Automated Web Scraping with R

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Skip intro — To the contents slide.

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: Parliamentary communication allowances do not increase electoral turnout or incumbents' vote share
- teaching workshops, also on
    - writing reproducible research papers
    - version control and collaboration
    - working with Twitter data
    - creating academic websites
- more information available at resulumit.com

The Workshop — Overview

- One day, on how to automate the process of extracting data from websites
  - 150+ slides, 15+ 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 hand-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

The Workshop — Organisation

- Breakout in groups of two for exercises
  - participants learn as much from their partner as from instructors
  - switch partners after every other part
  - leave your breakout room manually, when everyone in the group is ready

- Type, rather than copy and paste, the code that you will find on these slides
  - typing is a part of the learning process
  - slides are, and will remain, available at resulumit.com/teaching/scrp_workshop.html

- When you have a question
  - ask your partner
  - google together
  - ask me

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(url = "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

- Codes and texts 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
  - with some results, such as browsers 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

Back to the contents slide.

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
    - especially while in a breakout room
  - ability to scroll across long codes on some slides

- Access at https://resulumit.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, 2020).

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 and processing data
  - an alternative: python

- 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 & Ren, 2020), for checking permissions to scrape websites
- `polite` (Perepolkin, 2019), for compliance with permissions to scrape websites
- `dplyr` (Wickham et al, 2021), for data manipulation

R Script — Start Your Script

- Check that you are in the newly 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
  - to avoid the `Untitled123` problem
  - 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 `RSelenium` 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/

Other Resources*

- `RSelenium` vignettes
  - available at https://cran.r-project.org/web/packages/RSelenium/vignettes/basics.html
- R for Data Science (Wickham & Grolemund, 2019)
  - open access at https://r4ds.had.co.nz
- Text Mining with R: A Tidy Approach (Silge & 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
      - e.g., scraping a commercial website to create a rival website
    - physically
      - 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

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

- In case you write your own protocol one day, note that
  - the keys start with capital letters
  - they are followed by a colon :

Considerations — the Ethics — `robots.txt` — Syntax

- Websites define their own values
  - after a colon and a white space

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

- 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

Considerations — the Ethics — `robots.txt` — Syntax

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

```
# thank you for respecting our protocol

User-agent: *
Allow: /
Disallow: /about/
Crawl-delay: 5    # five second delay, to ensure our servers are not overloaded
```

Considerations — the Ethics — `robots.txt` — Syntax

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` — Syntax

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` — Syntax

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 — `robotstxt`

- The `robotstxt` packages 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
  - `robotstxt`, which gets complete protocols
  - `paths_allowed`, which checks protocols for one or more specific paths

Considerations — the Ethics — `robotstxt`

Use the `robotstxt` function to get a protocol

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

```
robotstxt(
  domain = NULL,
  ...
)
```

Considerations — the Ethics — `robotstxt`

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

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

Considerations — the Ethics — `robotstxt`

Use the `paths_allowed` function to checks 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 — `robotstxt`

```
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

07:30

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

- via a browser and with the `robotstxt` function
- 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

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

- with the `robotstxt` function

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 4 and Part 5 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. Webpage Source Code

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Webpage 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

Webpage Source Code — View in Browser

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

Webpage Source Code — View in Browser — DOM

Browsers also offer putting source codes in a structure

- known as DOM (document object model), initiated by the `F12` key on Chrome

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

Webpage Source Code — 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>
```

Webpage Source Code — 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>
```

Webpage Source Code — 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>
```

Webpage Source Code — HTML — the Root

`html` is 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>
```

Webpage Source Code — 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>
```

Webpage Source Code — HTML — Overview

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>
```

Webpage Source Code — HTML — Syntax

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

Webpage Source Code — HTML — Syntax

Most elements have some content

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

This is a one sentence paragraph.

Webpage Source Code — HTML — Syntax

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

Webpage Source Code — HTML — Syntax

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

- the id attribute is not visible to the visitors
- 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

- there are some other attributes that are visible

Webpage Source Code — HTML — Syntax

There could be more than one attribute in an 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

- there could be more than one attribute in an element
  - with a white space in between them
- the `class` attribute can apply to multiple elements
  - while the `id` attribute must be unique on a page

Webpage Source Code — HTML — Important Elements & Attibutes

Links are provided with the a (anchor) element

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

Click here to google things.

Note that

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

Webpage Source Code — HTML — Links

Links

```
<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 to google things.

Note that

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

Webpage Source Code — HTML — Lists

The `<lu>` tag introduces un-ordered lists, while the `<li>` 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 the `<lo>` tag instead

Webpage Source Code — HTML — Notes

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

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


</ul>
```

- 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

Exercises

10:00

6) Re-create the body of 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 an attribute to an element

- which is not already on the original page
- hints:
  - there are at least two attributes for the list elements on the original page
  - google to see what attributes list items accept
  - https://www.w3schools.com/ is a great place to look at
  - save this document as we will continue working on it

Webpage Source Code — CSS — Overview

- CSS stands for cascading stylesheets
  - 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

Webpage Source Code — CSS — Syntax

CSS is written in rules

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

.count {background-color:yellow;}

#sentence-count {color:red;}
```

Webpage Source Code — 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
    - among attributes, classes and ids

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

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;}
```

Webpage Source Code — 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:14px;}
```

Webpage Source Code — 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

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

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;}
```

- Note that
  - properties are followed by a colon

Webpage Source Code — CSS — Syntax

- CSS is written in rules, with a syntax consisting of
  - one or more selectors
  - a declaration, with one or more properties and values

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

h1 h2 {color:blue;}

.count {background-color:yellow;}

#sentence-count {color:red; font-size:14px;}
```

- Note that
  - values are followed by a semicolon
  - `property:value;` pairs are separated by a white space

Webpage Source Code — 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>
```

Webpage Source Code — 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>
```

Webpage Source Code — 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

05:00

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 element and/or attributes

- no idea what to do? try
  - increasing the font size of the text in paragraph
  - change the colour of the second item in the list to red

Part 3. Scraping Static Pages

Back to the contents slide.

Static Pages — Overview

- We will collect data from static pages with the `rvest` package
  - static pages are those that display the same source code to all visitors
    - including the content — it does not change
  - every visitor sees the same page at a given URL
  - each page has a different URL
  - https://luzpar.netlify.app/ is a static page

- Scraping static pages involves two main tasks
  - download the source code from one or more pages to R
    - typically, the only interaction with the page itself
  - select the exact information needed from the source code
    - takes place locally, on your machine
    - the main functionality that `rvest` offers
      - with the help from selectors

Static Pages — `rvest` — Overview

- A relative small R package for web scraping
  - created by Hadley Wickham
  - popular — used by many for web scraping
    - downloaded 622,724 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 and 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">\n<meta charset
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="page-w
```

Static Pages — `rvest` — Get Source Code

You may wish to check the protocol first

```
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">\n<meta charset
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="page-w
```

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

- The `polite` package facilitates ethical scraping
  - recommended by `rvest`

- It divides the process of getting source code into two
  - check the protocol
  - get the source only if allowed

- It also
  - waits for a period of time
    - minimum by what is specified in the protocol
  - allows you to introduce yourself 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

```
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

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`

- Second, use the `scrape` function get source code
  - for an object created with the `bow` function

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

- Note that
  - `scrape` will only work if the results from `bow` are positive
    - creating a safety valve for ethical scraping
  - by piping, `bow` into `scrape`, you can avoid creating objects

Static Pages — `rvest` — Get Source Code

These two are equal, when 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" content="text/html; charset=UTF-8">\n<meta charset
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="page-w
```

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

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

Static Pages — `rvest` — Get Source Code

The difference occurs when there is a protocol against the access

```
bow(url = "https://luzpar.netlify.app/states/", user_agent = "googlebot")
```

```
## <polite session> https://luzpar.netlify.app/states/
##     User-agent: googlebot
##     robots.txt: 2 rules are defined for 2 bots
##    Crawl delay: 5 sec
##   The path is not scrapable for this user-agent
```

```
bow(url = "https://luzpar.netlify.app/states/", user_agent = "googlebot") %>%
    scrape()
```

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

## NULL
```

Static Pages — `rvest` — `html_elements`

- Get one or more HTML elements
  - specified with a selector
    - CSS or XPATH
  - we will work with css in this workshop
    - facilitated by Chrome and SelectorGagdet

```
html_element(x,
             css,
             xpath)

html_elements(x,
              css,
              xpath)
```

- Note that
  - there are two versions of the same function
    - singular one gets the first instance of an element
    - plural one gets all instances

Static Pages — `rvest` — `html_elements`

Get the anchor (a) elements on the homepage

```
bow(url = "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-circle text-muted
##  [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 fa-search" aria-
## [10] <a href="#" class="nav-link" data-toggle="dropdown" aria-haspopup="true" aria-label="Disp
## [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</span></a>
## [14] <a href="https://github.com/resulumit/scrp_workshop" target="_blank" rel="noopener">a wor
## [15] <a href="https://resulumit.com/" target="_blank" rel="noopener">Resul Umit</a>
```

Static Pages — `rvest` — `html_elements`

I would like to get only the URLs on the main body of the page

- SelectorGadget tells me the correct selector is `#title a`

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

```
## {xml_nodeset (9)}
## [1] <a href="https://github.com/resulumit/scrp_workshop" target="_blank" rel="noopener">a work
## [2] <a href="https://resulumit.com/" target="_blank" rel="noopener">Resul Umit</a>
## [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="noopener">Blogdown</a>
## [8] <a href="https://gohugo.io/" target="_blank" rel="noopener">Hugo</a>
## [9] <a href="https://github.com/wowchemy" target="_blank" rel="noopener">Wowchemy</a>
```

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

```
html_text(x, trim = FALSE)

html_text2(x, preserve_nbsp = FALSE)
```

- 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

Static Pages — `rvest` — `html_text`

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

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

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

```
## [[1]]
##                                        href                                                target
## "https://github.com/resulumit/scrp_workshop"                                             "_blank"
##                                         rel
##                                   "noopener"
##
## [[2]]
##                      href                  target                       rel
## "https://resulumit.com/"                 "_blank"              "noopener"
##
## [[3]]
##          href
## "/documents/"
##
## [[4]]
##               href
```

Static Pages — `rvest` — `html_attr`

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

```
## [1] "https://github.com/resulumit/scrp_workshop" "https://resulumit.com/"
## [3] "/documents/"                                 "/constituencies/"
## [5] "/members/"                                   "/states/"
## [7] "https://github.com/rstudio/blogdown"        "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 `/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(url = "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/resulumit/scrp_workshop" "https://resulumit.com/"
## [3] "https://luzpar.netlify.app/documents/"      "https://luzpar.netlify.app/constituencies/"
## [5] "https://luzpar.netlify.app/members/"        "https://luzpar.netlify.app/states/"
## [7] "https://github.com/rstudio/blogdown"        "https://gohugo.io/"
## [9] "https://github.com/wowchemy"
```

Static Pages — `rvest` — `html_table`

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

```
bow(url = "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
```

Static Pages — `rvest`

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

```
tibble(

"Member" = bow(url = "https://luzpar.netlify.app/members/") %>%
        scrape() %>%
        html_elements(css = "td:nth-child(1)") %>%
        html_text(),

"Constituency" = bow(url = "https://luzpar.netlify.app/members/") %>%
        scrape() %>%
        html_elements(css = "td:nth-child(2)") %>%
        html_text(),

"Party" = bow(url = "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(url = "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

9) 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(url = "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

10) 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/files/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 5. 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
    - while the URL remains the same
  - depending on, for example, their own input
    - e.g., clicks, scrolls
  - https://luzpar.netlify.app/documents/ is a page with a dynamic part

- Dynamic pages are more difficult than static pages to scrape
  - it involves three, instead of two, steps
  - we will have a new package, `RSelenium`, for the additional step

Dynamic Pages — Three Steps to Scrape

Scraping dynamic pages involves three main tasks

- 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
- Select the exact information needed from the source code
  - as for static pages
  - with the th`rvest` page

Dynamic Pages — `Rselenium` — Overview

- A package that integrates Selenium 2.0 WebDriver into R
  - created by John Harrison
  - downloaded 4,874 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
  - as it follows the logic behind Selenium

- It allows interacting with two things — and it is crucial that we are aware of the difference
  - browsers
    - e.g., opening a browser and navigating to a page
  - elements
    - 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
  - tying 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
  - tying to start two servers from the same port
  - any mismatch between the version and driver numbers

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

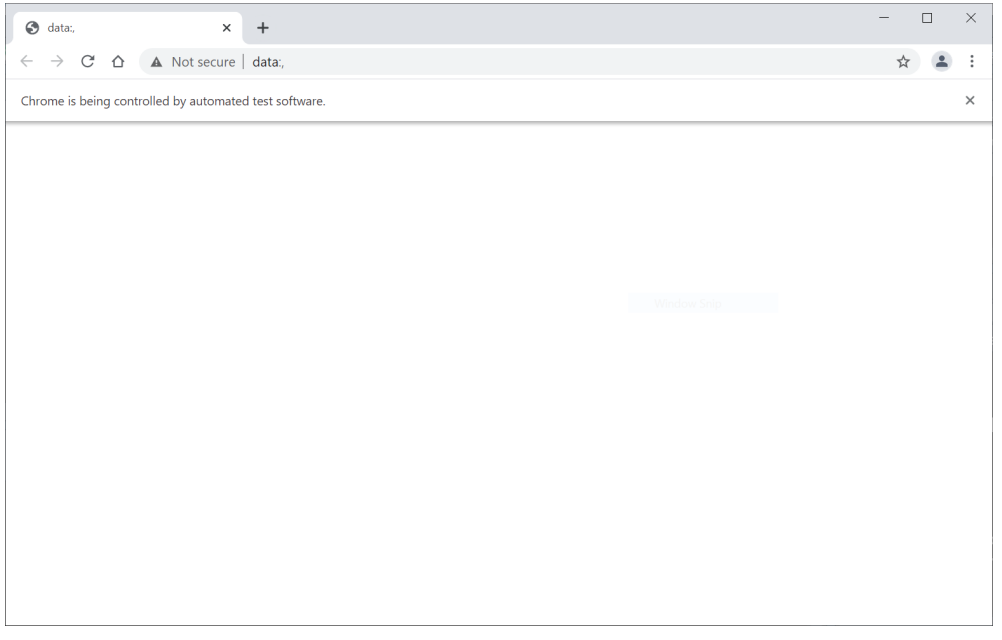
```
## $win32
## [1] "89.0.4389.23" "90.0.4430.24" "91.0.4472.19"
```

- Note that
  - you can only use the version that *you* get
  - not one of the version that you see 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

```
driver <- rsDriver(chromever = "90.0.4430.24"
```



- 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

Dynamic Pages — Browsers — Starting a Server

Separate the client and server as different objects

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

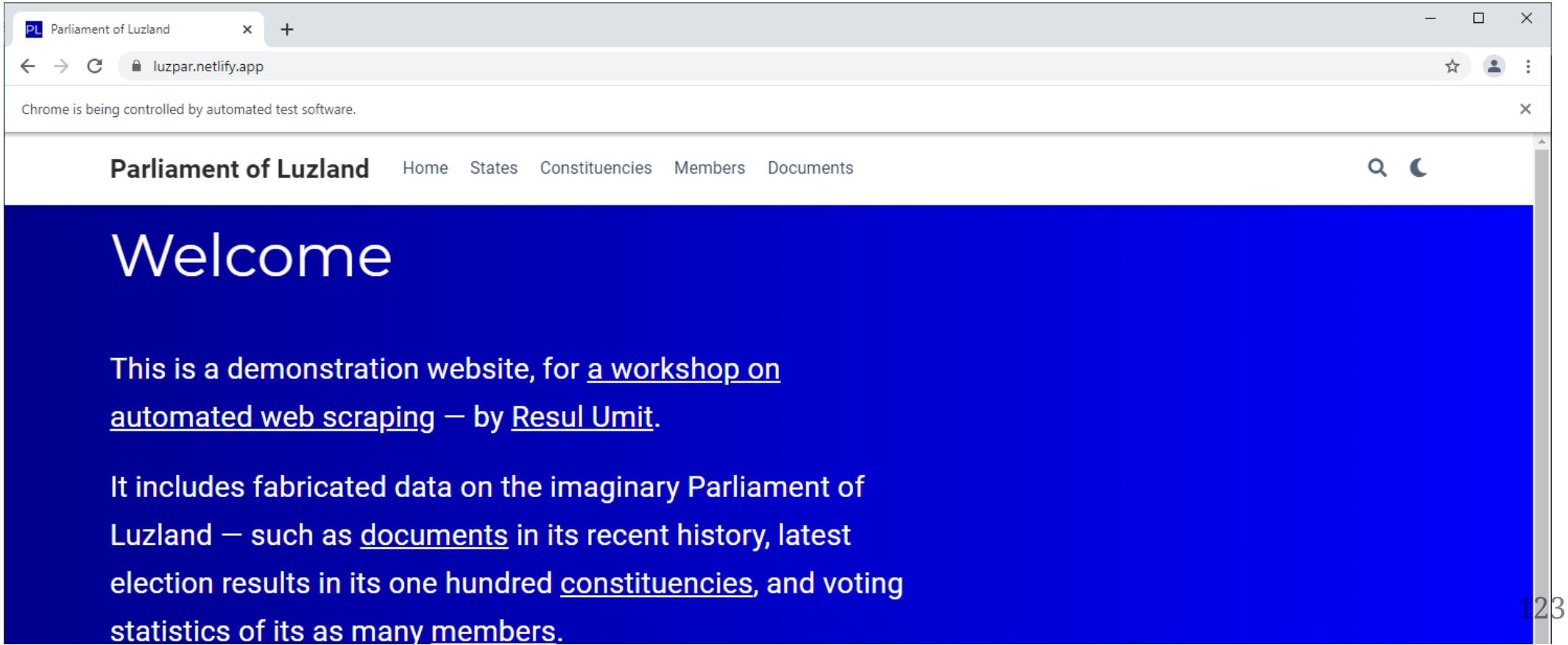
Note that

- `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`

Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser$navigate(url = "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
  - it is not necessary to type the name of the `url` argument

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()
```

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 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

Get the page source

- by combining the two package

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

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

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by using both packages

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

Note that

- this method gets the source for only what is physically visible on the browser
- window size and position might become important
  - you may wish to maximise the window

```
browser$browser$maxWindowSize()
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by using both packages

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

Note that

- we still need the `read_html()` function
  - to turn XML into HTML

Exercises

15:00

11) Navigate to and get the source code of a page

- e.g., https://luzpar.netlify.app/constituencies/
- by using both packages

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

- by typing the object name for your client into R console
  - followed by the dollar sign
  - and hitting the tab key on your keyboard if necessary
- read the description for one or more of them

14) Try one or more new methods

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

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

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

- Note that
  - the default selector is `xpath`
  - requires entering the `xpath` value

Dynamic Pages — Elements — Find

- Locate an element on the open browser
  - using CSS selectors

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

- Note that
  - typing "css", instead of "css selector", also works
  - there are other selector schemes as well, including
    - id
    - name
    - link text

Dynamic Pages — Elements — Find — Selectors

If there were a button on a page with the following DOM...

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

Any of the following 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

```
# navitage 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 fill 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

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

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

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

Note that

- the highlighted element fill 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`)
  - compare it to the find method

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()
```

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

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

- Note that
  - user provides values while the selenium keys are pre-defined

Dynamic Pages — Elements — Input — Selenium Keys

View the list of Selenium keys

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

```
##  [1] "null"         "cancel"       "help"         "backspace"    "tab"          "clear"
##  [7] "return"       "enter"        "shift"        "control"      "alt"          "pause"
## [13] "escape"       "space"        "page_up"      "page_down"    "end"          "home"
## [19] "left_arrow"   "up_arrow"     "right_arrow"  "down_arrow"   "insert"       "delete"
## [25] "semicolon"    "equals"       "numpad_0"     "numpad_1"     "numpad_2"     "numpad_3"
## [31] "numpad_4"     "numpad_5"     "numpad_6"     "numpad_7"     "numpad_8"     "numpad_9"
## [37] "multiply"     "add"          "separator"    "subtract"     "decimal"      "divide"
## [43] "f1"           "f2"           "f3"           "f4"           "f5"           "f6"
## [49] "f7"           "f8"           "f9"           "f10"          "f11"          "f12"
## [55] "command_meta"
```

Dynamic Pages — Elements — Input — Selenium Keys — Note

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

```
body <- broswer$findElement(using = "css", value = "body")
body$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

10:00

15) 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 fill in the search bar
  - hit enter

16) Scroll down programatically, and up

- to see all results

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(url = 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))

}
```

Exercise

30:00

17) 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, and adopt it to your needs

References

Back to the contents slide.

References

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Meissner, P., & Ren, K. (2020). robotstxt: A 'robots.txt' Parser and 'Webbot'/'Spider'/'Crawler' Permissions Checker. R package, version 0.7.13.

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The workshop ends here.

Congradulations for making it this far, and

thank you for joining me!

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