You've Been Hacked

An (Interactive) Course on Web Security

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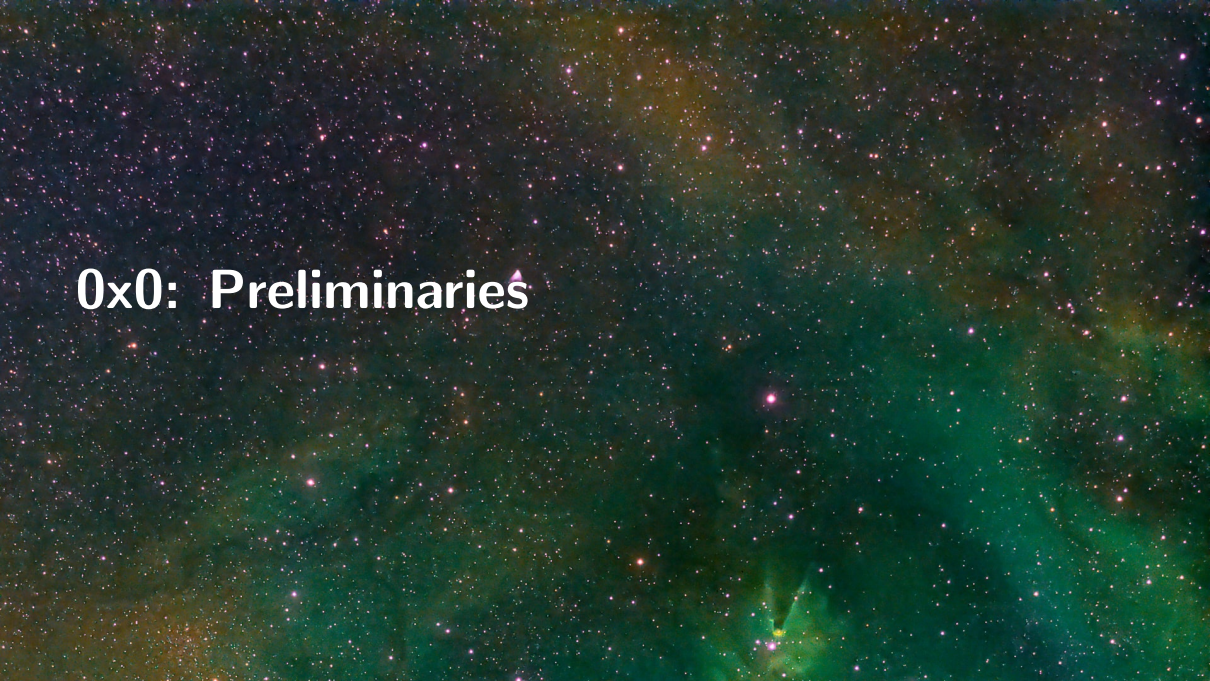

0x0: Preliminaries

whoami

short intro/bio.

man slides

(Interactive) course on web security based on Carsten Eiler's book "You've Been Hacked".
Who is the audience? How can I use the book? How can I explore the app?

Conventions

- Alice, Bob: legitimate, benign users
- Eve: malicious user, attacker
- Server: web server or service in the cloud running a web application or serving a website
- Client: web browser on a user's computer (and sometimes the entire user's computer)

`docker image ls`

Where are the instruction located for how to build the Docker files and use the repository?

0x1: Web Security 101

In a nutshell, **to find vulnerabilities in your web application**, ...

1. ... test various values for parameters used by the web application and see what happens (conceptually similar to fuzzing)
2. ... check web application code for bugs that may lead to security vulnerabilities (typically missing checks of input values or missing countermeasures against certain types of attacks)

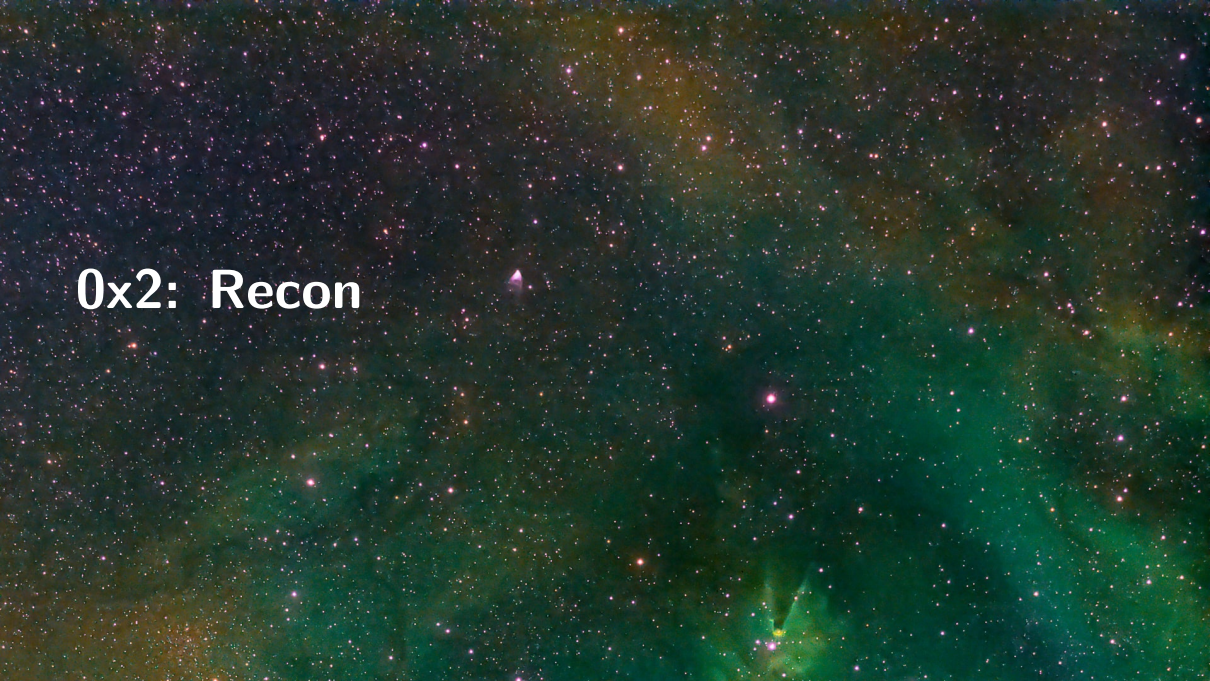
The Open Web Application Security Project (OWASP) maintains a list of Top 10 vulnerabilities in web applications.

Top 10 Web Application Security Risks

1. **Injection**. Injection flaws, such as SQL, NoSQL, OS, and LDAP injection, occur when untrusted data is sent to an interpreter as part of a command or query. The attacker's hostile data can trick the interpreter into executing unintended commands or accessing data without proper authorization.
2. **Broken Authentication**. Application functions related to authentication and session management are often implemented incorrectly, allowing attackers to compromise passwords, keys, or session tokens, or to exploit other implementation flaws to assume other users' identities temporarily or permanently.
3. **Sensitive Data Exposure**. Many web applications and APIs do not properly protect sensitive data, such as financial, healthcare, and PII. Attackers may steal or modify such weakly protected data to conduct credit card fraud, identity theft, or other crimes. Sensitive data may be compromised without extra protection, such as encryption at rest or in transit, and requires special precautions when exchanged with the browser.
4. **XML External Entities (XXE)**. Many older or poorly configured XML processors evaluate external entity references within XML documents. External entities can be used to disclose internal files using the file URI handler, internal file shares, internal port scanning, remote code execution, and denial of service attacks.
5. **Broken Access Control**. Restrictions on what authenticated users are allowed to do are often not properly enforced. Attackers can exploit these flaws to access unauthorized functionality and/or data, such as access other users' accounts, view sensitive files, modify other users' data, change access rights, etc.

Fahrplan

- Get to know your target
- Test for attacks on web application's state
- Test for attacks on authentication
- Test for cross-site-scripting (XSS)
- Test for SQL injection
- Test for other injection-based vulnerabilities
- Test for attacks on file operations
- Test for buffer overflows, format strings and integer bugs
- Test for architectural attacks
- Test for attacks on the web server


0x2: Recon

reconnaissance: *n*. 1. Military observation of a region to locate an enemy or ascertain strategic features. 2. Preliminary surveying or research.

Why Reconnaissance?

Hint: consider the anatomy of a typical cybersecurity attack.

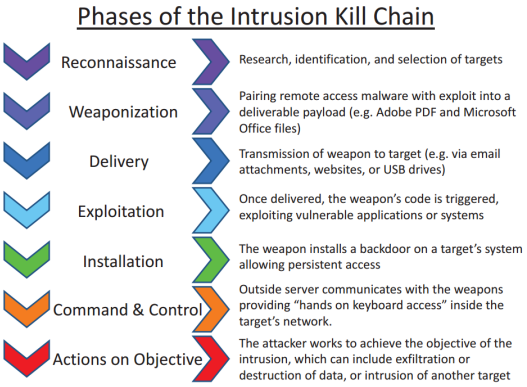
Kill Chain

The term kill chain was originally coined by the military to describe the structure of an attack: finding adversary targets suitable for engagement; fixing their location; tracking and observing; targeting with a suitable weapon or asset to create desired effects; engaging the adversary; assessing the effects;

In 2011, Hutchins et al [1] from Lockheed-Martin expanded this concept to an **intrusion kill chain** for (network) security. They defined intrusion kill chain as reconnaissance, weaponization, delivery, exploitation, installation, command and control (C2), and actions on objectives.

Later on, security organizations have adopted this concept under the name "cyber kill chain".

Intrusion Kill Chain



Source: Wikimedia Commons.

Mimicking the Attacker

Every attack starts by collecting information about the target, e.g., a web application ($\rightarrow$ cyber kill chain).

Likewise, to test a web application for security vulnerabilities, you must first get to know it. You must understand what functions it uses and what parameters these functions have. You have to test every parameter whether it can be exploited (e.g., using illegitimate values). You need to check whether the web application code contains known vulnerabilities.

Systematic collection and documentation allows you to understand what a real attacker would learn and where she could break your application's security.

Collecting Rudimentary Information

Document any **easy-to-spot hints** to security vulnerabilities:

- Suspicious comments in the HTML code (`<!-- default password:...`)
- Sensitive information embedded in the HTML code
- Error messages from the web application
- Error messages from the web server and HTTP responses

Learning the Web Application Structure

Catalogue **all pages, resources and parameters** that belong to or are used by the web application:

- using a general-purpose tool like `wget`
- using a special-purpose tool like the OWASP Zed Attack Proxy (ZAP) crawler
- by manually visiting all web pages of the application (works well for small web applications)

While `GET` parameters are displayed in the URL, you'll need a web proxy like OWASP ZAP to access `POST` parameters and cookies.

If your web application has different roles (guest, admin, ...), you'll have to test it for all these roles (i.e., first as a guest, then logged in as admin, etc.)

Investigating Individual Web Pages

Visit all pages and **inspect their source code**. Look for things like:

- **Leaky HTML comments** (comments containing e.g., code fragments, configuration parameters, server names, SQL table descriptions, etc.)
- **Hidden input fields** (`<input type='hidden' ...>`)
- **SQL queries** printed in the page source due to programming or configuration errors (reveal the structure of the database and the queries used)
- **IP addresses of internal servers**
- **Web or email addresses**, e.g., email addresses of the developers (might reveal who wrote the application. Maybe it's just an optical tweak of a well-known application?)

Investigating Parameters

Investigate **all parameters** passed to the application:

- What happens when you change their values or use invalid values, e.g., a string instead of an integer?
- Do invalid parameters return error message that leak information about the application like database table names?

Collecting More Information

- Are there unlinked resources likes directories or files?
- E.g., if there are links to files financial-report18.pdf and financial-report19.pdf, is there an unpublished file financial-report20.pdf?
- Are there any hints to the structure of file names or sub directories?
- E.g., if the web application contains user profiles, is it possible to access an arbitrary profile using `user-[number].html` or `user.php?id=[number]`?
- Are there unlinked sub-directories like `test/` or `admin/`?
- Does the web server contain unused libraries or example application code that contains hints to known vulnerabilities or the internals of the web application?
- What else is running on the server? SSH?

Investigating Client-Side Code

What input parameters are sanitized in the client-side code (JavaScript or plain HTML)?

Investigating Client-Side Code: Static Pages

If user input is checked, i.e., sanitized, at client side (either in JavaScript or in HTML), chances are that no sanitization is implemented on the server.
Because an attacker can easily manipulate the client-side code, she can manipulate the user inputs sent to the server.

Investigating Client-Side Code: Static Pages

Check **all input fields** like text input, drop-down menus, radio buttons and select tags for **constraints for their values**. E.g., is there a maximum text length for a text field? Are numeric input values scoped? If yes, change these values and check how the web application is behaving.

Investigating Client-Side Code: Static Pages

There are 3 ways to change the client-side values:

- Parameters transmitted via `GET` requests can be manipulated directly in the URL
- Parameters transmitted via `POST` requests can be manipulated directly in a local copy of the website code
- On the fly, using a proxy like the OWASP ZAP or web developer tools in the web browser

Investigating Client-Side Code: Static Pages

Hidden forms (`type="hidden"`) are sometimes used to store values used by the web application. A classic mistake is to store the price of the items in a web shop application (since you can easily manipulate them before sending them to the server).

A Trivial Example

Say there is a drop-down menu to select the number of items to be added to a shopping cart. The drop-down menu allows numbers in the range 0 to 100. What happens when you set this parameter to a negative value and transmit it to the server? Maybe there is no sanitization on the server side because only values greater or equal to zero can be selected from the drop-down menu? In this case, the final price is calculated by multiplying the price of the item with a negative number.

Collecting JavaScript-related Information

After checking HTML, next step is to check the JavaScript code.

- Is JavaScript used to validate input data? If so, maybe the check on the server side is omitted.
- What files and scripts are being loaded? Any known vulnerabilities?
- Are there vulnerabilities in the JavaScript program logic itself? Any logic flaws that can be exploited?

Reconnaissance of the Demo Application

Files:

`style.css`

Directories & Paths:

`admin/index.php?sprache=de`	Administration area
`backend/index.php?sprache=de`	Backend
`kontakt.php`	Contact form
`kontakt.php?datei=mail.txt`	Contact form
`kontakt-html5.php`	Contact form with email
`empfehle.php`	Recommend function
`angriffe/index.html`	Attacks (just a description)
`index.php?sprache=de`	Starting page
`index.php?plugin=plugin&sprache=de`	Included plugin
`index.php?aktion=plugin2&sprache=de`	Included plugin

Reconnaissance of the Demo Application

```
URL parameters in index.php:
--------------------------------------------------------------------------
Select language:
  sprache=de
  sprache=en

Select entry:
  aktion=anzeigen&id=1&sprache=de
  aktion=anzeigen&id=2&sprache=de
  aktion=anzeigen&id=3&sprache=de
```

Reconnaissance of the Demo Application

Forms:

Search:

```html
<form action="index.php" method="GET">
   <input type="hidden" name="sprache" value="de">
   <input type="text" name="nach" value="Suchbegriff" size="20" maxlength="250">
   <input name="aktion" value="suchen" type="submit">
</form>
```

Login:

```html
<form action="index.php" method="POST">
    <input type="hidden" name="sprache" value="de"><br>
    Benutzername:<br>
    <input type="text" name="benutzer" value="gast" size="50" maxlength="100"><br>
    Passwort:<br>
    <input type="text" name="passwort" value="gast" size="50" maxlength="100"><br>
    <input type="submit" name="aktion" value="einloggen">
</form>
```

Reconnaissance of the Demo Application

```
Misc:
-------------------------------------------------------------------------------
In the individual entries (posts), there is a comment `<!-- ID: 1 -->`, `<!-- ID: 2 -->`, etc.


Parameters     Known values
-------------------------------------------------------------------------------
aktion             `anzeigen` (with `id` & `sprache`)
aktion             `einloggen` (with `user` & `password` & `sprache`)
aktion             `registrieren` (with `real` & `benutzer` & `password` & `sprache`)
aktion             `suchen` (with `nach` & `sprache`)
aktion             `ausloggen`
aktion             `plugin2` (with `sprache=de`)
aktion             `einloggen` (with `benutzer`, `passwort`, `sprache`)
aktion             `upload`
aktion             `loeschen`
aktion             `wirdBenutzer`
aktion             `wirdAutor`
aktion             `sperren`
benutzer           String, maxlength=100 (with `aktion=einloggen | registrieren`)
id                 Number, 1 - 3 (with `aktion=anzeigen`)
nach               String, maxlength=250 (with `aktion=suchen`)
passwort           String, maxlength=100 (with `aktion=einloggen | registrieren`)
real               String, maxlength=100 (with `aktion=registrieren`)
MAX_FILE_SIZE      A constant 128000 (with `aktion=upload`)
```

Reconnaissance of the Demo Application

```
Actions and Special Cases
-------------------------------------------------------------------------------
suchen          the value of the parameter `nach` appears on the web page
anzeigen        in case of a wrong ID, no entries (or warnings) appear in the source code a
anzeigen        `id`=<letter> => SQL error: 1054: Unknown column 'a' in 'where clause'
anzeigen        `id`=' => SQL error: 1064: You have an error in your SQL syntax; check the
syntax to use near ''' at line 1
einloggen       contradictory statements: "Sie sind nicht angemeldet!" and "Anmeldung als g
einloggen       the user name from the logon form is potentially used in the web page outpu
einloggen       identical error message with correct user name/wrong password and wrong use
ausloggen       potentially no protection against CSRF
registrieren    trying to register with an existing user name (gast) => SQL error: 1062: Du
`upload`        are only GIF and JPEG files allowed?


SQL Database
-------------------------------------------------------------------------------
Table           'Benutzer_Name'
```


0x3: Stateful Attacks

State in Web Applications

- HTTP, the protocol for transferring data between the server and the client, is stateless
- Example: HTTP doesn't manage information about pages previously visited by the client, i.e., any URL can be requested by the client at any time.
- If statefulness is required (e.g., page B shall only be served if the client has previously visited page A), the web application must manage a *session*

Statefulness: Web Shop Example

- Malicious user adds items into the shopping cart
- She then skips the page where credit card information must be entered and proceeds directly to the checkout page
- If the web application doesn't enforce the correct sequence of pages, the user would successfully place an order without having entered any payment details

Managing State Information

There are two options to manage state information in web:

- the state information is stored on the server; the users are identified using a *session ID*
- the state information is stored on the client

Hidden Input Fields

State information can be located in hidden input fields, e.g.,

```
<input name="id" value="1234" type="hidden">
```

Such data fields can be easily manipulated using a tool like ZAP-Proxy or using web developer tools in the web browser. Thus, an attacker can easily manipulate hidden input fields.

Detecting Hidden Input Field Vulnerabilities

For every hidden input field in the application, you must examine whether the web application's behavior changes if the values of these input fields are altered.
A classical anti-pattern (luckily not so common anymore) is the use of hidden input fields for storing item price in a web shop. Yet another example is the storage of the user's status, e.g., a signed in user instead of a "guest" or administrator instead of a standard user.

Defending against Hidden Input Field Attacks

- Core issue with hidden input fields: state information is stored *on the client* where it can be easily manipulated by a malicious user
- Main defense philosophy: *never trust the client*
- Critical information must always be stored on the server
- Values received from the client must always be checked & validated
- If values must be stored on the client (e.g., session IDs), they should be encrypted or hashed

URL Parameters

- (State) information can be transmitted in the URL
- In contrast to forms, transmitting information via URL parameters does not require clicking a submit button

URL Parameters: Finding Vulnerabilities

- Using URL parameters to transmit information is a threat, because it is trivial to manipulate them
- Look for URL parameters identified during the recon phase
- Investigate what happens when you change these parameters. Does this cause an unexpected and unintended change of the state of the web application?
- `http://www.webapp.example/editprofile.php?id=123`
- What happens when you change `id`? Can you edit the profile of a different user?
- Are there (hidden) parameters to activate debug information, e.g., `debug=on`, `debug=1` or `debug=true`?

Defending against URL Parameter Manipulation

- Core issue with URL parameters: state information is stored *on the client* where it can be easily manipulated by a malicious user
- URL parameters must always be checked & validated
- If possible, they should be encrypted or hashed

Cookie Parameters

- For a long time, cookies were the only option to persistently store data on the client
- It is still the prevailing solution
- Cookies are frequently used for user identification, e.g., at consecutive visits of a web application
- Attacks based on cookie manipulation are called *cookie poisoning*

Cookies

- Persistent vs non-persistent cookies
- `secure` vs `HttpOnly` cookies
- Persistent cookies are stored on client's hard drive as long as their date is validated
- Non-persistent cookies are stored in RAM and are deleted when the web browser is closed
- `secure` cookies are transmitted only via an HTTPS connection
- `HttpOnly` cookies are transmitted via HTTP or HTTPS, but cannot be accessed by JavaScript

Cookie Parameters: Storage and Manipulation

- All web browsers store cookies in known file system locations and in known formats
- An attacker can easily manipulate this data before it is used by a web application
- It is possible to manipulate cookies *on the fly*, e.g., using a tool like the ZAProxy

Cookie Parameters: Storage and Manipulation

- Unlike with URL parameters, the attacker can also manipulate the date when the cookie expires, i.e., she can manipulate the cookie's lifetime
- In general, cookies can give you access to things like sessions, profiles, etc.

Cookie Parameters: Storage and Manipulation

Example:

- `weather.xyz` offers detailed weather information against payment
- `weather.xyz` uses cookies that contain `userID` to identify users
- The cookie is valid for the user's subscription period, e.g., a month
- Information stored in the cookie is processed by `weather.xyz` without additional authentication
- Attack 1: malicious user manipulates `userID` to access `weather.xyz` as another user
- Attack 2: malicious user extends their subscription by manipulating the cookie expiration date (by changing the Unix-timestamp in the cookie)
- Attack 3: cookies often store the number of failed login attempts. When they reach a specific threshold, say 5, `weather.xyz` deactivates that user account for 10 minutes to protect against brute force attacks. The attacker bypasses this defense by setting the value of failed login attempts to 0 after each login attempt. Since this can be easily automated, brute force attacks become trivial.

Cookie Parameters: Finding Vulnerabilities

- For every cookie found during recon phase, you must check whether a parameter manipulation results in an illegal state change of the web application
- Manipulation should also include cookie parameters like expiration
- To detect cookie-related vulnerabilities more efficiently, *decrease* the expiration date and check whether the web application denies its service
- As an alternative – if you have access to the server-side source code of the web application – check whether the source code uses the cookie expiration date as input parameter

Cookie Parameters: Defending Against Attacks

- In general, cookie poisoning – attacks that manipulate cookies – cannot be eliminated
- Cookies are stored on the client and a malicious user can always manipulate data on the client (even data of other users)
- Two prominent attacks in this context are *cross-site-scripting* (XSS) and *cross-site-request-forgery* (CSRF)
- Attacker exploits web browser capabilities to set a cookie for a different domain

Cookie Parameters: Defending Against Attacks

- As a general rule, never trust data supplied by the client
- For example, store subscription's expiration date or the number of failed login attempts on the server
- If storing data on the client is unavoidable, encrypt or hash that data
  - Question to the audience: why?

URL Jumping

- Eve abuses the intended sequence of web pages. This gives her access to functions that by design must be unavailable at that point in time.

URL Jumping: An Example

In a typical web shop, the intended sequence of transactions – i.e., pages that a shop's customer visits – could look something like this:

1. Search for a suitable product at `www.shop.xyz/catalogue.php`
2. add an article to the shopping cart at `www.shop.xyz/add.php`
3. verify the customer order at `www.shop.xyz/order.php`
4. provide shipping information (customer's postal address) at `www.shop.xyz/shipping.php`
5. enter credit card information at `www.shop.xyz/payment.php`
6. checkout & finish the order at `www.shop.xyz/checkout.php`

URL Jumping: An Example

- If the attackercan jump from step 4 (`www.shop.xyz/shipping.php`) directly to step 6 (`www.shop.xyz/checkout.php`), she might be able to order an item without paying for it
- Another example: the attackercould try to post a message to an online forum with creating an account
- In general, the attackertries to identify URLs that must be called in a specific sequence and tries to manipulate this sequence

URL Jumping: Locating the Vulnerabilities

- Make a complete list of URLs in your web application and whether certain URLs must be called in a specific order
- Use information gathered during recon phase
- For every URL sequence:
  - Call the URLs in the intended order and document the parameters passed to the web application
  - Diverge from the intended sequence and see what happens. Are there any error messages (e.g., "You first must create a user") or are specific URL/pages not accessible?
  - If there is no error message and the URLs can be accessed in any order, check whether this represents an actual, exploitable vulnerability

Defense against URL Jumping

- URL jumping is a security issue only when the sequence in which URLs are accessed is relevant for the web application
- In that case, you need to check that the correct sequence is used, e.g., `checkout.php` would check if the user previously visited `payment.php` which, in turn, would check if the user previously visited `shipping.php`

Defending against URL Jumping

There are 3 options to identify a previously visited URL:

1. The URL (or the corresponding ID) is stored in a hidden input field or in an URL parameter
2. The URL (or the corresponding ID) is stored in a cookie
3. The URL, from which the user is allegedly coming, is compared to the `Referer` field value in the HTTP header

Defending against URL Jumping

- As shown previously, option 1 (hidden input field) and option 2 (cookie) are insecure as they can be easily manipulate by the attacker
- That leaves us with option 3 (`Referer` value)

An HTTP request could look like this:

```
Get /checkout.php HTTP/1.1
Host: www.shop.xyz
User-Agent: Mozilla/5.0 (Macintosh; U; PPC Mac OS X; de-de) [.
Accept: */*
Accept-Encoding: gzip, deflate
Accept-Language: de-de
Connection: keep-alive
Referer: https://www.shop.xyz/payment.php
```

Defending against URL Jumping

- The `Referer` value is automatically set by the web browser
- In case of a bookmark or a direct entry in the web browser's address field the `Referer` value does not exist in the HTTP header
- However, the `Referer` value can be omitted by the web browser (for privacy reasons), removed from the HTTP request by a proxy or manipulated by the attacker
- `Referer` value can be manipulated using a tool like ZAProxy or using a dedicated client where the individual values of the HTTP header can be defined manually
- So `Referer` value is also insecure

Defending against URL Jumping

- In the end, the only effective defense against URL jumping – similar to other attacks – is to store state information on the server
- Specifically, the information about the visited URLs for each user can be stored temporarily in the web application (or persistently in a database)

Session Highjacking

- Numerous attacks can be alleviated by storing state information on the server (instead of client)
- In that case, the web application needs a way to identify the user
- The notion of a *session* is used to associate state information (stored on the server) to a specific user
- The web application assigns each session a unique *session identifier* (session-ID)

Session Highjacking

- Session-ID is a number or a combination of numbers and letters that uniquely identifies a session
- Session-ID is assigned to the client (user) upon the first HTTP request to the web application
- Every subsequent request carries the session-ID so that the web application can identify the client (user) and retrieve the corresponding state information stored on the server

Session Highjacking

- Because the session-ID must be stored on the client, it can be manipulated or stolen
- An attack exploiting this vulnerability is referred to as *session hijacking*
- The attackergets hold of the session-ID information to gain unauthorized access to the web application

Session Highjacking

```
Name=Alice
userID=1234
last=2021-08-24
```

- A special case of session hijacking is the so-called *authorization bypass*
- Example: web application identifies the client (user) based on a cookie containing the user name, the user ID and the date of the last session
- Is there are user with ID 1235?
- The attackercan change `userID` and use the manipulated cookie to take on the identity of another user

Finding Session Highjacking Vulnerabilities

- First, identify the session-ID in the web application, e.g., search for parameters whose names contain `ID`, `TOKEN`, `SESSIONID`, `ID` or similar strings. These parameters can be located in hidden input fields, URL parameters or in cookies.
- Once you identified a potential session-ID, change it and check whether you can impersonate another user

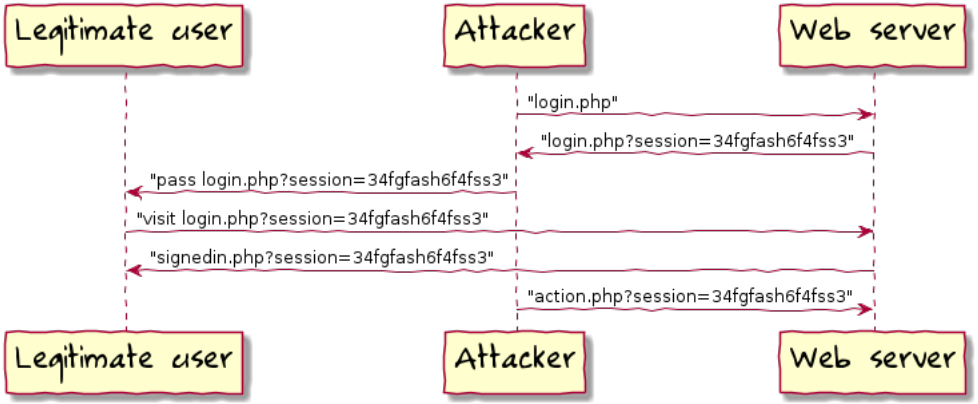
Defending against Session Highjacking

- Session hijacking requires a valid session-ID. The attackerhas essentially 4 options to get hold of it:
  - Cross-site-scripting (XSS): XSS attacks are commonly used to steal cookies (more on this later). Make sure your web application has no XSS vulnerabilities. In addition, you can set `HTTPOnly` flag to prevent access to cookies from within JavaScript
  - Eavesdropping network traffic: if the attackercan read network traffic between the client and the web application, she can extract the session-ID. Ensure that you web application uses TLS (HTTPS).
  - Searching logfiles: if the attackerhas access to the web server (or proxy) logfiles, she can search them for session-IDs that were transmitted via `GET` requests. Session-ID should therefore be transmitted in cookies or via `POST` requests.
  - Brute-force attack: the attackercan try to guess the format of your session-IDs and try out various (random) combination until she finds a valid session-ID. You should use large random values as session-IDs.

Defending against Session Highjacking

- Performing session identification based on the combination of the session-ID and the IP address of the client makes session hijacking more difficult
- Instead of the IP address, you can also use e.g., the `User-Agent` header (i.e., user the client browser "model" as an additional identification factor)
- To reduce session hijacking-related risks, you should end the sessions after a specific time and make the corresponding session-IDs invalid
- This can be done using a "hard" time-out (e.g., every session ends after 30 minutes) or a "soft" time-out (e.g., session ends after 10 minutes of inactivity)

Session Fixation



- Instead of stealing or guessing the session-ID, the attackerattempts to fixate other user's session-ID
- Session fixation attacks are typically web based and rely on session identifiers being accepted from URL parameters or POST data

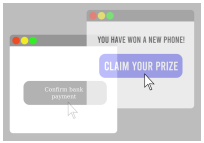
Detecting Session Fixation Vulnerabilities

- Use the information from the recon phase to identify session-IDs
- Call the web application with a session-ID that is already used, i.e., has been set by the web application
- Example: if the entry to the web application is `www.examle.xyz` and the web application, in turn, returns `www.example.xyz/index.php?session=[valid-session-ID]`, call this URL directly
- If you can login and your session-ID is `[valid-session-ID]`, you've found a session fixation vulnerability
- If session-ID is transmitted in a cookie, use ZAProxy to manipulate it

Defending against Session Fixation

- Make sure your web application generates a new, random session-ID each time a user logs in
- The same behaviour must be implemented when a new users signs up
- Some web applications accept arbitrary session-IDs, i.e., session-IDs that they have not generated
- This makes Eve's life easier because she doesn't need to obtain a valid session-ID
- Thus, your web application should only accept session-IDs that it actually generated
- Make sure it's impossible to reactivate expired sessions with known "old" session-IDs. If a session expired, a new session must be created with a new session-ID and a new state. Otherwise Eve can mount replay attacks.
- You should also leverage the information in HTTP header's `Referer` field. If the observed sequence of URLs doesn't match the expected sequence, either URL jumping is taking place or two clients (users) are using the same session-ID

Clickjacking



- Eve tricks Alice into clicking on something different from what Alice perceives and, as a result,
- This way, Eve can trick Alice into performing undesired actions by clicking on concealed links
- Clickjacking works because JavaScript allows to load a transparent layer over a web page and have the user's input affect that transparent layer without the user noticing
- For clickjacking to work, Alice must visit a page under Eve's control (because JavaScript is needed to create the transparent layer)

Image source: Wikimedia

Clickjacking

Example:

- Alice receives an email with a link to a video about a news item on a page under Eve's control
- Eve overlays a product page on Amazon on top of the "play" button of the news video
- Alice clicks on "play" to start the video, but actually buys the product from Amazon
- Eve can only send a single click, so she relies on the fact that Alice is both logged into Amazon.com and has the 1-click ordering enabled

Clickjacking

- Technically, Eve embeds the target page an an iframe into the web page that will be displayed to Alice
- Eve reduces the size of the iframe such that only the target link is included; the rest of the target page is beyond the iframe
- Eve can configure the iframe to follow the mouse pointer. So regardless where Alice clicks, she will always clock on the target link
- Finally, Eve adjusts the opacity of the `div` element that spans the iframe such that the iframe becomes invisible to Alice
- After tricking Alice into clicking the target link, Eve can bring the visible page into the foreground so that Alice will likely not notice the attack

Detecting Clickjacking Vulnerabilities

- Check whether your application contains pages where only authenticated users can perform certain actions
- Then, check whether these pages can be embedded in iframes

Defending against Clickjacking

- To defeat clickjacking, you must prevent relevant web pages of your web application from being embedded in an iframe
- A *framebuster* is a small JS script that prevents the web page from being displayed in a frame (however, HTML5 capabilities – loading a page in a frame with the `sandbox` attribute – allow Eve to bypass any framebusters)
- `X-Frame-Option` header can be used (by the web server) to specify preferred framing policy:
  - `deny` prevents any framing
  - `sameorigin` prevents framing by external sites
  - `allow-from origin` allows framing only by the specified site
- The `frame-ancestors` directive of the Content Security Policy can be used to allow or disallow embedding a web page in an iframe

Cross-Site Request Forgery

- Cross-Site Request Forgery (CSRF) attacks exploit web application's trust in Alice to perform unauthorized actions on her behalf
- Eve's goal is to trick Alice into unknowingly submitting an HTTP/web request to a web application that Alice has privileged access to (but Eve does not)
- Unlike Cross-Site Scripting (XSS) which exploits the trust a user has for a particular site, CSRF exploits he trust that a site has in a user's browser
-

Cross-Site Request Forgery

- At risk are web applications that perform actions based on input from trusted and authenticated users without requiring the user to authorize the specific action
- For instance, a user who is authenticated by a cookie saved in the user's web browser could unknowingly send an HTTP request to a site that trusts the user and thereby cause an unwanted action

Cross-Site Request Forgery

Example 1:

- `www.server.xyz/app/index.php?action=logout` is used to log out users
- The web application identifies users through a session-ID stored in a cookie
- The cookie is automatically sent by the user's web browser
- The web application is an online forum where links can be stored in posts
- Eve publishes a post with the above link disguised by an `<a href="...">more info here</a>`
- Alice clicks on the link and is logged out

Cross-Site Request Forgery

Example 2:

- New user is added when `www.server.xyz/app/admin/adduser.php?name=NAME&pass=PWD` is called by an admin
- The web application identifies users through a session-ID stored in a cookie
- Eve prepares a malicious web page and tricks the admin to open this page
- The web page contains `<img src=www.server.xyz/app/admin/adduser.php?name=eve&pass=eve">`
- The (loged in via cookie) admin opens the malicious page
- Admin's web browser sends a `GET` request to load the image
- The URL to create a new user is called instead
- The cookie to authenticate the admin is automatically sent by her web browser

Cross-Site Request Forgery

Example 3:

- Instead of a `GET` request, the web application uses a form – and, thus, a `POST` request – to add new users:

```
<form method="post" action="http://www.server.xyz/app/admin
  Name: <input name="username"> <br>
  Passwort: <input name="password"> <br>
  <input type=submit value="Add User">
</form>
```

- The data sent to the application is in the `POST` request, i.e., it doesn't show in the URL
- Eve prepares a malicious web page and tricks the admin to open this page
- The web page contains a form that is auto-submitted upon opening the pages:

```
<form name="csrf" method="post" action="http://www.server.x
  <input type="hidden" name="username" value="eve">
  <input type="hidden" name="password" value="eve">
```

Cross-Site Request Forgery

Example 3 (cont'd):

- Eve prepares a malicious web page and tricks the admin to open this page
- The web page contains a form that is auto-submitted upon opening the pages:

```
<form name="csrf" method="post" action="http://www.server.x
  <input type="hidden" name="username" value="eve">
  <input type="hidden" name="password" value="eve">
</form>
<script>document.CSRF.submit()</script>
```

- The (loged in via cookie) admin opens the malicious page
- The form is submitted automatically, as if the admin clicked on "Add User"
- The cookie to authenticate the admin is automatically sent by her web browser

Cross-Site Request Forgery

- Essentially, it is sufficient to trick an authorized user to send a maliciously crafted HTTP request
- As a result, CSRF is not limited to web pages
- Any document format that supports scripting can be exploited, e.g., HTML e-mails and multimedia files

Detecting CSRF Vulnerabilities

- A web application is susceptible to CSRF when it implements actions that can be triggered via a static URL (`GET` request) or a static `POST` request (like a static form)
- To prevent CSRF attacks, the corresponding URLs or forms (`POST` requests) contain the so-called *Anti-CSRF-Token*
- The *anti-CSRF-token* is a random value that Eve cannot guess
- The action associated with the `GET` or `POST` request is only performed if the token contains the correct value

Detecting CSRF Vulnerabilities

- Thus, you need to check whether all `GET` and `POST` requests perform an action that requires authorization contain a CSRF-token
- Check whether these requests contain parameters that change every time the request is Sensitive
- If any of these requests is static, i.e., doesn't change over time, the web application is vulnerable to CSRF

Defending against CSRF

- You must add a unique, random token to every relevant `GET` and `POST` request
- It is important that the token has sufficient entropy so that Eve cannot simply send multiple request with highly likely token values
- The web application must only perform actions when the correct token is supplied
- Then, Eve cannot prepare a valid request because she can't guess the random token value (she could learn the token value using XSS, though)
- For really important actions, you should add an additional password check

Defending against CSRF

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Defending against CSRF

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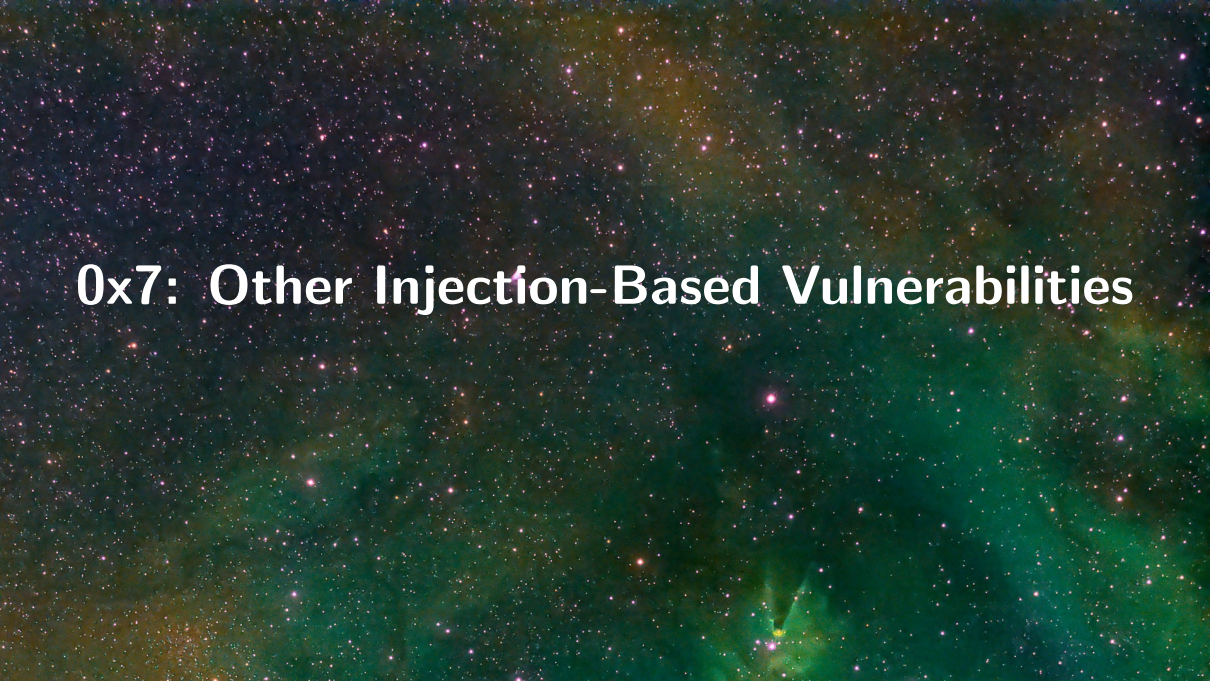
0x4: Attacks on Authentication

0x5: Cross-Site-Scripting (XSS)

0x6: SQL Injection


0x7: Other Injection-Based Vulnerabilities

0x8: Attacks on File Operations

0x9: Buffer Overflows, Format Strings and Integer Bugs

0xA: Architectural Attacks

0xB: Attacks on the Web Server


0xC: Misc

More Things to Consider

One

More Things to Consider

One Two

More Things to Consider

One Two Three

Bibliography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