

Maintenance of Selenium Tests for Web Applications

Laurent Christophe, Reinout Stevens, Coen De Roover,
Wolfgang De Meuter

`{lachrist, resteven, cderoove, wdmeuter}@vub.ac.be`

What is Selenium?

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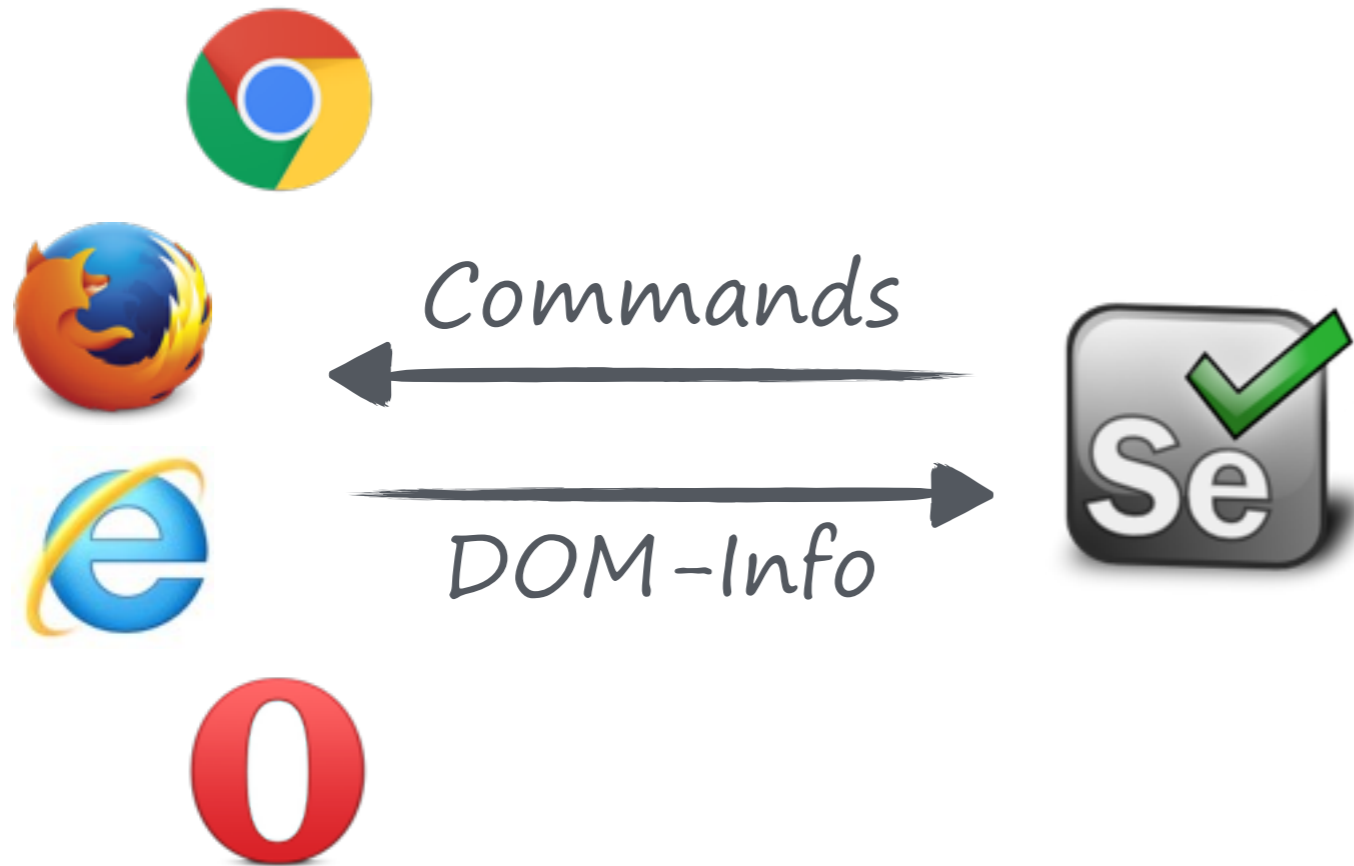
Selenium automates
browsers!



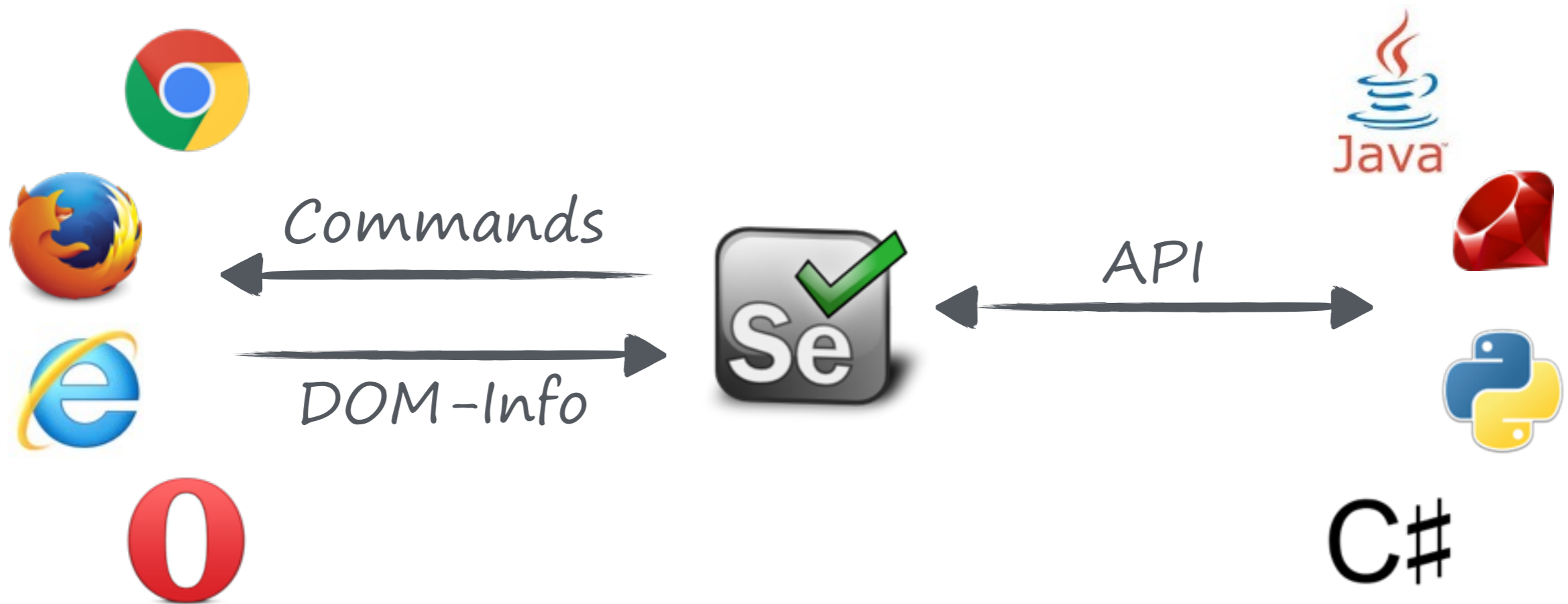
What is Selenium?



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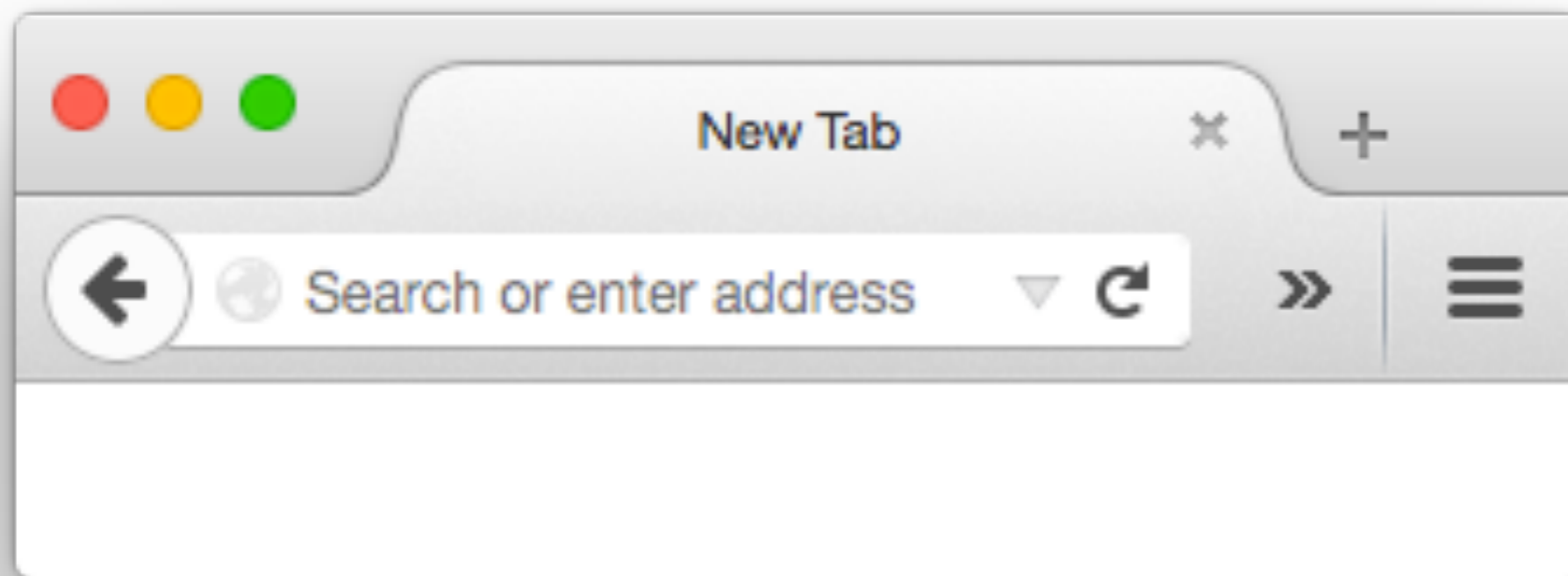


Test Breakage

```
WebDriver driver = new FirefoxDriver();  
driver.get("http://www.birthdate.com");  
WebElement field = driver.findElement(By.name("birthdate"));  
field.sendKeys("19-08-1989");  
field.submit();  
assertEquals(driver.getTitle(), "adult");  
driver.quit();
```

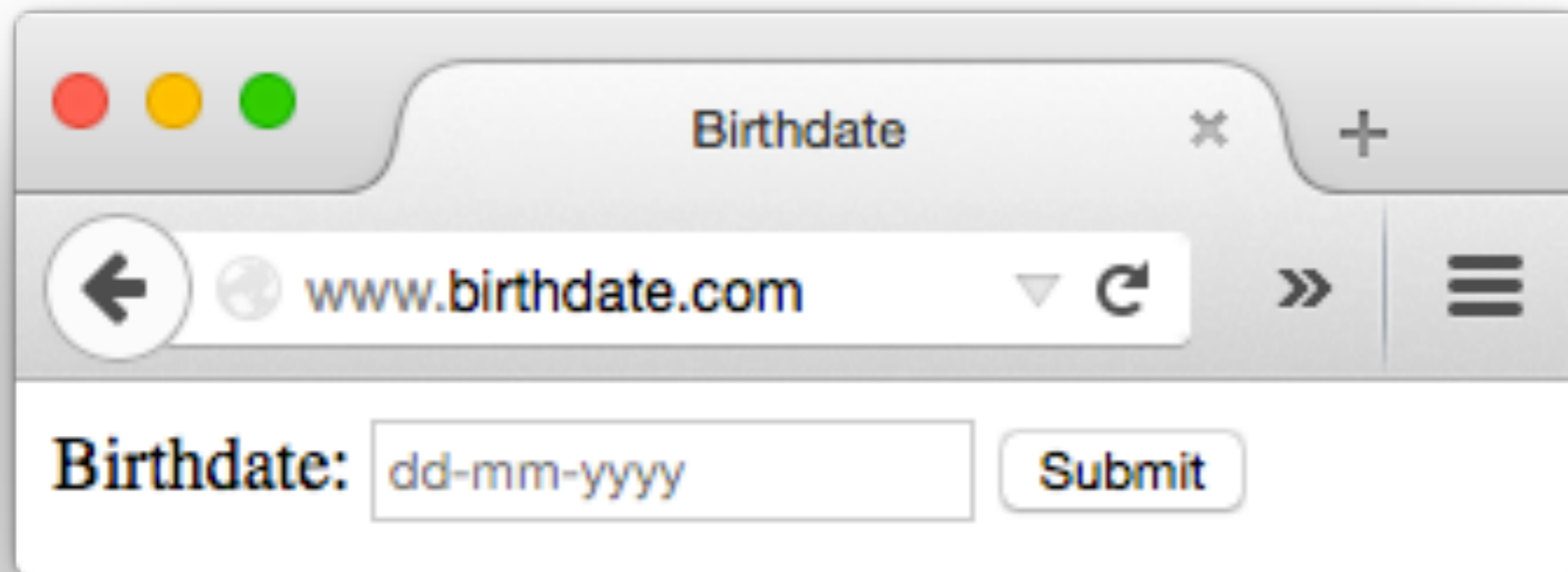
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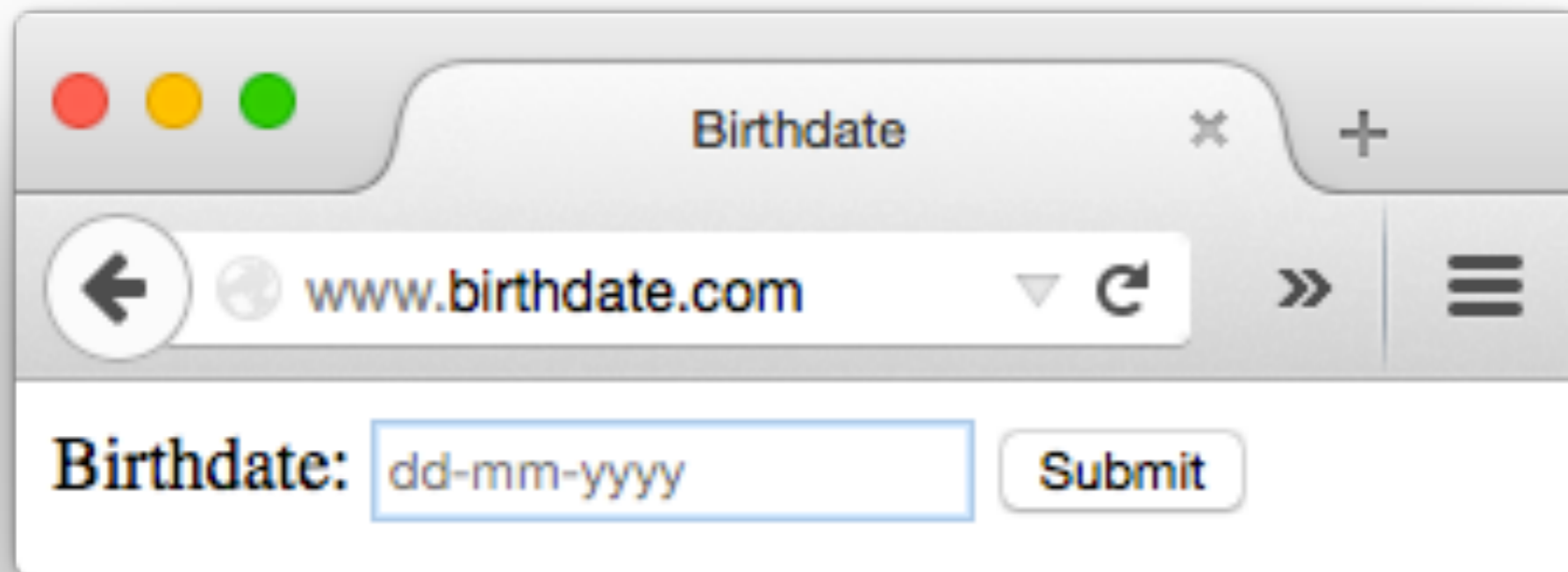
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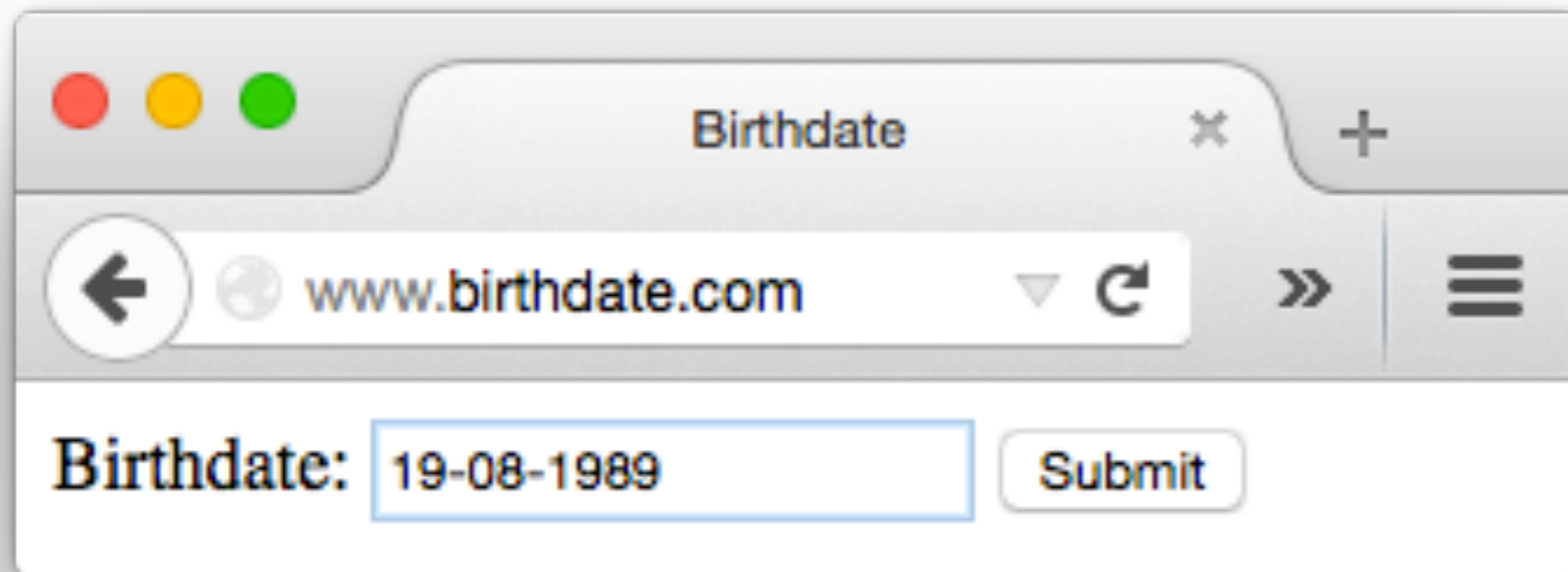
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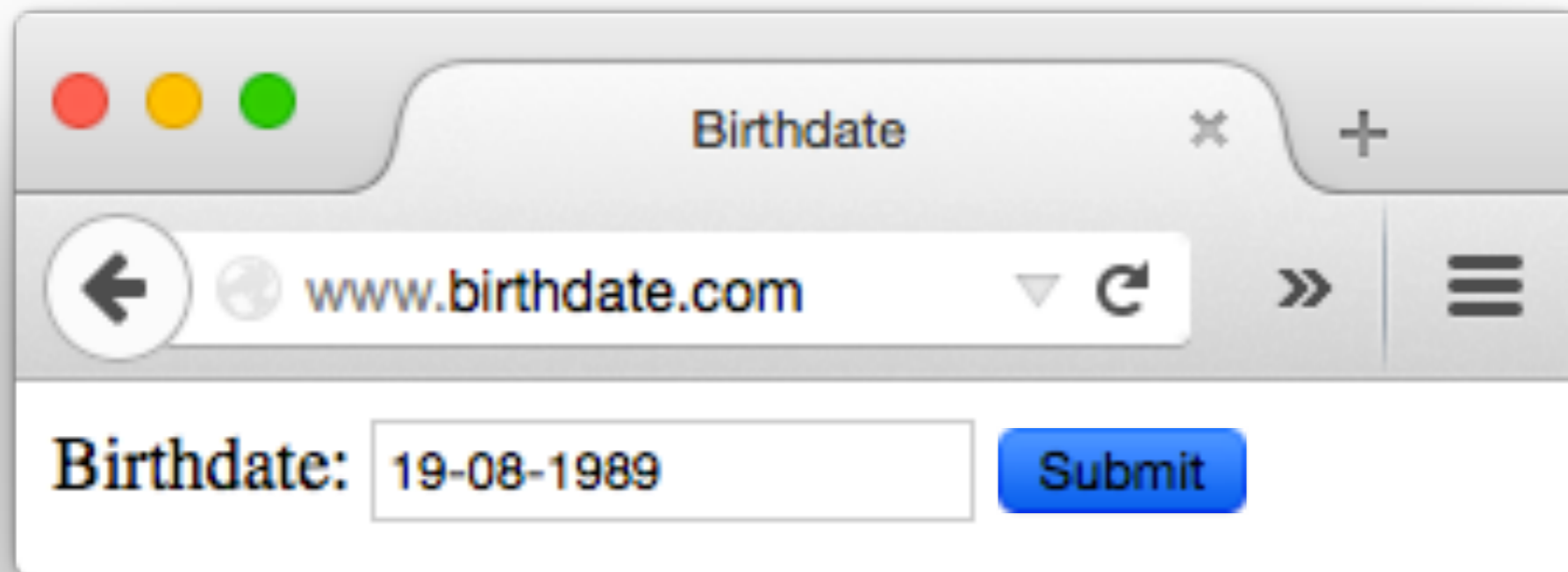
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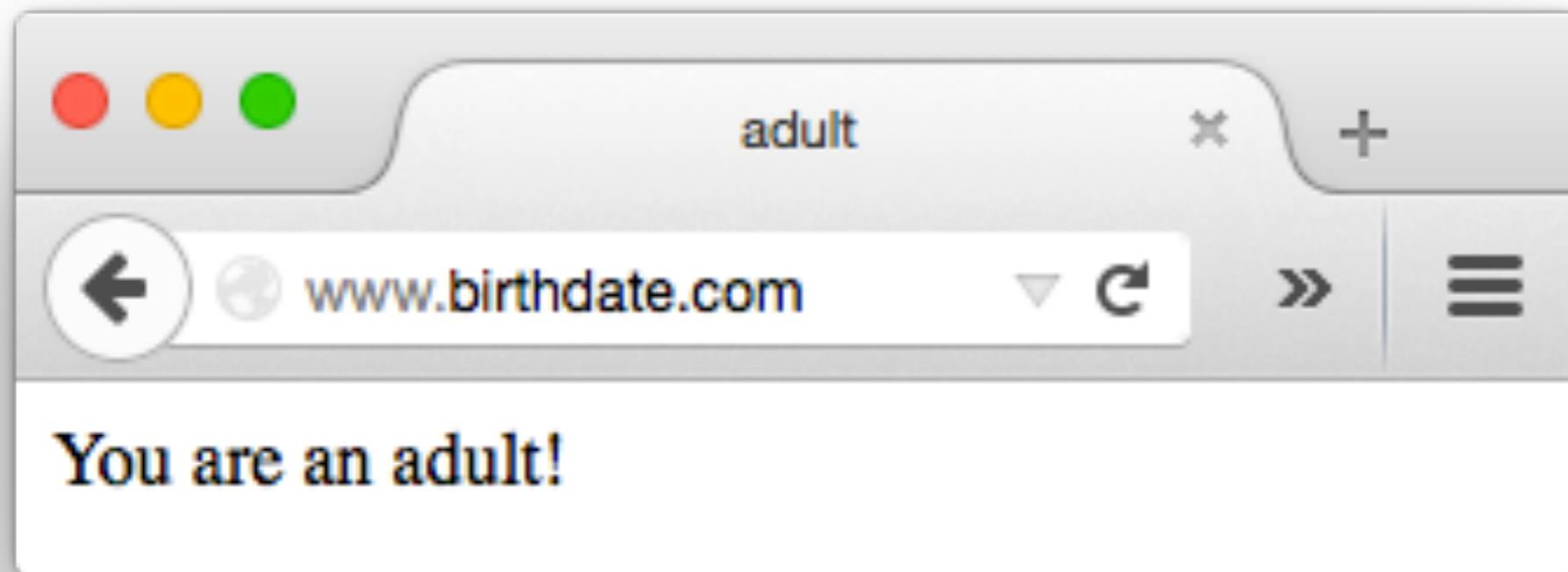
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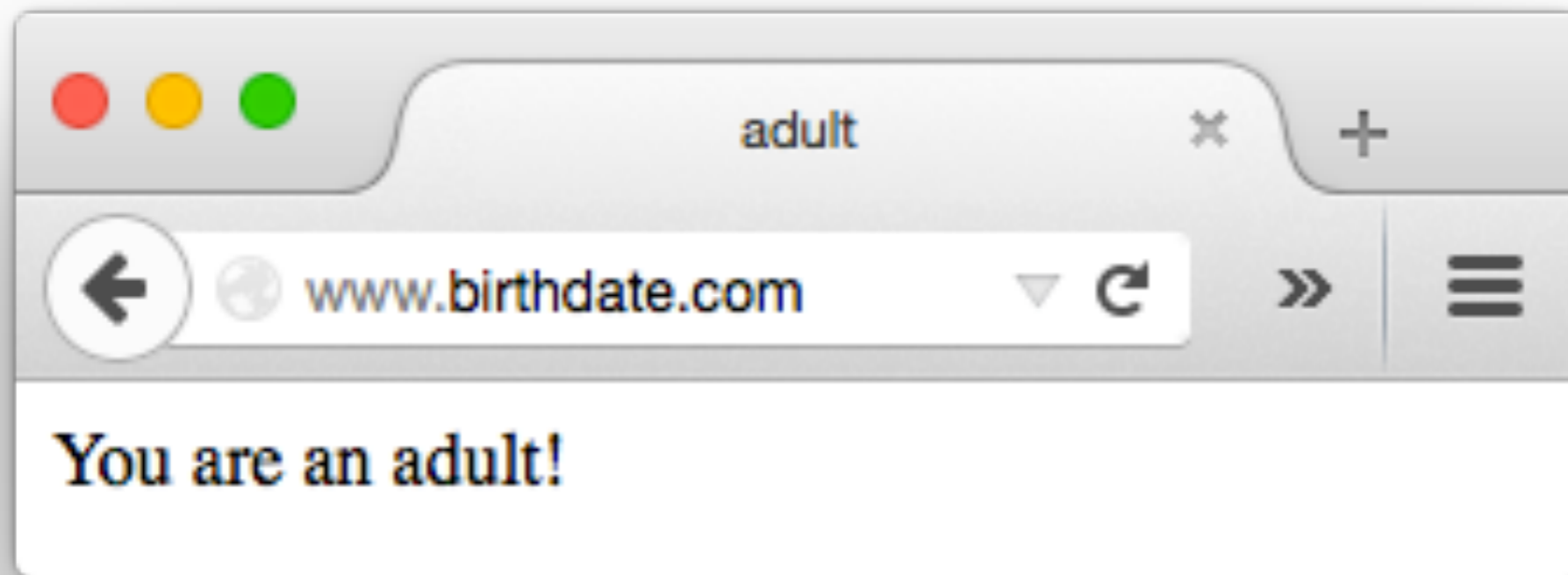
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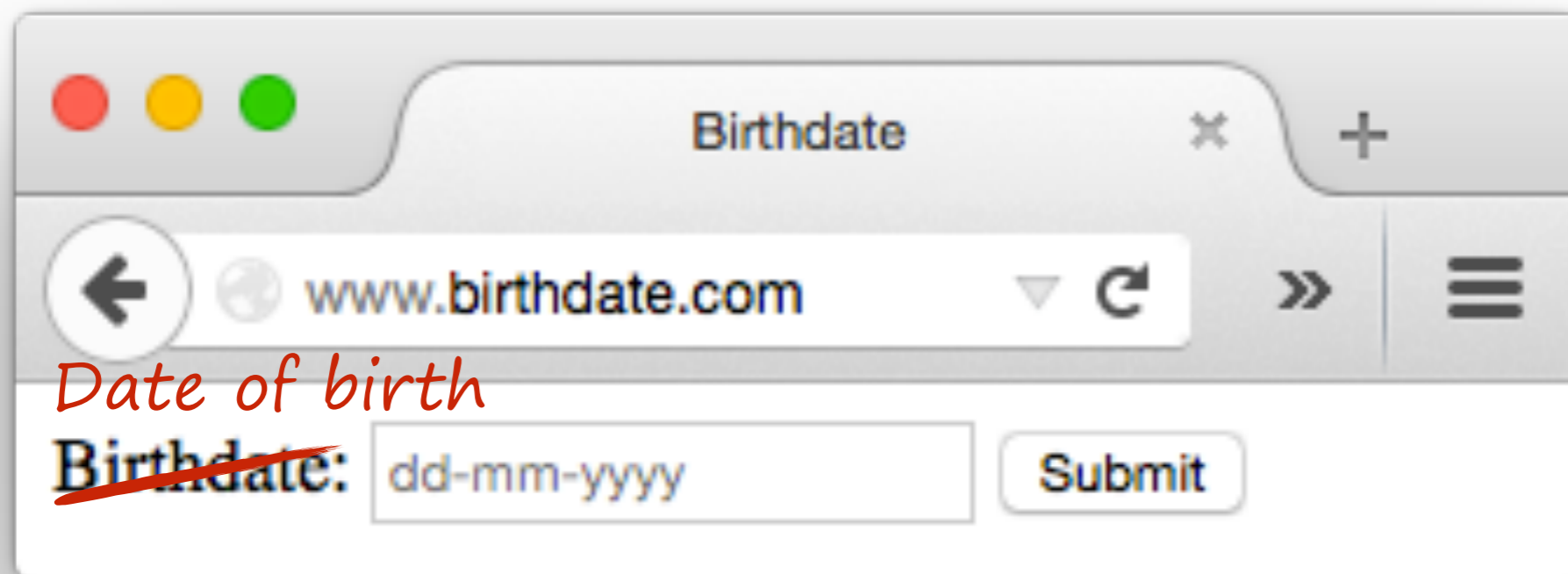


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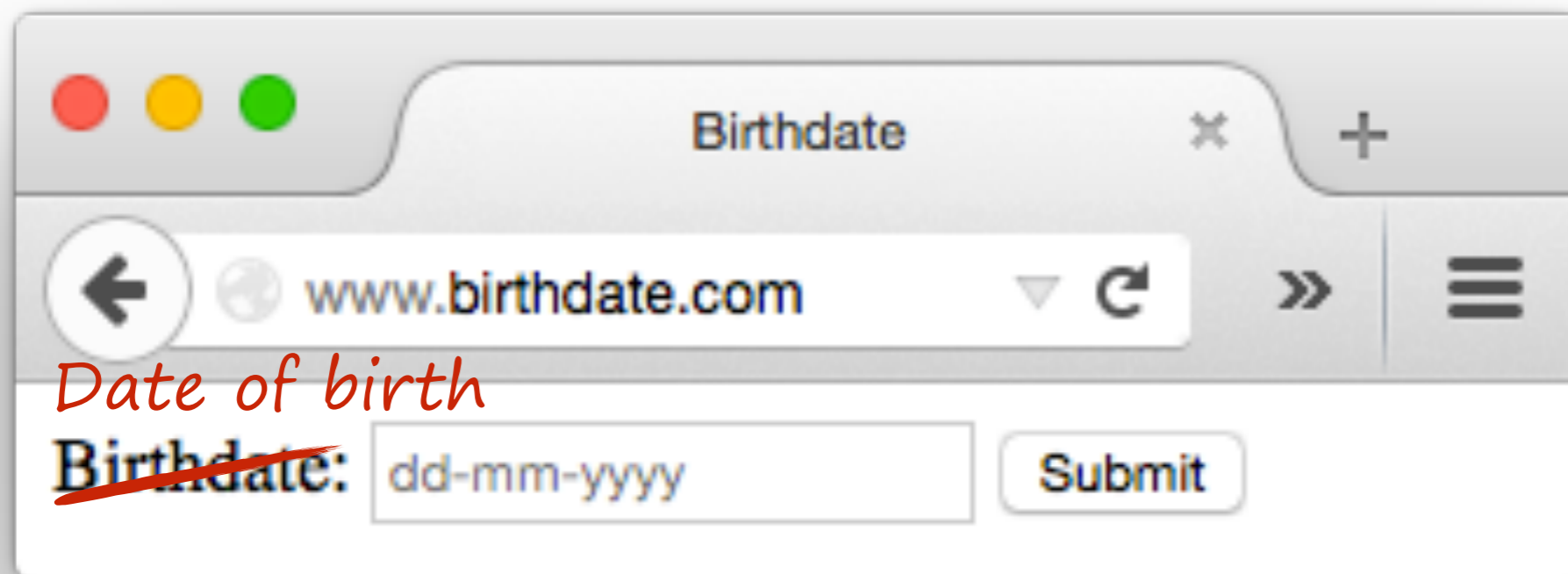
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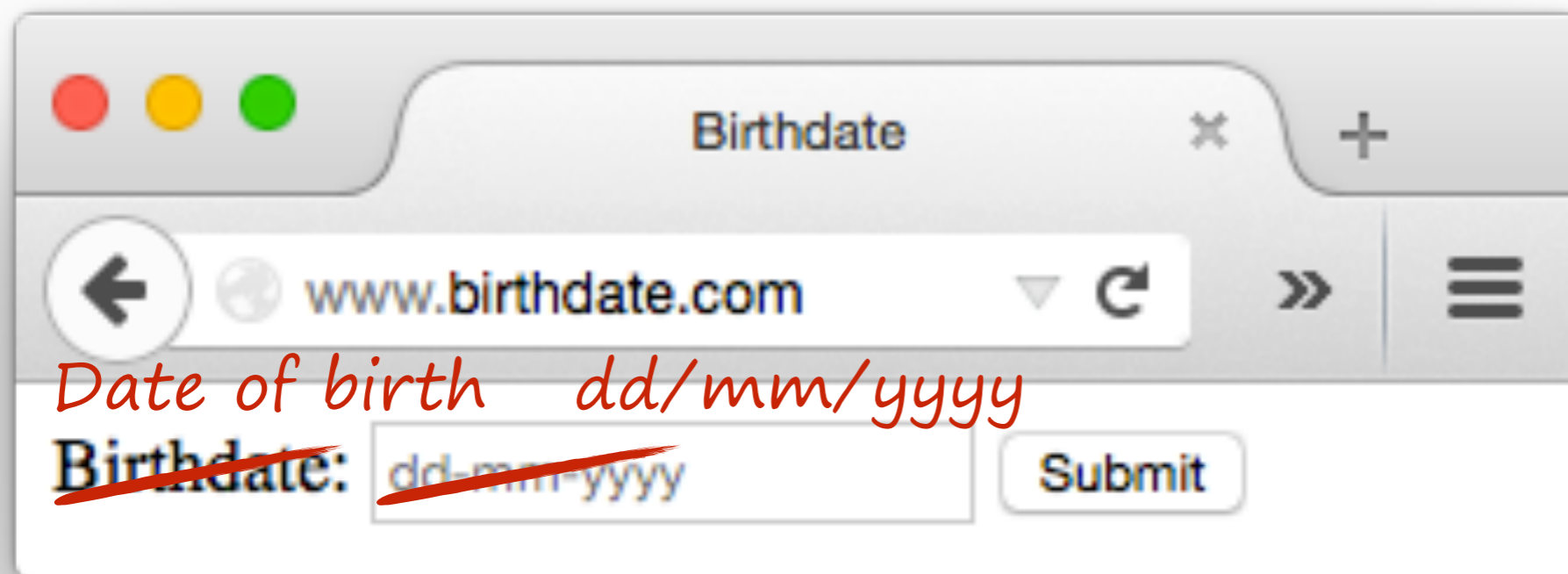
"date-of-birth"



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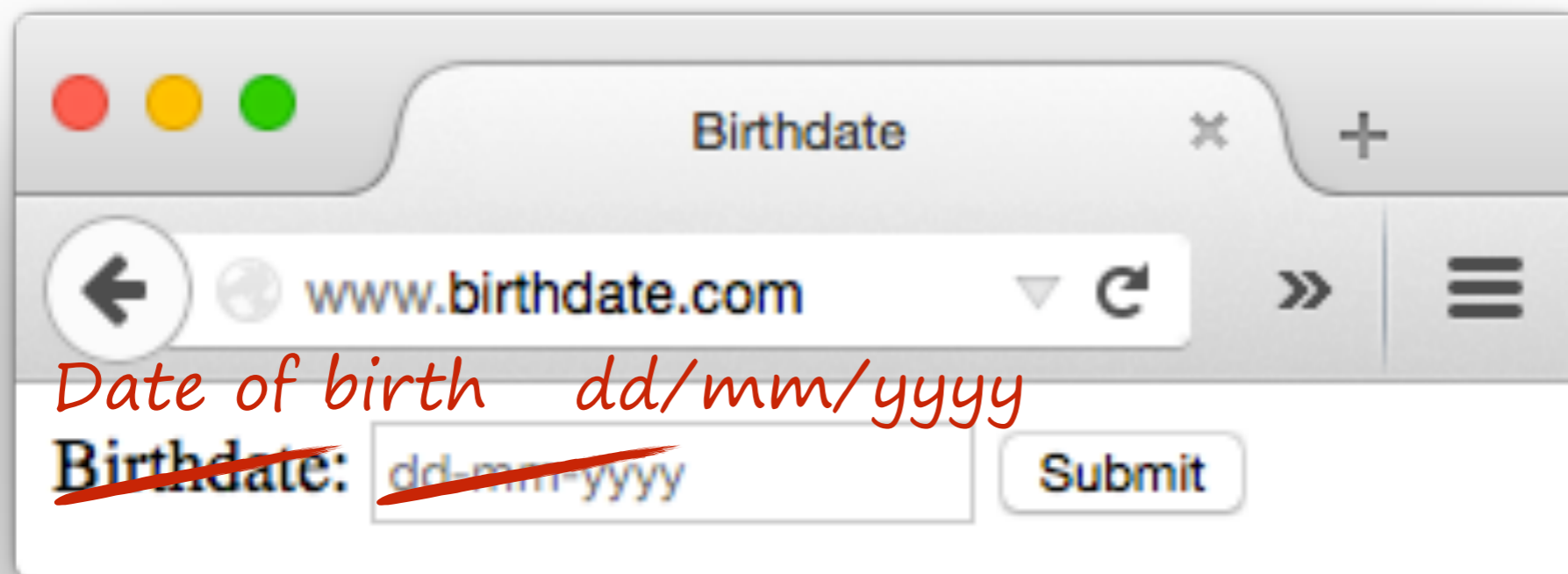
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WebDriver driver = new FirefoxDriver();
driver.get("http://www.birthdate.com");
WebElement field = driver.findElement(By.name("birthdate"));
field.sendKeys("19-08-1989"); "19/08/1989"
field.submit();
assertEquals(driver.getTitle(), "adult");
driver.quit();
```

"date-of-birth"

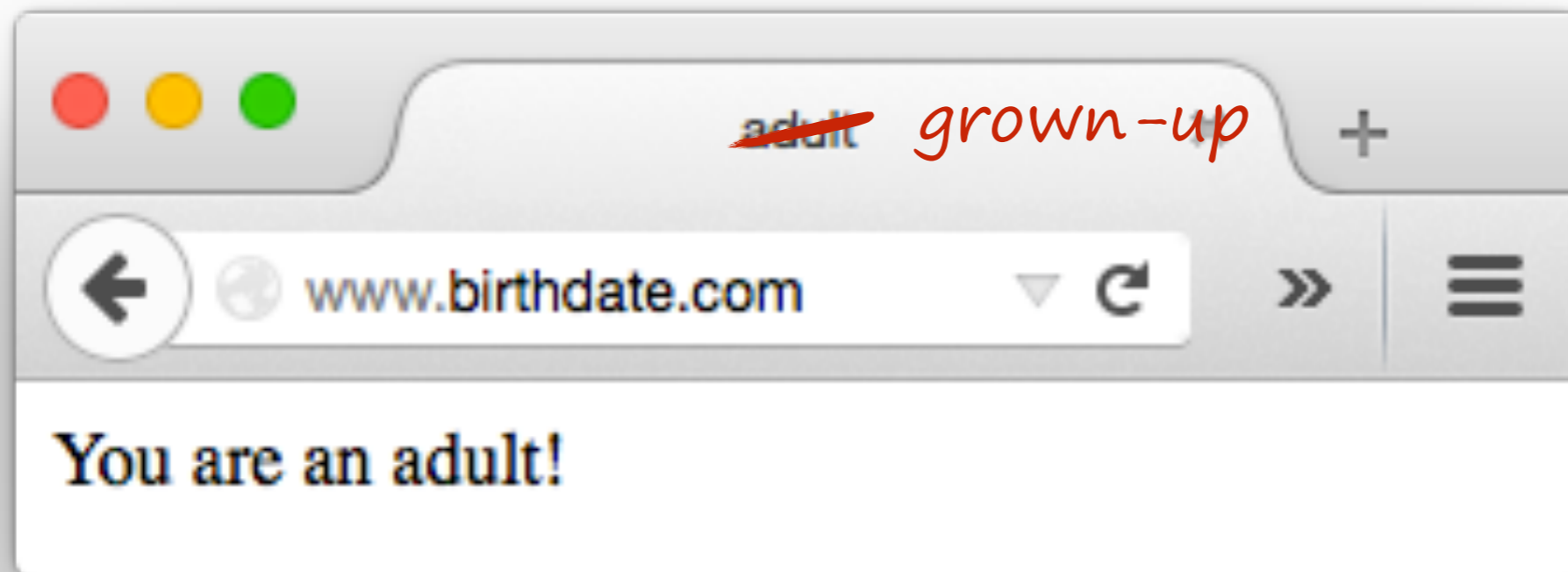


Test Breakage

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WebElement field = driver.findElement(By.name("birthdate"));  
field.sendKeys("19-08-1989"); "19/08/1989"  
field.submit();  
assertEquals(driver.getTitle(), "adult");  
driver.quit();
```

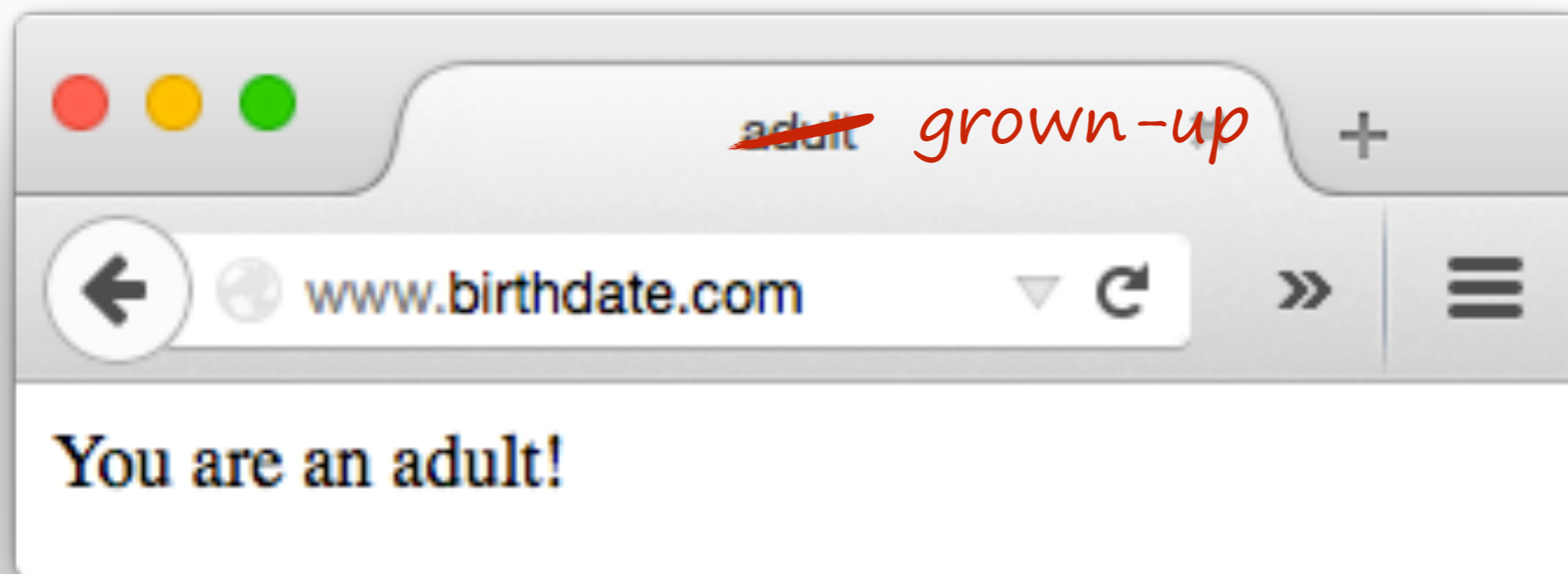
"date-of-birth"

"19/08/1989"



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driver.get("http://www.birthdate.com");  
WebElement field = driver.findElement(By.name("birthdate"));  
field.sendKeys("19-08-1989"); "19/08/1989"  
field.submit();  
assertEquals(driver.getTitle(), "adult"); "grown-up"  
driver.quit();
```



Scraping GitHub

<https://github.com/search?q=openqa.selenium&ref=searchresults&type=Code&utf8=✓>



Explore Gist Blog Help

Search

openqa.selenium

Repositories	4
Code	416,708
Issues	11
Users	

We've found 416,708 code results



detro/ghostdriver – package-list

Last indexed on Jul 23

1 | org. openqa . selenium .phantomjs



anna1219/EduVideoApp – package-list

Last indexed on Jul 25

1 | com.thoughtworks. selenium
2 | com.thoughtworks. selenium .condition
3 | org. openqa . selenium

Languages

Java

162,985

Scraping GitHub

The image shows a Selenium script on the left and a GitHub search results page on the right. A Selenium icon with a green checkmark is positioned above the code. Two curved arrows connect the Selenium code to the GitHub page: one from the Selenium icon to the search input field, and another from the 'Code' repository count to the Selenium code.

```
1 import java.util.Iterator;
2 import java.util.List;
3
4 import org.openqa.selenium.By;
5 import org.openqa.selenium.WebDriver;
6 import org.openqa.selenium.WebElement;
7 import org.openqa.selenium.firefox.FirefoxDriver;
8
9 public class Scraper {
10
11     public static class RateLimitException extends Exception {
12         public RateLimitException(String msg) {
13             super(msg);
14         }
15     }
16
17     private static void printLinks(WebDriver driver) {
18         String xpath = "//div[@class='code-search-results']";
19         List links = driver.findElements(By.xpath(xpath));
20         Iterator iter = links.iterator();
21         while(iter.hasNext()) {
22             xpath = ".//p[@class='text']/a";
23             List links = iter.next().findElements(By.xpath(xpath));
24             String repositoryURL = links.get(0).getAttribute("href");
25             String fileURL = links.get(1).getAttribute("href");
26             System.out.println(repositoryURL + " " + fileURL);
27         }
28     }
29
30     private static void fetchURL(WebDriver driver, String url)
31         throws RateLimitException {
32         driver.get(url);
33         List links = driver.findElements(By.xpath("//a"));
34         Iterator iter = links.iterator();
35         while(iter.hasNext()) {
36             if (iter.next().getText().contains("Whoa there!")) {
37                 throw new RateLimitException("GitHub rate exceeded!");
38             }
39         }
40     }
41
42     public static void main(String[] args)
43         throws RateLimitException, InterruptedException {
44         int minSize = 1000;
45         int maxSize = 1050;
46         long delay = 1000;
47         WebDriver driver = new FirefoxDriver();
48         String url = "https://github.com/search?ref=searchresults";
49         url = url + "?q=openqa.selenium";
50         url = url + "&type=code";
51         url = url + "&per_page=" + minSize;
52         url = url + "&page=" + 1;
53         for (int i = 1; i <= 100; i++) {
54             fetchURL(driver, url + "&page=" + i);
55             Thread.sleep(delay);
56             printLinks(driver);
57         }
58         driver.quit();
59     }
60 }
```

<https://github.com/search?q=openqa.selenium&ref=searchresults&type=Code&utf8=✓>

Search

We've found 416,708 code results

Category	Count
Repositories	4
Code	416,708
Issues	11
Users	

Languages

Java	162,985
------	---------

Repository results:

- 1 **org.openqa.selenium.phantomjs**
- 2 **com.thoughtworks.selenium**
- 3 **com.thoughtworks.selenium.condition**

Scraping GitHub

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1 import java.util.Iterator;
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6 import org.openqa.selenium.WebElement;
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11     public static class RateLimitException extends Exception {
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13             super(msg);
14         }
15     }
16
17     private static void printHits(WebDriver driver) {
18         String xpath = "//div[@class='code-search-results']";
19         List hits = driver.findElements(By.xpath(xpath));
20         Iterator iter = hits.iterator();
21         while(iter.hasNext()) {
22             xpath = ".//div[@class='code-search-result']";
23             List links = iter.next().findElements(By.xpath(xpath));
24             String repositoryURL = links.get(0).getAttribute("href");
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52         url = url + "&size=" + maxSize;
53         for (int i = 1; i <= 100; i++) {
54             fetchURL(driver, url + "&p=" + i);
55             Thread.sleep(delay);
56             printHits(driver);
57         }
58         driver.quit();
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```

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Languages
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detro/ghostdriver – package-list
 Last indexed on Jul 23
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anna1219/EduVideoApp – package-list
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 1 com.thoughtworks.selenium
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Language	Keyword	# Repositories	# Files
Java	openqa.selenium	4287	113435
Python	from selenium import webdriver	1800	6207
Ruby	require selenium webdriver	1503	9169
C#	using OpenQA.Selenium	558	14473
JavaScript	require selenium webdriver	237	643

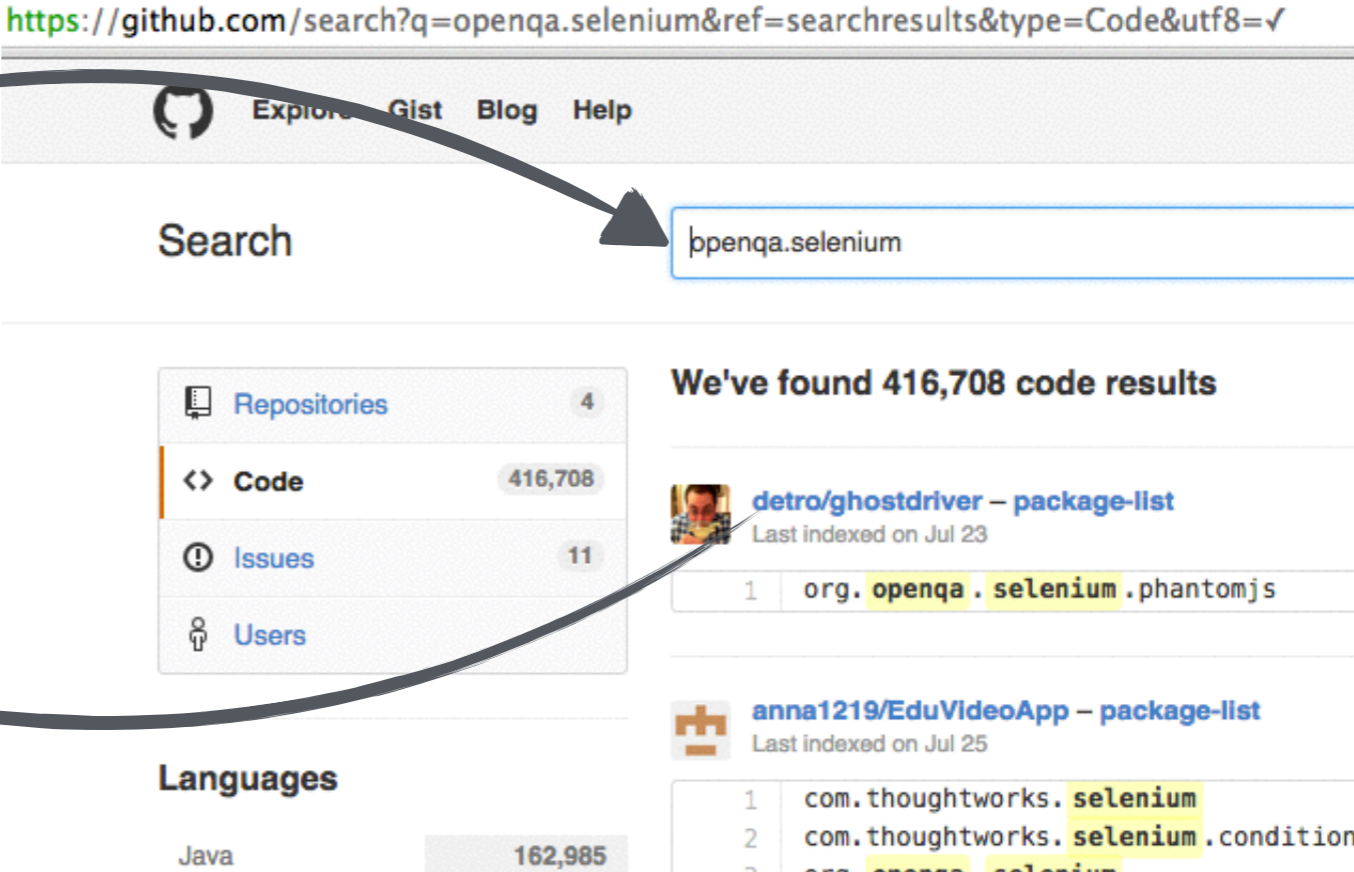
Scraping GitHub



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6 import org.openqa.selenium.WebElement;
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39         }
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49         url = url + "&type=code";
50         url = url + "&q=openqa";
51         url = url + "&q=openqa.selenium";
52         url = url + "&size=" + minSize + " " + maxSize;
53         for (int i = 1; i <= 100; i++) {
54             fetchURL(driver, url + "&p=" + i);
55             Thread.sleep(delay);
56             printHits(driver);
57         }
58         driver.quit();
59     }
60 }

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Search

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- Repositories: 4
- Code: 416,708
- Issues: 11
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Languages

- Java: 162,985

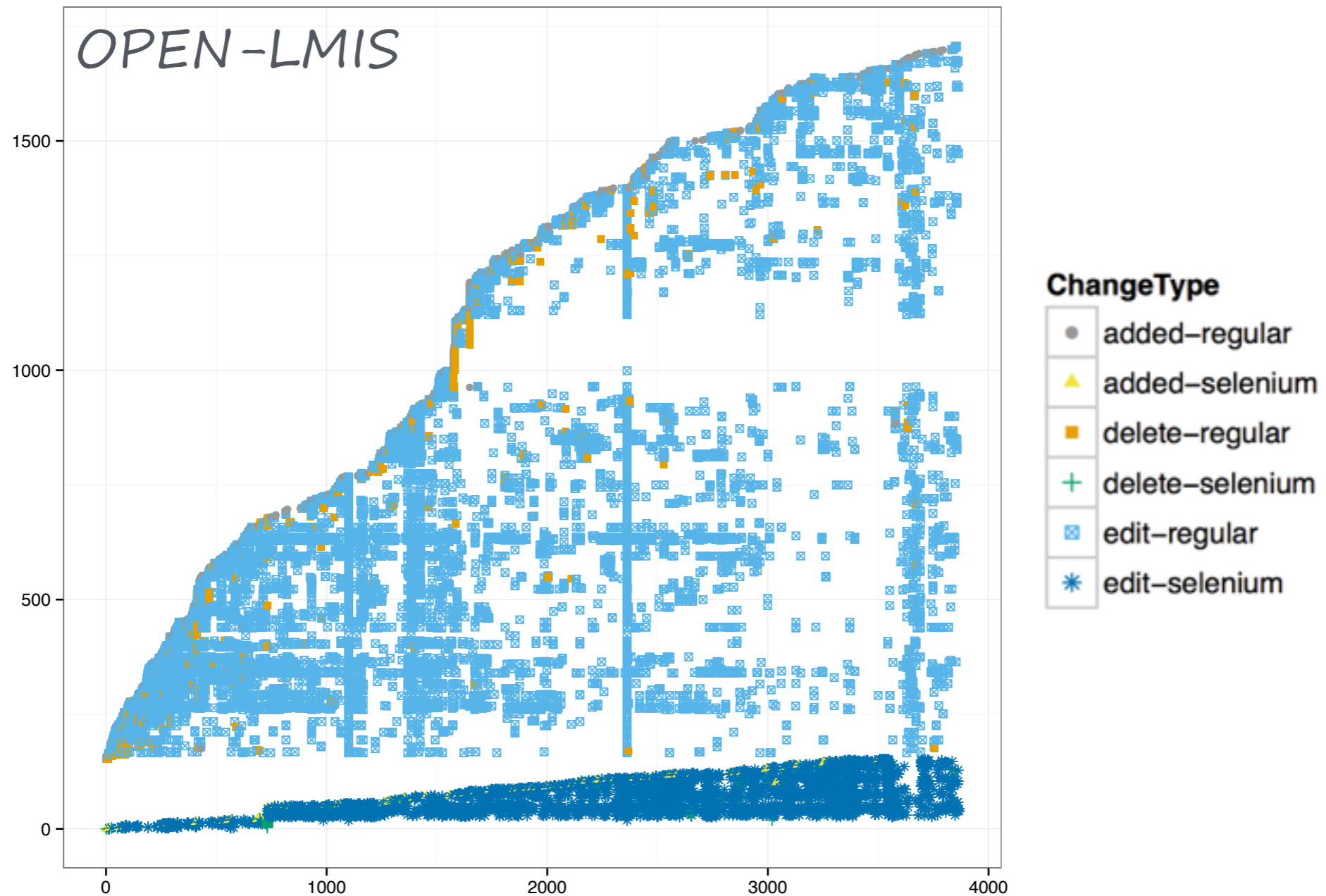
Results:

- detro/ghostdriver – package-list (Last indexed on Jul 23)
- 1 org.openqa.selenium.phantomjs
- anna1219/EduVideoApp – package-list (Last indexed on Jul 25)
- 1 com.thoughtworks.selenium
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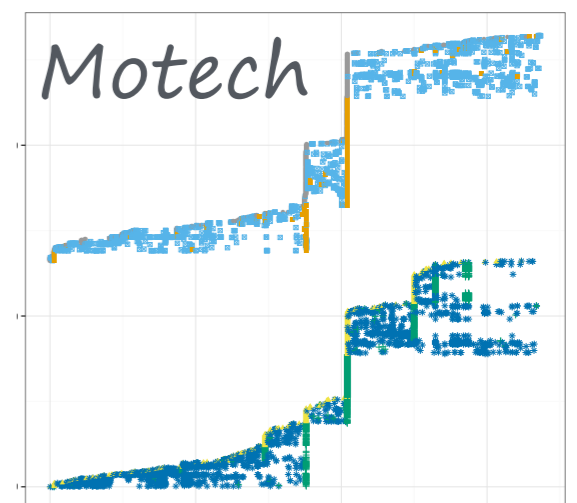
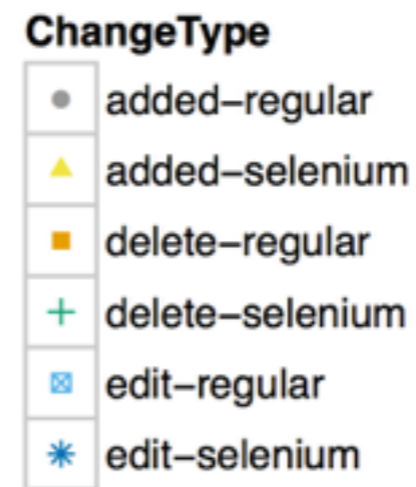
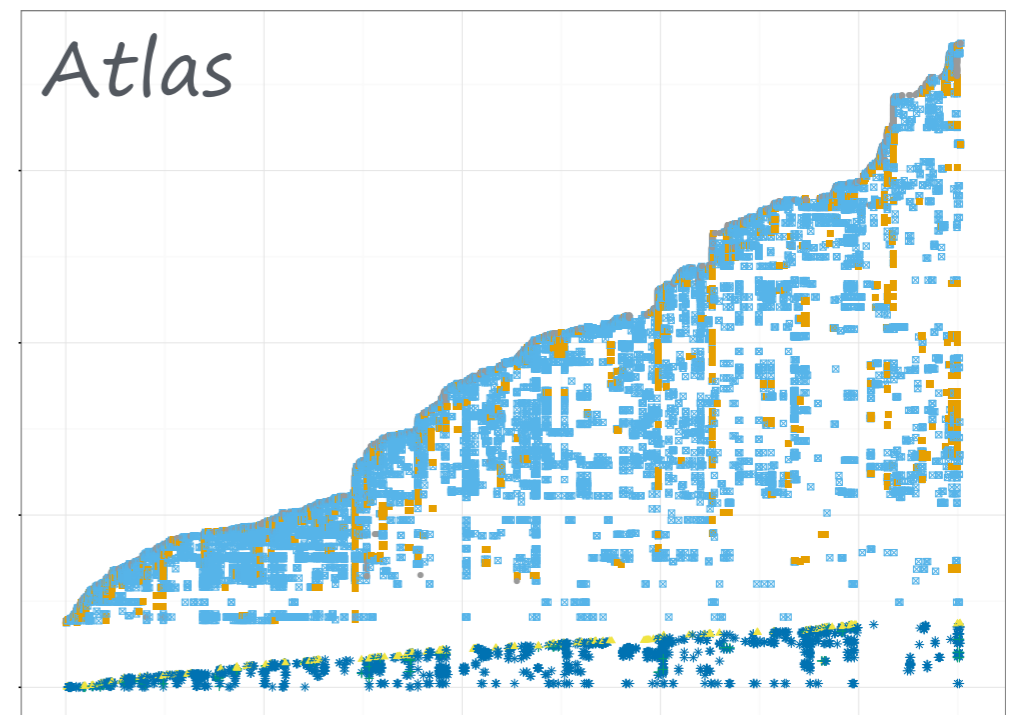
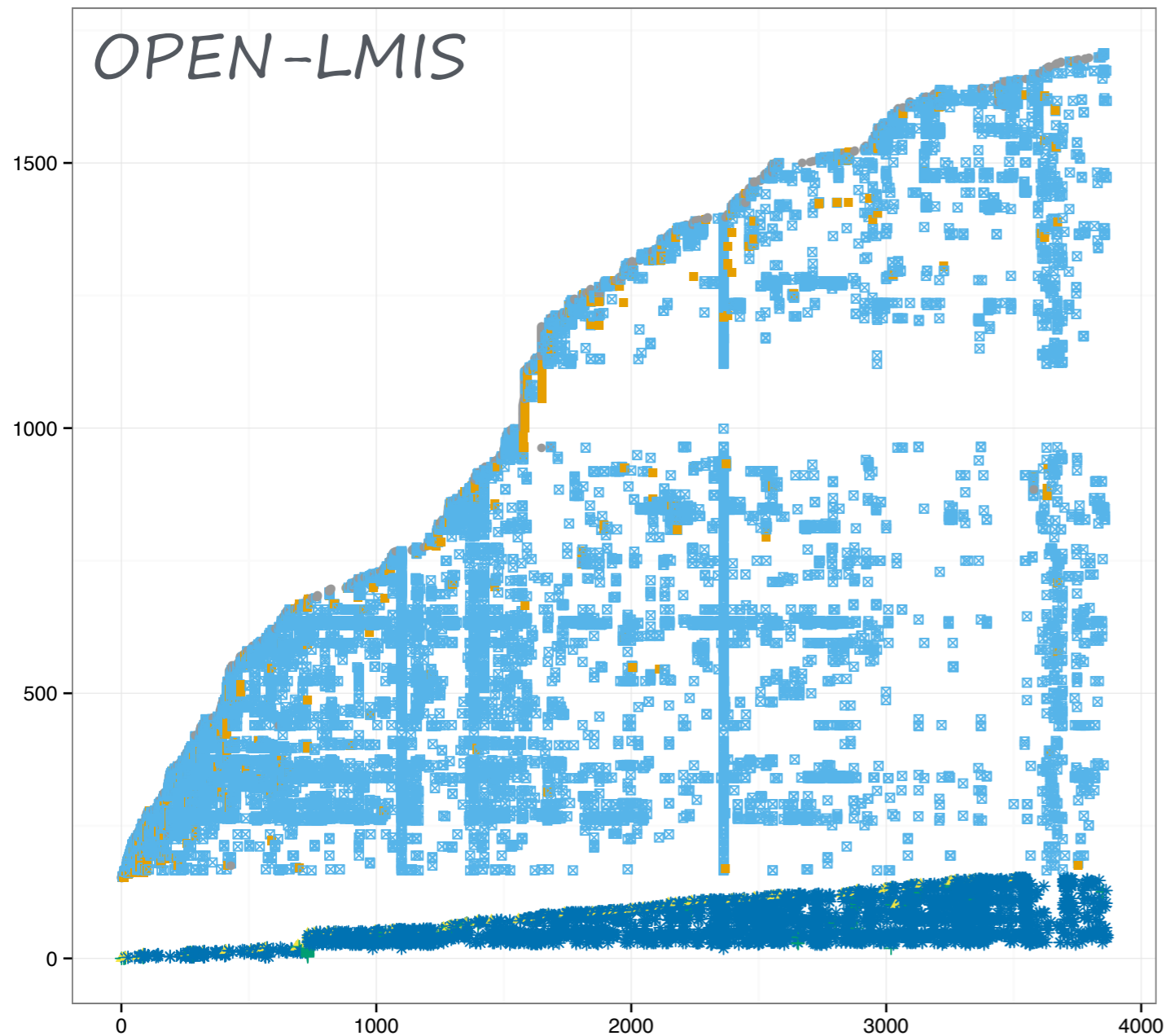
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Gene Atlas, EEG, MiFos, Tama, OpenLMIS, XWiki, Zanata, Zimbra

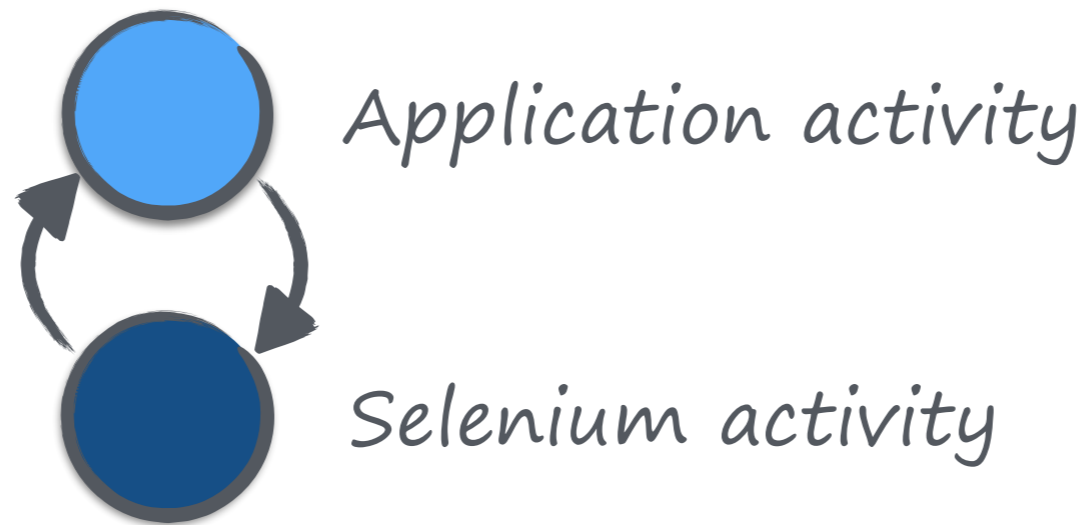
Change History View



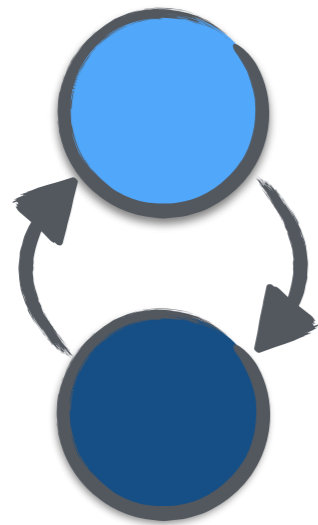
Change History View



Co-Evolution Metrics



Co-Evolution Metrics



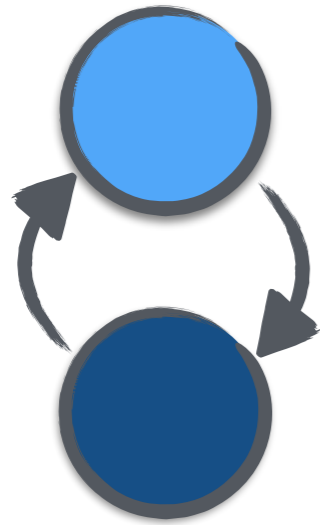
Application activity

*11.23 Commits
4.33 Days*

Selenium activity

*1.59 Commits
0.66 Days*

Co-Evolution Metrics



Application activity

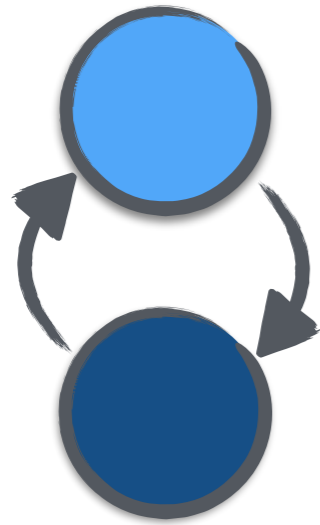
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Co-Evolution Metrics

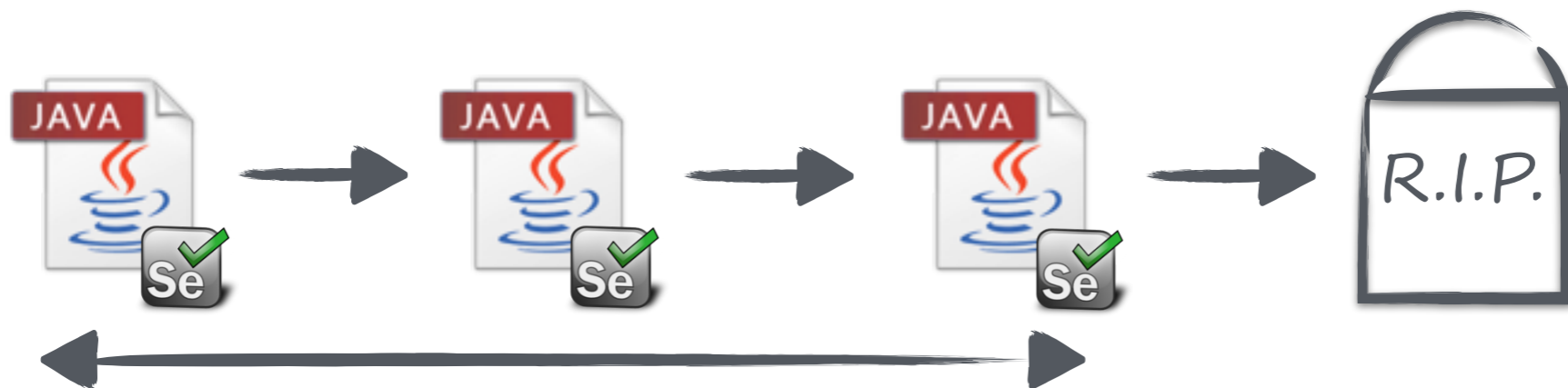


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4.33 Days

Selenium activity

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0.66 Days



190 Days - 510 Commits - 2.3 Modifications

Change Occurrence

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field.submit();  
assertEquals(driver.getTitle(), "adult");  
driver.quit();
```

Project	Total	Locator	Command	Demarcator	Asserts	Constants
Atlas	8068	90	3	104	3282	2586
XWiki	68665	115	154	24	1490	3114
Tama	31821	95	89	43	36	571
Zanata	12959	497	119	0	1	906
EEG/ERP	248	3	0	0	6	24
OpenLMIS	69792	2550	401	8	3454	8972

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@Test, @After, @Bug, ...



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XWiki	68665	115	154	24	1490	3114
Tama	31821	95	89	43	36	571
Zanata	12959	497	119	0	1	906
EEG/ERP	248	3	0	0	6	24
OpenLMIS	69792	2550	401	8	3454	8972

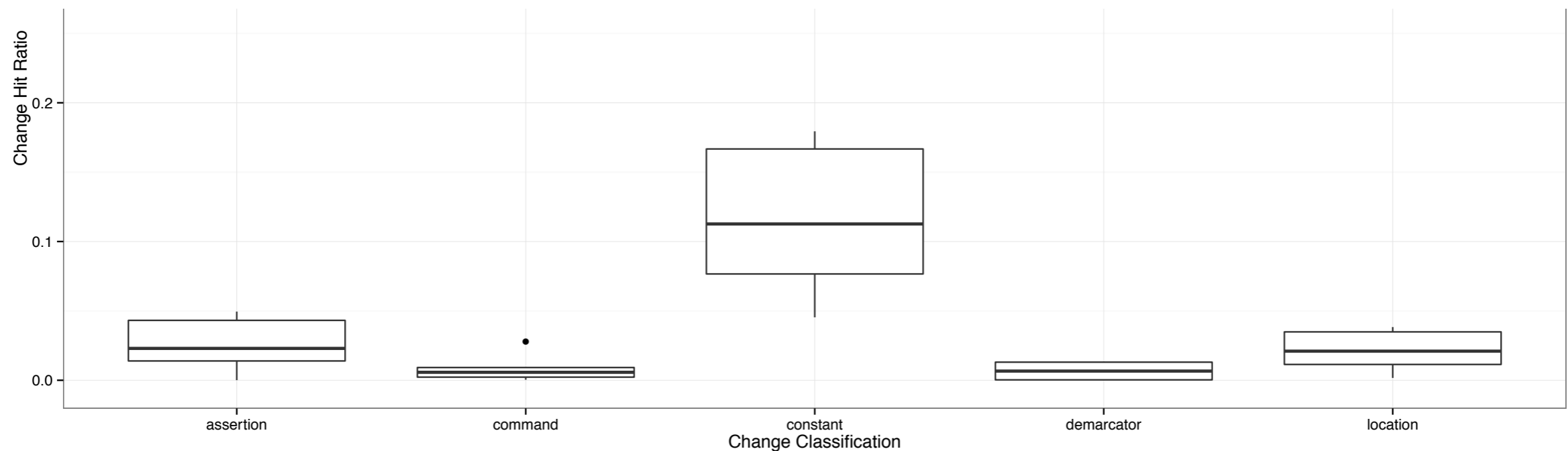
Change Occurrence

```
WebDriver driver = new FirefoxDriver();  
driver.get("http://www.birthdate.com");  
WebElement field = driver.findElement(By.name("birthdate"));  
field.sendKeys("19-08-1989");  
field.submit();  
assertEquals(driver.getTitle(), "adult");  
driver.quit();
```

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What to Take Home

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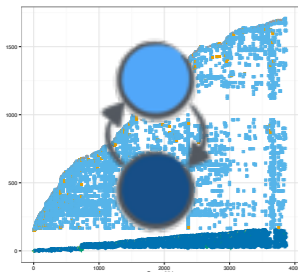


Automated functional testing is a real “thing”!

What to Take Home



Automated functional testing is a real “thing”!

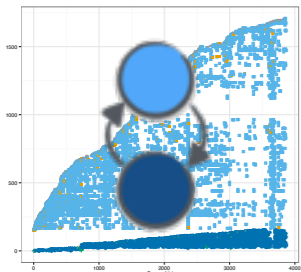


Test scripts co-evolve with the rest of the application

What to Take Home



Automated functional testing is a real “thing”!



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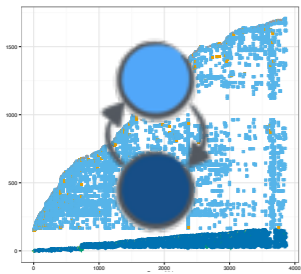


Test scripts survive very few changes

What to Take Home



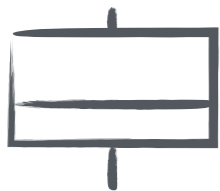
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Test scripts co-evolve with the rest of the application



Test scripts survive very few changes



Many test repairs involve constants