

CS1632: Systems Testing the Web with Selenium

Wonsun Ahn

Background

- Systems testing: testing the entire system as a whole
 - We would like to automate systems testing, just like we did for unit testing
- So far, all of our testing has been text-based java programs
 - A.k.a. Command Line Interface (CLI) programs
- Automating testing for CLI programs is easy!
 - Just create an “input script” and redirect to stdin
 - Redirect stdout to file and compare to expected output

Automated Systems Test for CLI Programs Using Bash

```
#!/bin/bash
```

```
# Test case 1: Drink empty coffee and lose
```

```
echo -e "D\n" | java -jar coffeemaker.jar > observed.out  
diff observed.out expected.lose.out
```

```
# Test case 2: Drink properly brewed coffee and win
```

```
echo -e "L\nN\nN\nL\nN\nN\nN\nL\nD\n" | java -jar  
coffeemaker.jar > observed.out  
diff observed.out expected.win.out
```

Automated Systems Test for GUI Programs

- Turns out that not every program is a CLI program
 - Web pages, mobile applications, windows applications, etc.
 - A.k.a. Graphical User Interface (GUI) programs
 - How do we deal with these?
- The theory behind testing remain the same
 - Compare **observed behavior vs. expected behavior**
 - Preconditions
 - Execution steps
 - Postconditions
- But we need different tools to automate testing GUI programs

Insight: GUI Apps \approx Text-based Apps

- GUI apps also have a text representation for the output
 - It's just that the text is rendered into a graphical representation for end-user
- Example: Web applications with HTML (HyperText Markup Language)
 - HTML text is fetched from web server when a URL is requested
 - HTML text is rendered by web browser into graphical elements
- Example: Mobile applications with XML (Extensible Markup Language)
 - XML text is fetched from mobile app server or generated by app
 - XML text is rendered by Android / iOS into graphical elements
- So, in theory, GUI apps could be tested just like text-based apps
 - Using a simple string comparison of expected and observed output text
 - Assuming rendering is bug-free (safe to assume for modern browsers, Android / iOS)

Testing a Web App like a Text-based App

```
#!/bin/bash
```

```
# Test case 1: Fetch index.html and compare
```

```
wget example.com/index.html
```

```
diff index.html index.expected.html
```

```
# Test case 2: Fetch about.html and compare
```

```
wget example.com/about.html
```

```
diff index.html about.expected.html
```

1. HTML page is fetched from web server using `wget` utility
2. Fetched HTML page is compared against the expected HTML page
 - Do you see any problems with this testing methodology?

Problems with Naïve HTML Comparison

1. Tests are unreadable

- An HTML page can contain hundreds of elements
- Unclear which value in which element the test is trying to check

2. Tests are fragile

- Trivial changes in HTML that don't impact final display can break test
- Changing any part of page (even unrelated to test case) will break test

3. JavaScript code is not functionally tested

- In naïve approach, JS code is compared letter by letter to expected JS code
- Changes in JS code that don't change functionality (e.g. commenting) can break test

1. Tests are Unreadable

- Which HTML element are we testing?

```
<html>
<head>
  <title>Example Domain</title>
  <style type="text/css">
    a:link, a:visited {
      color: #38488f;
    }
  </style>
</head>
<body>
  <a href="https://www.iana.org/domains/example">More info</a>
</body>
</html>
```

Diagram illustrating HTML elements and their associated test questions:

- Title text?** points to the `<title>Example Domain</title>` element.
- CSS URL link color?** points to the `color: #38488f;` CSS rule.
- URL link?** points to the `https://www.iana.org/domains/example` href attribute.
- Body text?** points to the `More info` text content of the link.

2. Tests are Fragile

- Are the two really different when displayed? (Hint: No)

[Expected HTML]

```
<html>
<head>
  <title>Example</title>
</head>
<body>
  ...
</body>
</html>
```

[Observed HTML]

```
<HTML>
<HEAD>
  <TITLE>Example</TITLE>
</HEAD>
<BODY>
  ...
</BODY>
</HTML>
```

3. JavaScript code is not functionally tested

- Are the two really different when displayed? (Hint: No)

[Expected HTML]

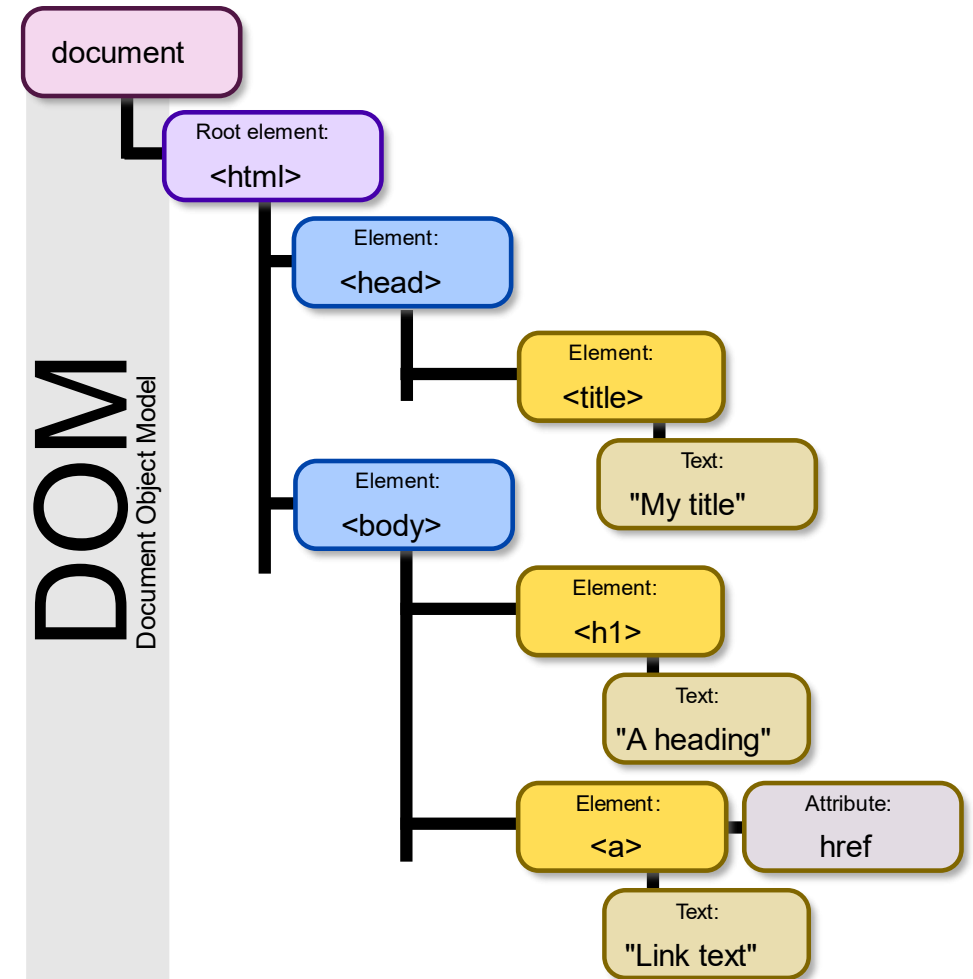
```
<html>
  <head>
    <script>
      function doAlert() {
        var msg = 'hello';
        alert(msg);
      }
    </script>
  </head>
  <body onload="doAlert();"></body>
</html>
```

[Observed HTML]

```
<html>
  <head>
    <script>
      function doAlert() {
        var message = 'hello';
        alert(message);
      }
    </script>
  </head>
  <body onload="doAlert();"></body>
</html>
```

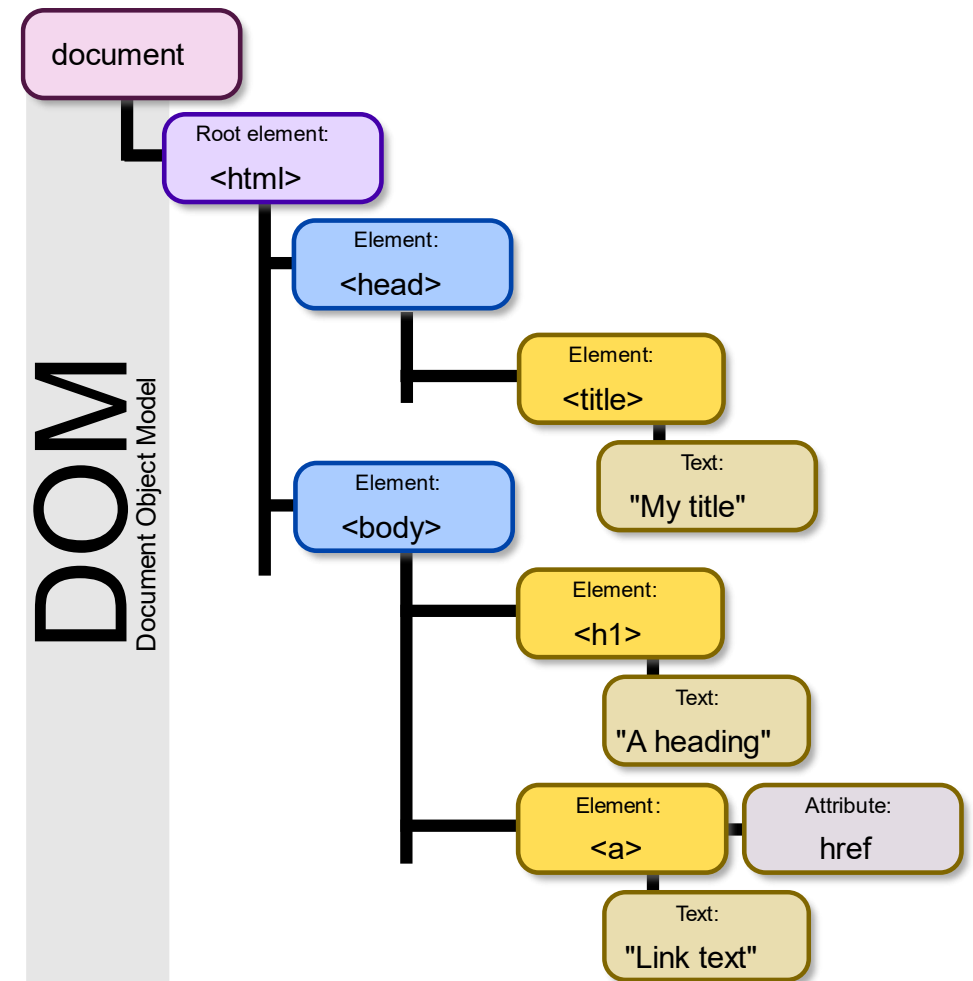
Solution: Web Testing Frameworks

- Why did this happen?
 - Treating HTML as plain text is too simplistic
- HTML is organized into a hierarchy
 - With rich semantic information
 - Elements consist of content and attributes
 - Attributes describe layout of elements and how they interact with end-user
 - `<script>` elements allow client-side JavaScript code that handles user interactions



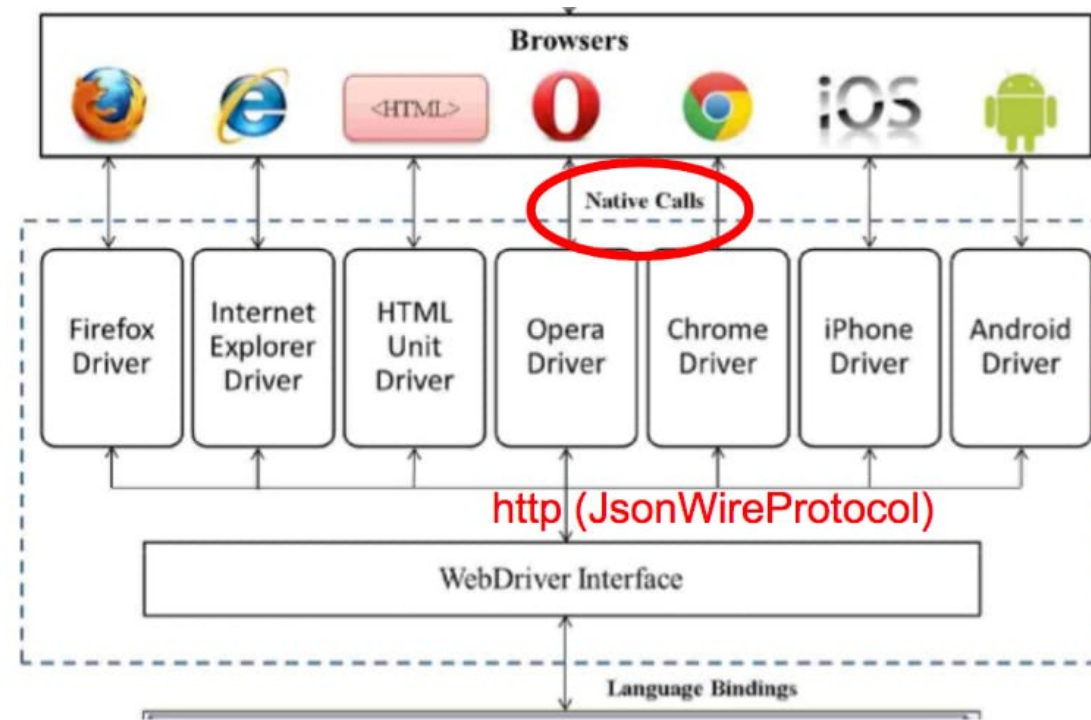
Solution: Web Testing Frameworks

- *Web testing framework*: Framework for testing web apps at a semantic level
 - Provides APIs to parse HTML into a tree data structure and search it
 - Provides APIs to emulate events like clicking or typing, testing JavaScript code
 - Automated testing script is written by calling APIs to simulate a user interaction
 - Requires *web driver* implementations for each type of web browser



What is a Web Driver?

- An *interface* to instruct the behavior of web browsers
 - Primarily intended to allow writing of automated tests
 - Also used to write scripts to automate repeated tasks (e.g. ordering delivery)
- Web browser writers implement driver for their own web browser
 - Matching web driver is used to test web app on a particular browser platform



With a Web Testing Framework ...

1. Tests are readable

- Obvious from web driver API calls which HTML elements are being tested

2. Tests are not fragile

- Trivial changes in HTML do not impact HTML parse tree, so won't break test
- Changing unrelated part of page won't break test since specific elements are tested

3. JavaScript code is functionally tested

- Framework allows events to be emulated that trigger JavaScript function calls
- Framework allows direct calls to JavaScript functions as part of script
- Changes in JavaScript code that don't change functionality won't break test

Selenium: A Web Testing Framework

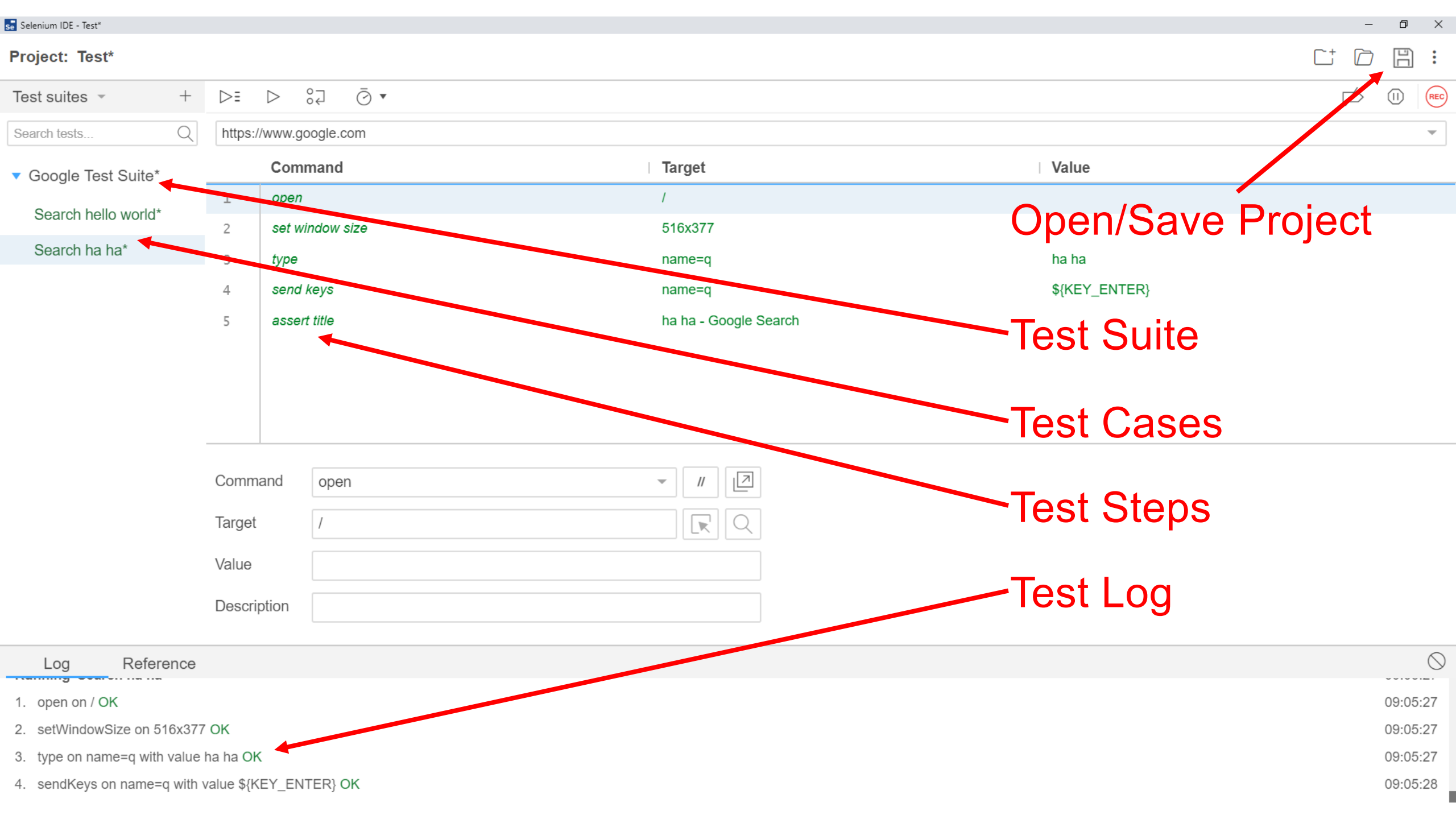
- *Selenium*: An open-source web testing framework
 - Licensed under Apache License 2.0
 - Works with Windows, OS X, Linux, other OSes
 - Works with Java, Ruby, Python, other languages
- *Selenium = WebDriver + Grid + IDE*
 - *Selenium WebDriver*: Drivers available for Chrome and Firefox
 - *Selenium Grid*: Grid computing server to run Selenium tests in parallel
<https://www.selenium.dev/documentation/en/grid/>
 - *Selenium IDE*: Browser extension for automated test script generation
<https://www.selenium.dev/selenium-ide/>

Getting Started with Selenium IDE

1. Go to <https://www.selenium.dev/selenium-ide/>
2. Add the appropriate extension for your web browser
(By clicking on Chrome Download or Firefox download)
3. Install extension when taken to the webstore page
4. Click on the "Se" icon in the upper right-hand corner

Selenium IDE

- What we would call a “test plan”, Selenium calls a “test suite”
- Test suites contain test cases
- Test cases contain test steps



Project: Test*

Test suites ▾



Search tests...



https://www.google.com

▼ Google Test Suite*

Search hello world*

Search ha ha*

Command

Target

Value

1	open	/
2	set window size	516x377
3	type	name=q ha ha
4	send keys	name=q \${KEY_ENTER}
5	assert title	ha ha - Google Search

Open/Save Project

Test Suite

Test Cases

Test Steps

Test Log

Command

open



//



Target

/



Value

Description

Log

Reference

1. open on / OK
2. setWindowSize on 516x377 OK
3. type on name=q with value ha ha OK
4. sendKeys on name=q with value \${KEY_ENTER} OK

09:05:27

09:05:27

09:05:27

09:05:28

Creating a Simple Test Case

1. Create a new test case
 - Select “Tests” in upper left dropdown box
 - Click on the “+” button
2. Record an operation (Press “REC” button)
3. Do something
4. Stop recording
5. Run test case - it does what you just did

Add new test case

TEST CASE NAME

Search yolo

ADD

CANCEL

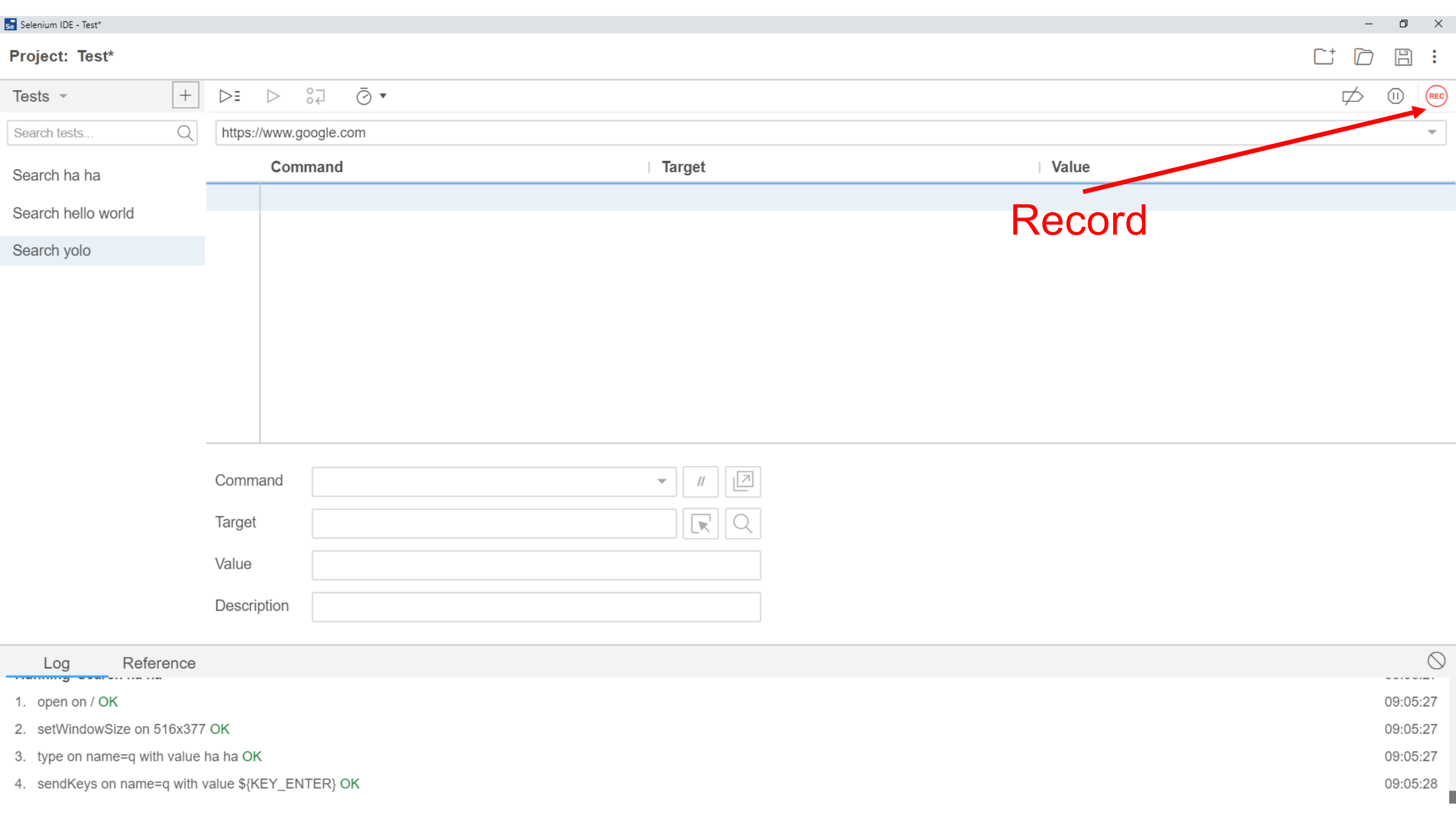
Command open

Target /

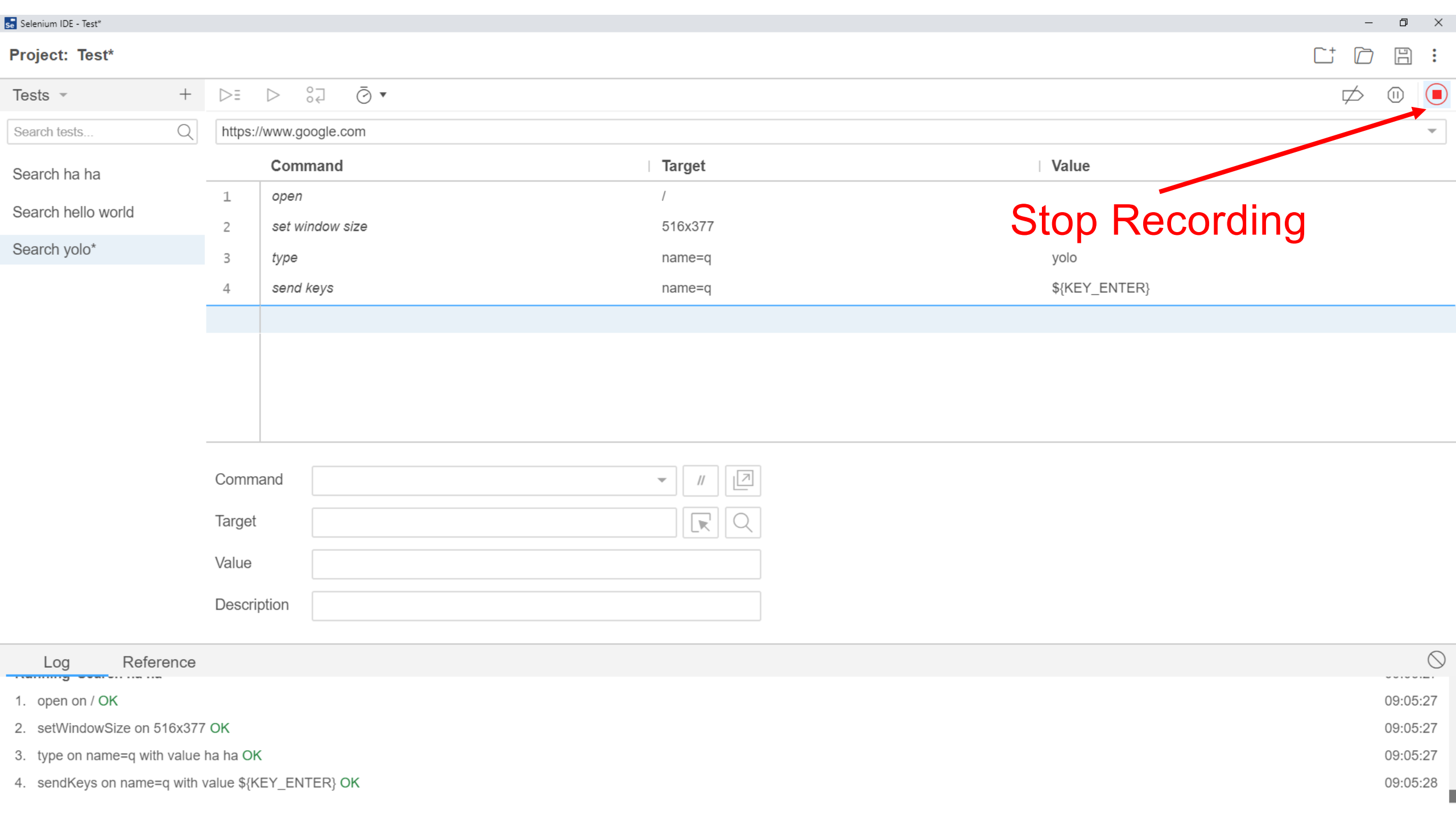
Value

Description

1. open on / OK
2. setWindowSize on 516x377 OK
3. type on name=q with value ha ha OK
4. sendKeys on name=q with value \${KEY_ENTER} OK



Record



Stop Recording

Selenium IDE - Test*

Project: Test*

Tests ▾

+

▶▶⌂⌚▼

⌂⌚⏹

Search tests... 🔍

https://www.google.com

Search ha ha

Search hello world

Search yolo*

	Command	Target	Value
1	open	/	
2	set window size	516x377	
3	type	name=q	yolo
4	send keys	name=q	\${KEY_ENTER}

Command

Target

Value

Description

Log

Reference

1. open on / OK

2. setWindowSize on 516x377 OK

3. type on name=q with value ha ha OK

4. sendKeys on name=q with value \${KEY_ENTER} OK

09:05:27

09:05:27

09:05:27

09:05:28

Autogenerated Script:

1. Open URL “/”
at google.com

2. Type “yolo”
on element name=q

3. Press enter key
on element name=q

Components of a Test Step

- Command – What to do
 - E.g. open a page, click on something, type
- Target – To what?
 - E.g. A URL or an element on the page
- Value – Using what value?
 - E.g. Type what?

Editing a Script After Recording

- You can modify a recorded script or create one from scratch
- Deleting a test step:
 1. Click on the test step you want to delete, highlighting it
 2. Press the “delete” key
- Modifying a test step:
 1. Click on the test step you want to modify, highlighting it
 2. Modify or choose Command / Target / Value / Description
- Adding a test step:
 1. Click on the row below the last command to add a test step, highlighting it
 2. Fill in or choose Command / Target / Value / Description
- Reordering test steps: just click and drag

	Command	Target	Value
1	open	/	
2	set window size	516x377	
3	type	name=q	yolo
4	send keys	name=q	\${KEY_ENTER}
5	//		

Command

Target

Value

Description

add selection

answer on next prompt

assert

assert alert

assert checked

assert confirmation

assert editable

//

Pulldown to peruse;
Type to search command

Log

Reference

1. open on / OK

2. setWindowSize on 516x377 OK

3. type on name=q with value ha ha OK

4. sendKeys on name=q with value \${KEY_ENTER} OK

09:05:27

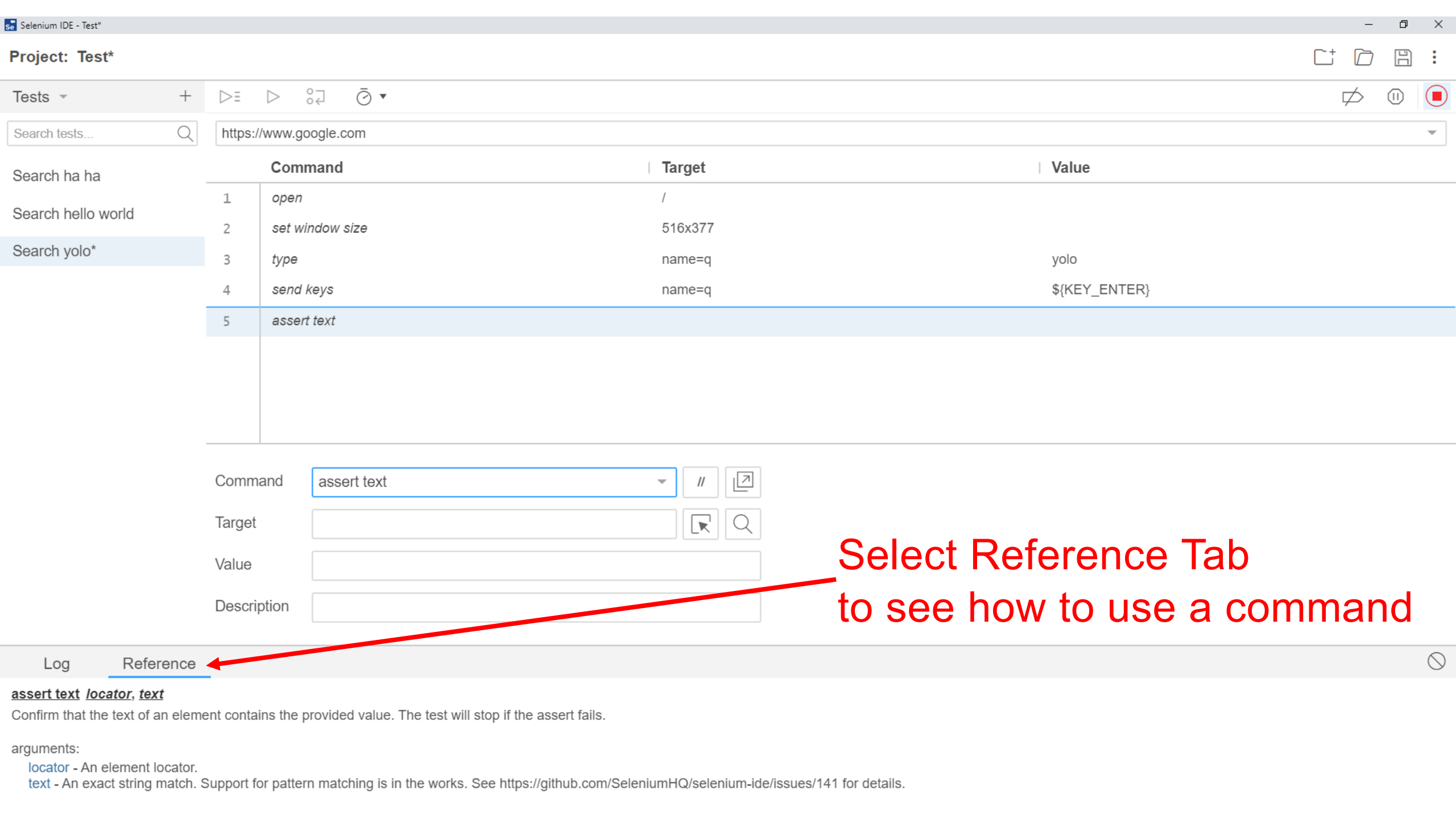
09:05:27

09:05:27

09:05:28

Common Commands

- open [url](#): Opens a URL and waits for the page to load before proceeding
 - Arguments: [url](#) - The URL to open (may be relative or absolute).
- click [locator](#): Clicks on a target element (e.g. a link, button, or textbox)
 - Arguments: [locator](#) - An element locator
- type [locator](#), [value](#): Sets the value of an input field, as though you typed it
 - Arguments: [locator](#) - An element locator, [value](#) - The value to input
- assert text [locator](#), [text](#): Check that text of element contains provided value
 - Arguments: [locator](#) - An element locator, [text](#) - The provided string to match
- Note: 1st argument always goes to Target, 2nd argument to Value
 - If unsure of command, always use the “Reference” tab at the bottom



Select Reference Tab
to see how to use a command

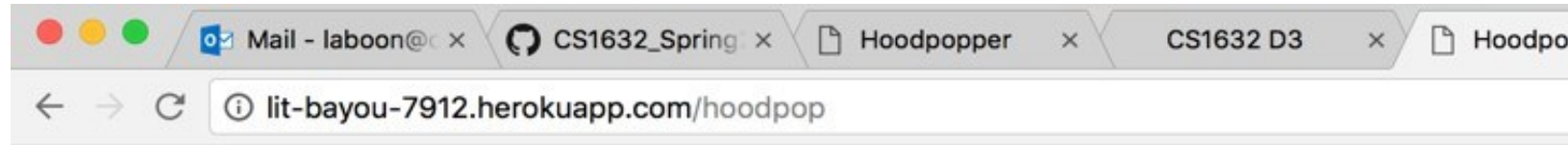
Don't Forget the Assertion in the End

- Purpose of a Selenium test case is to check a postcondition
 - Just like any other test case we have seen so far
- Like JUnit, assertions are used to check postconditions in Selenium

A Subset of Selenium Assertions...

- assert text [locator](#), [text](#): Check that text of element contains provided text
 - Arguments: [locator](#) - An element locator, [text](#) - The provided string to match
- assert title [text](#): Check that title of current page contains provided text
 - Arguments: [text](#) - The provided string to match
- assert element present [locator](#): Check that element is present in page
 - Arguments: [locator](#) - An element locator
- assert [variable name](#), [expected value](#): Check that variable is expected value
 - Arguments: [variable name](#) - The name of a variable
[expected value](#) - The result you expect a variable to contain
 - “Catch all” for assertions. Values can be stored in variables during script execution
 - Variables can store return values of JavaScript code run using “execute script”
 - If-then-else statements and while loops can be used to update variable values

Filling in Target Locator String



Hood Popped - Compile Operation

```
== disasm: <RubyVM::InstructionSequence:<compiled>@<compiled>>=====
0000 trace 1 ( 1)
0002 putobject_OP_INT2FIX_O_1_C_
0003 putobject_OP_INT2FIX_O_1_C_
0004 opt_plus <callinfo!mid:+, argc:1, ARGS_SKIP>
0006 leave
```

[Back](#)

How do I generate the target locator string for this text element?

Different Types of Locator Strings

- *Locator*: A string that can uniquely identify an HTML element
- There can be multiple *locators* for the same element on a web page
 - XPath: locate using unique XML path to element
 - Id: locate using a unique element ID attribute
 - CSS: locate using an element CSS class attribute
(if not unique, may locate saying for example “3rd element using this class”)
 - Other attributes: locate using other HTML attributes (e.g. name)
- Some locator strings are better than others
 - Web pages change all the time – due to changes in content or design
 - Some locator strings are more resilient to changes than others
 - E.g. A unique ID locator will always be able to locate the correct element.
But an XPath locator may need to change if path to element changes.

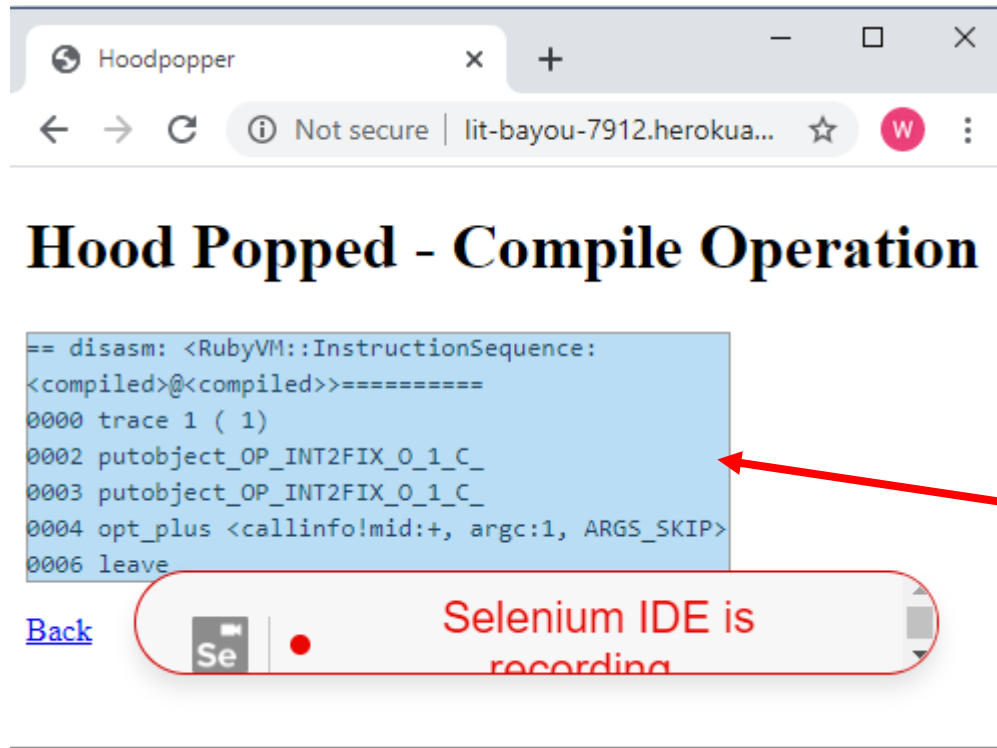
Using Selector to Generate Locator String

Command	<input type="text" value="assert text"/>	<input type="button" value="//"/>	<input type="button" value="🔍"/>
Target	<input type="text"/>	<input type="button" value="👉"/>	<input type="button" value="🔍"/>
Value	<input type="text"/>	<div>Select target in page</div>	
Description	<input type="text"/>		

Select

- Selector button automatically generates locator strings for you!

Using Selector to Generate Locator String



Click on HTML element
you want to target

- Selected HTML element will highlight to blue when you hover over it

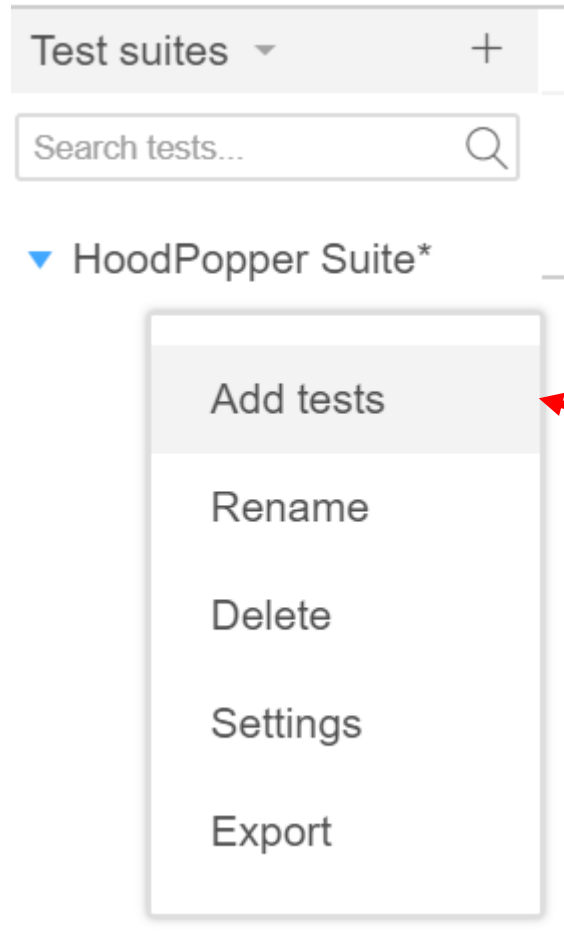
Using Selector to Generate Locator String

Command	<input type="text" value="assert text"/>	<input type="button" value="//"/>	<input type="button" value="🔗"/>
Target	<input type="text" value="css=code"/>	<input type="button" value="🔍"/>	<input type="button" value="🔍"/>
Value	<input type="text"/>		
Description	<input type="text"/>		

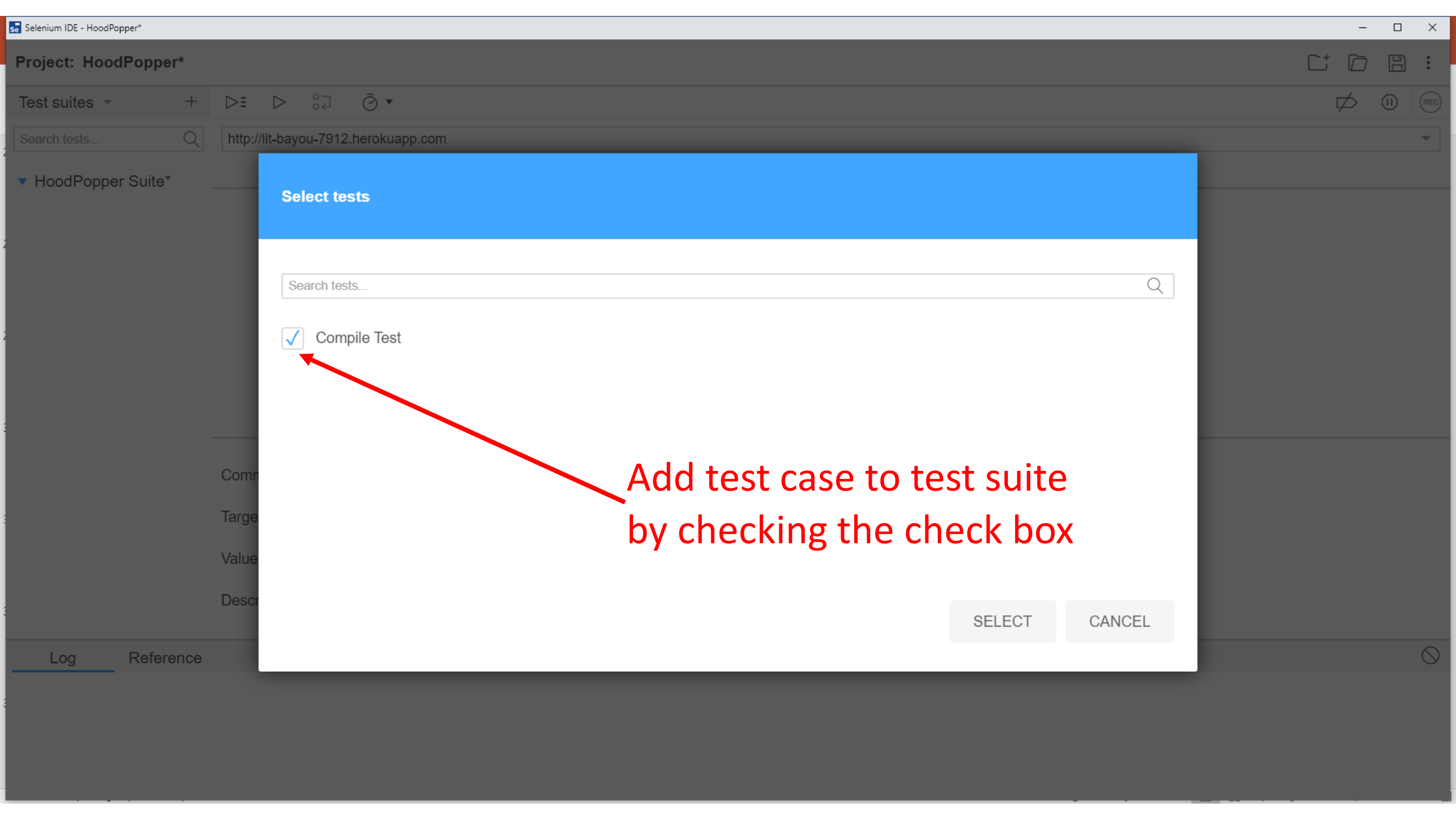
Fills in target for you automatically!

- Clicking on drop down button displays a list of options to choose from
- Choose the best option you think will be the most resilient to change
- You can even type in your own locator string (once you get the hang of it)

Adding a test case to a test suite



Select “Add tests” after right-clicking on Test Suite



Select tests

Search tests...

☒ Compile Test

Add test case to test suite
by checking the check box

SELECT

CANCEL

No Textbook Reading for This Chapter

- Instead, please skim over:
<https://www.selenium.dev/selenium-ide/docs/en/api/commands>
 - It shows all the assertions you can do and more!
- If you are interested, Appium is Selenium for Mobile Apps:
<http://appium.io/>