Automated Testing for Web Applications

In this lab, we will use three case studies to learn different security automation techniques for use against the vulnerable NodeGoat site. The first case is to automate OWASP ZAP by using the ZAP-CLI, which will help identify any initial security issues on the website before authentication. In the second case, we will be using selenium to do the user sign-in, in order to access some authenticated pages and identify more potential security issues. In the final case, we will use JMeter to do the sign-in with external CSV data and detect potential command injection security issues.

The topics that will be covered in this lab are as follows:

- Web security automation testing with OWASP ZAP using the CLI
- Web security automation testing with ZAP and Selenium
- Web security testing with ZAP, JMeter, and DDT with FuzzDB

Case 1 -- web security scanning with ZAP-CLI

In this small NodeGoat web security testing scenario, we will automate OWASP ZAP by using the ZAP-CLI for security smoke testing. The ZAP-CLI provides a quick scan, which is handy because it achieves the following in one command:

- Open a URL to the target website
- Spider scan to discover web resources (URLs) extensively on the target website
- Active scan to identify more potential security issues by using known attacks

We will perform the following steps to execute the ZAP-CLI and review the security results by

Step 1 -- Using ZAP-CLI

To ensure the success of the ZAP-CLI installation, you may try this command with help options:

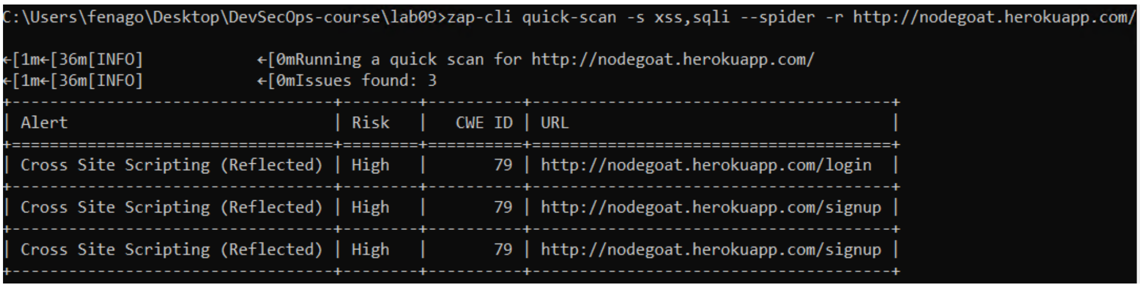
```
zap-cli quick-scan --help
```

Step 2 -- ZAP quick scan using the ZAP-CLI

To do a ZAP-CLI quick scan with specified XSS and SQL injection security policies, the following command can be used. The ZAP-CLI may require the API Key of ZAP. To access or disable the API Key, configure the [Disable the API Key] checkbox under the OWASP UI menu, [Tools] | [Options...] | [API]:

```
zap-cli quick-scan -s xss,sqli --spider -r http://nodegoat.herokuapp.com/
```

It will take a while for ZAP to finish the spider and active scan. Confirm using ZAPI GUI that scan have been completed.



```
C:\Users\fenago\Desktop\DevSecOps-course\lab09>zap-cli quick-scan -s xss,sqli --spider -r http://nodegoat.herokuapp.com/

←[1m←[36m[INFO]            ←[0mRunning a quick scan for http://nodegoat.herokuapp.com/
←[1m←[36m[INFO]            ←[0mIssues found: 3
+----------------------------------+--------+----------+--------------------------------------+
| Alert                            | Risk   |   CWE ID | URL                                  |
+==================================+========+==========+======================================+
| Cross Site Scripting (Reflected) | High   |       79 | http://nodegoat.herokuapp.com/login  |
+----------------------------------+--------+----------+--------------------------------------+
| Cross Site Scripting (Reflected) | High   |       79 | http://nodegoat.herokuapp.com/signup |
+----------------------------------+--------+----------+--------------------------------------+
| Cross Site Scripting (Reflected) | High   |       79 | http://nodegoat.herokuapp.com/signup |
+----------------------------------+--------+----------+--------------------------------------+
```

Step 3 -- generate a report

There are a few ways we can generate an OWASP ZAP report. The first is to use [alerts] to show a summary list of the security issues:

```
zap-cli alerts
```

Furthermore, we can also use [report] to generate a detailed HTML or XML report. The XML report can be used to import into other security reporting tools, which we will introduce in Lab 15, *Summary of Automation Security Testing Tips*:

```
zap-cli report -o   ZAP_Report.html  -f html
```

To generate the XML format report, execute this command:

```
zap-cli report -o ZAP_Report.xml -f xml
```

Uses of ZAP-CLI or ZAP RESTful API to automate the OWASP ZAP scan? The ZAP RESTful API is provided by default in ZAP, while the ZAP-CLI will require to install [zapcli]. If you only need basic web scan operations, the ZAP-CLI may fit your needs. However, if you need more control over ZAP, the ZAP RESTful API will be recommended.

Case 2 -- web security testing with ZAP & Selenium

In this case for the security testing of NodeSign signin, we will be using a Selenium script to automate the following UI steps and OWASP ZAP will be running as a proxy mode to monitor and analyze all security issues based on HTTP requests/responses. We will do the sign-in with a valid username and password, then visit every authenticated page without further data input and updates. The purpose of this testing is to do a security smoke test of every authenticated page.

Here are the UI steps automated by Selenium:

- Visit the sign-in page: http://nodegoat.herokuapp.com/login
- Sign in with username = **user1** and password = **User1_123**
- Visit the contributions page after sign-in
- Visit the allocation page
- Visit the profile

Follow the following instructions to proceed the testing.

Step 1 -- Selenium Python script

We will create the Selenium Python script [NodeGoat_SigIn.py]. The Selenium script will launch the Firefox browser. Firefox web driver (geckodriver) is already downloaded and added in PATH, it can be found here: https://github.com/mozilla/geckodriver/releases.

This sample code shows a Selenium/Python script used to log in to NodeGoat with **user1/User1_123** credentials:

```
# -*- coding: utf-8 -*-
# NodeGoat_SignIn.py
from selenium import webdriver
from selenium.webdriver.common.by import By
from selenium.webdriver.common.keys import Keys
from selenium.webdriver.support.ui import Select
from selenium.common.exceptions import NoSuchElementException
from selenium.common.exceptions import NoAlertPresentException
import unittest, time, re

class SignIn(unittest.TestCase):
    def setUp(self):
        self.driver = webdriver.Firefox()
        self.driver.implicitly_wait(30)

    def test_sign_in(self):
        driver = self.driver
        driver.get("http://nodegoat.herokuapp.com/login")
        driver.find_element_by_id("userName").clear()
        driver.find_element_by_id("userName").send_keys("user1")
        driver.find_element_by_id("password").clear()
        driver.find_element_by_id("password").send_keys("User1_123")
        driver.find_element_by_xpath("//button[@type='submit']").click()
        driver.get("http://nodegoat.herokuapp.com/contributions")
        driver.find_element_by_xpath("//button[@type='submit']").click()
        driver.get("http://nodegoat.herokuapp.com/contributions")
        driver.get("http://nodegoat.herokuapp.com/allocations/2")
        driver.get("http://nodegoat.herokuapp.com/profile")


    def tearDown(self):
        self.driver.quit()


if __name__ == "__main__":
    unittest.main()
```

Step 2 -- running ZAP as a proxy

In Lab 5, *Security API and Fuzz Testing*, and Lab 6, *Web Application Security Testing*, we introduced the installation and use of ZAP. Here, we will only discuss how to launch the browser with the Selenium script and the specified ZAP proxy, which is [127.0.0.1:8090] in our case.

Approach 1 -- Selenium Profile

In this approach, we define the selenium script to use the specified proxy as [127.0.0.1:8090]. This will require a certain modification of the selenium script. Here is the sample script, which shows how to define the browser proxy. The [self.driver = webdriver.Firefox()] will need additional profile preference settings, as shown in this example:

```
# "Selenium Proxy Sample.py"
from selenium import webdriver
import warnings
warnings.simplefilter(action='ignore', category=Warning)


# Replace the 'self.driver = webdriver.Firefox()' with the following
profile = webdriver.FirefoxProfile()
profile.set_preference('network.proxy_type',1)
profile.set_preference('network.proxy.http',"127.0.0.1")
profile.set_preference('network.proxy.http_port',"8090")
driver=webdriver.Firefox(profile)
# End of Replacement


driver.get('http://nodegoat.herokuapp.com/login')
driver.close()
```

Run the script as follows:

```
cd C:\Users\fenago\Desktop\DevSecOps-course\lab11

python "Selenium Proxy Sample.py"
```

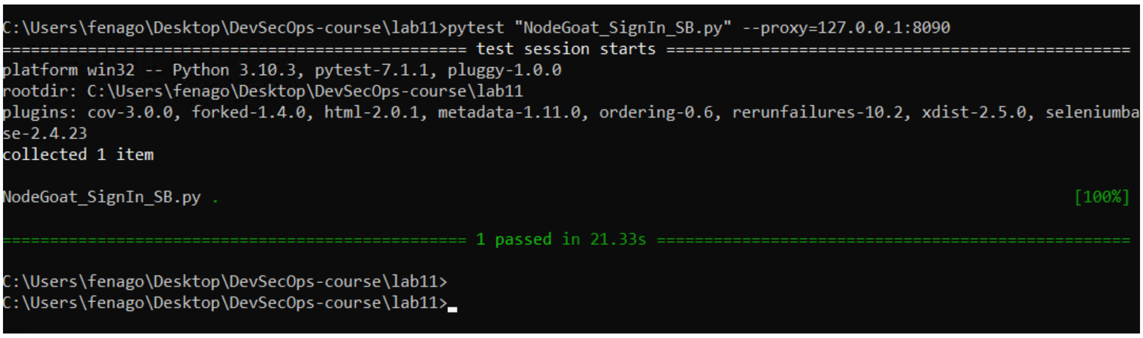
Approach 2 -- using SeleniumBASE

If the script is done by using SeleniumBASE, the browser proxy can be specified with proxy command options. Please be aware that our example, [NodeGoat_SignIn.py], cannot be executed directly by using SeleniumBASE. Here are the steps to convert our original selenium script into SeleniumBASE style. The steps work under the assumption that SeleniumBASE is installed, which can be done with [pip install seleniumbase]:

```
seleniumbase convert NodeGoat_SignIn.py
```

Then, we may execute the command with the proxy [127.0.0.1:8090]: The previous command will generate [NodeGoat_SignIn_SB.py]:

```
pytest "NodeGoat_SignIn_SB.py" --proxy=127.0.0.1:8090
```



```
C:\Users\fenago\Desktop\DevSecOps-course\lab11>pytest "NodeGoat_SignIn_SB.py" --proxy=127.0.0.1:8090
=============================================== test session starts ================================================
platform win32 -- Python 3.10.3, pytest-7.1.1, pluggy-1.0.0
rootdir: C:\Users\fenago\Desktop\DevSecOps-course\lab11
plugins: cov-3.0.0, forked-1.4.0, html-2.0.1, metadata-1.11.0, ordering-0.6, rerunfailures-10.2, xdist-2.5.0, seleniumba
se-2.4.23
collected 1 item

NodeGoat_SignIn_SB.py .                                                                                       [100%]

=============================================== 1 passed in 21.33s =================================================

C:\Users\fenago\Desktop\DevSecOps-course\lab11>
C:\Users\fenago\Desktop\DevSecOps-course\lab11>
```

When the testing is stable, it's suggested to execute the selenium testing script in headless mode. It means the testing will proceed without launching a real browser. It will simulate the execution in memory. This will improve the testing stability and cycle. For the uses of SeleniumBASE, specify the headless option, for example:

```
pytest "NodeGoat_SignIn_SB.py" --proxy=127.0.0.1:8090 --headless --browser=chrome
```

Step 3 -- generate ZAP report

The ZAP security testing report can be generated by one of the followings:

```
CURL "http://127.0.0.1:8090/OTHER/core/other/htmlreport/?formMethod=GET" >
ZAP_Report.HTML
```

Alternatively, if the ZAP-CLI is installed, the HTML report can be generated with this command:

```
zap-cli report -o   ZAP_Report.html  -f html
```

Case 3 -- fuzz XSS and SQLi testing with JMeter

In *Case 3*, we will demonstrate the same user flows as in *Case 2*. The key difference in *Case 3* is that we will have the data input with SQL injection payloads. This will be done by using Jmeter with FuzzDB and CSV Config elements. In Lab 13, *Automated Infrastructure Security*, we will also demonstrate how to do fuzz SQLi testing with selenium and Robot Framework.

Testing scenarios

After user sign-in, particularly in step 6, we will be using JMeter to send HTTP requests with FuzzDB security loads through the OWASP ZAP proxy to the target testing website, NodeGoat.

The testing steps are as follows:

1. Sign in to NodeGoat with the username **User1** and password **User1_123**
2. Visit the contributions page
3. Visit the allocations page
4. Visit the memos page
5. Visit the profile page
6. **Input the security payloads for SQL and command injection testing on the profile update page**
7. Log out
8. Generate the security reports in OWASP ZAP

During these steps, OWASP ZAP will be used to analyze the HTTP request/response traffic to identify potential security issues. The general steps to complete the automation testing will be as follows:

1. Set up the ZAP Proxy on port [8090] and JMeter
2. Define the JMeter scripts
3. Launch JMeter in the CLI with ZAP Proxy
4. Generate the ZAP report with the CLI
5. Shut down ZAP

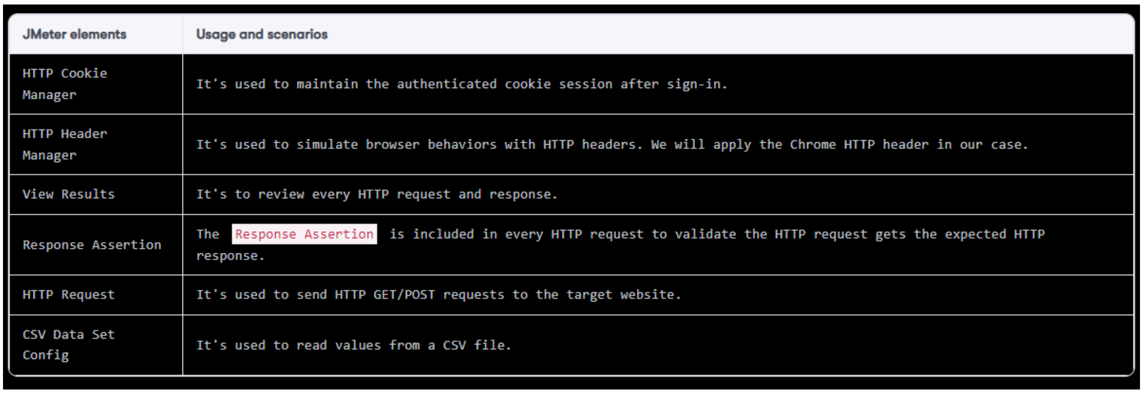
Step 1 -- prepare environment

To prepare the environment for this security testing scenario, we will mainly need JMeter, ZAP, and FuzzDB.

Step 2 -- define the JMeter scripts

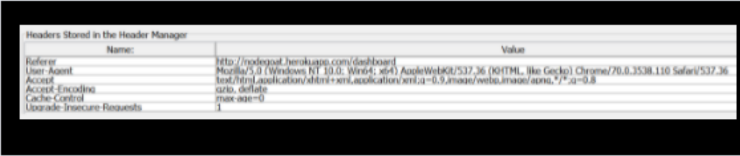
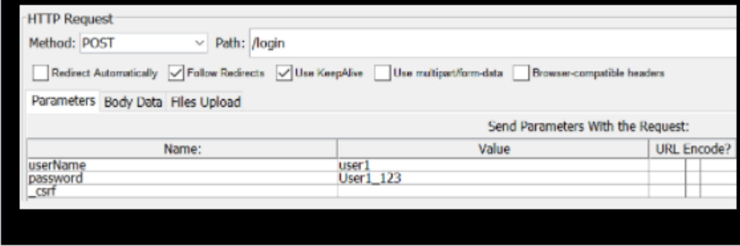
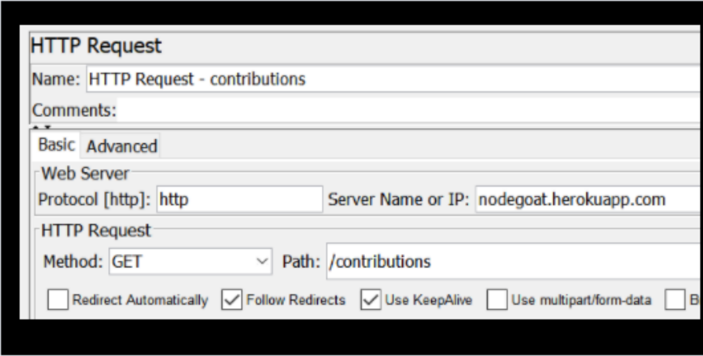
Solution: JMX file has been saved in `C:\Users\fenago\Desktop\DevSecOps-course\lab11\NodeGoat.jmx`

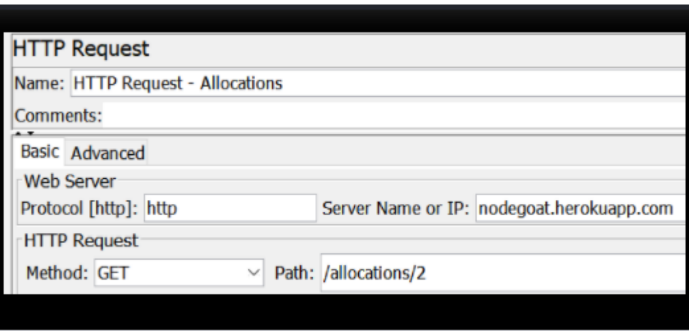
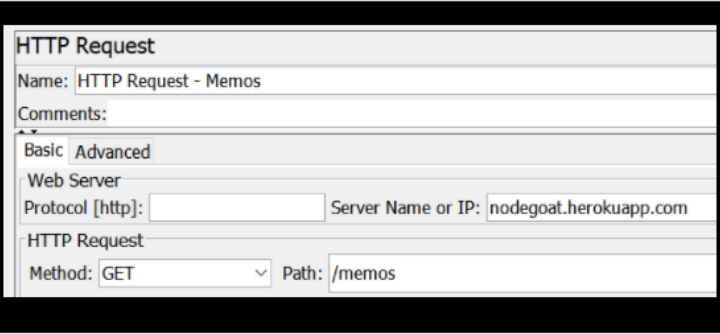
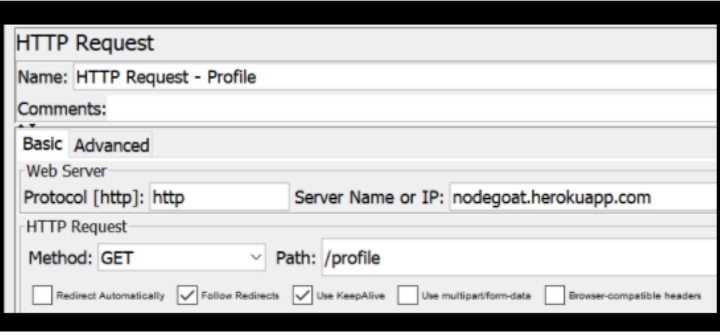
Using JMeter can be very complex. In our case, we will only use parts of the necessary elements to complete the testing scenario. This table lists the use of JMeter elements in our case and also the configuration needed in each element:

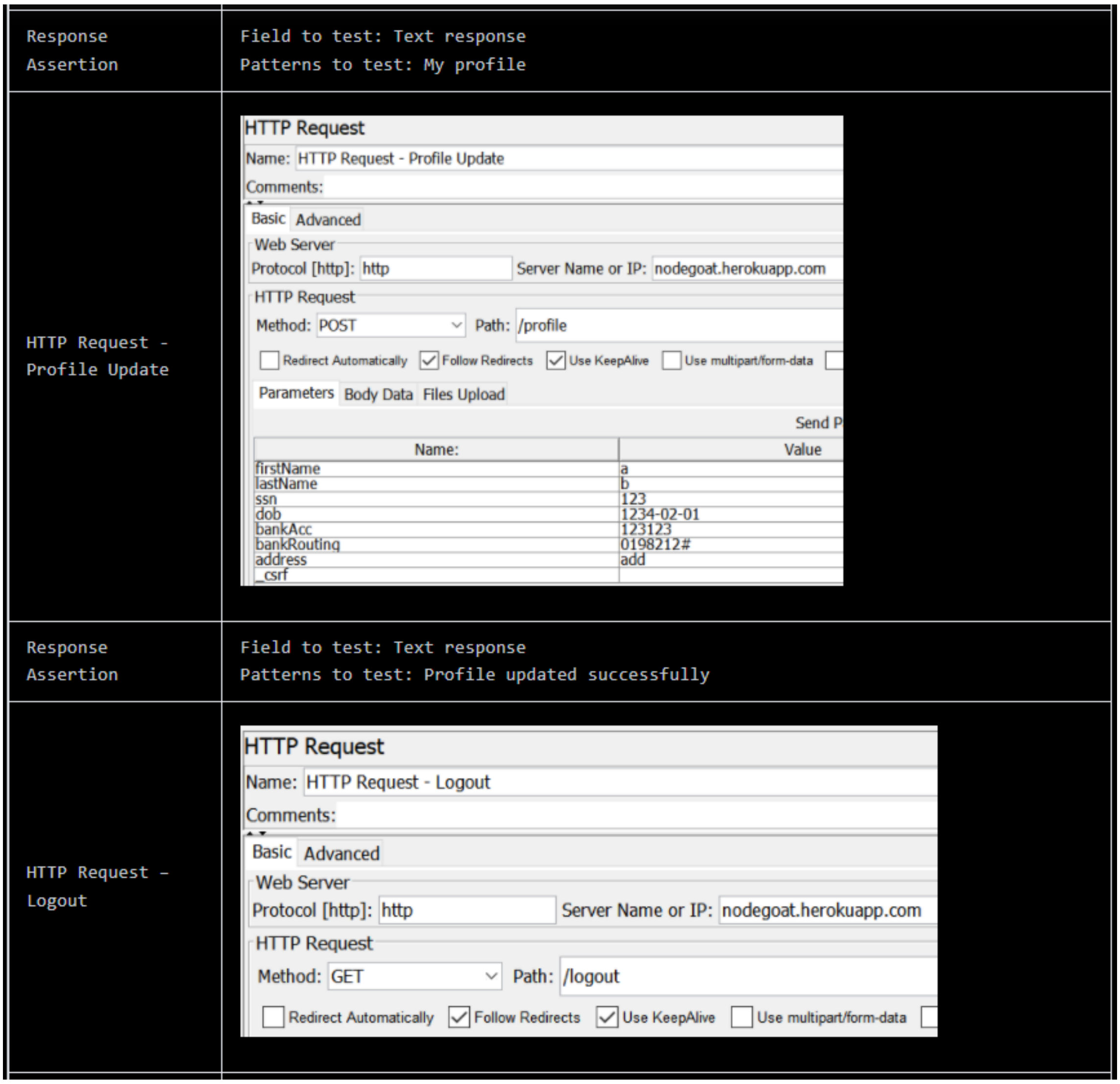


JMeter elements	Usage and scenarios
HTTP Cookie Manager	It's used to maintain the authenticated cookie session after sign-in.
HTTP Header Manager	It's used to simulate browser behaviors with HTTP headers. We will apply the Chrome HTTP header in our case.
View Results	It's to review every HTTP request and response.
Response Assertion	The `Response Assertion` is included in every HTTP request to validate the HTTP request gets the expected HTTP response.
HTTP Request	It's used to send HTTP GET/POST requests to the target website.
CSV Data Set Config	It's used to read values from a CSV file.

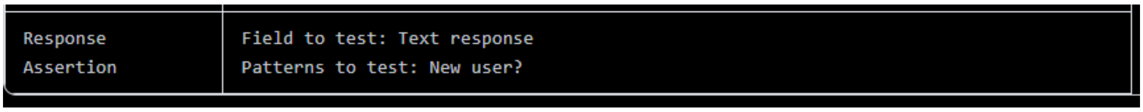
We will create a JMeter Script with the following configurations, and save the script as [NodeGoat.jmx]:

JMeter elements	Configuration
HTTP Cookie Manager	No need to do any configuration.
HTTP Header Manager	 Headers Stored in the Header Manager Name: / Value Referer: http://nodegoat.herokuapp.com/dashboard User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/70.0.3538.110 Safari/537.36 Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8 Accept-Encoding: gzip, deflate Cache-Control: max-age=0 Upgrade-Insecure-Requests: 1
View Results Tree	No need to do any configuration.
HTTP Request - NodeGoat Sign	 HTTP Request Method: POST Path: /login □ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive □ Use multipart/form-data □ Browser-compatible headers Parameters Body Data Files Upload Send Parameters With the Request: Name: / Value / URL Encode? userName: user1 password: User1_123 _csrf
Response Assertion	Fields to test: Text response Patterns to test: Employee retirement savings management
HTTP Request – contributions	 HTTP Request Name: HTTP Request - contributions Comments: Basic Advanced Web Server Protocol [http]: http Server Name or IP: nodegoat.herokuapp.com HTTP Request Method: GET Path: /contributions □ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive □ Use multipart/form-data □ B
Response Assertion	Field to test: Text response Patterns to test: Employee pre-tax

HTTP Request - Allocations	 HTTP Request Name: HTTP Request - Allocations Comments: Basic Advanced Web Server Protocol [http]: http Server Name or IP: nodegoat.herokuapp.com HTTP Request Method: GET Path: /allocations/2
Response Assertion	Field to test: Text response Patterns to test: Stock performance
HTTP Request - Memos	 HTTP Request Name: HTTP Request - Memos Comments: Basic Advanced Web Server Protocol [http]: Server Name or IP: nodegoat.herokuapp.com HTTP Request Method: GET Path: /memos
Response Assertion	Field to test: Text response Patterns to test: Send a memo
HTTP Request - Profile	 HTTP Request Name: HTTP Request - Profile Comments: Basic Advanced Web Server Protocol [http]: http Server Name or IP: nodegoat.herokuapp.com HTTP Request Method: GET Path: /profile ☐ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive ☐ Use multipart/form-data ☐ Browser-compatible headers



Response Assertion	Field to test: Text response Patterns to test: My profile
HTTP Request - Profile Update	HTTP Request Name: HTTP Request - Profile Update Comments: Basic Advanced Web Server Protocol [http]: http Server Name or IP: nodegoat.herokuapp.com HTTP Request Method: POST Path: /profile ☐ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive ☐ Use multipart/form-data ☐ Parameters Body Data Files Upload Send P Name: Value firstName a lastName b ssn 123 dob 1234-02-01 bankAcc 123123 bankRouting 0198212# address add _csrf
Response Assertion	Field to test: Text response Patterns to test: Profile updated successfully
HTTP Request - Logout	HTTP Request Name: HTTP Request - Logout Comments: Basic Advanced Web Server Protocol [http]: http Server Name or IP: nodegoat.herokuapp.com HTTP Request Method: GET Path: /logout ☐ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive ☐ Use multipart/form-data ☐



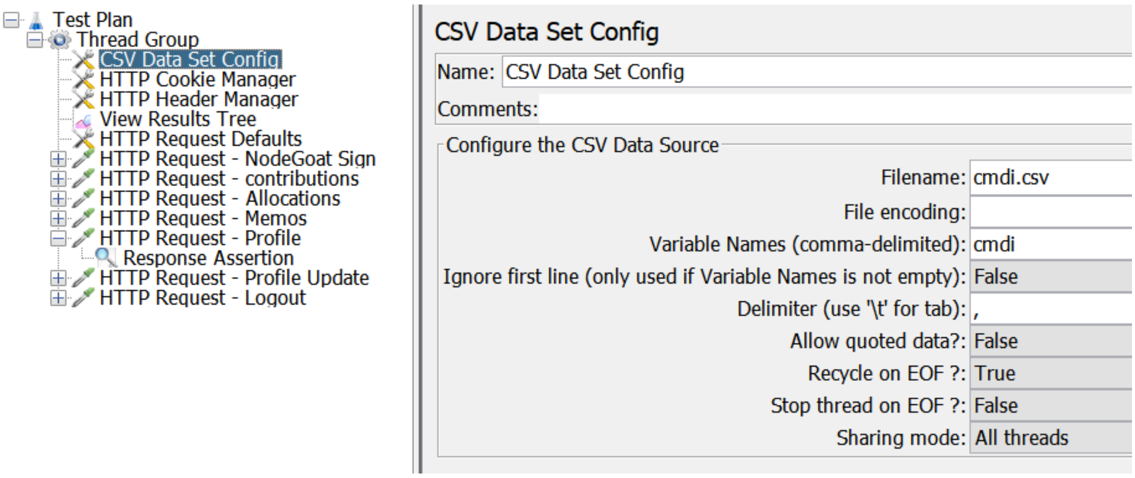
Response Assertion	Field to test: Text response Patterns to test: New user?

Step 3 -- prepare security payloads

From the sources of FuzzDB, we will prepare two files `cmdi.csv` for the data input of profile update. In the JMeter script, [CSV Data Set Config] will be added with the following configuration:

- [Filename]: `cmdi.csv`
- [Variable Names (comma-delimited)]: [cmdi]

This screenshot shows the JMeter script with [CSV Data Set Config]:



- Test Plan
  - Thread Group
    - CSV Data Set Config
    - HTTP Cookie Manager
    - HTTP Header Manager
    - View Results Tree
    - HTTP Request Defaults
    - HTTP Request - NodeGoat Sign
    - HTTP Request - contributions
    - HTTP Request - Allocations
    - HTTP Request - Memos
    - HTTP Request - Profile
      - Response Assertion
    - HTTP Request - Profile Update
    - HTTP Request - Logout

CSV Data Set Config

Name: CSV Data Set Config

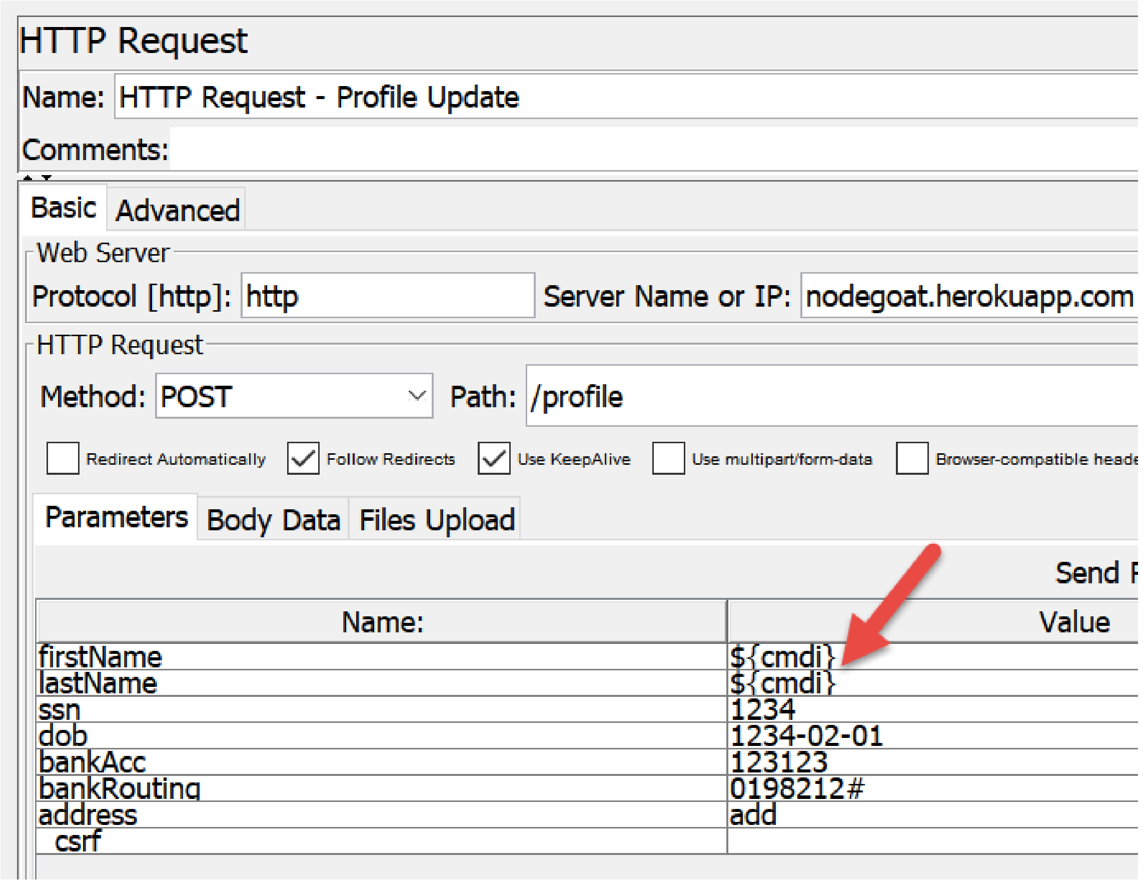
Comments:

Configure the CSV Data Source

Filename:	cmdi.csv
File encoding:	
Variable Names (comma-delimited):	cmdi
Ignore first line (only used if Variable Names is not empty):	False
Delimiter (use '\t' for tab):	,
Allow quoted data?:	False
Recycle on EOF ?:	True
Stop thread on EOF ?:	False
Sharing mode:	All threads

CSV Data Set Config for Command Injection in JMeter

Then, we can use the [${cmdi}] variable in [HTTP Request - Profile Update]. For example, we replace the value of [firstName] and [lastName] with [${cmdi}] to do command injection testing:



HTTP Request

Name: HTTP Request - Profile Update

Comments:

Basic | Advanced

Web Server

Protocol [http]: http   Server Name or IP: nodegoat.herokuapp.com

HTTP Request

Method: POST   Path: /profile

□ Redirect Automatically ☑ Follow Redirects ☑ Use KeepAlive □ Use multipart/form-data □ Browser-compatible heade

Parameters | Body Data | Files Upload

Send P

Name:	Value
firstName	${cmdi}
lastName	${cmdi}
ssn	1234
dob	1234-02-01
bankAcc	123123
bankRouting	0198212#
address	add
csrf	

HTTP Request for Command Injection Testing in JMeter

To do the loop and read all the variables in `cmdi.csv`, we still need to change the [Loop Count] settings in [Thread Group]. For example, we will do the loop 10 times with each value in the `cmdi.csv`:

- Loop Count: 10

Step 4 -- launch JMeter in CLI with ZAP proxy

To launch JMeter in console mode, we will specify the proxy to OWASP ZAP by using the [-H]:

```
cd C:\Users\fenago\Desktop\DevSecOps-course\lab11

jmeter    -n   -H   localhost -P   8090   -t    NodeGoat.jmx      -l
NodeGoat_result.jtl  -j  NodeGoat_result.log
```

In addition, the proxy settings of JMeter can also be configured by using [HTTP Request Defaults] under the [Advanced] tab.

Step 5 -- generate a ZAP report

The ZAP security testing report can be generated by one of the followings:

```
CURL "http://127.0.0.1:8090/OTHER/core/other/htmlreport/?formMethod=GET" >
ZAP_Report.HTML
```

Should I select Selenium or JMeter as our security automation framework? Both tools can achieve similar testing results. Selenium simulates user behaviors in a real browser, but it may produce unexpected errors during UI testing. On the other hand, JMeter only sends HTTP requests and verifies HTTP responses, without rendering the UI in a browser. In addition, for the selection of tools, we may also consider integration with existing security or automation frameworks. For example, if the team has built all the automation based on JMeter, then JMeter may be a better choice for security automation.

Summary

In this lab, we have demonstrated three technical approaches to NodeGoat security automation testing. The first approach is to use the ZAP-CLI to do a quick scan of the target website. This kind of testing can be used as a smoke test for every release. It helps us to identify potentially serious security issues. We also applied Selenium and JMeter to guide ZAP for authenticated pages and other web UI flows. Selenium can launch the browser to simulate a user's web operation behavior. JMeter sends the HTTP requests and asserts the HTTP responses for the API-level user sign-in flow.