School of Computing and Information Systems

COMP90074: Web Security, Semester 2 2023

Assignment 2 (worth 12.5%)

Due date: 11:59pm, Sunday September 17

1 Introduction

This assignment is the second of two programming assignments in this subject (together worth 25% of your mark). This assignment is worth 12.5% of your mark. It is done individually.

You will find, analyse, exploit, and fix a range of vulnerabilities in a simple web application. Your submission will include a short report (as a plain text file) plus client exploit code that you will write for this assignment.

Note that the marking scheme is a little different to Assignment 1. See below.

Your code can be written in any language; however it should be packaged in a docker container with a script, or instructions on how, to run it. We provide a sample docker container for an exploit client written in Python, as a starting point.

2 The Web Application

The web application implements a simple authenticated, private blog system. Users log-in with username/passwords and can then record private messages, i.e. messages posted by a particular user should be accessible only to that user. Anyone can create a new account, allowing them to log-in and use the system. A logged-in user can delete messages that they have posted and can also delete their own account, which should also delete all of their messages making them inaccessible to anyone else.

User account details (usernames, password hashes) are stored in an SQL database table `users`. A separate table `messages` is used to store the messages that have been posted.

Initial conditions. When the web application starts, there are no entries in the `messages` table and the `users` table contains a single `admin` account.

The `admin` account. The `admin` account is assumed to be trusted. It is allowed to delete other user accounts. When the server application starts, a new password is generated for the `admin` account. This password is generated by choosing one at random from a list of common passwords. This simulates an administrator who chooses a common password, but whose exact password is unknown even to those who have the source code of the application.

Password storage and checking. The md5 algorithm (mentioned in lectures) is used to hash passwords before they are stored in the SQL database. When a user submits their password, its md5 hash is computed and compared to what is stored in the database.

The `users` table of the database also stores for each user how many successive incorrect login attempts have been made (i.e. ones with the wrong password). When this number of attempts reaches 3, the account is locked out. Correctly logging in resets this count to zero.

3 Your Tasks

3.1 Find, Analyse, and Fix the Vulnerabilities (8 marks)

The application contains at least four known vulnerabilities. The known vulnerabilities are *not* XSS or SQL injection vulnerabilities. Instead they are drawn from the following vulnerability classes: broken authentication, broken access control, and security misconfiguration.

Your first task is to identify each vulnerability and to analyse it. What kind of vulnerability is it? What is its cause? How can it be exploited? If it is exploited, what bad things might an attacker be able to do?

Then, you should devise, implement and test fixes for the vulnerabilities.

You should write a short report as a plain text file `vulnerabilities.txt`. For each vulnerability you should document:

- The type of vulnerability;
- Where is it in the original source code (relevant files and line numbers) and its root cause;
- How the vulnerability could be exploited;
- What the impact of the vulnerability could be; and
- How you fixed the vulnerability.

There are **two** marks allocated for each of the four known vulnerabilities: 1 mark for correctly describing the vulnerability, how it can be exploited, and its impact; and 1 mark for correctly fixing the vulnerability.

A bonus mark will be awarded to any student who identifies an unknown vulnerability in the web application. Of course you don't know which vulnerabilities we already know about. Therefore, document all vulnerabilities that you find.

3.2 Exploit the Web Application (4 marks)

Understanding the impact of a vulnerability in isolation tells only part of the story. In reality, vulnerabilities are often most dangerous when they are leveraged together by an attacker to achieve something that couldn't have been achieved by exploiting each vulnerability on its own.

The vulnerabilities that this application contains can be leveraged together by an attacker to allow a non-`admin` user (i.e., an arbitrary person on the web who doesn't know the `admin` password) to cause malicious code to be run by *any* user of the application.

Your task is to work out how to combine the vulnerabilities you have discovered to achieve this effect.

To do this, you need to implement a client exploit program that sends and receives HTTP requests/responses to the server. Your client begins not knowing the `admin` password. Its job is to cause code, created by your client, to be executed by any logged-in user who visits the web application.

To do so, it may or may not need to exploit all of the vulnerabilities you identified.

Your client will be a *proof-of-concept*: that is, a program that demonstrates the potential for harm without actually causing any harm. Specifically, your client's job is to inject code so that any logged-in user of the web application sees a popup alert saying "This site has been hacked!".

Your client can be written in any programming language you choose. However, it *must* be packed in a docker container that comprises all dependencies required to run it (i.e., your client should be "dockerised"). We provide a sample docker container for a client written in Python that uses the `requests` library to send and receive HTTP requests to the server.

Handling Session Cookies Note that when a user logs in to the web application, a session cookie is set and is returned in the response. However, the response after logging in (that contains this cookie) is a 302 redirect response that redirects the client to load the login page.

Some libraries (including the Python `requests` library) will automatically follow redirects. But in doing so, the final response they return may not contain the session cookie that was set after logging in.

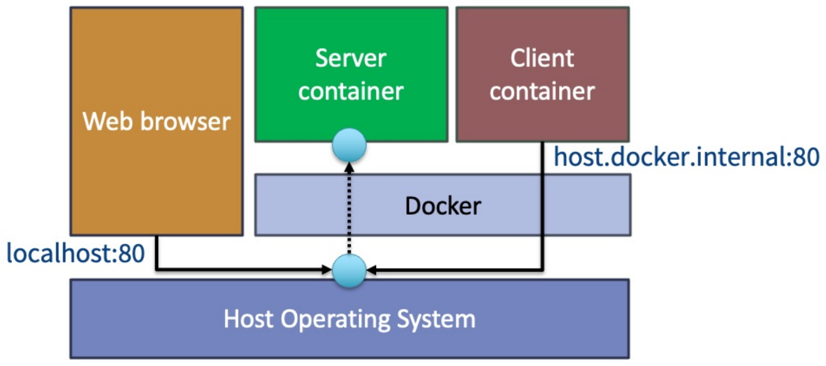
Therefore, in such cases, if your exploit client is logging-in to the application, it may need to manually disable redirect following when sending the login request, so that it can extract the session cookie from the response. That session cookie will need to be included in subsequent requests to the application that the client makes, after logging-in.

Client communication from its own docker container. This means your client will be running inside its own docker container. To communicate with the server, this means your client needs to send requests to the host `host.docker.internal`.

The server is also running inside its own docker container. It listens on port 80. The server can be accessed from outside the server docker container because when the server is started, docker instructs the host operating system to forward requests to port `localhost:80` to port 80 inside the docker container. This is why you can connect to the server by visiting `localhost` in your web browser.

The exploit client, inside its own docker container, can talk to the host operating system by connecting to `host.docker.internal`. If it connects to `host.docker.internal` on port 80, then that connection is forwarded to port 80 inside the server docker container, thereby allowing the client to communicate with the server even though they are both inside docker containers.[1]

This situation is depicted in the diagram below.



Running your client. You should provide a `run_client.sh` script that executes the necessary docker commands to start your client. A sample `run_client.sh` script is provided for the sample dockerised client in Python.

Alternatively, you can document the necessary commands in a `README` file.

We will test your client by first starting the original, vulnerable server. Then in a separate terminal we will run your client. After running your client, we will connect to the server in a web browser and create a new user account and log-in. After logging in, we expect to see an alert popup message appear in the browser saying "This site has been hacked!".

Clients that successfully carry out the entire exploit will receive 4 marks. Those that demonstrate an exploit of at least one identified vulnerability will receive at most 1 mark. Those that demonstrate exploitation of at least two vulnerabilities but without achieving the entire exploit as described above will receive at most

[1]Of course there are other ways the client could communicate with the server using docker networking features; however, the above scenario is perhaps simplest for our purposes.

2 marks. Clients that can successfully log-in as the `admin` user but without achieving the entire exploit as described above will receive at most 3 marks.

3.3 Clarity (0.5 marks)

The remaining 0.5 marks will be awarded for solutions whose report and exploit client are both clearly written and well-documented.

4 Submission

You should submit a single ZIP file that contains at least the following:

- `vulnerabilities.txt`: Your vulnerability report.
- `Dockerfile`: The docker file for your client.
- `run_client.sh` or `README.md`: A script or instructions for running your dockerised client.
- ...remaining code for your client ...

You should *not* submit your fixed version of the server. Instead your fixes should be clearly and unambiguously described in your `vulnerabilities.txt` file.

5 Academic Integrity

All work that you submit must be your own or if derived from elsewhere it must be appropriately acknowledged (see below).

You can discuss the assignment with others to help clarify your understanding of what is being asked. You *cannot* share your answers or your thinking about how to answer a particular part of the assignment with others.

You can make use of certain online resources to help you write code for this assignment, ***so long as you acknowledge the use of such sources and clearly document which code came from them***. These include passive searches using Google, or asking questions to ChatGPT, Github Copilot and similar tools.

All code derived from such sources needs to be appropriately labelled, including the source from which it was derived and how (see below). Otherwise you risk an academic misconduct allegation.

For example, if you derive part of your code from ChatGPT, Copilot, etc., then you need to add comments identifying which pieces of code were derived and what was the prompt you used to query ChatGPT, Copilot, etc.

Similarly, if you derive code from code you find on the web, you need to add comments identifying which code was derived and the source from which it was derived (i.e., a URL that points to the original code / stackoverflow post, etc.)

This also applies to code that you derive by looking at the subject materials (lecture demo code, workshop/tutorial code, lecture slides, tutorial handouts etc.). If you derive your code from such sources, you must label which code was derived this way and the original source.

To repeat: **all derived code that you submit needs to be appropriately labelled, including the source from which it was derived and how it was derived. Otherwise you risk an academic misconduct allegation.**

If you are unsure, email the subject coordinator to ask.

6 Late Penalty and Extensions

Late submissions will attract a 10% penalty (1.25 marks) for each day they are late.

If you require an extension (e.g., for medical reasons, or other reasons supported by the university's extension policy, see `https://ask.unimelb.edu.au/faq/5667/applying-for-an-extension/`) of less than 10 days then you should email the subject coordinator *as soon as you become aware of the circumstances that have impacted your ability to complete the assignment*. Don't wait until the last minute to ask for an extension.