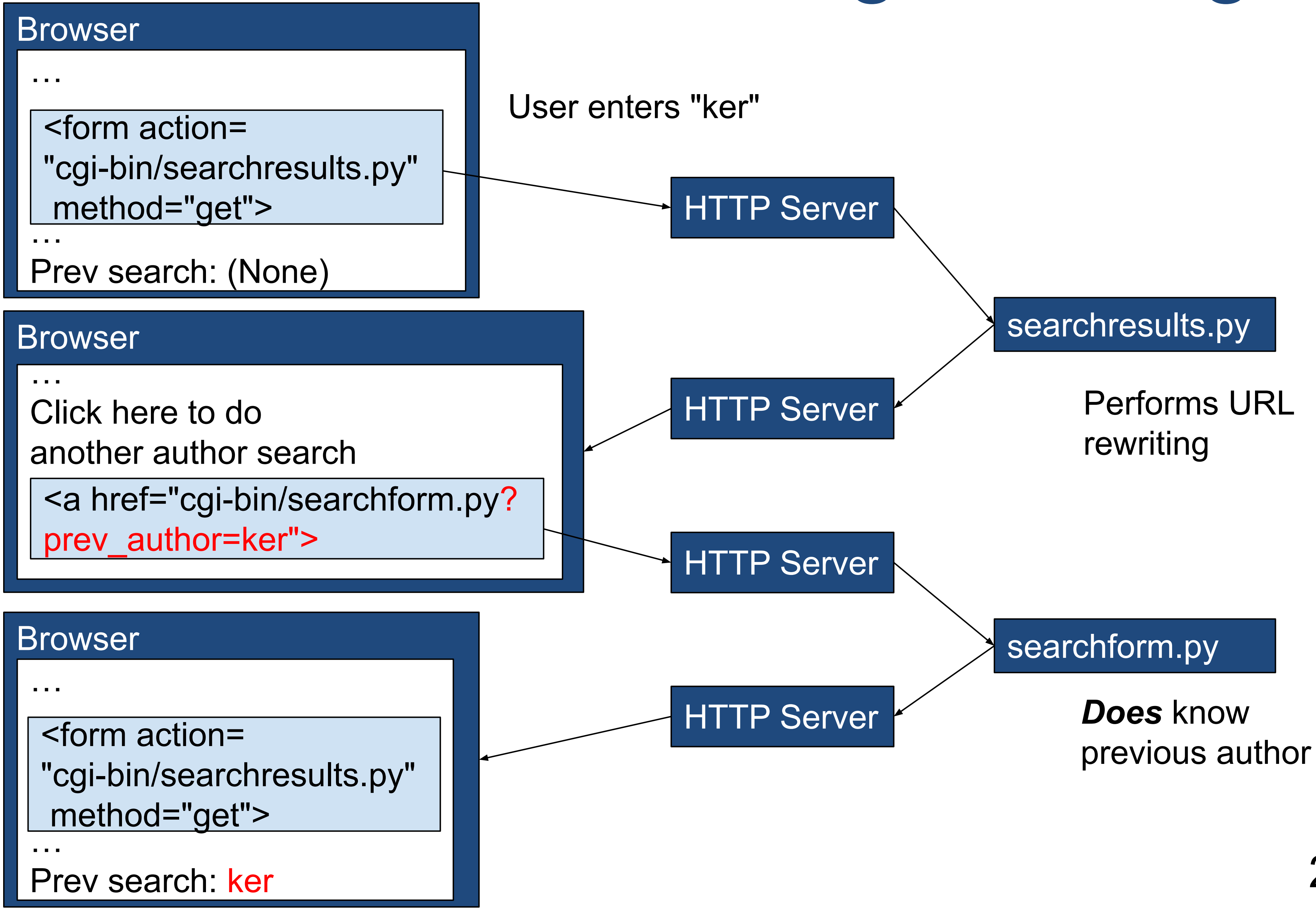
Stateful Web Programming

- Generalizing…
- **Problem**:
  - HTTP is a ***stateless*** protocol
    - Neither the browser nor the HTTP server remembers previous interactions

Stateful Web Programming

- **Problem:**
  - HTTP is a stateless protocol
- **Solution 1**: ***URL rewriting***
  - Append state data to end of URL

Stateful Web Programming



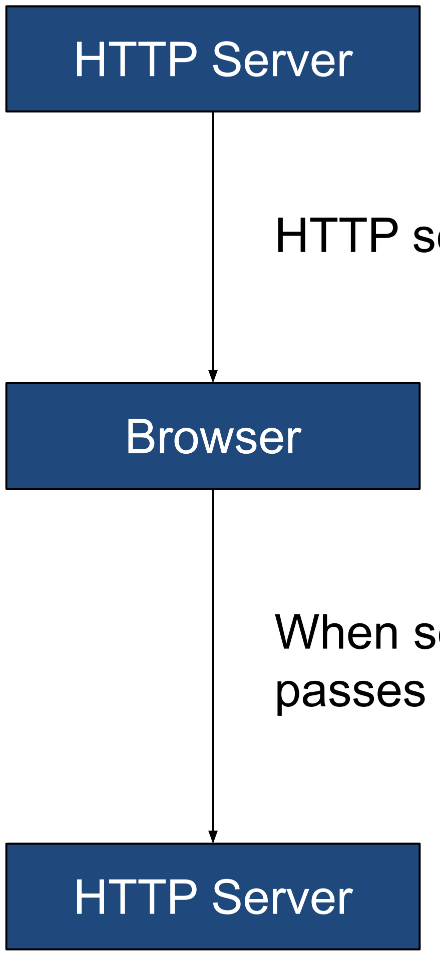
Agenda

- Fundamental example
- Stateful web programming
- **Stateful web programming with cookies**

Stateful Web Pgmming: Cookies

- **Problem:**
  - HTTP is a stateless protocol
- **Solution 1**: **URL rewriting**
  - Append state data to end of URL
- **Solution 2**: ***Cookies***

Stateful Web Pgmming: Cookies



HTTP server places state in cookie

HTTP server passes cookie to browser as HTTP header

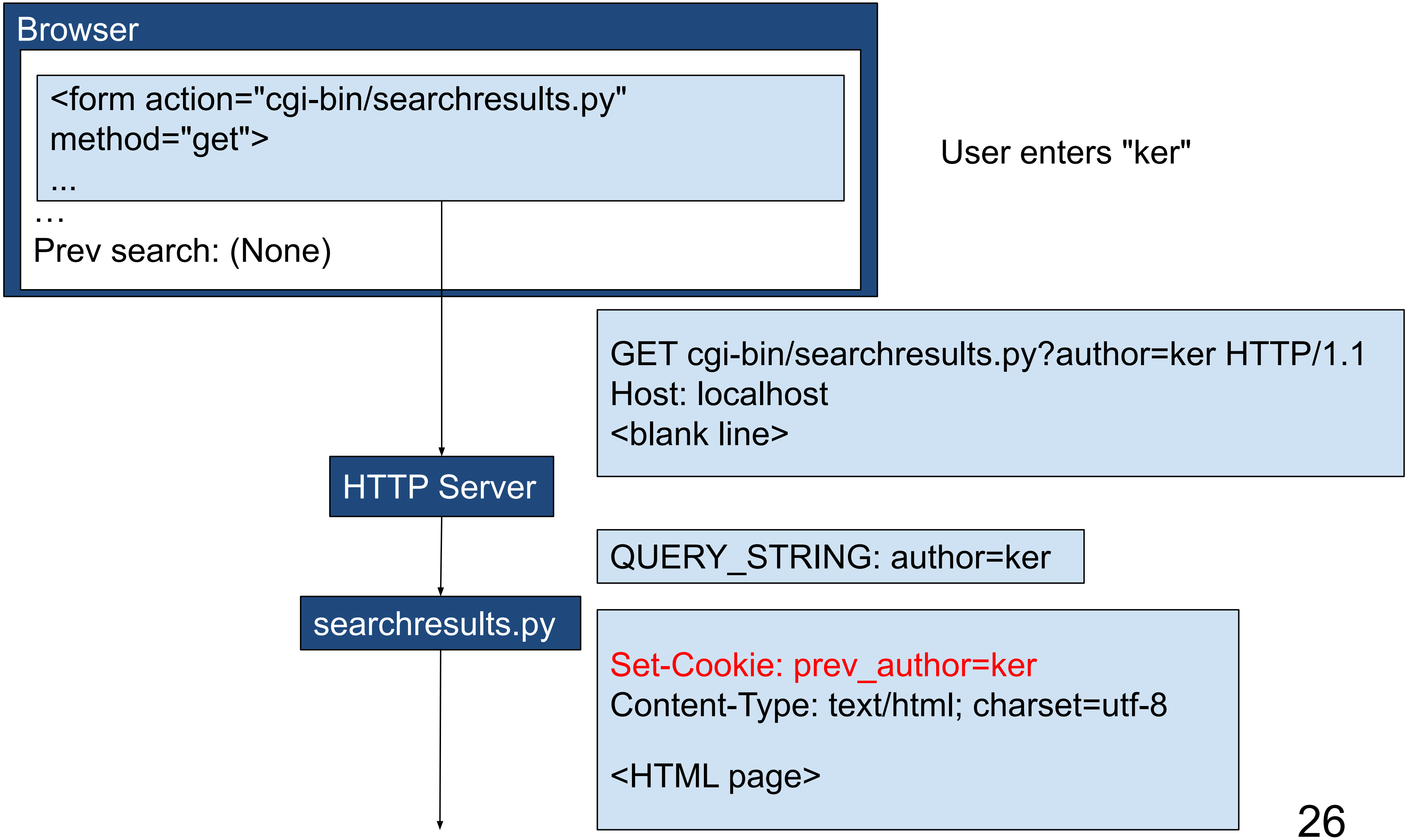
Browser saves cookie (in memory or client file system)

When sending subsequent HTTP request to same app, browser passes cookie to HTTP server as HTTP header

Stateful Web Pgmming: Cookies

- Cookie attributes:
  - Name
  - Content
  - Host & path
  - Expiration date
  - …

Stateful Web Pgmming: Cookies



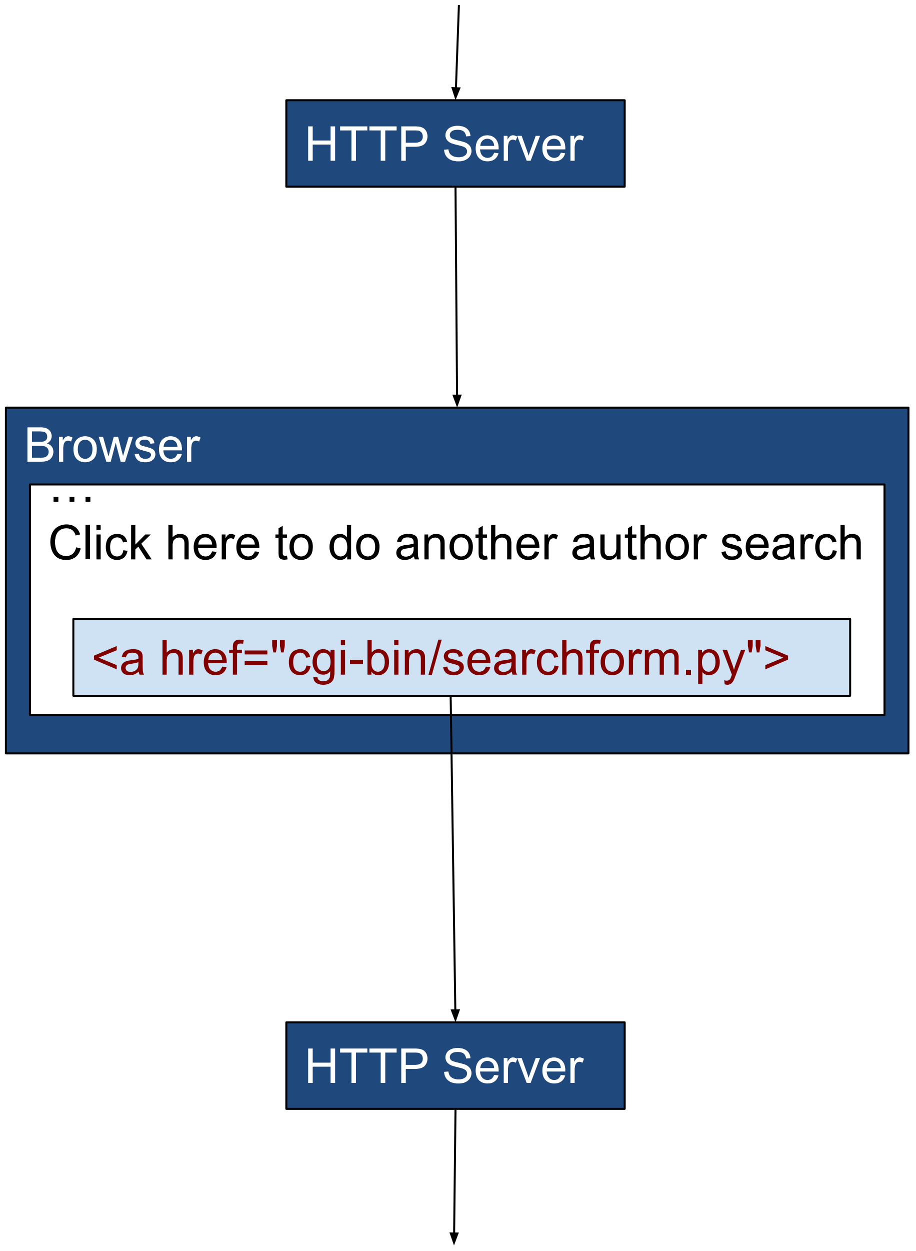
```
<form action="cgi-bin/searchresults.py"
method="get">
...
...
Prev search: (None)
```

```
GET cgi-bin/searchresults.py?author=ker HTTP/1.1
Host: localhost
<blank line>
```

```
QUERY_STRING: author=ker
```

```
Set-Cookie: prev_author=ker
Content-Type: text/html; charset=utf-8

<HTML page>
```

Stateful Web Pgmming: Cookies


HTTP Server
Browser
…
Click here to do another author search
<a href="cgi-bin/searchform.py">
HTTP Server

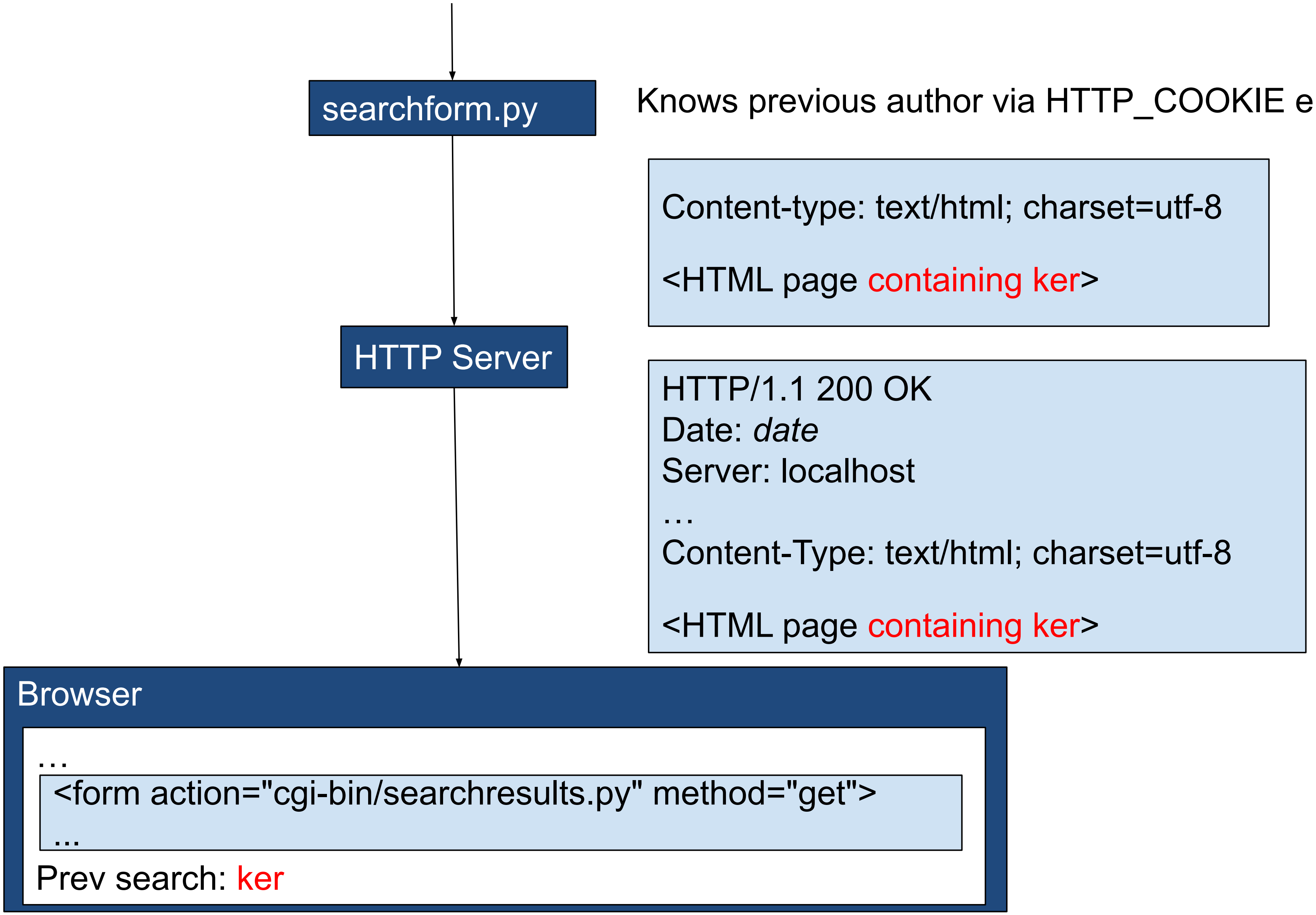
```
HTTP/1.1 200 OK
Date: date
Server: localhost
…
Set-Cookie: prev_author=ker
Content-Type: text/html; charset=utf-8

<HTML page>
```

Browser saves cookie

```
GET cgi-bin/searchform.py HTTP/1.1
Host: localhost
Cookie: prev_author=ker
<blank line>
```

```
HTTP_COOKIE: prev_author=Ker
```

Stateful Web Pgmming: Cookies



Knows previous author via HTTP_COOKIE env var

```
Content-type: text/html; charset=utf-8

<HTML page containing ker>
```

```
HTTP/1.1 200 OK
Date: date
Server: localhost
…
Content-Type: text/html; charset=utf-8

<HTML page containing ker>
```

```
…
<form action="cgi-bin/searchresults.py" method="get">
...
Prev search: ker
```

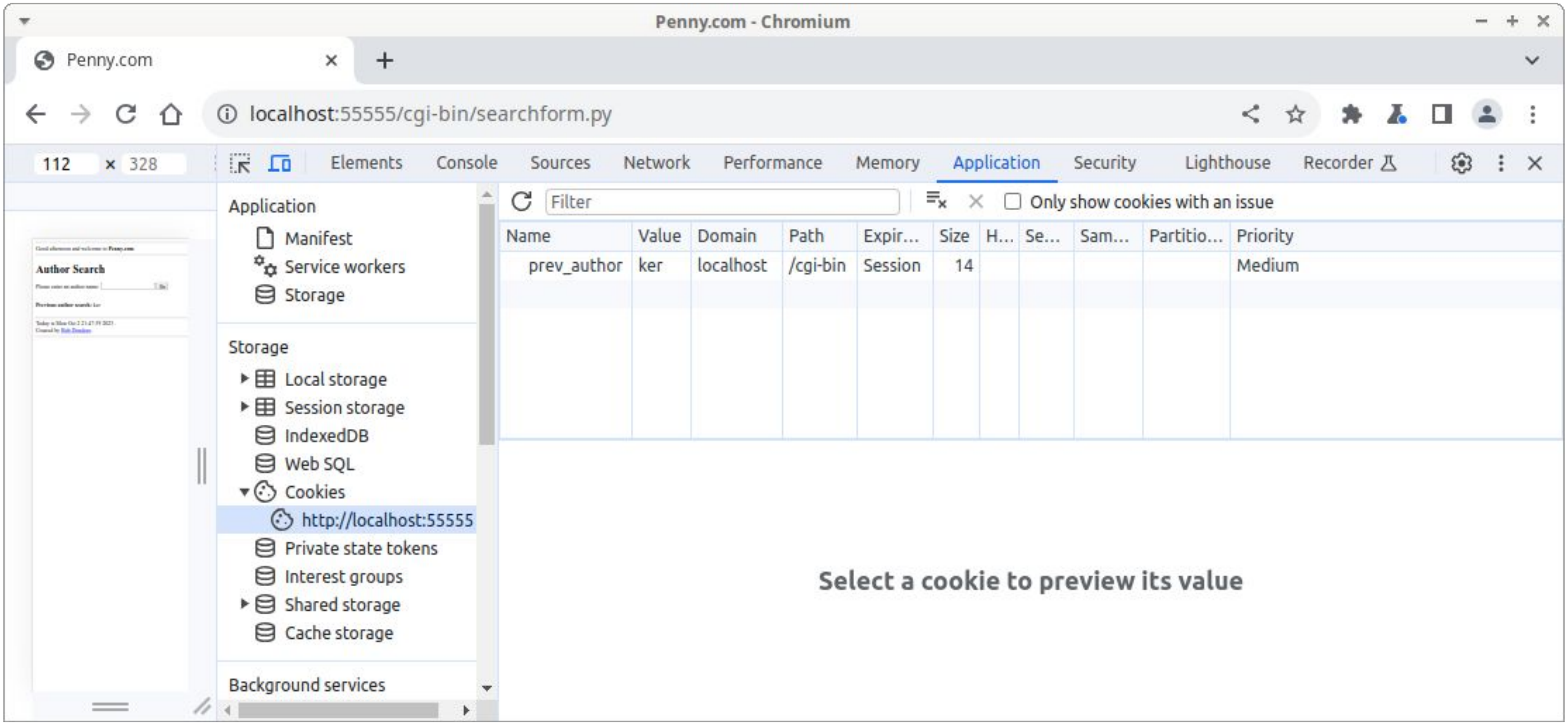
Stateful Web Pgmming: Cookies

- See **PennyCgiState** app
  - runserver.py
  - penny.sql
  - penny.sqlite
  - index.html
  - cgi-bin/database.py
  - cgi-bin/parseargs.py
  - **cgi-bin/searchform.py**
  - **cgi-bin/searchresults.py**

Stateful Web Pgmming: Cookies

- Viewing cookies in Chrome:
  - Browse to a page in the Penny application after the cookie has been created
  - From the menu at the upper right…
    - More tools →
    - Developer tools →
    - Application →
    - Cookies →
    - Select http://localhost:55555

Stateful Web Pgmming: Cookies



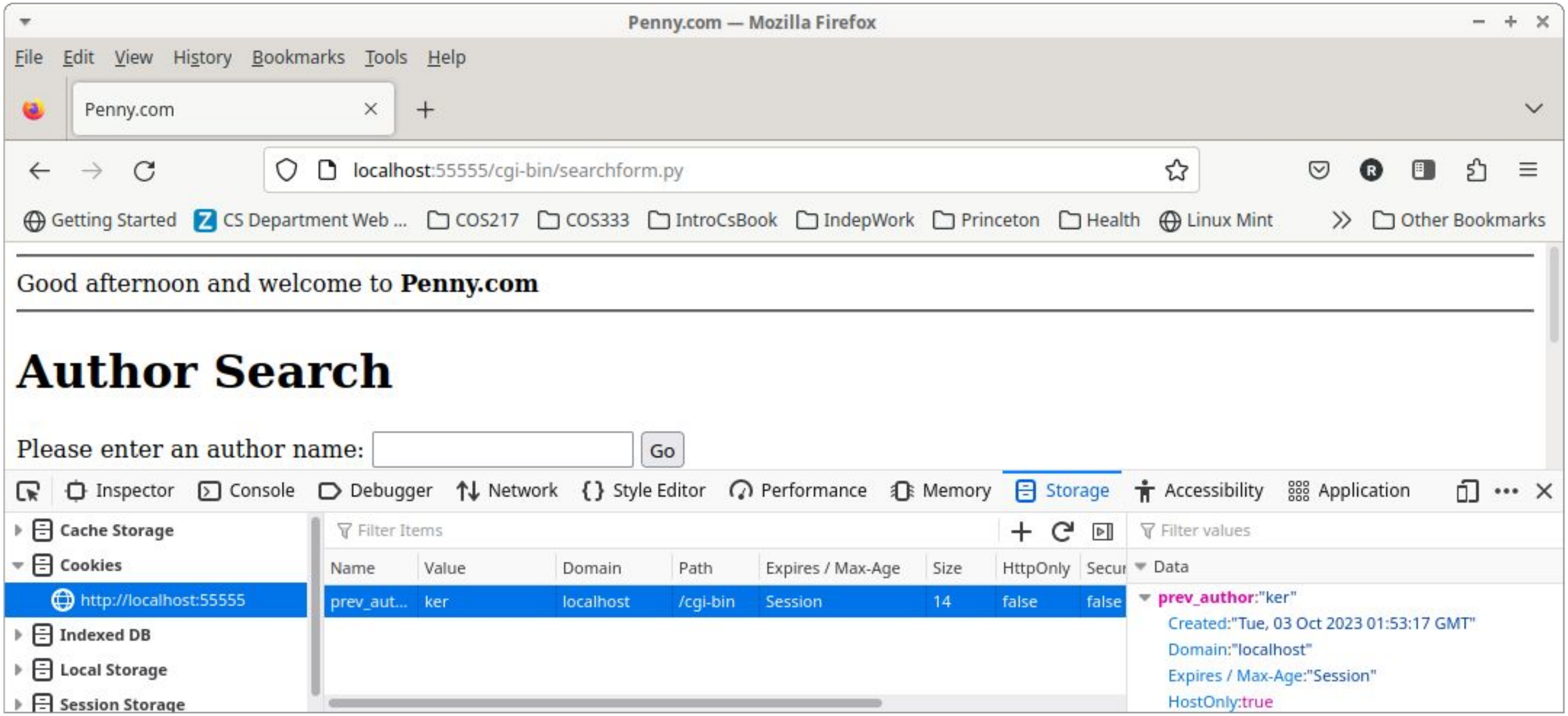
Name	Value	Domain	Path	Expir…	Size	H…	Se…	Sam…	Partitio…	Priority
prev_author	ker	localhost	/cgi-bin	Session	14					Medium

Select a cookie to preview its value

Stateful Web Pgmming: Cookies

- Viewing cookies in Firefox:
  - Browse to a page in the Penny application after the cookie has been created
  - From the menu at the upper right…
    - More tools →
    - Web Developer Tools →
    - Storage →
    - Cookies →
    - Select http://localhost:55555

Stateful Web Pgmming: Cookies



Good afternoon and welcome to **Penny.com**

Author Search

Please enter an author name: [ ] Go

Name	Value	Domain	Path	Expires / Max-Age	Size	HttpOnly	Secur
prev_aut...	ker	localhost	/cgi-bin	Session	14	false	false

Data
prev_author:"ker"
Created:"Tue, 03 Oct 2023 01:53:17 GMT"
Domain:"localhost"
Expires / Max-Age:"Session"
HostOnly:true

Lecture Summary

- In this lecture we covered:
  - A fundamental example
  - Stateful web programming

Lecture Series Summary

- In this lecture series we covered:
  - CGI programming
  - CGI using the HTTP GET method
  - CGI using the HTTP POST method
  - GET vs. POST
  - A fundamental example
  - Stateful web programming
- See also:
  - **Appendix 1**: Cookie Problems
  - **Appendix 2**: Python Decorators

More Information

- The COS 333 *Lectures* web page provides references to supplementary information

Appendix 1:
Cookie Problems

Cookie Problems

- **Problem 1**:
  - Cookie size is limited to 4K bytes
- **Solution**:
  - Cookie content stored on server-side (in database), indexed by a unique key
  - Cookie contains key only

Cookie Problems

- **Problem 2**:
  - Browser user may block cookies for *all* websites
    - Chrome
      - Settings ⟶ Privacy & Security ⟶ Site Settings ⟶ Cookies and site data ⟶ Block all cookies
    - Firefox:
      - Settings ⟶ Privacy & Security ⟶ Custom ⟶ Cookies ⟶ All Cookies

Cookie Problems

- **Problem 2 (cont.)**:
  - Browser user may block cookies for *some* websites
    - Encouraged by the ***European General Data Protection Regulation (GDPR)***

Cookie Problems

- **Problem 2 (cont.)**:

> The **GDPR legislation** requires all multinational companies to provide an opt-in whereby website owners receive a user's permission to use cookies before they can be stored on a user's web browsers…
>
> https://us.norton.com/blog/privacy/should-i-accept-cookies

Cookie Problems

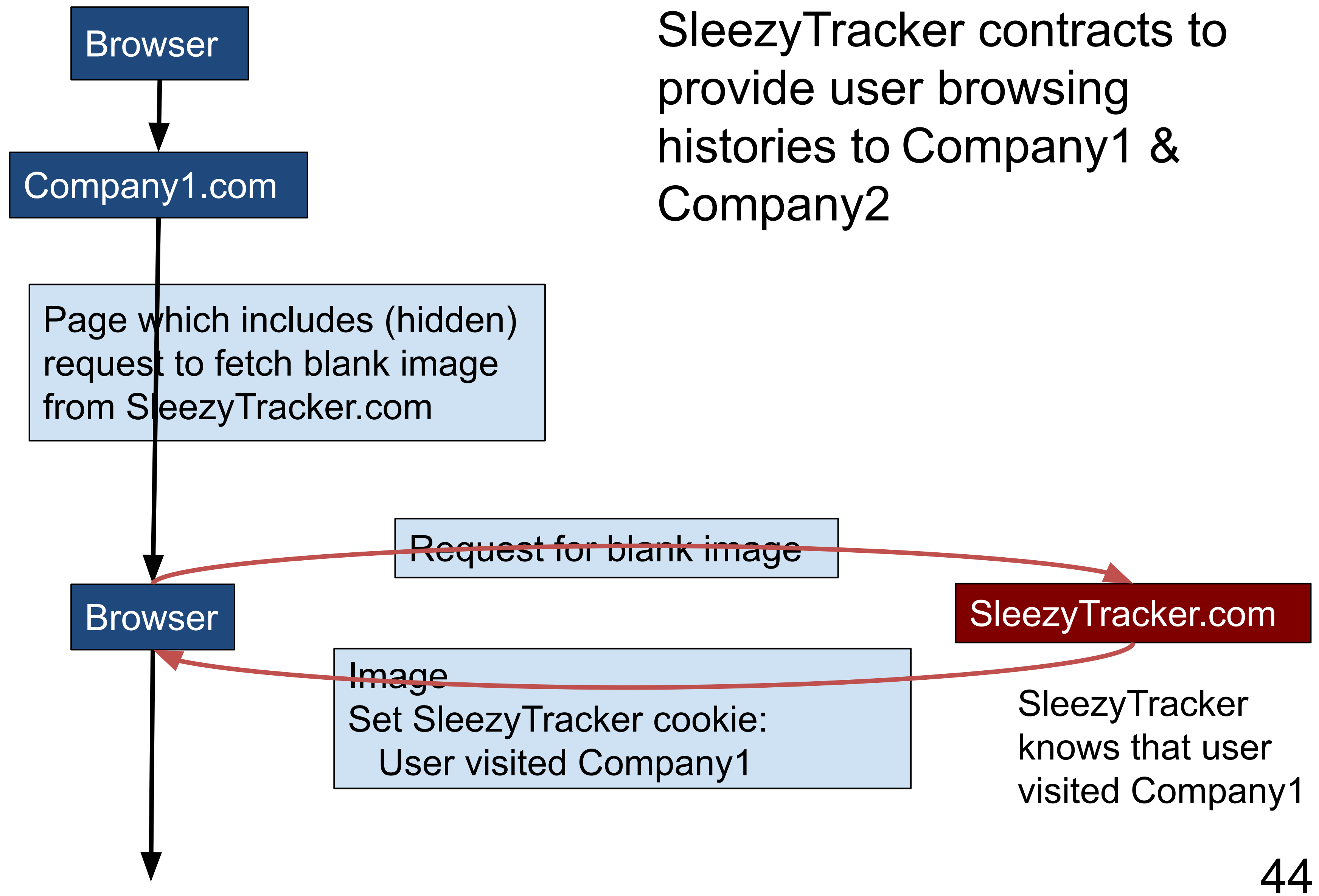
- **Solution**:
  - Ask the user to enable cookies! Or...
  - Add more logic
    - Use URL rewriting
    - Legal?

Cookie Problems

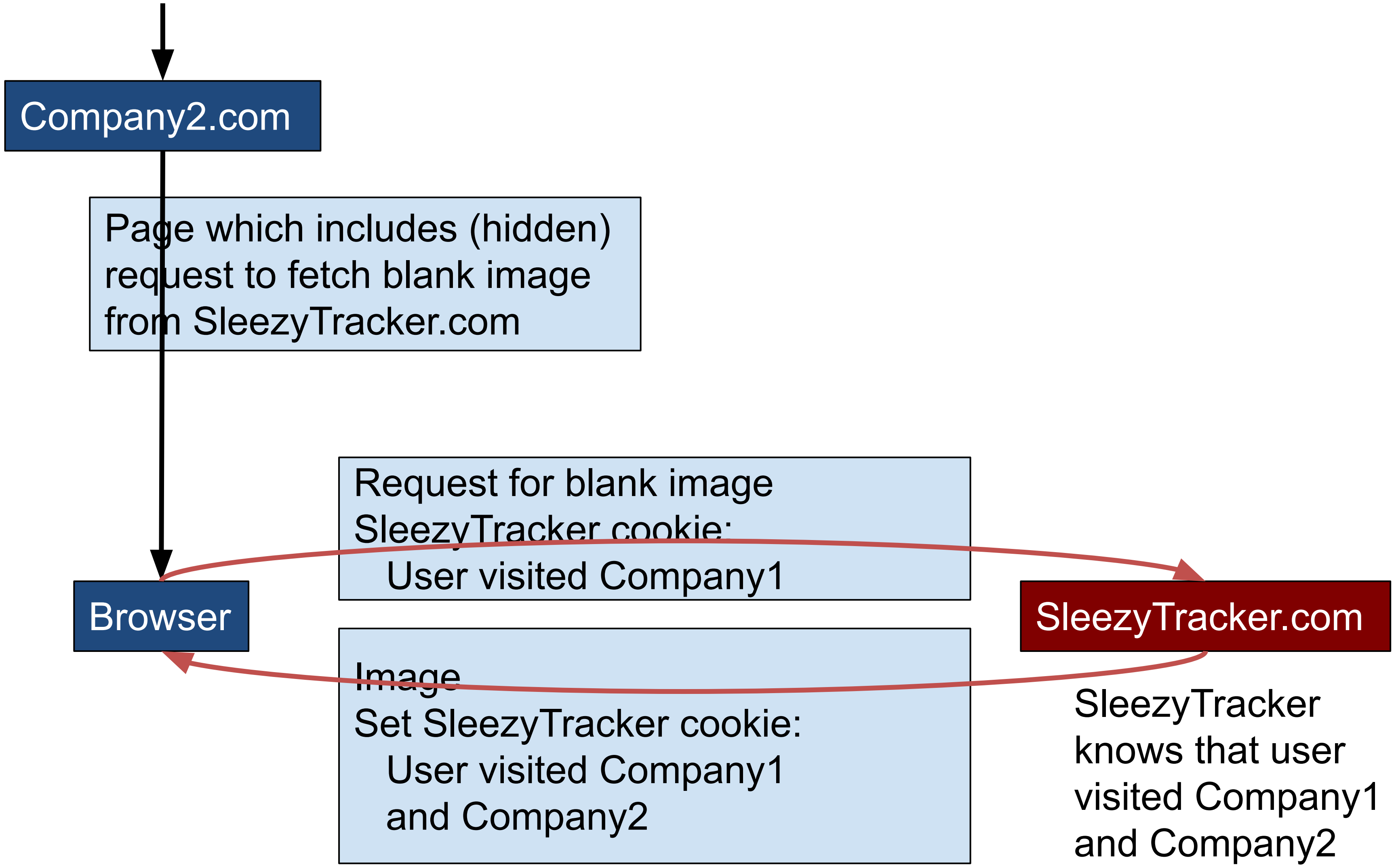
- **Problem 3**:
  - ***Third-party cookies*** can invade privacy
    - See https://en.wikipedia.org/wiki/Cookie_stuffing

Cookie Problems

SleezyTracker contracts to provide user browsing histories to Company1 & Company2


Browser
Company1.com
Page which includes (hidden) request to fetch blank image from SleezyTracker.com
Request for blank image
SleezyTracker.com
Browser
Image
Set SleezyTracker cookie:
User visited Company1
SleezyTracker knows that user visited Company1

Cookie Problems


Company2.com
Page which includes (hidden) request to fetch blank image from SleezyTracker.com
Browser
Request for blank image
SleezyTracker cookie:
User visited Company1
SleezyTracker.com
Image
Set SleezyTracker cookie:
User visited Company1
and Company2
SleezyTracker knows that user visited Company1 and Company2

SleezyTracker provides user browsing histories to Company1 & Company2

Cookie Problems

- **Solution**: Tell browser to refuse third-party cookies
  - Chrome
    - Settings → Privacy & Security → Site Settings → Cookies and site data → Block third-party cookies
  - Firefox:
    - Settings → Privacy & Security → Custom → Cookies → Cross-site tracking cookies, and isolate other cross-site cookies

Appendix 2:
Python Decorators

Python Decorators

```
def sqr(i):
    return i * i

def main():
    result = sqr(5)
    print(result)

if __name__ == '__main__':
    main()
```

Wanted:

sqr() prints “sqr was called” each time it is called

Python Decorators

```
def sqr(i):
    print('sqr was called')
    return i * i

def main():
    result = sqr(5)
    print(result)

if __name__ == '__main__':
    main()
```

OK, but…

   Requires edit of def of `sqr()`

Python Decorators

```
def print_name_decorator(f):
    def fwrapper(i):
        print(f.__name__, 'was called')
        return f(i)
    return fwrapper

def sqr(i):
    return i * i
sqr = print_name_decorator(sqr)
   # Defines fwrapper as this:
   #     def fwrapper(i):
   #         print('sqr', 'was called’)
   #         return sqr(i)
   # and then does this:
   #     sqr = fwrapper

def main():
    result = sqr(5)
    print(result)

if __name__ == '__main__':
    main()
```

One approach

Trace:

```
result = sqr(5)
result = fwrapper(5)
   fwrapper(5) prints 'sqr was called'
   fwrapper(5) returns sqr(5)
result = 25
```

Prints:

```
sqr was called
25
```

Python Decorators

```
def print_name_decorator(f):
    def fwrapper(i):
        print(f.__name__, 'was called')
        return f(i)
    return fwrapper

@print_name_decorator
def sqr(i):
    return i * i

def main():
    result = sqr(5)
    print(result)

if __name__ == '__main__':
    main()
```

Using a decorator

Prints:

```
sqr was called
25
```