Scraping with Python

Isaiah Hull

Sveriges Riksbank

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References

1. "Web Scraping with Python: Collecting Data from the Modern Web"
   - Ryan Mitchell (2015)
2. "Python Web Scraping"
   - Katharine Jarmul & Richard Lawson (2017)

Overview

Introduction

How does a browser work?[1]

- Alice has a website.
- Bob wants to view Alice's site.
- Bob's computer creates a header and body.
  - Header = MAC address + Alice's IP address.
  - Body = GET request for index.html.
- Header and body bundled as packet and sent to Alice via intermediary servers.
- Alice's server locates the file and returns it to Bob.

[1] See Mitchell (2015) for additional detail.

Introduction

<u>How does a browser work?</u>

- A browser isn't needed for anything Bob did.
- We can do this with Python.

Introduction

How does a browser work?

```
#lecture1_example1.py

$user python
>>> from urllib2 import urlopen
>>> url "http://www.math.unm.edu/
writingHTML/tut/index.html"
>>> html = urlopen(url)
>>> print(html.read())
```

Introduction

How does a browser work?

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 3.2//EN">
<html>
<head>
<title>Writing HTML</title>
<META name="..."> </head>
<body bgcolor="FFFFFF">
...
<p>
We suggest that you proceed through the lessons in order,
but at any time you can return to the index to jump to a
different lesson.  Within each lesson you can compare
your work to a sample file for that lesson.  ...
<p>
...
</body>
</html>
```

Introduction

Scraping ethics

- Check robots.txt file before scraping.
  - Lists suggested restrictions on automated interaction.
  - Good Internet ethics.
  - Lowers probability of an IP ban.
  - Protocol: http://www.robotstxt.org
- Robots.txt examples:
  - https://www.ecb.europa.eu/robots.txt
  - http://www.bcb.gov.br/robots.txt

Introduction

Scraping ethics

```
User-agent: *
Sitemap: https://www.ecb.europa.eu/sitemap.xml
Disallow: /*_content.bg.html$
Disallow: /*_content.cs.html$
Disallow: /*_content.da.html$
Disallow: /*_content.de.html$
Disallow: /*_content.el.html$
...
Disallow: /ecb/10ann/shared/movies/
Disallow: /ecb/educational/pricestab/shared/movie/
Disallow: /ecb/educational/shared/movies/
...
Crawl-delay: 5
```

Introduction

Scraping ethics

- User-agent: * → Rules apply to all users.
- Sitemap: ... → Sitemap located here.
- Disallow: ... → Don't scrape this URL.
- Crawl-delay: 5 → Use a 5-second delay between requests.

Introduction

Scraping ethics

```
...
User-agent:  Offline Explorer/1.9
Disallow:  /
...
User-agent:  htdig/3.1.4 (****@bcb.gov.br)
Disallow:
...
User-agent:  *
Disallow:  css/*
...
```

Introduction

Scraping ethics

- ```
  User-agent: Offline Explorer/1.9
  Disallow: /
  ```
  - → User-agent: Offline Explorer/1.9 shouldn't scrape any pages.

  ```
  User-agent: htdig/3.1.4 (****@bcb.gov.br)
  Disallow:
  ```
  - → User-agent: htdig/3.1.4 (****@bcb.gov.br) is unrestricted.
- ```
  User-agent: *
  Disallow: css/*
  ```
  - → All other user-agents are restricted.

Introduction

Scraping ethics

- Use the sitemap to improve scraping efficiency.
  - Avoid crawling and scraping duplication.
  - Avoid visiting old pages if unnecessary.

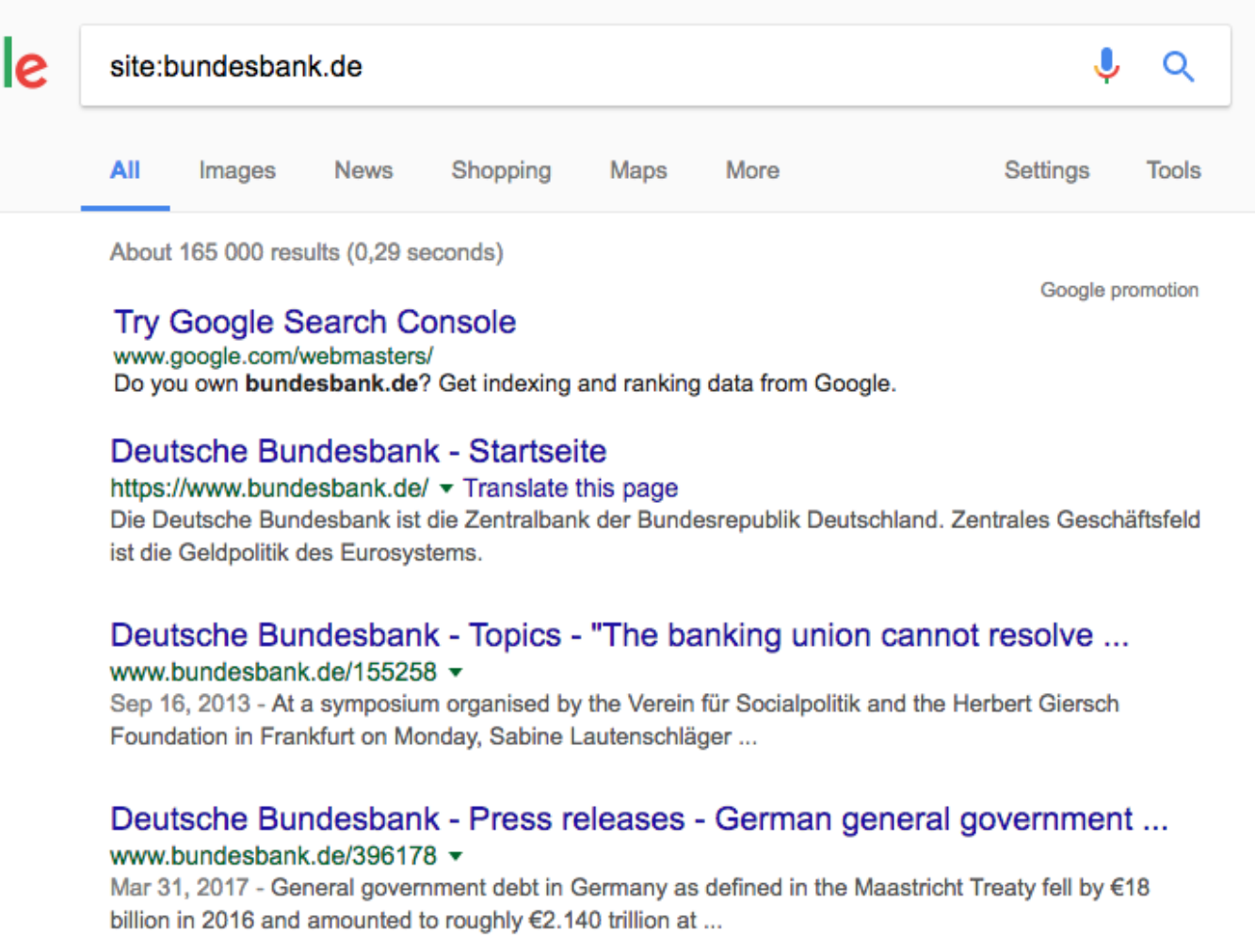
Introduction

Estimating website size

- Crawling and scraping strategy may depend on website size.
- Estimate site size.
- Use the "site" parameter on Google to obtain estimate.
  - site:bundesbank.de

Introduction

Estimating website size



Introduction

Identifying website technology

```
$user pip install wad
$user wad -u https://pypi.python.org
```

Introduction

Identifying website technology


```
{
    "https://pypi.python.org/pypi": [
        {
            "type": "cache-tools",
            "app": "Varnish",
            "ver": null
        },
        {
            "type": "web-servers",
            "app": "Nginx",
            "ver": "1.10.3"
        }
    ]
}
```

Introduction

Identifying website technology

- Example
  - Varnish front-end cache tools.
  - Nginx back-end webserver.
- Dynamic content
  - ASP.NET
  - JQuery
  - Modernizer

Scraping

BeautifulSoup

- Python package for HTML and XML parsing.
- Generates parse tree from extracted code.
- Allows programmers to access and modify HTML.
- Fixes HTML errors, layouts, and indenting.

Scraping

BeautifulSoup

- Broken HTML

```
<ul class=country>
        <li>Area
        <li>Population
</ul>
```

BeautifulSoup

```
#lecture1_example2.py

$user pip install bs4
$user python
>>> from bs4 import BeautifulSoup
>>> broken_html = "<ul
class=country><li>Area<li>Population</ul>"
>>> soup = BeautifulSoup(broken_html)
>>> fixed_html = soup.prettify()
>>> print(fixed_html)
```

Scraping

BeautifulSoup

- Fixed HTML

```
<ul class="country">
    <li>
        Area
    </li>
    <li>
        Population
    </li>
</ul>
```

Scraping

BeautifulSoup

Parser	License	Implementation language(s)	Latest date*	HTML parsing[1]	HTML5-compliant parsing	Clean HTML**	Update HTML***
Lambda Soup	BSD-2-Clause	OCaml	2016-12-10[2]	Yes	Yes	?	?
html.parser	Python S. F. L.	Python	2016-06-27[3]	Yes	?	No	No
Html Agility Pack	Microsoft Public License	C#	2016-07-14[4]	Yes	?	No	?
Beautiful Soup	Python S. F. L.	Python	2016-08-02[5]	Yes	Partial[6]	Yes	Yes
Gumbo	Apache License 2.0	C	2015-05-01	Yes	Yes	?	?
html5ever	Apache License 2.0	Rust	2016-02-23	Yes	Yes	?	?
html5lib	MIT License	Python (and PHP, six years ago)	2016-07-15[7]	Yes	Yes	Yes	No
HTML::Parser	Perl license	Perl	2013-03-28	Yes	No[8]	?	?
WebGear	GPL3	Perl	2017-03-10	Yes	Yes	?	?
htmlPurifier	GNU Lesser GPL	PHP	2009-03-25[9]	No	No	Yes	Yes
HTML Tidy	W3C license	ANSI C	2017-03-01[10]	Yes[11]	Yes	Yes[11]	Yes
HtmlUnit	Apache License 2.0	Java	2016-05-27[12]	Yes	?	No	No
HtmlCleaner	BSD License[13]	Java	2015-08-24	No	No	Yes	?
Hubbub	MIT License	C	2016-02-16	Yes	Yes[14]	?	?

https://en.wikipedia.org/wiki/Comparison_of_HTML_parsers

Scraping

BeautifulSoup

```
#lecture1_example3.py

$user python
>>> from urllib2 import urlopen
>>> from bs4 import BeautifulSoup
>>> url = "https://en.wikipedia.org/
wiki/Richard_Thaler"
>>> html = urlopen(url)
>>> soup = BeautifulSoup(html.read())
>>> print(soup.h1)
<h1 class="firstHeading" id="firstHeading"
lang="en">Richard Thaler</h1>
>>> print(soup.h1.text)
Richard Thaler
```

Scraping

BeautifulSoup

- html.read() → retrieve HTML content
- BeautifulSoup(html.read()) → convert HTML into BeautifulSoup object
  - html → head → body → h1 → div
  - soup.html.body.h1 = soup.body.h1 = soup.html.h1

Scraping

BeautifulSoup

- Exception handling
  - 404 Page Not Found
  - 500 Internal Server Error
- urlopen throws HTTPError in all cases
- Use try/except structure

Scraping

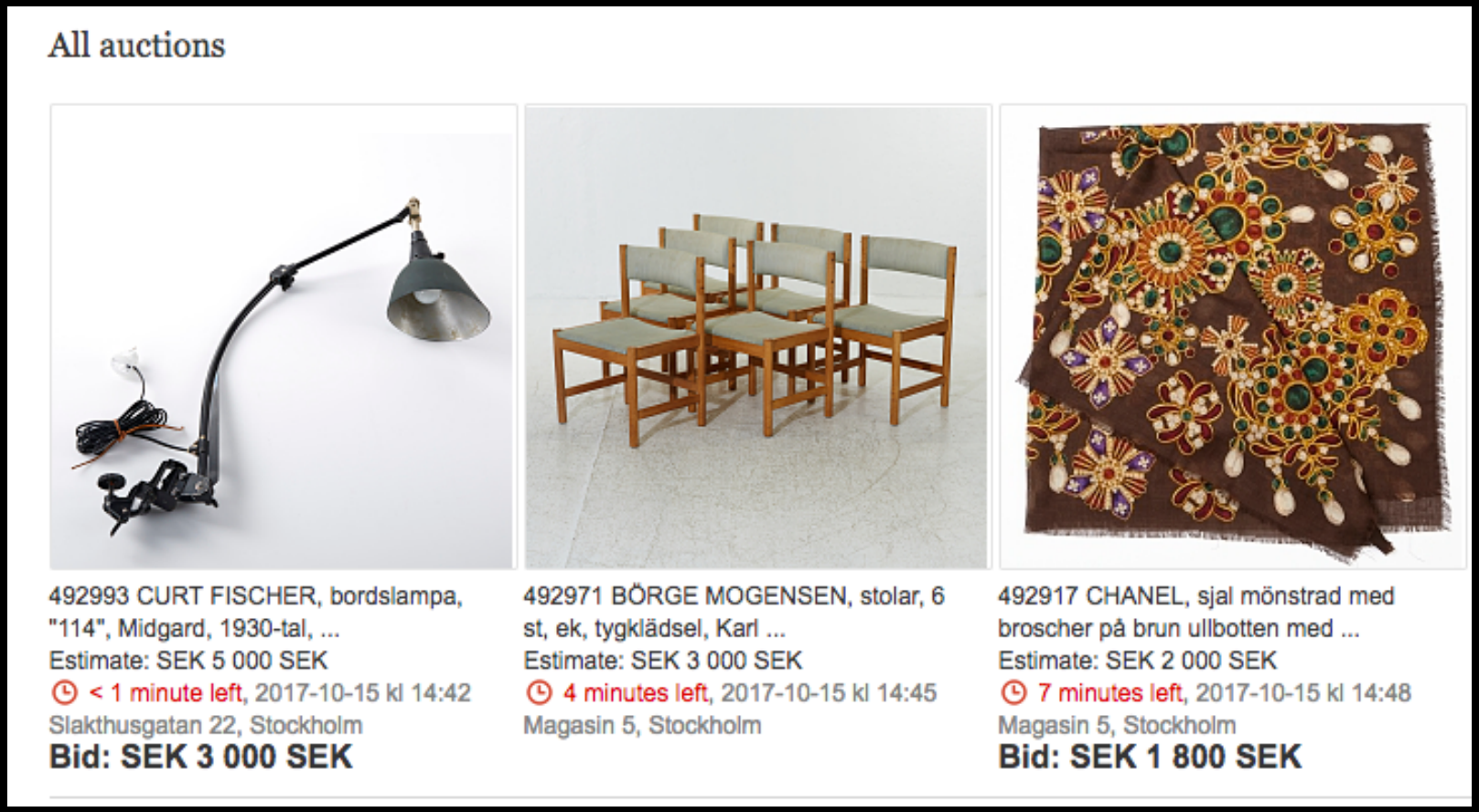
BeautifulSoup

```
#lecture1_example4.py

$user python
>>> from bs4 import BeautifulSoup
>>> from urllib2 import urlopen
>>> from urllib2 import HTTPError
>>> import time
>>> url = "http://google.com/404"
>>> try:
        html = urlopen(url)
        soup = BeautifulSoup(html.read())
>>> except HTTPError as e:
        if str(e).find(`404')!=-1:
            time.sleep(60)
            ...
```

Scraping

BeautifulSoup



https://online.auktionsverket.se

Scraping

BeautifulSoup

```
#lecture1_example5.py

$user python
>>> from urllib2 import urlopen
>>> from bs4 import BeautifulSoup
>>> url = "https://online.auktionsverket.com/"
>>> html = urlopen(url)
>>> soup = BeautifulSoup(html.read())
```

BeautifulSoup

```
#lecture1_example5.py (continued)

>>> soup.title
<title>Stockholms Auktionsverk Online</title>
>>> soup.title.name
'title'
>>> soup.title.string
u'Stockholms Auktionsverk Online'
>>> soup.title.parent.name
'head'
>>> soup.p
<p>Invitation to consign</p>
```

BeautifulSoup

```
#lecture1_example5.py (continued)

>>> soup.a
<a href="/"><div style="padding-left:0.7em;
padding-right:0.4em; float:left;">Home</div></a>
>>> soup.find_all('a')
[<a href="/"><div style="padding-left:0.7em;
padding-right:0.4em; float:left;">Home</div></a>, <a
href="http://auktionsverket.com/news/"><div
style="padding-left:0.25em; padding-right:0.4em;
float:left; margin-left:0.4em;">Right now</div></a>,
...
```

BeautifulSoup

```
#lecture1_example5.py (continued)

>>> links = soup.find_all('a')
>>> for link in links[0:5]:
        print link
<a href="/"><div style="padding-left:0.7em; padding-right: ...
<a href="http://auktionsverket.com/news/"> ...
<a href="http://auktionsverket.com/buy/kop-online...
<a href="http://auktionsverket.com/salja/">...
<a href="http://auktionsverket.com/sell/valuations/">...
```

Scraping

BeautifulSoup

- Documentation

  https://www.crummy.com/software/BeautifulSoup/bs4/doc/

Scraping

Lxml

- Built on XML parsing library in C
- Faster than BeautifulSoup
- More difficult to install on Windows

Scraping

Lxml

A

Joseph Aldy
Associate Professor of Public Policy
79 John F. Kennedy St. Taubman-Ofer Bldg 382
| 617-496-7213
Email | Mailing Address

Graham Allison
Douglas Dillon Professor of Government
79 John F. Kennedy St. Littauer Bldg 346
| 617-496-6099
Email | Mailing Address

Scraping

Lxml

```
#lecture1_example6.py

$user pip install lxml
$user python
>>> from lxml import html
>>> from urllib2 import urlopen
>>> import cssselect
>>> url = "https://www.hks.harvard.edu/
faculty-directory"
>>> page = urlopen(url).read()
>>> tree = html.fromstring(page)
>>> h2 = tree.cssselect('h2')
>>> print(h2[5].text_content().strip())
Joseph Aldy
```

Lxml

```
#lecture1_example6.py (continued)
>>> for name in h2[5:]:
        print(name.text_content().strip())
Joseph Aldy
Graham Allison
Alan Altshuler
Matthew Andrews
Arthur Applbaum
Cecile Aptel
Christopher Avery
...
```

Scraping

Lxml

- Documentation

  http://lxml.de/

Lambda expressions

- One-line functions
- May be passed to functions
- BeautifulSoup accepts as arguments
- Can be combined with find_all()

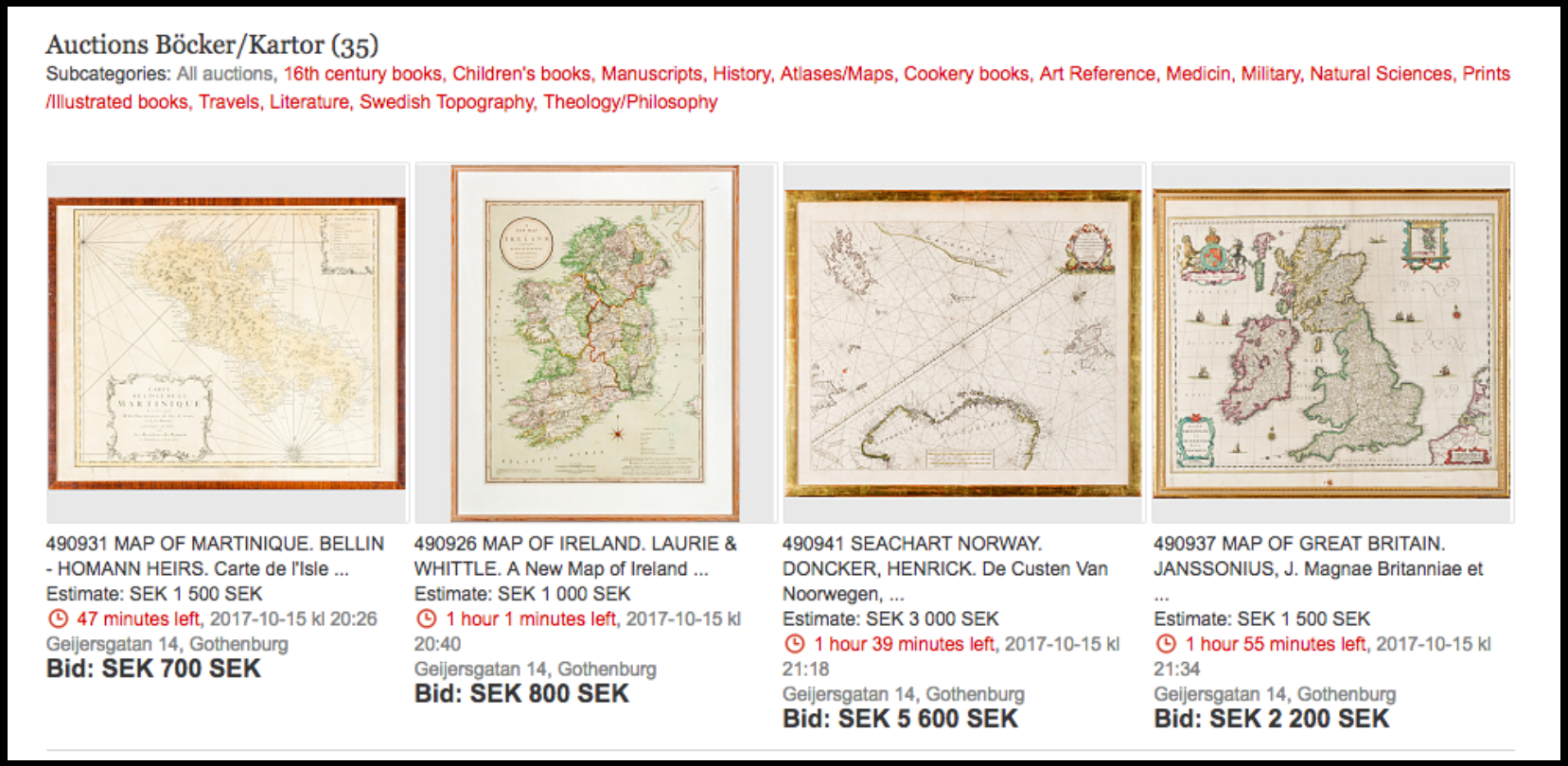
Lambda expressions

```
#lecture1_example7.py

$user python
>>> from urllib2 import urlopen
>>> from bs4 import BeautifulSoup
>>> import re
>>> url = "https://online.auktionsverket.com/
auktion/Bocker/'
>>> html = urlopen(url)
>>> soup = BeautifulSoup(html.read())
```

Scraping

Lambda expressions



Lambda expressions

```
#lecture1_example7.py (continued)

>>> maps = soup.findAll(lambda tag:
tag.text.find('IRELAND')>-1)
>>> ireland_map = maps[1].text
>>> print(ireland_map)
490926 MAP OF IRELAND. LAURIE  WHITTLE. A New Map of
Ireland ...Estimate:  SEK 1 000 SEK
1 hour 1 minutes left, 2017-10-15 kl
20:40Geijersgatan 14, Gothenburg
Bid:  SEK 800 SEK
```

Scraping

Regular expressions

- Rules for string matching
- String satisfies conditions → return it
- Examples:
  - aa* → the letter a, followed by any number of a's.
  - bbb → three consecutive b's.
  - (cb)* → any multiple of the pair cb
  - (d|) → d or no d

Scraping

Regular expressions

- Examples:
  - $[A-Za-z]+$ → contains at least one uppercase letter or one lowercase letter.
  - $[A-Za-z0-9\_.+]+$ → contains at least one uppercase letter, one lowercase letter, one number 0-9, a period, a plus sign, or an underscore.
  - * → matches preceding character(s) 0 or more times
  - + → matches preceding character(s) 1 or more times
  - [] → matches any character within brackets

Regular expressions: examples

```
test_string = """
At 7:00 on 10/10/2015, the central bank announced a
$40,000,000,000 bond purchase.  It also lowered its
target rate to 0.25%.
"""
```

Regular expressions: examples

1. Extract time string.
2. Find the dollar amount of bonds.
3. Extract the date string.
4. Extract the interest rate.
5. Remove $ and % symbols.

Regular expressions: examples

```
# Extract the time string

$user python
>>> import re
>>> test_string = """
At 7:00 on 10/10/2015, the central bank announced a
$40,000,000,000 bond purchase.  It also lowered its
target rate to 0.25%.
"""
```

Regular expressions: examples

```
# Extract the time string
>>> pattern = re.compile('\d:\d\d')
>>> re.search(pattern, test_string).group()
7:00
```

Regular expressions: examples

```
# Extract the time string

>>> pattern = re.compile('\d{1,2}:\d{2}')
>>> re.search(pattern, test_string).group()
7:00
```

Regular expressions: examples

```
# Extract the time string

>>> pattern = re.compile('[0-9]{1,2}:[0-9]{2}')
>>> re.search(pattern, test_string).group()
7:00
```

Regular expressions: examples

```
# Find the dollar amount of bonds

>>> pattern = re.compile('\$\d+')
>>> re.search(pattern, test_string).group()
$40
```

Regular expressions: examples

```
# Find the dollar amount of bonds

>>> pattern = re.compile('\$(\d|,)+')
>>> re.search(pattern, test_string).group()
$40,000,000,000
```

Regular expressions: examples

```
# Extract the date string

>>> pattern = re.compile(`\d{1,2}/\d{1,2}/\d{4}')
>>> re.search(pattern, test_string).group()
'10/10/2015'
```

Regular expressions: examples

```
# Extract the interest rate
>>> pattern = re.compile(`\d+\.\d+%')
>>> re.search(pattern, test_string).group()
0.25%
```

Regular expressions: examples

```
# Remove all % and $ symbols
>>> pattern = re.compile(`(\%|\$)')
>>> no_symbols = re.sub(pattern, ``,
test_string).group()
>>> print no_symbols
```

Regular expressions: examples

```
At 7:00 on 10/10/2015, the central bank announced a
40,000,000,000 bond purchase.  It also lowered its
target rate to 0.25.
```

Scraping

Regular expressions

- Documentation
  - https://docs.python.org/2/library/re.html
- Regex Tester
  - https://pythex.org/

Scraping

Regular expressions

```
#lecture1_example7.py (continued)

>>> map_ascii = re.sub(r`[^\x00-\x7F]+',` ', map)
>>> re.findall("[0-9]+ hour [0-9]+ minutes",
map_ascii)
[u'1 hour 1 minutes']
>>> re.findall("SEK [0-9]+",map_ascii)[1]
u`SEK 800'
```

XPath selectors

- Parse trees often fail to properly clean up code
- Difficult to reliably extract same element
- Alternative to CSS selector
- Based on XML document hierarchy

XPath selectors

- Examples:
  - All link → `//a'
  - All divs with class "green" → `//div[@class="green"]'
  - Select ul with id "country" → `//ul[@id="country"]'
  - Select text from all paragraphs → `//p/text()'

Scraping

CSS selectors

- Examples:
  - All link → `a′
  - All divs with class "green" → `div.green′
  - Select ul with id "country" → `ul#country′
  - Select text from all paragraphs → `p′*

Crawling

Overview

- Scrapers target a specific site or sites to collect detailed information
- Crawlers collect more generic information from many sites
  - Entire Internet
  - Targeted top-level domain

Single-Domain Crawling

```
#lecture1_example8.py

$user python
>>> from urllib2 import urlopen
>>> from bs4 import BeautifulSoup
>>> import re
>>> url = “https://en.wikipedia.org/wiki/Commodity”
>>> html = urlopen(url)
>>> soup = BeautifulSoup(html.read())
>>> for link in soup.findAll("a"):
        if “href” in link.attrs:
            print(link.attrs[“href”])
```

Crawling

Single-Domain Crawling

#mw-head
#p-search
...
/wiki/Legal_personality
/wiki/Cooperative
/wiki/Corporation
...
/wiki/Economic_development
/wiki/Economic_statistics
/wiki/File:Coffee_Beans_Photographed_in_Macro.jpg
/wiki/File:Loose_leaf_darjeeling_tea_twinings.jpg
/wiki/Yerba_mate
/wiki/Coffee_bean

Crawling

Single-Domain Crawling

```
#lecture1_example8.py (continued)

>>> for link in soup.find("div",
{"id":"bodyContent"}).findAll("a",
href=re.compile("^(/wiki/)((?!:).)*$")):
            if "href" in link.attrs:
                print(link.attrs["href"])
```

Crawling

Single-Domain Crawling

/wiki/Commodity_(album)
/wiki/Business_administration
/wiki/Management
/wiki/Business
/wiki/Accounting
/wiki/Management_accounting
/wiki/Financial_accounting
/wiki/Financial_audit
/wiki/Legal_personality
/wiki/Cooperative
/wiki/Corporation
/wiki/Limited_liability_company

Crawling

A Random Crawl

```
#lecture1_example9.py

$user python
>>> from urllib2 import urlopen
>>> from bs4 import BeautifulSoup
>>> import datetime
>>> import random
>>> import time
>>> import re
>>> html = urlopen("https://en.wikipedia.org")
>>> soup = BeautifulSoup(html.read())
>>> links = soup.find("div",
{"id":"bodyContent"}).findAll("a",
href=re.compile("^(/wiki/)((?!:).)*$"))
```

A Random Crawl

```
#lecture1_example9.py (continued)

>>> while len(links) > 0:
            link = links[random.randint(0,
            len(links)-1)].attrs["href"]
            print(link)
            html = urlopen("https://en.wikipedia.org/"
           +link)
            soup = BeautifulSoup(html.read())
            links = soup.find("div",
            {"id":"bodyContent"}).findAll("a", href =
            re.compile("^(/wiki/)((?!:).)*$"))
            time.sleep(5)
```

Crawling

A Random Crawl

```
/wiki/Tropical_Storm_Arthur_(2008)
/wiki/Grangemoor_Park
/wiki/List_of_Pok%C3%A9mon
/wiki/President_of_the_United_States
/wiki/Sea_surface_temperature
```

Crawling

Additional Tools

- Scrapy → web crawling
  - https://docs.scrapy.org/en/latest/
- Portia → visual scraping
  - https://github.com/scrapinghub/portia
- Scrapely → automated scraping
  - https://pypi.python.org/pypi/scrapely

Dynamic Content

JavaScript

- JavaScript most common form of dynamic content
  - jQuery
  - Google Analytics
  - Google Maps
- Runs in browser, rather than on web server
- Browser reads and executes script
- Does not require user to reload page
- Enclosed in <script> ... </script> tags

Dynamic Content

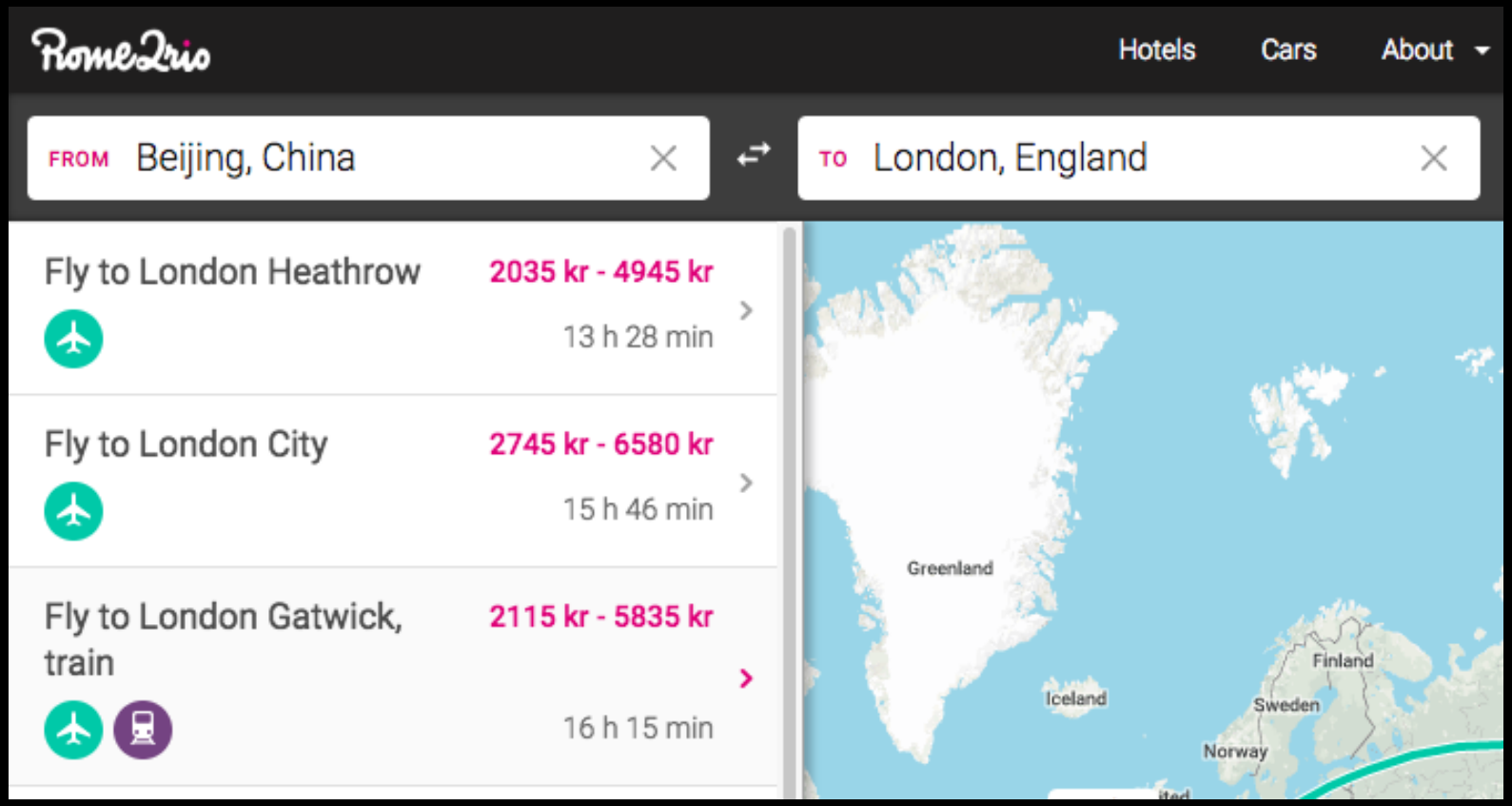
JavaScript

- JavaScript console in Chrome
  - Windows/Linux: Ctrl + Shift + J
  - Mac: Cmd + Opt + J
- Example

```
> function square(x){
      var y = x**2;
      return y
  }
<· undefined
> y = square(10)
<· 100
```

Dynamic Content

JavaScript



https://www.rome2rio.com/s/Beijing/London

Dynamic Content

JavaScript

```
>>> wad -u https://www.rome2rio.com/s/Beijing/London
{
...
        {
                "type":  "javascript-frameworks",
                "app":  "jQuery",
                "ver":  "1.9.1"
        },
...
}
```

Dynamic Content

JavaScript

- jQuery → dynamic HTML generation
  - Not executed → missing HTML
- More dynamic content
  - Ajax → asynchronous javascript and XML
  - DHTML → dynamic HTML

Dynamic Content

Selenium

- Originally developed for website testing
- Used for browser automation
- Can execute dynamic elements in browser
- May be run in headless mode
  - PhantomJS
  - Firefox
  - Chrome

Dynamic Content

Selenium

```
#lecture1_example10.py

$user python
>>> from selenium import webdriver
>>> from selenium.webdriver.common.keys import Keys
>>> driver = webdriver.PhantomJS()
>>> driver.set_window_size(1200, 600)
>>> driver.get("https://www.google.com/")
>>> driver.find_element_by_id("a").
send_keys("python")
```

Dynamic Content

Selenium

```
#lecture1_example10.py (continued)
>>> driver.find_element_by_id("a").
send_keys(Keys.RETURN)
>>> print driver.current_url
https://www.google.com/?q=python
>>> driver.quit()
```

Dynamic Content

Selenium selectors

Single elements:

- `find_element_by_id`
- `find_element_by_name`
- `find_element_by_xpath`
- `find_element_by_link_text`

Dynamic Content

Selenium selectors

Single elements:

- `find_element_by_partial_link_text`
- `find_element_by_tag_name`
- `find_element_by_class_name`
- `find_element_by_css_selector`

Dynamic Content

Selenium selectors

Multiple elements:

- `find_elements_by_name`
- `find_elements_by_xpath`
- `find_elements_by_link_text`

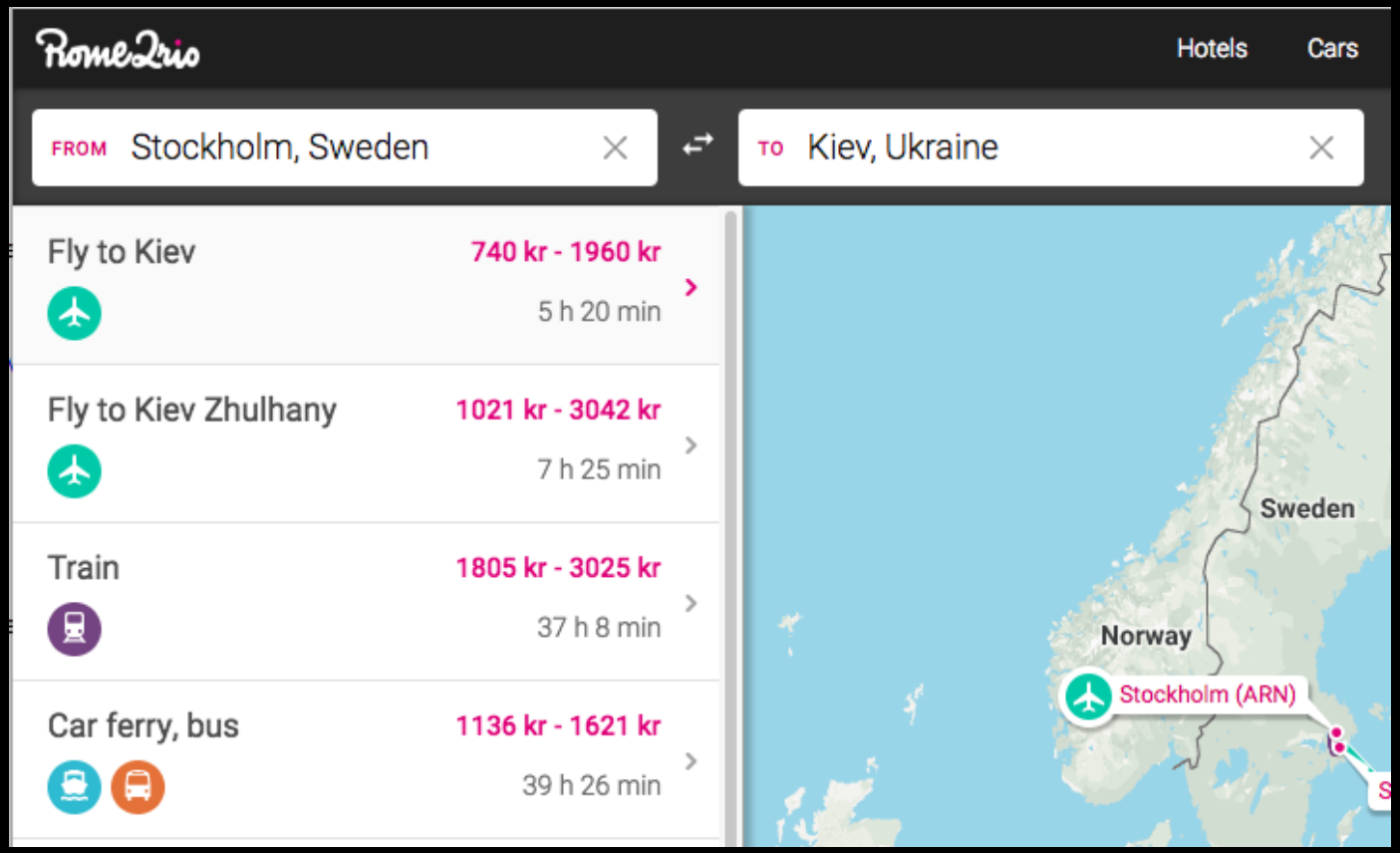
Dynamic Content

Selenium selectors

Multiple elements:

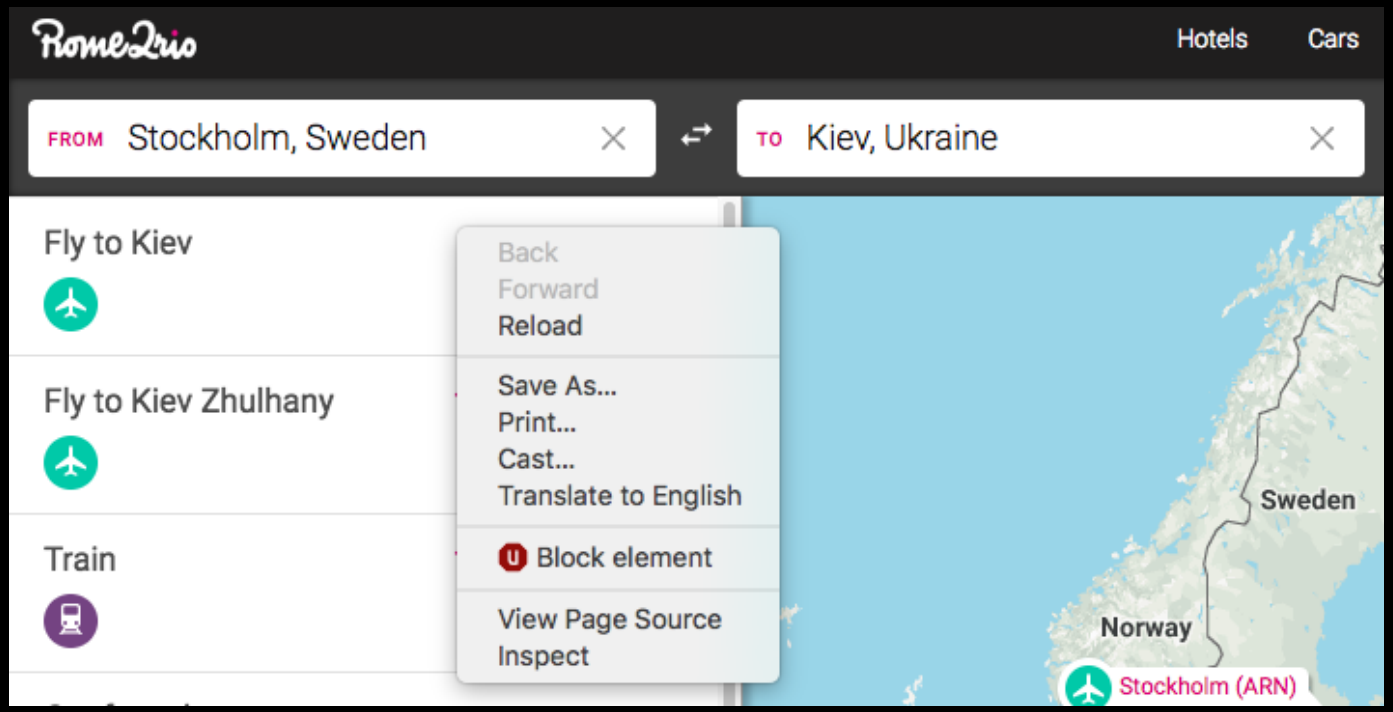
- `find_elements_by_partial_link_text`
- `find_elements_by_tag_name`
- `find_elements_by_class_name`
- `find_elements_by_css_selector`

Finding selectors in Chrome



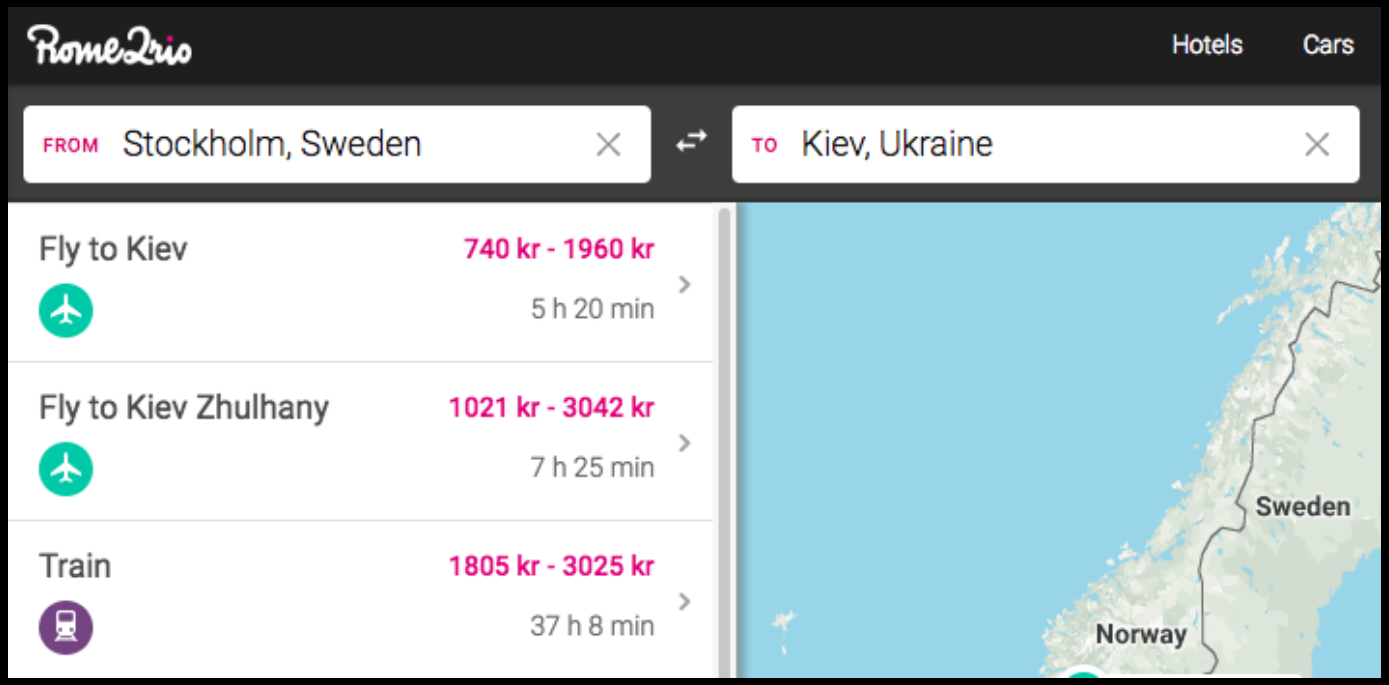
https://www.rome2rio.com/s/Stockholm/Kiev

Finding selectors in Chrome



https://www.rome2rio.com/s/Stockholm/Kiev

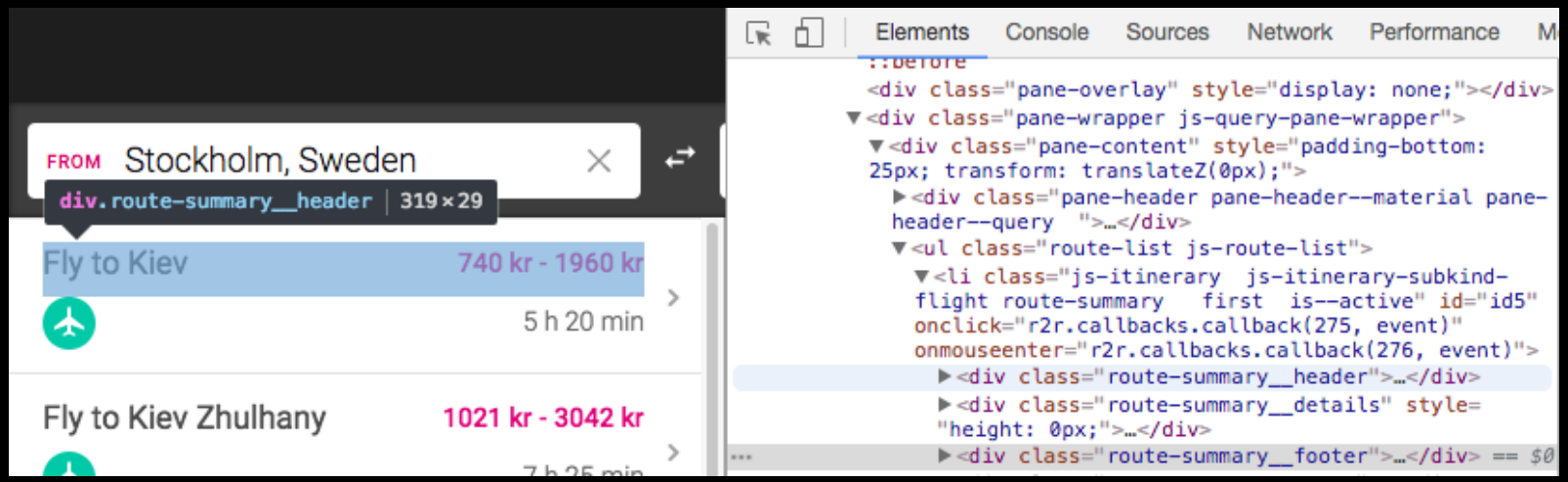
Finding selectors in Chrome



https://www.rome2rio.com/s/Stockholm/Kiev

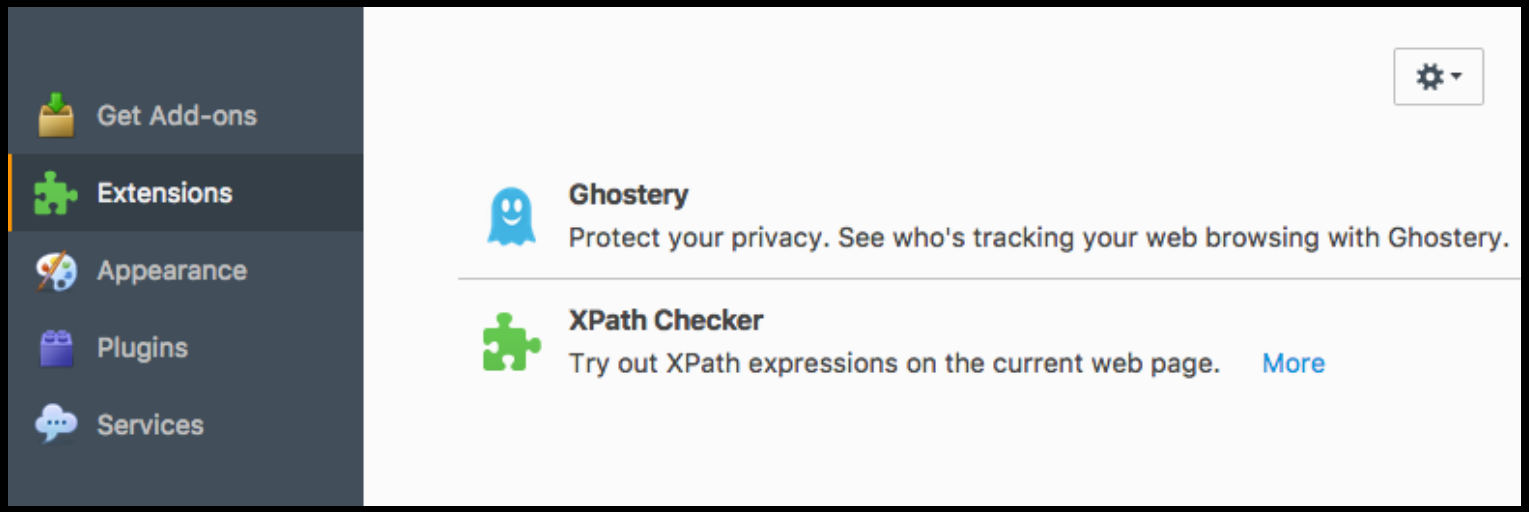
Scraping

Finding selectors in Chrome



https://www.rome2rio.com/s/Stockholm/Kiev

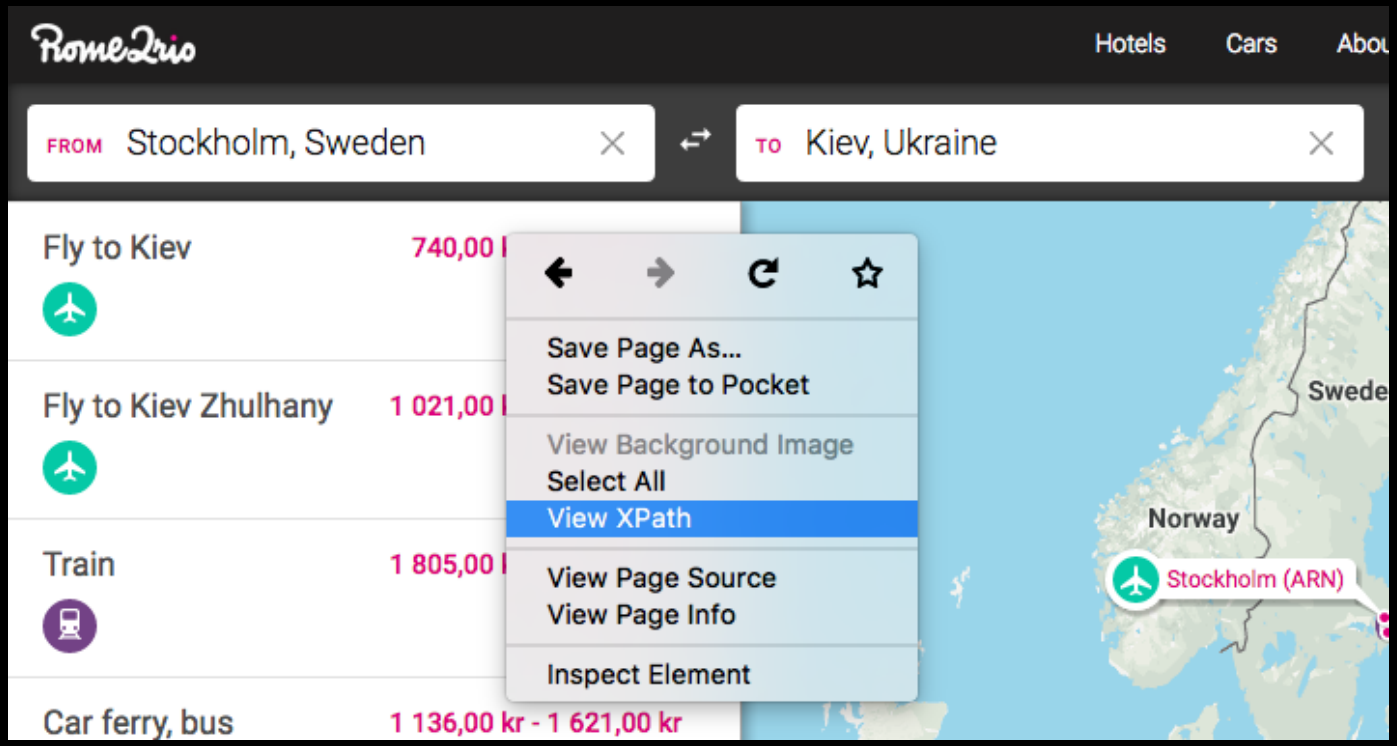
Finding selectors in Firefox



https://www.rome2rio.com/s/Stockholm/Kiev

Scraping

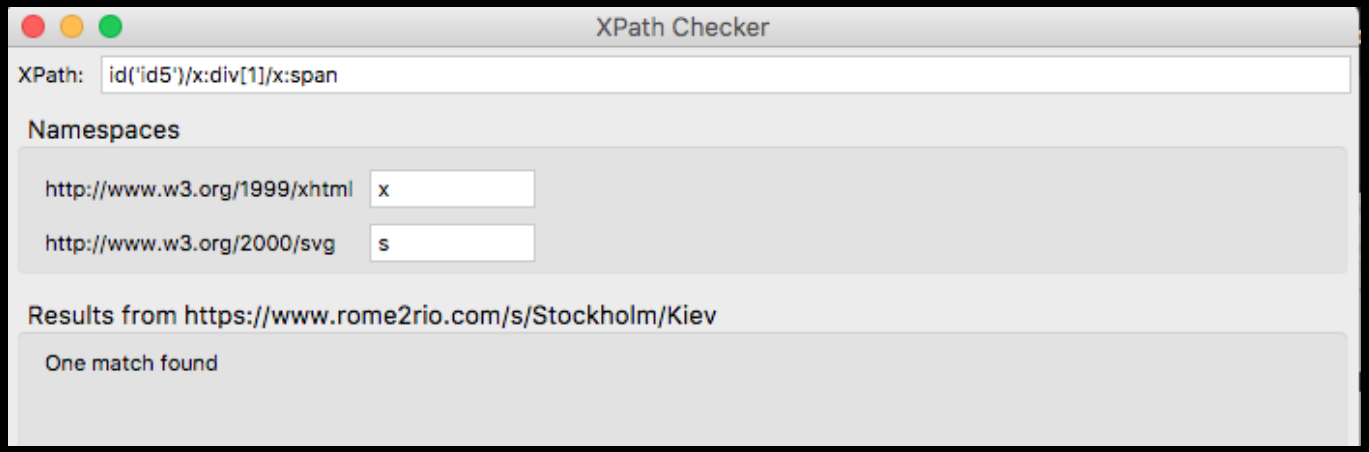
Finding selectors in Firefox



https://www.rome2rio.com/s/Stockholm/Kiev

Scraping

Finding selectors in Firefox



https://www.rome2rio.com/s/Stockholm/Kiev

Dynamic Content

Xpath selectors

```
#lecture1_example11.py

$user python
>>> from selenium import webdriver
>>> driver = webdriver.PhantomJS()
>>> driver.set_window_size(1200, 600)
>>> driver.get("https://www.rome2rio.com/
s/Stockholm/Kiev")
>>> xpath_element =
driver.find_element_by_xpath("//*[@id='id5']/div[1]")
>>> print xpath_element.text
Fly to Kiev 740 kr - 1960 kr
```

CSS Selectors

```
#lecture1_example11.py (continued)
>>> css_element = driver.\
find_element_by_css_selector("div.route-
summary__header")
>>> print css_element.text
Fly to Kiev 740 kr - 1960 kr
>>> css_element = driver.\
find_elements_by_css_selector("div.route-
summary__header")
>>> for element in css_elements:
        print element.text
```

Dynamic Content

Selenium selectors

Fly to Kiev 740 kr - 1960 kr
Fly to Kiev Zhulhany 1021 kr - 3042 kr
Train 1805 kr - 3025 kr
Car ferry, bus 1136 kr - 1621 kr
Bus 900 kr - 1350 kr
Car ferry, night train 1400 kr - 2430 kr

Dynamic Content

Selenium

- Documentation
  - https://selenium-python.readthedocs.io/

Logins

Overview

- HTTP POST requests
- Check robots.txt
- Content is often gated behind logins
  - Forums
  - Social media
  - User-generated content

Logins

POST request

vBulletin Message

Register at Small Business Forums

You have entered an invalid username or password. Please enter the correct details and try again. Don't forget that the password is case sensitive. Forgotten your password? Click here!

You have used 1 out of 5 login attempts. After all 5 have been used, you will be unable to login for 15 minutes.

The administrator may have required you to register before you can view this page.

Log in

User Name:

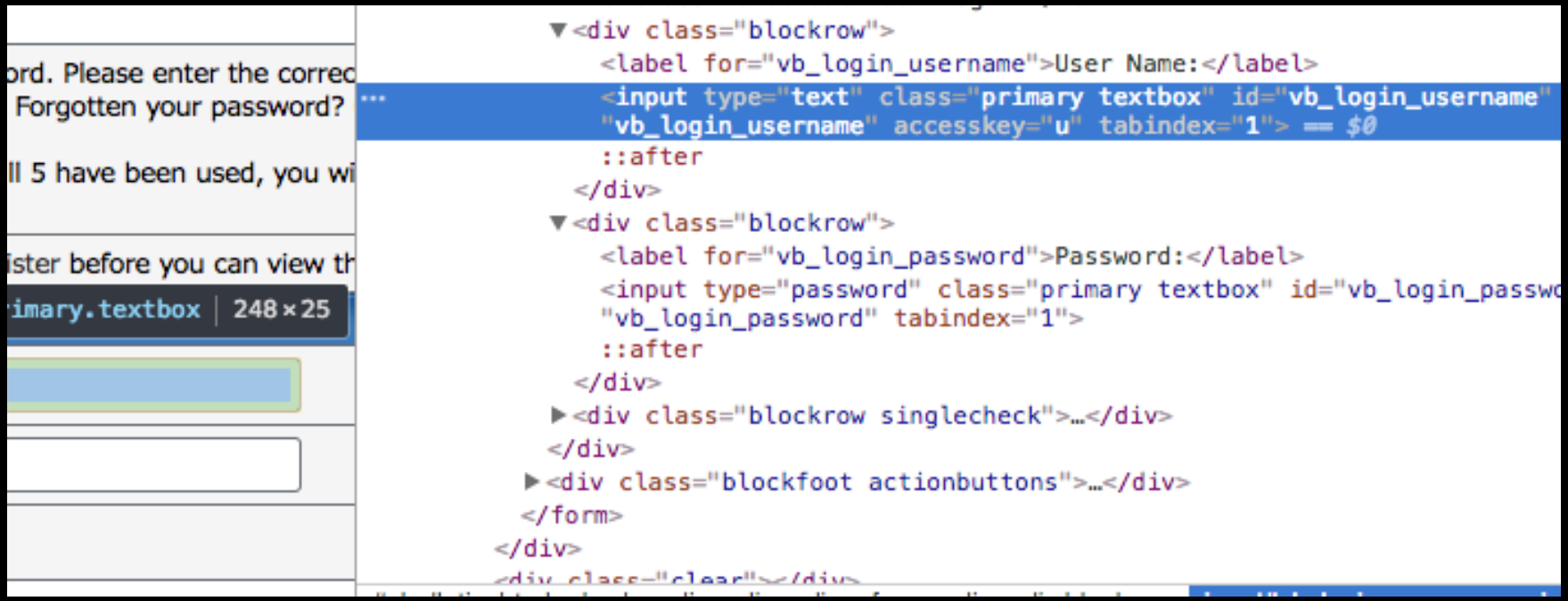
Password:

Remember Me?

Log in | Reset Fields

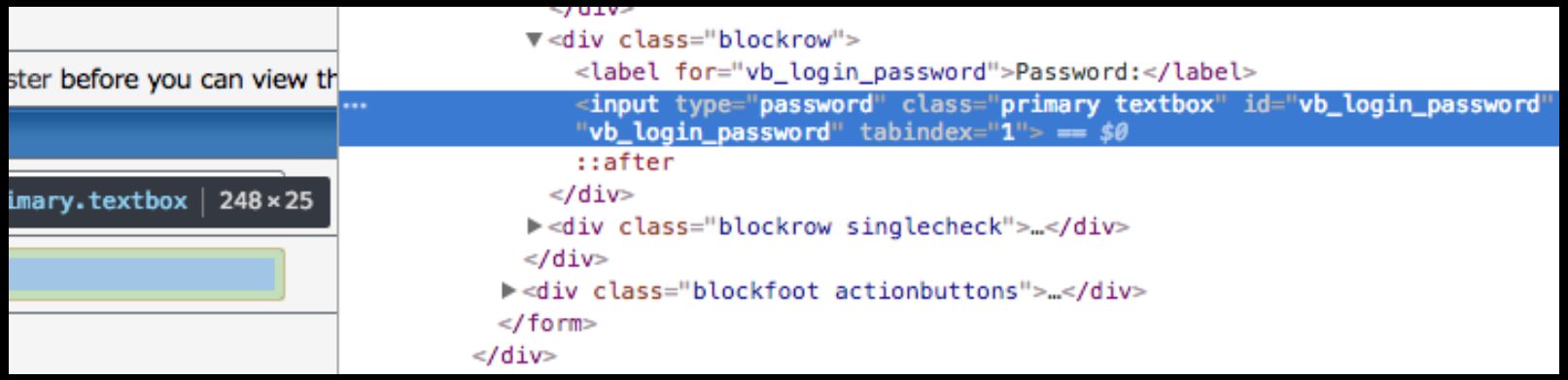
Logins

POST request



Logins

POST request



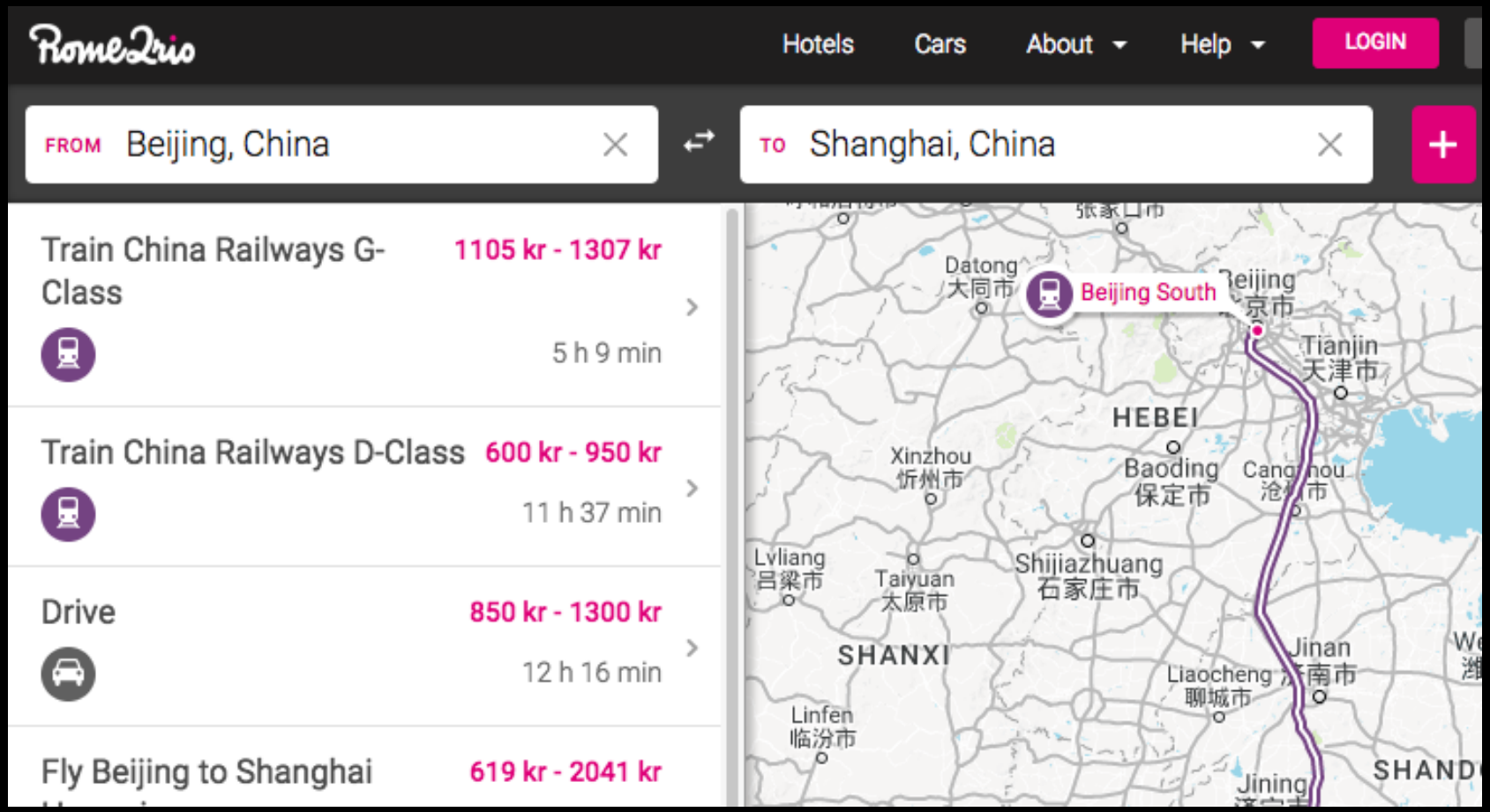
Logins

POST request

```
#lecture1_example12.py
$user python
>>> import requests
>>> params = {'vb_login_username':
'user@gmail.com', 'vb_login_password':  'mypassword'}
>>> r =
requests.post("https://www.example.com/...",
data=params)
```

Storing Data

CSV Files



Storing Data

CSV files

```
#lecture1_example13.py
$user pip install numpy
$user pip install pandas
$user python
>>> from selenium import webdriver
>>> import numpy as np
>>> import pandas as pd
>>> driver = webdriver.PhantomJS()
>>> driver.set_window_size(1200, 600)
>>> driver.get("https://www.rome2rio.com/s/
Beijing/Shanghai")
```

Storing Data

CSV files

```
#lecture1_example13.py (continued)
>>> prices = driver.find_elements_by_
css_selector(`span.routesummary__price.js-itinerary-
price.tip-west')
>>> modes = driver.find_elements_by_
css_selector(`h2.routesummary__title')
>>> durations = driver.find_elements_by_
css_selector(`span.routesummary__duration.tip-west')
```

Storing Data

CSV files

```
#lecture1_example13.py (continued)
>>> prices = [price.text for price in prices]
>>> modes = [mode.text for mode in modes]
>>> durations = [duration.text for duration in
durations]
>>> data = pd.DataFrame(np.vstack([modes,
prices,durations]).T, columns=[`mode',
`price',`duration'])
>>> data.to_csv(`../Beijing-Shanghai.csv',
index=None)
>>> print data
```

Storing Data

CSV files

	Mode	Price	Duration
0	Train China Railways G-Class	1105 kr - 1307 kr	5 h 9 min
1	Train China Railways D-Class	600 kr - 950 kr	11 h 37 min
2	Drive	850 kr - 1300 kr	12 h 16 min
3	Fly Beijing to Shanghai Hongqiao	619 kr - 2041 kr	4 h 1 min
4	Fly Beijing Nanyuan Apt to Shanghai Hongqiao	840 kr - 2560 kr	3 h 46 min
5	Fly Beijing Nanyuan Apt to Shanghai Pudong	940 kr - 2490 kr	3 h 50 min
6	Fly Beijing to Shanghai Pudong	819 kr - 3171 kr	4 h 14 min
7	Train to Tianjin, fly to Shanghai Hongqiao	827 kr - 2531 kr	5 h 4 min

Storing Data

Additional Storage Methods

- JSON
  - https://docs.python.org/2/library/json.html
- Pandas
  - http://pandas.pydata.org/pandas-docs/version/0.18.0/
- MySQL
  - https://pymysql.readthedocs.io/en/latest/

Concurrent Downloading

Multithreading and Multiprocessing

- Scraping and crawling tasks may require data collection from thousands of URLs
- Concurrent downloading can substantially reduce the time to complete tasks
- Python has several options
  - `from multiprocessing import Pool` → multiprocessing
  - `import multiprocessing.dummy`
- No need for delays if URLs are distributed across multiple sites

Concurrent Downloading

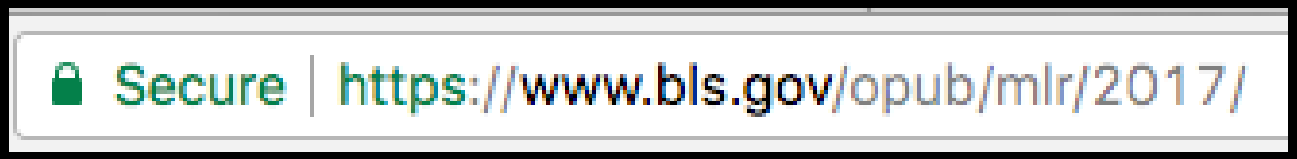
Multithreading and Multiprocessing

Concurrent Downloading

Multithreading and Multiprocessing

Concurrent Downloading

Multithreading and Multiprocessing



Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py

$user python
>>> from urllib2 import urlopen
>>> from bs4 import BeautifulSoup
>>> from multiprocessing import Pool
>>> import multiprocessing.dummy
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)
>>> threads = 5
>>> processes = 5
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)

>>> date_range = range(1980, 1985)
>>> thread_pl = multiprocessing.dummy.Pool(thread)
>>> process_pl = multiprocessing.Pool(process)
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)

>>> def url_opener(year):
        html = urlopen("https://www.bls.gov
        /opub/mlr/"+str(year)).read()
        soup = BeautifulSoup(html)
        links = soup.findAll("a")
        links = [link for link in links if
        link[`href'].find(`bls.gov/opub/mlr')>-1]
        return links
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)
>>> thread_links = thread_pl.map(url_opener,
date_range)
>>> process_links = process_pl.map(url_opener,
date_range)
>>> thread_links = sum(thread_links, [])
>>> process_links = sum(process_links, [])
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)
>>> print len(thread_links)
360
>>> print len(process_links)
360
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)
>>> thread_links[:5]
```

Concurrent Downloading

Multithreading and Multiprocessing

```
[<a href="https://www.bls.gov/opub/mlr/1981/12/art4full.pdf">The
unemployment insurance system:  its financial structure</a>,
<a
href="https://www.bls.gov/opub/mlr/1981/12/art1full.pdf">Unemployment,
labor force trends, and layoff practices in 10 countries</a>,
<a href="https://www.bls.gov/opub/mlr/1981/12/art3full.pdf">Bargaining
calendar will be heavy in 1982</a>,
<a
href="https://www.bls.gov/opub/mlr/1981/12/art2full.pdf">International
comparisons of trends in productivity and labor costs</a>,
<a href="https://www.bls.gov/opub/mlr/1981/12/art5full.pdf">Employment
created by construction expenditures</a>]
```

Concurrent Downloading

Multithreading and Multiprocessing

```
#lecture1_example14.py (continued)
>>> process_links[:5]
```

Concurrent Downloading

Multithreading and Multiprocessing

```
[<a href="https://www.bls.gov/opub/mlr/1981/12/art4full.pdf">The
unemployment insurance system:  its financial structure</a>,
<a
href="https://www.bls.gov/opub/mlr/1981/12/art1full.pdf">Unemployment,
labor force trends, and layoff practices in 10 countries</a>,
<a href="https://www.bls.gov/opub/mlr/1981/12/art3full.pdf">Bargaining
calendar will be heavy in 1982</a>,
<a
href="https://www.bls.gov/opub/mlr/1981/12/art2full.pdf">International
comparisons of trends in productivity and labor costs</a>,
<a href="https://www.bls.gov/opub/mlr/1981/12/art5full.pdf">Employment
created by construction expenditures</a>]
```

Summary

- Introduction
  - How a browser works
  - Scraping ethics
  - Estimating a website's size
  - Identifying technologies used

Summary

- Scraping
  - BeautifulSoup
  - Lxml
  - Lambda expressions
  - Regular expressions
  - XPath and CSS selectors

Summary

- Crawling
  - Single-Domain Crawling
  - Random Crawling
  - Scrapy
  - Portia
  - Scrapely

Summary

- Dynamic Content
  - JavaScript
  - Ajax
  - Selenium
  - Selectors

Summary

- Logins
  - Sending POST requests

Summary

- Storing Data
  - CSV
  - JSON
  - Pandas
  - MySQL

Summary

- Concurrent Downloading
  - Multithreading
  - Multiprocessing