

Automated Web Scraping with R

Resul Umit

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[I can teach this workshop at your institution — Email me.](#)

Who am I?

Resul Umit

- post-doctoral researcher in political science at the University of Oslo
- teaching and studying representation, elections, and parliaments
 - a recent publication: the effects of casualties in terror attacks on elections
- teaching workshops, also on
 - writing reproducible research papers
 - version control and collaboration
 - working with Twitter data
 - creating academic websites
- more information available at resulmit.com

The Workshop — Overview

- One and a half day, on how to automate the process of extracting data from websites
 - 180+ slides, 30+ exercises
 - a **demonstration website** for practice
- Designed for researchers with basic knowledge of R programming language
 - does not cover programming with R
 - e.g., we will use existing functions and packages
 - ability to work with R will be very helpful
 - but not absolutely necessary — this ability can be developed during and after the workshop as well

The Workshop — Motivation

- Data available on websites provide attractive opportunities for academic research
 - e.g., parliamentary websites were the main source of data for my PhD
- Acquiring such data requires
 - either a lot of resources, such as time
 - or a set of skills, such as automated web scraping
- Typically, such skills are not part of academic training
 - for my PhD, I visited close to 3000 webpages to collect data manually
 - on members of ten parliaments
 - multiple times, to update the dataset as needed

The Workshop — Motivation — Aims

- To provide you with an understanding of what is **ethically** possible
 - we will cover a large breath of issues, not all of it is for long-term memory
 - hence the slides are designed for self study as well
 - awareness of what is ethical and possible, Google, and perseverance are all you need
- To start you with acquiring and practicing the skills needed
 - practice with the demonstration website
 - plenty of data, stable structure, and an ethical playground
 - start working on a real project

The Workshop — Contents

Part 1. Getting the Tools Ready

- e.g., installing software

Part 2. Preliminary Considerations

- e.g., ethics of web scraping

Part 3. HTML Basics

- e.g., elements and attributes

Part 4. CSS Selectors

- e.g., selecting an element

Part 5. Scraping Static Pages

- e.g., getting text from an element

Part 6. Scraping Dynamic Pages

- e.g., clicking to create an element

[To the list of references.](#)

The Workshop — Organisation

- I will go through a number of slides...
 - introducing things
 - demonstrating how-to do things
- ... and then pause, for you to use/do those things
 - e.g., prepare your computer for the workshop, and/or
 - complete a number of exercises
- We are here to help
 - ask me, other participants
 - consult Google, **slides**, **answer script**
 - type, rather than copy and paste, the code you will find on the slides or the script

The Workshop — Organisation — Slides

03 : 00

Slides with this background colour indicate that your action is required, for

- setting the workshop up
 - e.g., installing R
- completing the exercises
 - e.g., checking website protocols
 - these slides have countdown timers
 - as a guide, not to be followed strictly

The Workshop — Organisation — Slides

- Code and text that go in R console or scripts appear as such – in a different font, on gray background
 - long codes and texts will have their own line(s)

```
bow("https://luzpar.netlify.app/members/") %>%  
  scrape() %>%  
  html_elements(css = "td+ td a") %>%  
  html_attr("href") %>%  
  url_absolute(base = "https://luzpar.netlify.app/")
```

The Workshop — Organisation — Slides

- Code and text that go in R console or scripts appear as such — in a different font, on gray background
 - long codes and texts will have their own line(s)
- Results that come out as output appear as such — in the same font, on green background
 - except for some results, such as a browser popping up
- Specific sections are highlighted yellow as such for emphasis
 - these could be for anything — codes and texts in input, results in output, and/or texts on slides
- The slides are designed for self-study as much as for the workshop
 - *accessible*, in substance and form, to go through on your own

Part 1. Getting the Tools Ready

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Workshop Slides — Access on Your Browser

- Having the workshop slides* on your own machine might be helpful
 - flexibility to go back and forward on your own
 - ability to scroll across long codes on some slides
- Access at https://resulunit.com/teaching/scrp_workshop.html
 - will remain accessible after the workshop
 - might crash for some Safari users
 - if using a different browser application is not an option, view the [PDF version of the slides](#) on GitHub

* These slides are produced in R, with the `xaringan` package ([Xie, 2022](#)).

Demonstration Website — Explore on Your Browser

05 : 00

- There is a demonstration website for this workshop
 - available at <https://luzpar.netlify.app/>
 - includes fabricated data on the imaginary Parliament of Luzland
 - provides us with plenty of data, stable structure, and an ethical playground
- Using this demonstration website for practice is recommended
 - tailored to exercises, no ethical concern
 - but not compulsory — use a different one if you prefer so
- Explore the website now
 - click on the links to see an individual page for
 - states, constituencies, members, and documents
 - notice that the documents section is different than the rest
 - it is a page with dynamic frame

R — Download from the Internet and Install

- Programming language of this workshop
 - created for data analysis, extending for other purposes
 - e.g., accessing websites
 - allows for all three steps in one environment
 - accessing websites, scraping data, and processing data
- Download R from <https://cloud.r-project.org>
 - optional, if you have it already installed — but then consider updating*
 - the `R.version.string` command checks the version of your copy
 - compare with the latest official release at <https://cran.r-project.org/sources.html>

* The same applies to all software that follows — consider updating if you have them already installed. This ensures everyone works with the latest, exactly the same, tools.

RStudio — Download from the Internet and Install

- Optional, but highly recommended
 - facilitates working with R
- A popular integrated development environment (IDE) for R
 - an alternative: **GNU Emacs**
- Download RStudio from <https://rstudio.com/products/rstudio/download>
 - choose the free version
 - to check for any updates, follow from the RStudio menu:

Help -> Check for Updates

RStudio Project — Create from within RStudio

- RStudio allows for dividing your work with R into separate projects
 - each project gets dedicated workspace, history, and source documents
 - [this page](#) has more information on why projects are recommended
- Create a new RStudio project for for this workshop, following from the RStudio menu:

```
File -> New Project -> New Directory -> New Project
```
- Choose a location for the project with Browse . . .
 - avoid choosing a synced location, e.g., Dropbox
 - likely to cause warning and/or error messages
 - if you must, pause syncing, or add an sync exclusion

R Packages — Install from within RStudio*

02:00

Install the packages that we need

```
install.packages(c("rvest", "RSelenium", "robotstxt", "polite", "dplyr"))
```

* You may already have a copy of one or more of these packages. In that case, I recommend updating by re-installing them now.

R Packages — Install from within RStudio

Install the packages that we need

```
install.packages(c("rvest", "RSelenium", "robotstxt", "polite", "dplyr"))
```

We will use

- `rvest` ([Wickham, 2021](#)), for scraping websites
- `RSelenium` ([Harrison, 2020](#)), for browsing the web programmatically
- `robotstxt` ([Meissner and Ren, 2020](#)), for checking permissions to scrape websites
- `polite` ([Perepolkin, 2019](#)), for compliance with permissions to scrape websites
- `dplyr` ([Wickham, François, Henry, and Müller, 2022](#)), for data manipulation

R Script — Start Your Script

- Check that you are in your recently created project
 - indicated at the upper-right corner of RStudio window
- Create a new R Script, following from the RStudio menu
 - File -> New File -> R Script
- Name and save your file
 - e.g., scrape_web.R
- Load rvest and other packages

```
library(rvest)
library(RSelenium)
library(robotstxt)
library(polite)
library(dplyr)
```

Java — Download from the Internet and Install

- A language and software that RSelenium needs
 - for automation scripts
- Download Java from <https://www.java.com/en/download/>
 - requires restarting any browser that you might have open

Chrome — Download from the Internet and Install

- A browser that facilitates web scraping
 - favoured by R Selenium and most programmers
- Download Chrome from <https://www.google.com/chrome/>

SelectorGadget — Add Extension to Browser

- An extension for Chrome
 - facilitates selecting what to scrape from a webpage
 - optional, but highly recommended
 - open source software
- Add the extension to your browser
 - search for it at <https://chrome.google.com/webstore/category/extensions>
 - if you cannot use Chrome, drag and drop this link to your bookmarks bar
- ScrapeMate is an alternative extension
 - for both Chrome and Firefox
 - on Firefox, search at <https://addons.mozilla.org/>

Solutions — Note Where They Are

- Solutions to exercises, or links to them, are available online
 - can be downloaded at <https://luzpar.netlify.app/exercises/solutions.R>
- I recommend the solutions to be consulted as a last resort
 - after a genuine effort to complete the exercises yourself first

Other Resources*

- R Selenium vignettes
 - available at <https://cran.r-project.org/web/packages/R Selenium/vignettes/basics.html>
- R for Data Science (Wickham and Grolemund, 2021)
 - open access at <https://r4ds.had.co.nz>
- Text Mining with R: A Tidy Approach (Silge and Robinson, 2017)
 - open access at tidytextmining.com
 - comes with a [course website](#) where you can practice

* I recommend these to be consulted not during but after the workshop.

Part 2. Preliminary Considerations

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Considerations — the Law

- Web scraping might be illegal
 - depending on who is scraping what, why, how — and under which jurisdiction
 - reflect, and check, before you scrape
- Web scraping might be more likely to be illegal if, for example,
 - it is harmful to the source commercially and/or physically
 - e.g., scraping a commercial website to create a rival website
 - e.g., scraping a website so hard and fast that it collapses
 - it gathers data that is
 - under copyright
 - not meant for the public to see
 - then used for financial gain

Considerations — the Ethics

- Web scraping might be unethical
 - depending on who is scraping what, why, and how
 - reflect before you scrape
- Web scraping might be more likely to be unethical if, for example,
 - it is — edging towards — being illegal
 - it does not respect the restrictions
 - as defined in `robots.txt` files
 - it harvests data
 - that is otherwise available to download, e.g., through APIs
 - without purpose, at dangerous speed, repeatedly

Considerations — the Ethics — robots.txt

- Most websites declare a robots exclusion protocol
 - making their rules known with respect to programmatic access
 - who is (not) allowed to scrape what, and sometimes, at what speed
 - within robots.txt files
 - available at, e.g., www.websiteurl.com/robots.txt
- The rules in robots.txt cannot not enforced upon scrapers
 - but should be respected for ethical reasons
- The language in robots.txt files is specific but intuitive
 - easy to read and understand
 - the robotstxt package makes these even easier

Considerations — the Ethics — robots.txt — Syntax

- It has pre-defined keys, most importantly
 - User-agent indicates who the protocol is for
 - Allow indicates which part(s) of the website can be scraped
 - Disallow indicates which part(s) must not be scraped
 - Crawl-delay indicates how fast the website could be scraped
- Note that
 - the keys start with capital letters
 - they are followed by a colon :

```
User-agent:  
Allow:  
Disallow:  
Crawl-delay:
```

Considerations — the Ethics — robots.txt — Syntax

- Websites define their own values
 - after a colon and a white space
- Note that
 - * indicates the protocol is for everyone
 - / indicates all sections and pages
 - /about/ indicates a specific path
 - values for Crawl-delay are in seconds
 - this website allows anyone to scrape, provided that
 - /about/ is left out, and
 - the website is accessed at 5-seconds intervals

```
User-agent: *  
Allow: /  
Disallow: /about/  
Crawl-delay: 5
```

Considerations — the Ethics — robots.txt — Examples

The protocol of this website only applies to Google

- Google is allowed to scrape everything
- there is no defined rule for anyone else

```
User-agent: googlebot  
Allow: /
```

Considerations — the Ethics — robots.txt — Examples

The protocol of this website only applies to Google

- Google is **disallowed** to scrape **two** specific paths
 - with no limit on speed
- there is no defined rule for anyone else

```
User-agent: googlebot  
Disallow: /about/  
Disallow: /history/
```


Considerations — the Ethics — robots.txt — Examples

This website has different protocols for different agents

- **Google** is allowed to scrape everything, with a 5-second delay
- **Bing** is not allowed to scrape anything
- **everyone else** can scrape the section or page located at `www.websiteurl/about/`

```
User-agent: googlebot
Allow: /
Crawl-delay: 5

User-agent: bing
Disallow: /

User-agent: *
Allow: /about/
```

Considerations — the Ethics — robots.txt — Notes

There are also some other, lesser known, directives

```
User-agent: *  
Allow: /  
Disallow: /about/  
Crawl-delay: 5  
Visit-time: 01:45-08:30
```

Files might include optional comments, written after the number sign #

```
# thank you for respecting our protocol  
  
User-agent: *  
Allow: /  
Disallow: /about/  
Visit-time: 01:45-08:30 # please visit when it is night time in the UK (GMT)  
Crawl-delay: 5 # please delay for five seconds, to ensure our servers are not overloaded
```

Considerations — the Ethics — robots.txt

- The robots.txt package facilitates checking website protocols
 - from within R — no need to visit websites via browser
 - provides functions to check, among others, the rules for specific paths and/or agents
- There are two main functions
 - robots.txt, which gets complete protocols
 - paths_allowed, which checks protocols for one or more specific paths

Considerations — the Ethics — robots.txt

Use the `robots.txt` function to get a protocol

- supply a base URL with the `domain` argument
 - as a string
 - probably the only argument that you will need

```
robots.txt(  
    domain = NULL,  
    ...  
)
```

Considerations — the Ethics — robots.txt

```
robotstxt(domain = "https://luzpar.netlify.app")
```

```
## $domain
## [1] "https://luzpar.netlify.app"
##
## $text
## [robots.txt]
## -----
##
## User-agent: googlebot
## Disallow: /states/
##
## User-agent: *
## Disallow: /exercises/
##
## User-agent: *
## Allow: /
## Crawl-delay: 2
##
##
##
```

Considerations — the Ethics — robots.txt

Check the list of permissions for the most relevant part in the output

```
robotstxt(domain = "https://luzpar.netlify.app")$permissions
```

```
##      field useragent      value
## 1 Disallow googlebot    /states/
## 2 Disallow      *    /exercises/
## 3   Allow      *          /
```

Considerations — the Ethics — robots.txt

Use the `paths_allowed` function to check protocols for one or more specific paths

- supply a base URL with the `domain` argument
- `path` and `bot` are the other important arguments
 - notice the default values
- leads to either `TRUE` (allowed to scrape) or `FALSE` (not allowed)

```
paths_allowed(  
  domain = "auto",  
  paths = "/",  
  bot = "*",  
  ...  
)
```

Considerations — the Ethics — robots.txt

```
paths_allowed(domain = "https://luzpar.netlify.app")
```

```
## [1] TRUE
```

```
paths_allowed(domain = "https://luzpar.netlify.app",  
              paths = c("/states/", "/constituencies/"))
```

```
## [1] TRUE TRUE
```

```
paths_allowed(domain = "https://luzpar.netlify.app",  
              paths = c("/states/", "/constituencies/"), bot = "googlebot")
```

```
## [1] FALSE TRUE
```


Exercises

10:00

1) Check the protocols for <https://www.theguardian.com>

- via (a) your browser and (b) with the `robotstxt` function in R
- compare what you see

2) Check a path with the `paths_allowed` function

- such that it will return `FALSE`
- taking the information from Exercise 1 into account
- hint: try looking at the list of permissions first

3) Check the protocols for any website that you might wish to scrape

- with the `robotstxt` function
- reflect on the ethics of scraping that website

Considerations — the Ethics — Speed

- Websites are designed for visitors with human-speed in mind
 - computer-speed visits can overload servers, depending on bandwidth
 - popular websites might have more bandwidth
 - but, they might attract multiple scrapers at the same time
- Waiting a little between two visits makes scraping more ethical
 - waiting time may or may not be defined in the protocol
 - lookout for, and respect, the `Crawl-delay` key in `robots.txt`
 - [Part 5](#) and [Part 6](#) covers how to wait
- Not waiting enough might lead to a ban
 - by site owners, administrators
 - for IP addresses with undesirably high number of visits in a short period of time

Considerations — the Ethics — Purpose

Ideally, we scrape for a purpose

- e.g., for academics, to answer one or more research questions, test hypotheses
 - developed prior to data collection, analysis
 - based on, e.g., theory, claims, observations
 - perhaps, even pre-registered
 - e.g., at [OSF Registries](#)

Considerations — Data Storage

Scraped data frequently requires

- large amounts of digital storage space
 - internet data is typically big data
- private, safe storage spaces
 - due to local rules, institutional requirements

Part 3. HTML Basics

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Source Code — Overview

- Webpages include more than what is immediately visible to visitors
 - not only text, images, links
 - but also code for structure, style, and functionality — interpreted by browsers first
 - **HTML** provides the structure
 - **CSS** provides the style
 - **JavaScript** provides functionality, if any
- Web scraping requires working with the source code
 - even when scraping only what is already visible
 - to choose one or more desired parts of the visible
 - e.g., text in table and/or bold only
- Source code also offers more, invisible, data to be scraped
 - e.g., URLs hidden under text

Source Code — Plain Text

The `Ctrl + U` shortcut displays source code — alternatively, right click and `View Page Source`

Source Code — DOM

Browsers also offer putting source codes in a structure, known as DOM (document object model)

- initiated by the F12 key on Chrome — alternatively, right click and Inspect

Exercises

05:00

4) View the source code of a page

- as plain code and as in DOM
- compare the look of the two

5) Search for a word or a phrase in source code

- copy from the front-end page
- search in plain text code or in DOM
 - using the Ctrl + F shortcut
- compare the look of the front- and back-end

HTML — Overview

- HTML stands for **hypertext markup language**
 - it gives the structure to what is visible to visitors
 - text, images, links
 - would a piece of text appear in a paragraph or a list?
 - depends on the HTML code around that text

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

HTML documents

- start with a **declaration**
 - so that browsers know what they are

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

HTML documents

- start with a declaration
 - so that browsers know what they are
- consist of **elements**
 - written in between opening and closing tags

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Root

`html` holds together the root element

- it is also the parent to all other elements
- its important children are the head and body elements

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Head

head contains metadata, such as

- titles, which appear in browser bars and tabs
- style elements

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Body

body contains the elements in the main body of pages, such as

- headers, paragraphs, lists, tables, images

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Syntax — Tags

Most elements have opening and closing tags

```
<p>This is a one sentence paragraph.</p>
```

This is a one sentence paragraph.

Note that

- tag name, in this case **p**, defines the structure of the element
- the closing tag has a forward slash **/** before the element name

HTML — Syntax — Content

Most elements have some **content**

```
<p>This is a one sentence paragraph.</p>
```

This is a one sentence paragraph.

HTML — Syntax — Attributes

Elements can have **attributes**

```
<p>This is a <strong id="sentence-count">one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Note that

- attributes are added to the opening tags
 - separated from anything else in the tag with a white space
- attribute string **sentence-count** could have been anything I could come up with
 - unlike the tag and attribute names — e.g., `strong`, `id` as they are pre-defined
- the `id` attribute has no visible effects
 - some other attributes, such as `style`, can have visible effects

HTML — Syntax — Attributes

There could be more than one attribute in a single element

```
<p>This is a <strong class="count" id="sentence-count">one</strong> sentence paragraph.</p>  
<p>There are now <strong class="count" id="paragraph-count">two</strong> paragraphs.</p>
```

This is a **one** sentence paragraph.

There are now **two** paragraphs.

Note that

- the same `class` attribute (e.i., `count`) can apply to multiple elements
 - while the `id` attribute must be unique on a given page

HTML — Syntax — Notes

Elements can be nested

```
<p>This is a <strong>one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Note that

- there are two elements above, a paragraph and a strong emphasis
- strong is said to be the child of the paragraph element
 - there could be more than one child
 - in that case, children are numbered from the left
- paragraph is said to be the parent of the strong element

HTML — Syntax — Notes

By default, multiple spaces and/or lines breaks are ignored by browsers

```
<ul><li>books</li><li>journal  
</li>  
  
</ul>
```

```
articles</li><li>reports
```

- books
- journal articles
- reports

Note that

- plain source code may or may not be written in a readable manner
 - this is one reason why DOM is helpful

HTML — Other Important Elements — Links

Links are provided with the a (anchor) element

```
<p>Click <a href="https://www.google.com/">here</a> to google things.</p>
```

Click [here](https://www.google.com/) to google things.

Note that

- href (hypertext reference) is a **required attribute** for this element
 - most attributes are optional, but some are required

HTML — Other Important Elements — Links

Links can have titles

```
<p>Click <a title="This text appears when visitors hover over the link"
href="https://www.google.com/">here</a> to google things.</p>
```

Click [here](https://www.google.com/) to google things.

Note that

- the `title` attribute is one of the optional attributes
 - it becomes visible when hovered over with mouse

HTML — Other Important Elements — Lists

The `` tag introduces un-ordered lists, while the `` tag defines lists items

```
<ul>
  <li>books</li>
  <li>journal articles</li>
  <li>reports</li>
</ul>
```

- books
- journal articles
- reports

Note that

- Ordered lists are introduced with the `` tag instead

HTML — Other Important Elements — Containers

The `<div>` tag defines a section, containing one or often more elements

```
<p>This is an introductory paragraph.</p>
<div style="text-decoration:underline;">
<p>In this important division there are two
elements, which are:</p>
<ul>
  <li>a paragraph, and</li>
  <li>an unordered list.</li>
</ul>
</div>

<p>This is the concluding paragraph.</p>
```

This is an introductory paragraph.

In this important division there are two elements, which are:

- a paragraph, and
- an unordered list.

This is the concluding paragraph.

HTML — Other Important Elements — Containers

The `` tag also defines a section, containing a part of an element

```
<p>This is an <span style="text-decoration:underline;">important paragraph</span>, which  
you must read carefully.</p>
```

This is an important paragraph, which you must read carefully.

Note that

- containers are useful in applying styles to sections
 - or, attributing classes or ids to them

Exercises

15:00

6) Re-create the page at <https://luzpar.netlify.app/states/> in R

- start an HTML file, following from the RStudio menu:

```
File -> New File -> HTML File
```

- copy the text from the website, paste in the HTML file
- add the structure with HTML code
- click Preview to view the result

7) Add at least one extra tag and/or attribute

- with a visible effect on how the page looks at the front end
 - hints:
 - google if you need to
 - www.w3schools.com has a lot resources
- save this document as we will continue working on it

Part 3. CSS Selectors

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CSS — Overview

- CSS stands for **cascading style sheets**
 - it gives the style to what is visible to visitors
 - text, images, links
 - would a piece of text appear in black or blue?
 - depends on the CSS for that text
- CSS can be defined
 - inline, as an attribute of an element
 - internally, as a child element of the head element
 - externally, but then linked in the head element

CSS — Syntax

- CSS is written in rules

```
p {font-size:12px;}
```

```
h1 h2 {color:blue;}
```

```
.count {background-color:yellow;}
```

```
#sentence-count {color:red; font-size:16px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more **selectors**, matching one or more HTML elements and/or attributes

```
p {font-size:14px;}
```

```
h1 h2 {color:blue;}
```

```
.count {background-color:yellow;}
```

```
#sentence-count {color:red; font-size:16px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more **selectors**, matching one or more HTML elements and/or attributes
- Note that
 - the syntax changes with the selector type
 - elements and attributes are written as they are

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:16px;}
```


CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more **selectors**, matching one or more HTML elements and/or attributes
- Note that
 - the syntax changes with the selector type
 - elements and attributes are written as they are
 - classes are prefixed with a full stop, ids with a number sign

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:16px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more **selectors**, matching one or more HTML elements and/or attributes
- Note that
 - the syntax changes with the selector type
 - elements and attributes are written as they are
 - classes are prefixed with a full stop, ids with a number sign
 - you can define the same rule for more than one element and/or attribute

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:16px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more selectors, matching one or more HTML elements and/or attributes
 - a **declaration**
- Note that
 - declarations are written in between two curly brackets

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:16px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more selectors, matching one or more HTML elements and/or attributes
 - a declaration, with one or more **properties**
- Note that
 - properties are followed by a colon

```
p {font-size: 14px;}  
h1 h2 {color: blue;}  
.count {background-color: yellow;}  
#sentence-count {color: red; font-size: 16px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more selectors, matching one or more HTML elements and/or attributes
 - a declaration, with one or more properties and values
- Note that
 - values are followed by a semicolon
 - property:value; pairs are separated by a white space

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:14px;}
```

CSS — Internal

- CSS rules can be defined internally
 - within the `style` element
 - as a child of the `head` element
- Internally defined rules apply to all matching selectors
 - on the same page

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color:blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

CSS — External

- CSS rules can be defined externally
 - saved somewhere linkable
 - defined with the the linked element
 - as a child of the head element
- Externally defined rules
 - are saved in a file with .css extension
 - apply to all matching selectors
 - on any page linked

```
<!DOCTYPE html>
<html>
  <head>
    <link rel="styles" href="simple.css">
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

CSS — Inline

CSS rules can also be defined inline

- with the `style` attribute
- does not require selector
- applies only to that element

```
<p>This is a <strong style="color:blue;">one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Exercise

07:30

8) Provide some simple style to your HTML document

- one that you created during the previous exercise
- using internal or external style, but not inline
 - so that you can practice selecting elements
- no idea what to do?
 - increase the font size of the text in paragraph
 - change the colour of the second item in the list to red
 - get more ideas from www.w3schools.com/css

Part 5. Scraping Static Pages

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Static Pages — Overview

- Static pages are those that display the same source code to all visitors
 - every visitor sees the same content at a given URL
 - for a different content, visitors go to a different page with a different URL
 - <https://luzpar.netlify.app/> is a static page
- Static pages are scraped typically in two steps
 - the `rvest` package can handle both steps
 - we may still wish to use other packages to ensure ethical scraping

Static Pages — Two Steps to Scrape

Scraping dynamic pages involves three main steps

- **Get** the source code into R
 - with the `rvest` or `polite` package, using URLs of these pages
 - typically, the only interaction with the page itself
- **Extract** the exact information needed from the source code
 - with the `rvest` package, using selectors for that exact information
 - takes place locally, on your machine

Static Pages — `rvest` — Overview

- A relative small R package for web scraping
 - created by [Hadley Wickham](#)
 - popular — used by many for web scraping
 - downloaded 494,966 times last month
 - some of it must be thanks to being a part of the tidyverse family
 - last major revision was in March 2021
 - better alignment with tidyverse
- A lot has already been written on this package
 - you will find solutions to, or help for, any issues online
 - see first the [package documentation](#), numerous tutorials — such as [this](#), [this](#), and [this](#)
- Comes with the recommendation to combine it with the `polite` package
 - for ethical web scraping

Static Pages — `rvest` — Get Source Code

Use the `read_html` function to get the source code of a webpage into R

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}  
## <html lang="en-us">  
## [1] <head>\n<meta http-equiv="Content-Type" content="text/html; charset=UTF-8 ...  
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-ma ...
```

Note that

- this is the first of two steps in scraping static pages
 - typically, the only interaction with the page itself
 - we still need to select the exact information that we need

Static Pages — rvest — Get Source Code

You may wish to check the protocol first, for ethical scraping

```
paths_allowed(domain = "https://luzpar.netlify.app/")
```

```
## [1] TRUE
```

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type" content="text/html; charset=UTF-8 ...
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-ma ...
```

Static Pages — `rvest` — Get Source Code — `polite`

- The `polite` package facilitates ethical scraping
 - recommended by `rvest`
- It divides the step of getting source code into two
 - check the protocol
 - get the source only if allowed
- Among its other functions are
 - waiting for a period of time
 - minimum by what is specified in the protocol
 - introducing you to website administrators while scraping

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the `bow` function to check the protocol
 - for a specific `URL`

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    ...  
)
```

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the `bow` function to check the protocol
 - for a specific URL
 - for a specific `agent`
- Note that
 - the `user_agent` argument can communicate information to website administrators
 - e.g., your name and contact details

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    force = FALSE,  
    ...  
)
```

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol

- for a specific URL
- for a specific agent
- for any **crawl-delay directives**

- Note that

- the delay argument cannot be set to a number smaller than in the directive
 - if there is one

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    force = FALSE,  
    ...  
)
```

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol

- for a specific URL
- for a specific agent
- for crawl-delay directives

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    force = FALSE,  
    ...  
)
```

- Note that

- the delay argument cannot be set to a number smaller than in the directive
 - if there is one
- the force argument is set to FALSE by default
 - avoids repeated, unnecessary interactions with web page
 - by caching, and re-using, previously downloaded sources

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol
- **Second**, use the scrape function get source code
 - for an object created with the bow function
- Note that
 - scrape will only work if the results from bow are positive
 - creating a safety valve for ethical scraping

```
scrape(bow,  
      ...  
      )
```

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol
- Second, use the scrape function get source code
 - for an object created with the bow function
- Note that
 - scrape will only work if the results from bow are positive
 - creating a safety valve for ethical scraping
 - by **pipng**, bow into scrape, you can avoid creating objects

```
scrape(bow,  
      ...  
      )
```

```
bow() %>%  
  scrape()
```

Static Pages — rvest — Get Source Code

These two pieces of code lead to the same outcome, as there is **no protocol against the access**

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type
## [2] <body id="top" data-spy="scroll" data-
```

```
bow("https://luzpar.netlify.app/") %>%
  scrape()
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type
## [2] <body id="top" data-spy="scroll" data-
```

Static Pages — rvest — Get Source Code

The difference occurs when there is a protocol against the access

```
read_html("https://luzpar.netlify.app/exercis
```

```
## {html_document}  
## <html>  
## [1] <head>\n<meta http-equiv="Content-Type  
## [2] <body>\r\n\r\n<h1>States of Luzland</h
```

```
bow("https://luzpar.netlify.app/exercises/exe  
scrape()
```

```
## Warning: No scraping allowed here!
```

```
## NULL
```


Exercises

05:00

9) Get the source code of the page at <https://luzpar.netlify.app/states/> in R

- using the `read_html` function

10) Get the same page source, this time in the `polite` way

- let the website know who you are
- define delay time

Static Pages — rvest — html_elements

- Get one or more HTML elements
 - from the `source code` downloaded in the previous step
- Note that
 - there are two versions of the same function
 - singular one gets the first instance of an element, plural gets all instances
 - if there is only one instance, both functions return the same result

```
html_element(x,  
             css,  
             xpath)
```

```
html_elements(x,  
              css,  
              xpath)
```

Static Pages — rvest — html_elements

- Get one or more HTML elements
 - from the source code downloaded in the previous step
 - specified with a selector, CSS or XPATH
- Note that
 - we will work with CSS only in this workshop
 - using CSS is facilitated by Chrome and SelectorGadget

```
html_element(x,  
             css,  
             xpath)
```

```
html_elements(x,  
              css,  
              xpath)
```

Static Pages — Finding Selectors

- Finding the correct selector(s) is the key to successful scraping, and there are three ways to do it
 - figure it out yourself, by looking at the source code and/or the DOM
 - difficult, time consuming, prone to error
 - use SelectorGadget or other browser extensions
 - easy and quick
 - works well when selecting both single and multiple elements
 - but sometimes not accurate
 - use the functionality that Chrome provides
 - an in-between option in terms of ease and time
 - works very well with single elements
- I recommend using
 - the SelectorGadget method first, and if it does not help
 - then the Chrome method, especially when selecting single elements

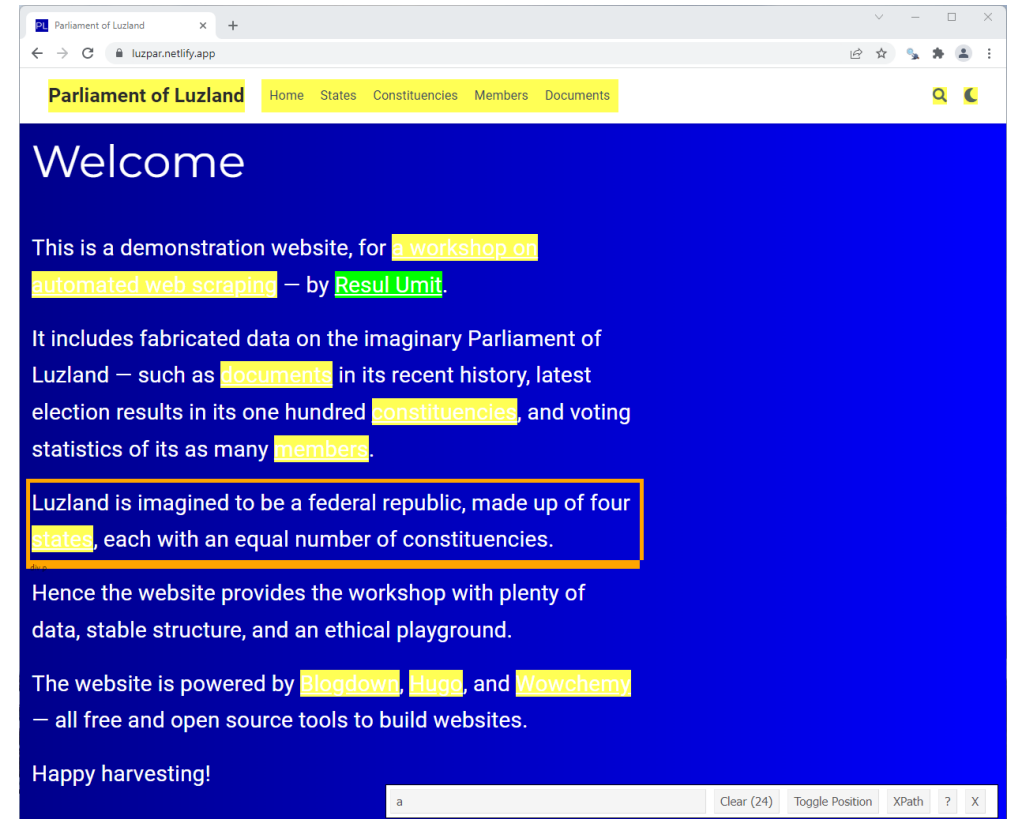
Static Pages — Finding Selectors — SelectorGadget

To find the selectors for the hyperlinks on the homepage of the Parliament of Luzland

1. visit the page on a Chrome browser
2. click on SelectorGadget to activate it
3. click on a hyperlink

Note that

- the element that you clicked is highlighted green
- many other elements, including menu items, are in yellow
- SelectorGadget says the selector is a



Static Pages — rvest — html_elements

Get the a (anchor) elements on the homepage

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "a")
```

```
## {xml_nodeset (24)}  
## [1] <a class="js-search" href="#" aria-label="Close"><i class="fas fa-times- ...  
## [2] <a class="navbar-brand" href="/">Parliament of Luzland</a>  
## [3] <a class="navbar-brand" href="/">Parliament of Luzland</a>  
## [4] <a class="nav-link active" href="/"><span>Home</span></a>  
## [5] <a class="nav-link" href="/states/"><span>States</span></a>  
## [6] <a class="nav-link" href="/constituencies/"><span>Constituencies</span></a>  
## [7] <a class="nav-link" href="/members/"><span>Members</span></a>  
## [8] <a class="nav-link" href="/documents/"><span>Documents</span></a>  
## [9] <a class="nav-link js-search" href="#" aria-label="Search"><i class="fas ...  
## [10] <a href="#" class="nav-link" data-toggle="dropdown" aria-haspopup="true" ...  
## [11] <a href="#" class="dropdown-item js-set-theme-light"><span>Light</span></a>  
## [12] <a href="#" class="dropdown-item js-set-theme-dark"><span>Dark</span></a>  
## [13] <a href="#" class="dropdown-item js-set-theme-auto"><span>Automatic</spa ...  
## [14] <a href="https://github.com/resulumit/scrp_workshop" target="_blank" rel ...  
## [15] <a href="https://resulumit.com/" target="_blank" rel="noopener">Resul Um ...
```

Static Pages — rvest — html_element

Get the **first** a (anchor) element on the homepage

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_element(css = "a")
```

```
## {html_node}  
## <a class="js-search" href="#" aria-label="Close">  
## [1] <i class="fas fa-times-circle text-muted" aria-hidden="true"></i>
```

Note that

- the function on this slide is the singular version

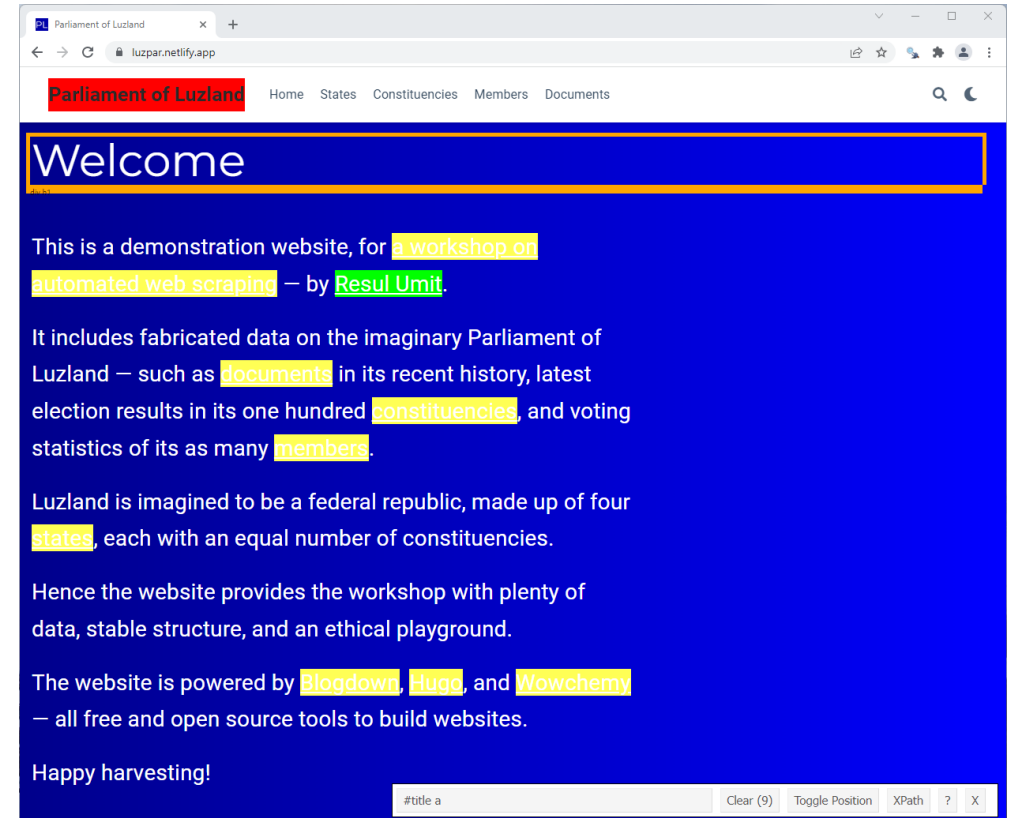
Static Pages — Finding Selectors — SelectorGadget

To exclude the menu items from selection

4. click on a menu item

Note that

- the element that you clicked is highlighted red
- other menu items are not highlighted at all
- SelectorGadget says the selector is now `#title a`



Static Pages — rvest — html_elements

Get the a (anchor) elements on the homepage with a #title attribute

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a")
```

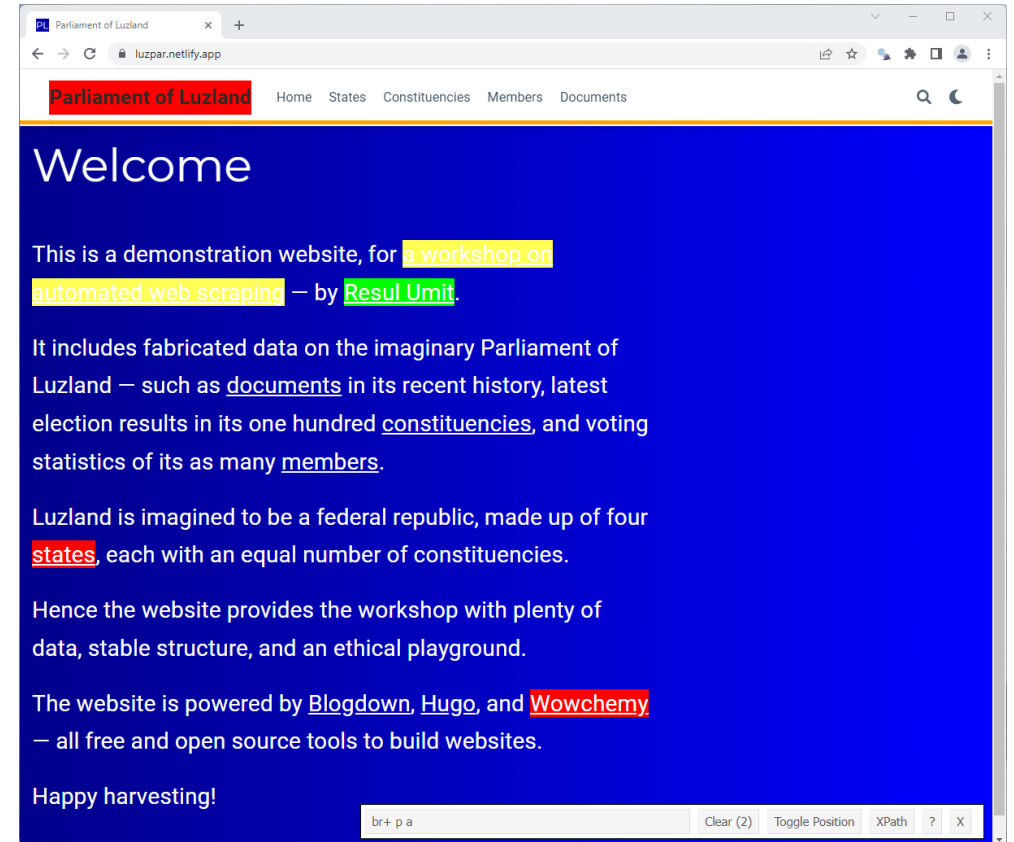
```
## {xml_nodeset (9)}  
## [1] <a href="https://github.com/resulmit/scrp_workshop" target="_blank" rel= ...  
## [2] <a href="https://resulmit.com/" target="_blank" rel="noopener">Resul Umi ...  
## [3] <a href="/documents/">documents</a>  
## [4] <a href="/constituencies/">constituencies</a>  
## [5] <a href="/members/">members</a>  
## [6] <a href="/states/">states</a>  
## [7] <a href="https://github.com/rstudio/blogdown" target="_blank" rel="noopen ...  
## [8] <a href="https://gohugo.io/" target="_blank" rel="noopener">Hugo</a>  
## [9] <a href="https://github.com/wowchemy" target="_blank" rel="noopener">Wowc ...
```

Static Pages — Finding Selectors — SelectorGadget

You can click further to exclude some and/or to include more elements

Note that the selection is colour-coded

- selected
- also included
- excluded
- not included at all



Static Pages — rvest — html_elements

Get the link behind the selected elements

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "br+ p a")
```

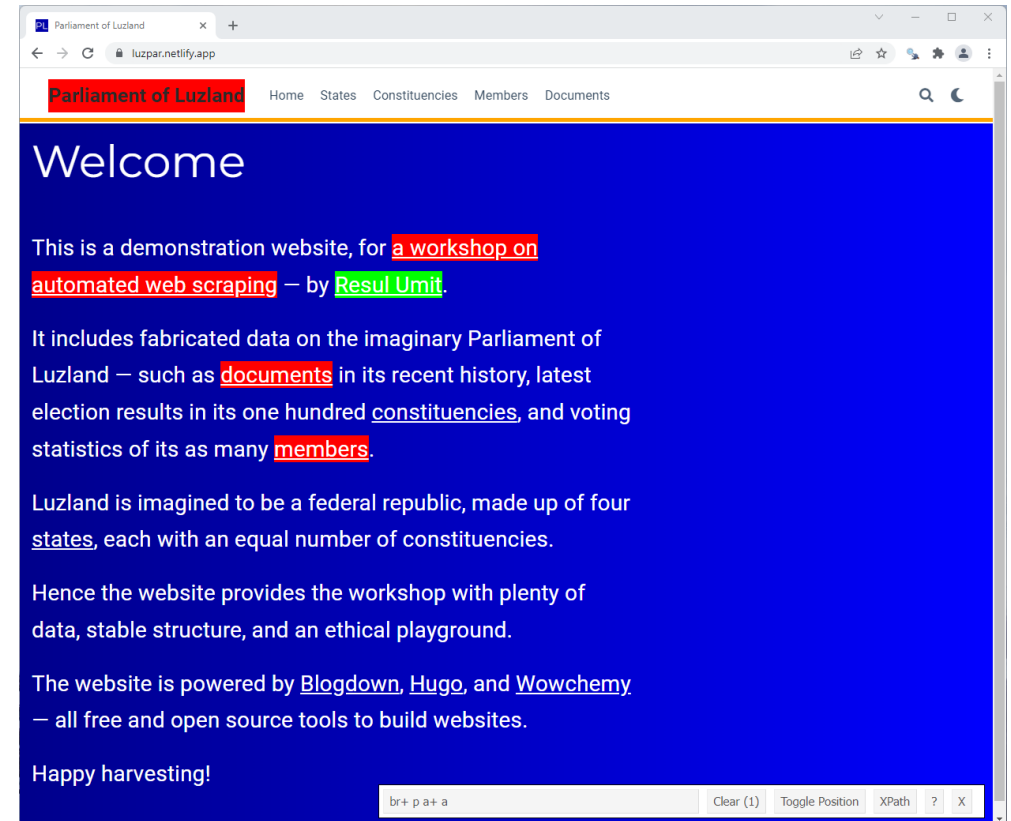
```
## {xml_nodeset (2)}  
## [1] <a href="https://github.com/resulunit/scrp_workshop" target="_blank" rel= ...  
## [2] <a href="https://resulunit.com/" target="_blank" rel="noopener">Resul Umi ...
```

Static Pages — Finding Selectors — SelectorGadget

You can click further to select **a single element**


```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "br+ p a+ a")
```

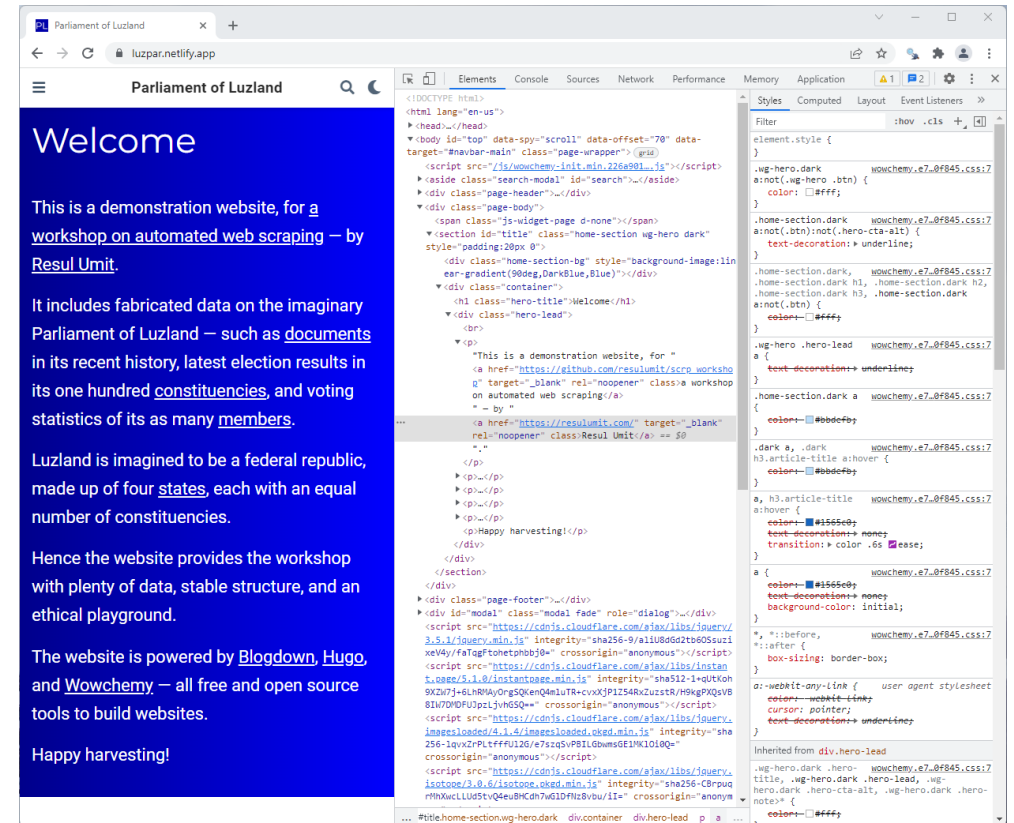
```
## {xml_nodeset (1)}  
## [1] <a href="https://resulimit.com/" target=
```



Static Pages — Finding Selectors — Chrome

To find the selector for a single element, you could also use Chrome itself

1. right click, and then Inspect
2. click 
3. click on an element on the front end
4. right click on the highlighted section in the DOM
5. follow Copy -> Copy selector



Static Pages — rvest — html_elements

Get the link behind one element, with css from Chrome

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title > div.container > div > p:nth-child(2) > a:nth-child(2)")
```

```
## {xml_nodeset (1)}  
## [1] <a href="https://resulunit.com/" target="_blank" rel="noopener">Resul Umi ...
```

Note that

- the selector is different than the one SelectorGadget returns
 - longer, and therefore, more specific and accurate
- but the outcome is the same

Exercises

10:00

11) Get the first item on the list on the page at <https://luzpar.netlify.app/states/>

- find the selector with the functionality Chrome offers

12) Get all items on the list

- find the selector with SelectorGadget

13) Get only the second and fourth items on the list

- using a single selector that would return both

Static Pages — `rvest` — `html_text`

- Get the text content of one or more HTML elements
 - for the elements already chosen
 - with the `html_elements` function
 - this returns what is already visible to visitors
- Note that
 - there are two versions of the same function
 - `html_text` returns text with any space or line breaks around it
 - `html_text2` returns plain text

```
html_text(x, trim = FALSE)
```

```
html_text2(x, preserve_nbsp = FALSE)
```


Static Pages — rvest — html_text

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_text()
```

```
## [1] "a workshop on automated web scraping"  
## [2] "Resul Umit"  
## [3] "documents"  
## [4] "constituencies"  
## [5] "members"  
## [6] "states"  
## [7] "Blogdown"  
## [8] "Hugo"  
## [9] "Wowchemy"
```

Exercises

05 : 00

14) Get the text on the list elements on the page at <https://luzpar.netlify.app/states/>

15) Get the constituency names on the page at <https://luzpar.netlify.app/constituencies/>

Static Pages — rvest — html_attr

- Get one or more attributes of one or more HTML elements
 - for the elements already chosen
 - with the `html_elements` function
 - attributes are specified with their name
 - not CSS or XPATH
- Note that
 - there are two versions of the same function
 - singular one gets a specified attribute
 - plural one gets all available attributes

```
html_attr(x, name, default = NA_character_)  
html_attrs(x)
```

Static Pages — rvest — html_attrs

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_attrs()
```

```
## [[1]]  
##                                href  
## "https://github.com/resulumit/scrp_workshop"  
##                                target  
##                                "_blank"  
##                                rel  
##                                "noopener"  
##  
## [[2]]  
##                                href                                target                                rel  
## "https://resulumit.com/"                                "_blank"                                "noopener"  
##  
## [[3]]  
##                                href  
## "/documents/"  
##
```

Static Pages — rvest — html_attr

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_attr(name = "href")
```

```
## [1] "https://github.com/resulunit/scrp_workshop"  
## [2] "https://resulunit.com/"  
## [3] "/documents/"  
## [4] "/constituencies/"  
## [5] "/members/"  
## [6] "/states/"  
## [7] "https://github.com/rstudio/blogdown"  
## [8] "https://gohugo.io/"  
## [9] "https://github.com/wowchemy"
```

Note that

- some URLs are given relative to the base URL
 - e.g., /states/, which is actually <https://luzpar.netlify.app/states/>
 - you can complete them with the `url_absolute` function

Static Pages — rvest — url_absolute

Complete the relative URLs with the url_absolute function

```
bow("https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_attr(name = "href") %>%  
  url_absolute(base = "https://luzpar.netlify.app")
```

```
## [1] "https://github.com/resulmit/scrp_workshop"  
## [2] "https://resulmit.com/"  
## [3] "https://luzpar.netlify.app/documents/"  
## [4] "https://luzpar.netlify.app/constituencies/"  
## [5] "https://luzpar.netlify.app/members/"  
## [6] "https://luzpar.netlify.app/states/"  
## [7] "https://github.com/rstudio/blogdown"  
## [8] "https://gohugo.io/"  
## [9] "https://github.com/wowchemy"
```

Exercises

05:00

16) Get the hyperlink attributes for the constituencies at <https://luzpar.netlify.app/constituencies/>

17) Create complete links to the constituency pages

Static Pages — rvest — html_table

Use the `html_table()` function to get the text content of table elements

```
bow("https://luzpar.netlify.app/members/") %>%  
  scrape() %>%  
  html_elements(css = "table") %>%  
  html_table()
```

```
## [[1]]  
## # A tibble: 100 x 3  
##   Member      Constituency Party  
##   <chr>      <chr>      <chr>  
## 1 Arthur Ali    Mühlshafen  Liberal  
## 2 Chris Antony  Benwerder   Labour  
## 3 Chloë Bakker  Steffisfelden Labour  
## 4 Rose Barnes   Dillon      Liberal  
## 5 Emilia Bauer  Kilnard     Green  
## 6 Wilma Baumann Granderry    Green  
## 7 Matteo Becker Enkmelo      Labour  
## 8 Patricia Bernard Gänsernten  Labour  
## 9 Lina Booth    Leonrau     Liberal  
## 10 Sophie Bos   Zotburg     Independent  
## # ... with 90 more rows
```


Static Pages — rvest

We can create the same tibble with `html_text`, which requires getting each variable separately to be merged

```
tibble(  
  "Member" = bow("https://luzpar.netlify.app/members/") %>%  
    scrape() %>%  
    html_elements(css = "td:nth-child(1) a") %>%  
    html_text(),  
  "Constituency" = bow("https://luzpar.netlify.app/members/") %>%  
    scrape() %>%  
    html_elements(css = "td:nth-child(2) a") %>%  
    html_text(),  
  "Party" = bow("https://luzpar.netlify.app/members/") %>%  
    scrape() %>%  
    html_elements(css = "td:nth-child(3)") %>%  
    html_text()  
)
```

Static Pages — rvest

Keep the number of interactions with websites to minimum

- by saving the source code as an object, which could be used repeatedly

```
the_page <- bow("https://luzpar.netlify.app/members/") %>%
  scrape()

tibble(
  "Member" = the_page %>%
    html_elements(css = "td:nth-child(1)") %>%
    html_text(),
  "Constituency" = the_page %>%
    html_elements(css = "td:nth-child(2)") %>%
    html_text(),
  "Party" = the_page %>%
    html_elements(css = "td:nth-child(3)") %>%
    html_text()
)
```

Exercise

15:00

18) Create a dataframe out of the table at <https://luzpar.netlify.app/members/>

- with as many variables as possible
- hints:
 - start with the code in the previous slide, and add new variables from attributes
 - the first two columns have important attributes
 - e.g., URLs for the pages for members and their constituencies
 - make these URLs absolute
 - see what other attributes are there to collect

Static Pages — Crawling — Overview

- Rarely a single page includes all variables that we need
 - instead, they are often scattered across different pages of a website
 - e.g., we might need data on election results — in addition to constituency names
- Web scraping then requires crawling across pages
 - using information found on one page, to go to the next
 - website design may or may not facilitate crawling
- We can write for loops to crawl
 - the speed of our code matters the most when we crawl
 - ethical concerns are higher

Static Pages — Crawling — Example

Task:

- I need data on the name and vote share of parties that came second in each constituency
- This data is available on constituency pages, but
 - there are too many such pages
 - e.g., <https://luzpar.netlify.app/constituencies/arford/>
 - I do not have the URL to these pages

Plan:

- Scrape <https://luzpar.netlify.app/members/> for URLs
- Write a for loop to
 - visit these pages one by one
 - collect and save the variables needed
 - write these variables into a list
 - turn the list into a dataframe

Static Pages — Crawling — Example

Scrape the page that has all URLs, for absolute URLs

```
the_links <- bow("https://luzpar.netlify.app/members/") %>%  
  scrape() %>%  
  html_elements(css = "td+ td a") %>%  
  html_attr("href") %>%  
  url_absolute(base = "https://luzpar.netlify.app/")  
  
# check if it worked  
head(the_links)
```

```
## [1] "https://luzpar.netlify.app/constituencies/muhlshafen/"  
## [2] "https://luzpar.netlify.app/constituencies/benwerder/"  
## [3] "https://luzpar.netlify.app/constituencies/steffisfelden/"  
## [4] "https://luzpar.netlify.app/constituencies/dillon/"  
## [5] "https://luzpar.netlify.app/constituencies/kilnard/"  
## [6] "https://luzpar.netlify.app/constituencies/granderry/"
```

Static Pages — Crawling — Example

Create an empty list

```
temp_list <- list()

for (i in 1:length(the_links)) {
  the_page <- bow(the_links[i]) %>% scrape()
  temp_tibble <- tibble(
    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),
    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),
    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()
  )
  temp_list[[i]] <- temp_tibble
}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Start a for loop to iterate over the links one by one

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```


Static Pages — Crawling — Example

Get the source code for the next link

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Get the variables needed, put them in a tibble

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}
```

Static Pages — Crawling — Example

Add each tibble into the previously-created list

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Turn the list into a tibble

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Check the resulting dataset

```
head(df, 10)
```

```
## # A tibble: 100 x 3
##   constituency second_party vote_share
##   <chr>         <chr>         <chr>
## 1 Mühlshafen    Green          26.1%
## 2 Benwerder     Conservative 24.8%
## 3 Steffisfelden Green          25.7%
## 4 Dillon        Conservative 27%
## 5 Kilnard       Conservative 28.8%
## 6 Granderry     Labour         26.1%
## 7 Enkmelo       Liberal        26.8%
## 8 Gänsernten    Green          26.6%
## 9 Leonrau       Conservative 25%
## 10 Zotburg      Conservative 28.4%
## # ... with 90 more rows
```

Exercise

45 : 00

19) Crawl into members' personal pages to create a rich dataset

- with members being the unit of observation

Hints:

- see an example dataset at https://luzpar.netlify.app/exercises/static_data.csv
- start with the related code in the previous slides, and adopt it to your needs
- practice with 3 members until you are ready to run the loop for all
 - e.g., by replacing `1:length(the_links)` with `1:3` for the loop

Part 6. Scraping Dynamic Pages

[Back to the contents slide.](#)

Dynamic Pages — Overview

- Dynamic pages are ones that display custom content
 - different visitors might see different content on the same page
 - at the same URL
 - depending on, for example, their own input
 - e.g., clicks, scrolls — while the URL remains the same
 - <https://luzpar.netlify.app/documents/> is a page with a dynamic part
- Dynamic pages are scraped typically in three steps
 - as opposed to two steps, in scraping static pages
 - we will use an additional package, RSeelenium, for the new step

Dynamic Pages — Three Steps to Scrape

Scraping dynamic pages involves three main steps

- **Create** the desired instance of the dynamic page
 - with the `RSelenium` package
 - e.g., by clicking, scrolling, filling in forms, from within R
- **Get** the source code into R
 - `RSelenium` downloads XML
 - `rvest` turns it into HTML
- **Extract** the exact information needed from the source code
 - as for static pages
 - with the `rvest` package

Dynamic Pages — RSeLenium — Overview

- A package that integrates **Selenium 2.0 WebDriver** into R
 - created by **John Harrison**
 - downloaded 6,901 times last month
 - last updated in February 2020
- A lot has already been written on this package
 - you will find solutions to, or help for, any issues online
 - see the **package documentation** and the **vignettes** for basic functionality
 - Google searches return code and tutorials in various languages
 - not only R but also Python, Java

Dynamic Pages — RSeLenium — Overview

- The package involves more methods than functions
 - code look slightly unusual for R
 - as it follows the logic behind Selenium
- It allows interacting with two things — and it is crucial that users are aware of the difference
 - with **browsers** on your computer
 - e.g., opening a browser and navigating to a page
 - with **elements** on a webpage
 - e.g., opening and clicking on a drop-down menu

Interacting with Browsers

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
 - so that you can control a web browser from within R

```
rsDriver(port = 4567L,  
        browser = "chrome",  
        version = "latest",  
        chromever = "latest",  
        ...  
)
```

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
 - so that you can control a web browser from within R
- Note that the defaults can cause errors, such as
 - trying to start two servers from the same port

```
rsDriver(port = 4567L,  
         browser = "chrome",  
         version = "latest",  
         chromever = "latest",  
         ...  
         )
```

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
 - so that you can control a web browser from within R
- Note that the defaults can cause errors, such as
 - trying to start two servers from the same port
 - any mismatch between the version and driver numbers

```
rsDriver(port = 4567L,  
        browser = "chrome",  
        version = "latest",  
        chromeversion = "latest",  
        ...  
)
```

Dynamic Pages — Browsers — Starting a Server

- The latest version of the driver is too new for my browser
 - I have to use an older version to make it work
 - after checking the available versions with the following code

```
binman::list_versions("chromedriver")
```

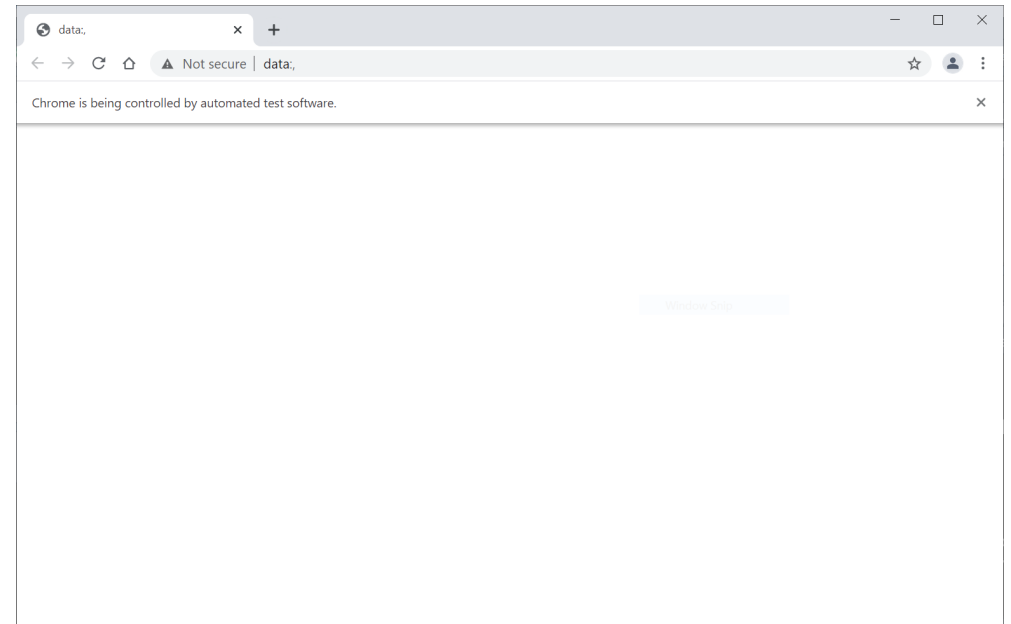
```
## $win32  
## [1] "100.0.4896.20" "100.0.4896.60" "102.0.5005.27" "102.0.5005.61"  
## [5] "103.0.5060.24" "89.0.4389.23" "90.0.4430.24" "91.0.4472.19"  
## [9] "99.0.4844.35" "99.0.4844.51"
```

- Note that
 - you can only use the version that *you* have
 - you might have a different the version than the ones on this slide

Dynamic Pages — Browsers — Starting a Server

- Then the function works
 - a web browser opens as a result
 - an R object named `driver` is created
- Note that
 - the browser says "Chrome is being controlled by automated test software."
 - you should avoid controlling this browser manually
 - you should also avoid creating multiple servers

```
driver <- rsDriver(chromeversion = "102.0.5005.27")
```



Dynamic Pages — Browsers — Starting a Server

Separate the `client` and `server` as different objects

```
browser <- driver$client  
server <- driver$server
```

Note that

- `rsDriver()` creates a client and a server
 - the code above singles out the client, with which our code will interact
 - client is best thought as the browser itself
 - it has the class of `remoteDriver`

Exercises

02:30

20) Start a server

- supply a driver version if necessary

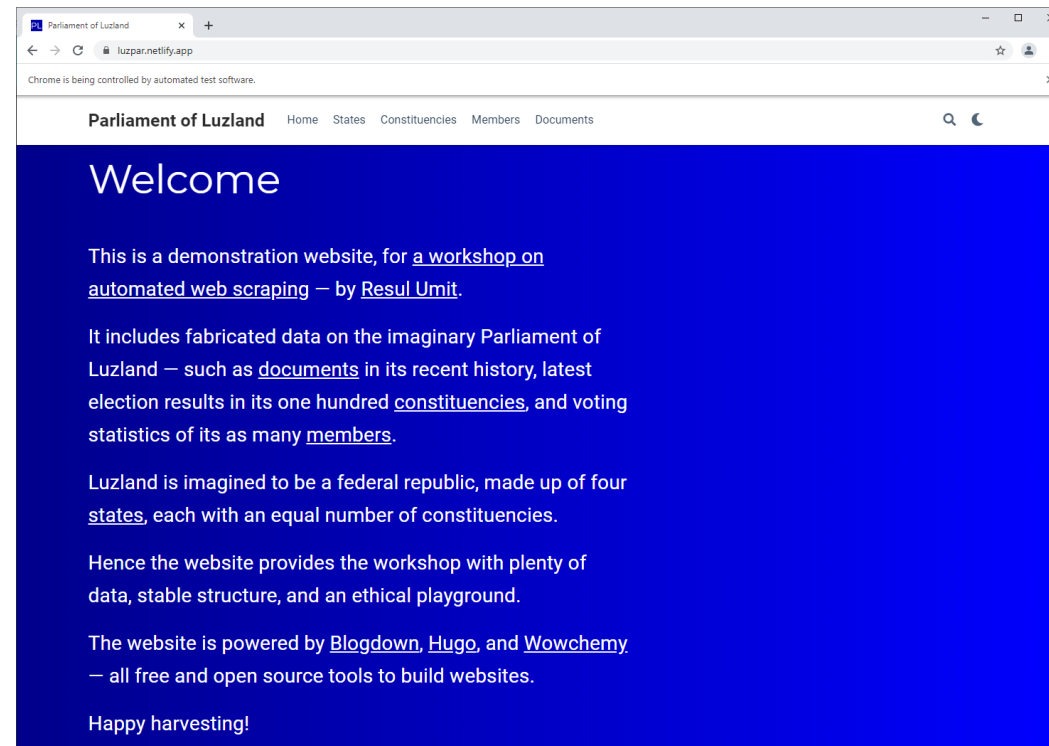
21) Single out the client

- call it browser to help you follow the slides

Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser.$navigate("https://luzpar.netlify.app")
```



Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser$navigate("https://luzpar.netlify.app")
```

Note that

- navigate is called a method, not a function
 - it cannot be piped %>% into browser
 - use the dollar sign \$ notation instead

Dynamic Pages — Browsers — Navigate

Check the description of any method as follows, with no parentheses after the method name

```
browser$navigate
```

```
Class method definition for method navigate()
function (url)
{
  "Navigate to a given url."
  qpath <- sprintf("%s/session/%s/url", serverURL, sessionInfo[["id"]])
  queryRD(qpath, "POST", qdata = list(url = url))
}
<environment: 0x00000173db9035a8>

Methods used:
  "queryRD"
```

Dynamic Pages — Browsers — Navigate

Go back to the previous URL

```
browser$goBack()
```

Go forward

```
browser$goForward()
```

Refresh the page

```
browser$refresh()
```

Exercises

10:00

22) Navigate to a website, and then to another one

- from within R, all the while observing the outcome in the automated browser

23) Go back, and go forward

24) See what other methods are available to interact with browsers

- read the description for one or more of them

25) Try one or more new methods

- e.g., take a screenshot of your browser
 - and view it in R

Dynamic Pages — Browsers — Navigate

Get the URL of the current page

```
browser$CurrentUrl()
```

Get the title of the current page

```
browser$getTitle()
```

Dynamic Pages — Browsers — Close and Open

Close the browser

- which will not close the session on the server
 - recall that we have singled the client out

```
browser$close()
```

Open a new browser

- which does not require the `rsDriver` function
 - because the server is still running

```
browser$open()
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

```
browser$getPageSource()[[1]]
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

```
browser$getPageSource()[[1]]
```

Note that

- this method returns a list
 - XML source is in the first item
 - this is why we need the `[[1]]` bit
- this is akin to `read_html()` for static pages
 - or `bow() %>% scrape()`
- `rvest` usually takes over after this step

Dynamic Pages — Browsers — Get Page Source

Extract the links on the homepage, with functions from both the `RSelenium` and `rvest` packages

```
browser$navigate(url = "https://luzpar.netlify.app")

browser$getPageSource()[[1]] %>%
  read_html() %>%
  html_elements("#title a") %>%
  html_attr("href")
```

```
[1] "https://github.com/resulimit/scrp_workshop"
[2] "https://resulimit.com/"
[3] "/documents/"
[4] "/constituencies/"
[5] "/members/"
[6] "/states/"
[7] "https://github.com/rstudio/blogdown"
[8] "https://gohugo.io/"
[9] "https://github.com/wowchemy"
```

Dynamic Pages — Browsers — Get Page Source

Extract the links on the page, with functions from both the R Selenium and rvest packages

```
browser$navigate(url = "https://luzpar.netlify.app")  
  
browser$getPageSource()[[1]] %>%  
  read_html() %>%  
  html_elements("#title a") %>%  
  html_attr("href")
```

Note that

- we are still using the `read_html()` function
 - to turn XML (coming from R Selenium) into HTML
- this is in fact not a dynamic page
 - we could do the same as above without R Selenium

Dynamic Pages — Browsers — Get Page Source

These two pieces of code lead to the same outcome, as the page we scrape is not dynamic

```
browser$navigate(url = "https://luzpar.netlify")
browser$getPageSource()[[1]] %>%
  read_html() %>%
  html_elements("#title a") %>%
  html_attr("href")
```

```
[1] "https://github.com/resulimit/scrp_worksh"
[2] "https://resulimit.com/"
[3] "/documents/"
[4] "/constituencies/"
[5] "/members/"
[6] "/states/"
[7] "https://github.com/rstudio/blogdown"
[8] "https://gohugo.io/"
[9] "https://github.com/wowchemy"
```

```
read_html("https://luzpar.netlify.app") %>%
  html_elements(css = "#title a") %>%
  html_attr("href")
```

```
## [1] "https://github.com/resulimit/scrp_wor"
## [2] "https://resulimit.com/"
## [3] "/documents/"
## [4] "/constituencies/"
## [5] "/members/"
## [6] "/states/"
## [7] "https://github.com/rstudio/blogdown"
## [8] "https://gohugo.io/"
## [9] "https://github.com/wowchemy"
```

Exercises

07:30

26) Get the page source for <https://luzpar.netlify.app/members/>

- using function(s) from `rvest` or `polite`

27) Get the same page source, using `RSelenium`

- compare the outcome with the one from Exercise 26

28) Collect names from <https://luzpar.netlify.app/members/>

- using functions from `rvest` only
- using `RSelenium` and `rvest` together
- compare the outcomes

Interacting with Elements

Dynamic Pages — Elements — Find

- Locate an element on the open browser
 - to be interacted later on
 - e.g., clicking on the element
- Note that
 - the default selector is xpath
 - requires entering the xpath value

```
findElement(using = "xpath",  
            value  
            )
```

Dynamic Pages — Elements — Find

- Locate an element on the open browser
 - using CSS selectors
- Note that
 - typing "css", instead of "css selector", also works
 - there are other selector schemes as well, including
 - id
 - name
 - link text

```
findElement(using = "css selector",  
             value  
             )
```

Dynamic Pages — Elements — Find — Selectors

If there were a button created by the following code ...

```
<button class="big-button" id="only-button" name="clickable">Click Me</button>
```

... any of the lines below would find it

```
browser$findElement(using = "xpath", value = '//*[@id = "only-button"]')  
browser$findElement(using = "css selector", value = ".big-button")  
browser$findElement(using = "css", value = "#only-button")  
browser$findElement(using = "id", value = "only-button")  
browser$findElement(using = "name", value = "clickable")
```

Dynamic Pages — Elements — Objects

Save elements as R objects to be interacted later on

```
button <- browser$findElement(using = ..., value = ...)
```

Note the difference between the classes of clients and elements

```
class(browser)
```

```
[1] "remoteDriver"  
attr(,"package")  
[1] "RSelenium"
```

```
class(button)
```

```
[1] "webElement"  
attr(,"package")  
[1] "RSelenium"
```

Dynamic Pages — Elements — Highlight

Highlight the element found in the previous step, with the `highlightElement` method

```
# navigate to a page
browser$navigate("http://luzpar.netlify.app/")

# find the element
menu_states <- browser$findElement(using = "link text", value = "States")

# highlight it to see if we found the correct element
menu_states$highlightElement()
```

Note that

- the highlighted element will flash for a second or two on the browser
 - helpful to check if selection worked as intended

Dynamic Pages — Elements — Highlight

Highlight the element found in the previous step, with the `highlightElement` method

```
# navigate to a page
browser$navigate("http://luzpar.netlify.app/")

# find the element
menu_states <- browser$findElement(using = "link text", value = "States")

# highlight it to see if we found the correct element
menu_states$highlightElement()
```

Note that

- the highlighted element will flash for a second or two on the browser
 - helpful to check if selection worked as intended
- the highlight method is applied to the element (`menu_states`), not to the client (`browser`)

Dynamic Pages — Elements — Click

Click on the element found in the previous step, with the `clickElement` method

```
# navigate to a page  
browser$navigate("http://luzpar.netlify.app/")  
  
# find an element  
search_icon <- browser$findElement(using = "css", value = ".fa-search")  
  
# click on it  
search_icon$clickElement()
```


Exercises

07:30

29) Go to <https://luzpar.netlify.app/constituencies/>, and click the next page button

- using the automated browser
- hint: to find the selector for the button, use an additional browser manually

30) While on the second page, click the next page button again

- hint: you will have to find the button again

Dynamic Pages — Elements — Input

- Provide input to elements, such as
 - text, with the `value` argument

```
sendKeysToElement(list(value,  
                      key  
                      )  
                  )
```

Dynamic Pages — Elements — Input

- Provide input to elements, such as
 - text, with the value argument
 - keyboard presses or mouse gestures, with the **key** argument
- Note that
 - user provides values while the selenium keys are pre-defined

```
sendKeysToElement(list(value,  
                        key  
                        )  
)
```

Dynamic Pages — Elements — Input — Selenium Keys

View the list of Selenium keys

```
as_tibble(selKeys) %>% names()
```

```
## [1] "null"      "cancel"    "help"      "backspace" "tab"
## [6] "clear"     "return"    "enter"     "shift"     "control"
## [11] "alt"       "pause"     "escape"    "space"     "page_up"
## [16] "page_down" "end"       "home"      "left_arrow" "up_arrow"
## [21] "right_arrow" "down_arrow" "insert"    "delete"    "semicolon"
## [26] "equals"    "numpad_0"  "numpad_1"  "numpad_2"  "numpad_3"
## [31] "numpad_4"  "numpad_5"  "numpad_6"  "numpad_7"  "numpad_8"
## [36] "numpad_9"  "multiply"  "add"       "separator" "subtract"
## [41] "decimal"   "divide"    "f1"        "f2"        "f3"
## [46] "f4"        "f5"        "f6"        "f7"        "f8"
## [51] "f9"        "f10"       "f11"       "f12"       "command_meta"
```

Dynamic Pages — Elements — Input — Selenium Keys — Note

Choosing the body element, you can scroll up and down a page

```
body <- browser$findElement(using = "css", value = "body")  
body$sendKeysToElement(list(key = "page_down"))
```

Dynamic Pages — Elements — Input — Example

Search the demonstration site

```
# navigate to the home page
browser$navigate("http://luzpar.netlify.app/")

# find the search icon and click on it
search_icon <- browser$findElement(using = "css", value = ".fa-search")
search_icon$clickElement()

# find the search bar on the new page and click on it
search_bar <- browser$findElement(using = "css", value = "#search-query")
search_bar$clickElement()

# search for the keyword "Law" and click enter
search_bar$sendKeysToElement(list(value = "Law", key = "enter"))
```

Dynamic Pages — Elements — Input — Example

Slow down the code where necessary, with the `Sys.sleep`

- for ethical reasons
- because R might be faster than the browser

```
# navigate to the home page
browser$navigate("http://luzpar.netlify.app/")

# find the search icon and click on it
search_icon <- browser$findElement(using = "css", value = ".fa-search")
search_icon$clickElement()

# sleep for 2 seconds
Sys.sleep(2)

# find the search bar on the new page and click on it
search_bar <- browser$findElement(using = "css", value = "#search-query")
search_bar$clickElement()

# search for the keyword "Law" and click enter
search_bar$sendKeysToElement(list(value = "Law", key = "enter"))
```

Dynamic Pages — Elements — Input — Clear

Clear text, or a value, from an element

```
search_bar$clearElement()
```


Exercise

15:00

31) Conduct an internet search programatically

- navigate to <https://duckduckgo.com/>
 - just to keep it simple, as Google would require you to scroll down and accept a policy
- find, highlight, and conduct a search

32) Scroll down programatically, and up

- to see all results

33) Go back, and conduct another search

- hint: you will have to find the search bar again

Dynamic Pages — Elements — Switch Frames

- Switch to a different frame on a page
 - some pages have multiple frames
 - you can think of them as browsers within browsers
 - while in one frame, we cannot work with the page source of another frame

```
switchToFrame(Id  
              )
```

- Note that
 - there is one such page on the demonstration website
 - <https://luzpar.netlify.app/documents/>
 - featuring a shiny app that lives originally lives at <https://resulumit.shinyapps.io/luzpar/>
 - the Id argument takes an element object, unquoted
 - setting it to NULL returns to the default frame

Dynamic Pages — Elements — Switch Frames

Switch to a non-default frame

```
# navigate to a page and wait for the frame to load
browser$navigate("https://luzpar.netlify.app/documents/")
Sys.sleep(4)

# find the frame, which is an element
app_frame <- browser$findElement("css", "iframe")

# switch to it
browser$switchToFrame(Id = app_frame)

#switch back to the default frame
browser$switchToFrame(Id = NULL)
```

Dynamic Pages — Scraping — Example

Task:

- I need to download specific documents published by the parliament
 - e.g., proposals and reports
- The related section of the website is a dynamic page
 - initially it is empty, and clicking on things do not change the URL

Plan:

- Interact with the page until it displays the desired list of documents
- Get the page source and separate the links
- Write a for loop to
 - visit the related pages one by one
 - download the documents

Dynamic Pages — Scraping — Example

Interact with the page until it displays the desired list of documents

```
# navigate to the desired page and wait a little
browser$navigate("https://luzpar.netlify.app/documents/")
Sys.sleep(4)

# switch to the frame with the app
app_frame <- browser$findElement("css", "iframe")
browser$switchToFrame(Id = app_frame)

# find and open the drop down menu
drop_down <- browser$findElement(using = "css", value = ".bs-placeholder")
drop_down$clickElement()

# choose proposals
proposal <- browser$findElement(using = 'css', "[id='bs-select-1-1']")
proposal$clickElement()

# choose reports
report <- browser$findElement(using = 'css', "[id='bs-select-1-2']")
report$clickElement()

# close the drop down menu
drop_down$clickElement()
```

Dynamic Pages — Scraping — Example

Get the page source and separate the links

```
the_links <- browser$getPageSource()[[1]] %>%  
  read_html() %>%  
  html_elements("td a") %>%  
  html_attr("href")  
  
print(the_links)
```

```
## [1] "https://luzpar.netlify.app/documents/human-rights-2021/"  
## [2] "https://luzpar.netlify.app/documents/greenhouse-gas-emissions-2021/"  
## [3] "https://luzpar.netlify.app/documents/tax-reform-2020/"  
## [4] "https://luzpar.netlify.app/documents/parliamentary-staff-2020/"  
## [5] "https://luzpar.netlify.app/documents/cyber-security-2019/"  
## [6] "https://luzpar.netlify.app/documents/electronic-cigarettes-2019/"
```

Dynamic Pages — Scraping — Example

Write a for loop to download PDFs

```
for (i in 1:length(the_links)) {  
  pdf_link <- bow(the_links[i]) %>%  
    scrape() %>%  
    html_elements(css = ".btn-page-header") %>%  
    html_attr("href") %>%  
    url_absolute(base = "https://luzpar.netlify.app/")  
  
  download.file(url = pdf_link, destfile = basename(pdf_link), mode = "wb")  
}
```

Exercise

30:00

34) Collect data on a subset of documents

- article tags and image credits
- for documents within the Law and Proposal categories
- published after 2019

Hint:

- start with the related code in the previous slides
 - modify as necessary

References

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The workshop ends here.

Congratulations for making it this far, and
thank you for joining me!

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