# Exploring OAuth 2.0

## A practical guide to securing your APIs

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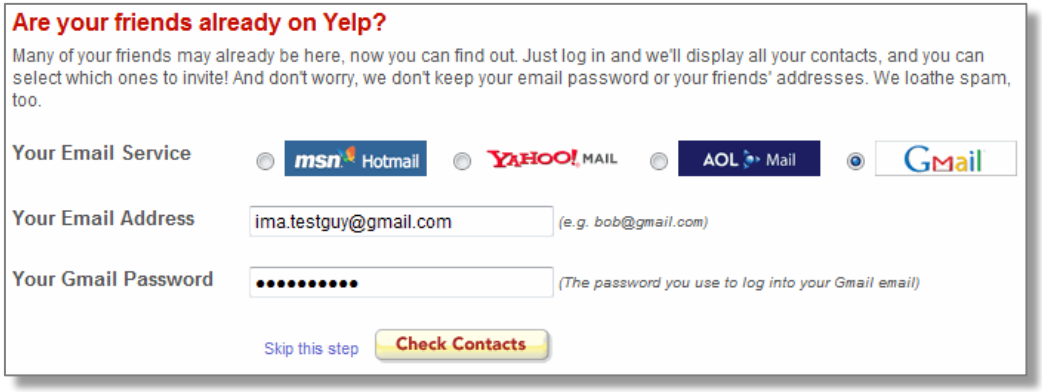
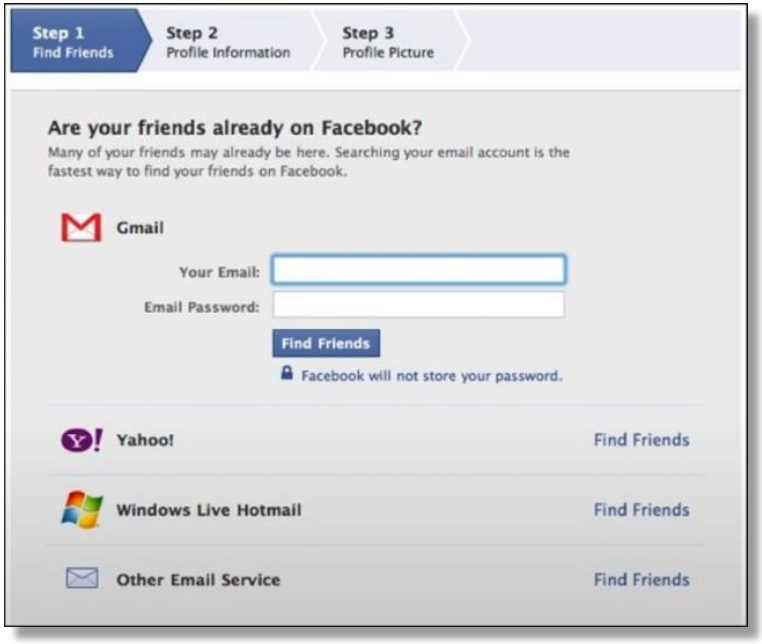
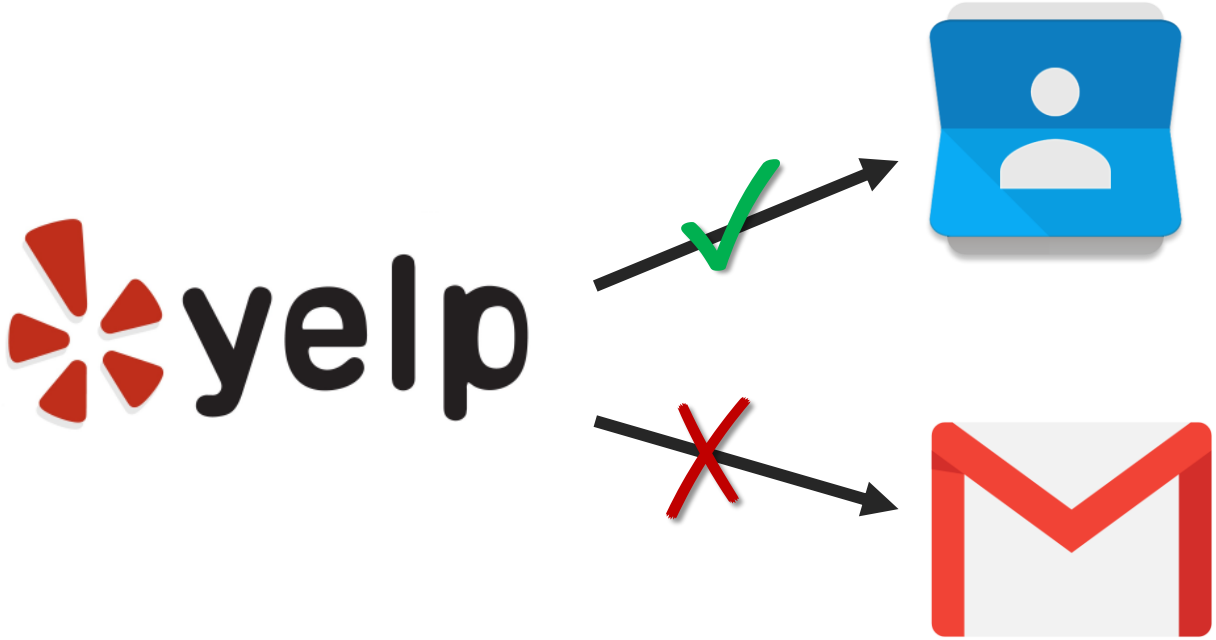
KU LEUVEN DistriNet



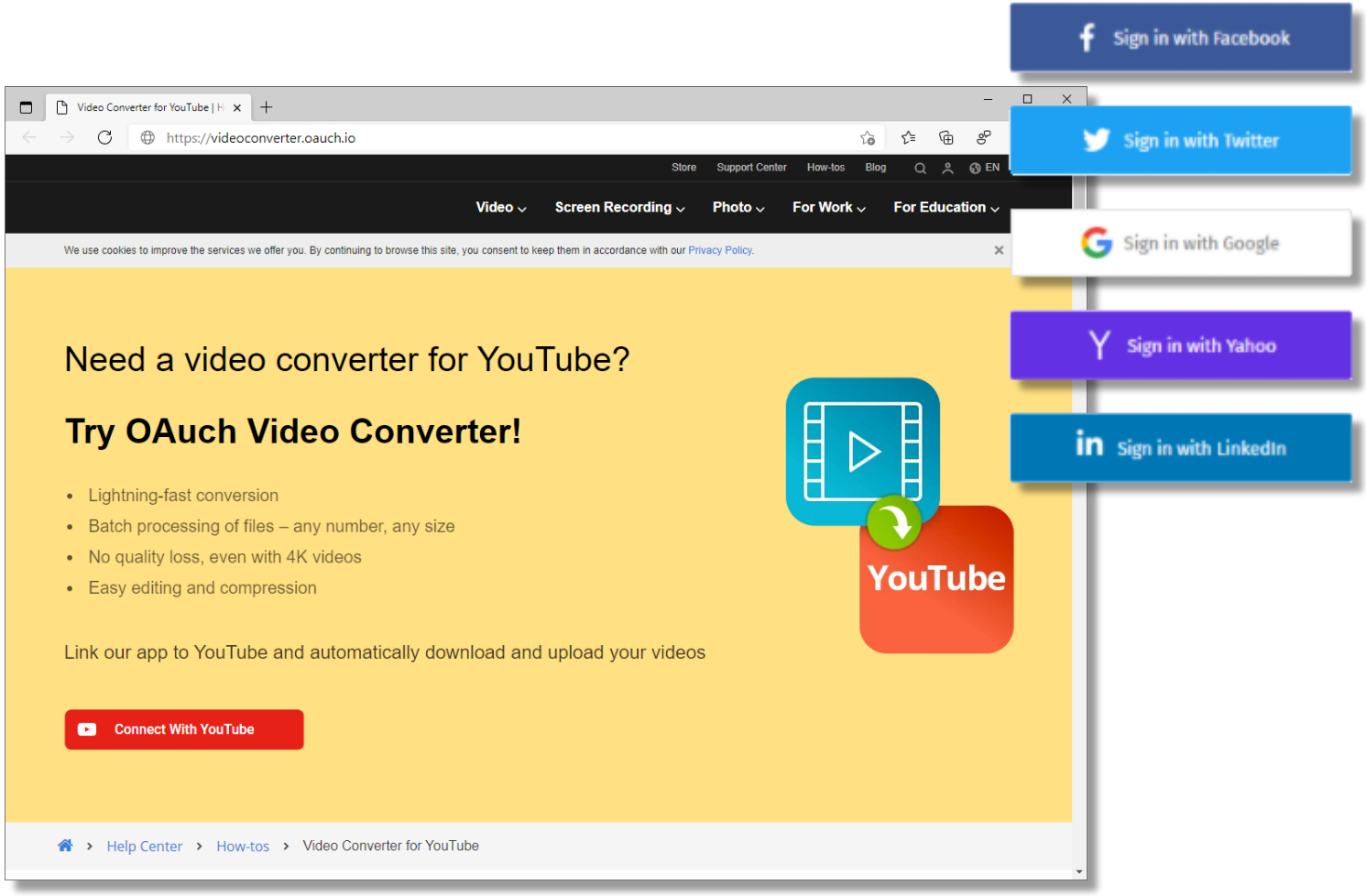




If a third party wanted access to an account,

you'de give them your password


yelp

So…
how can I let an app
**access my data**
without giving it my password?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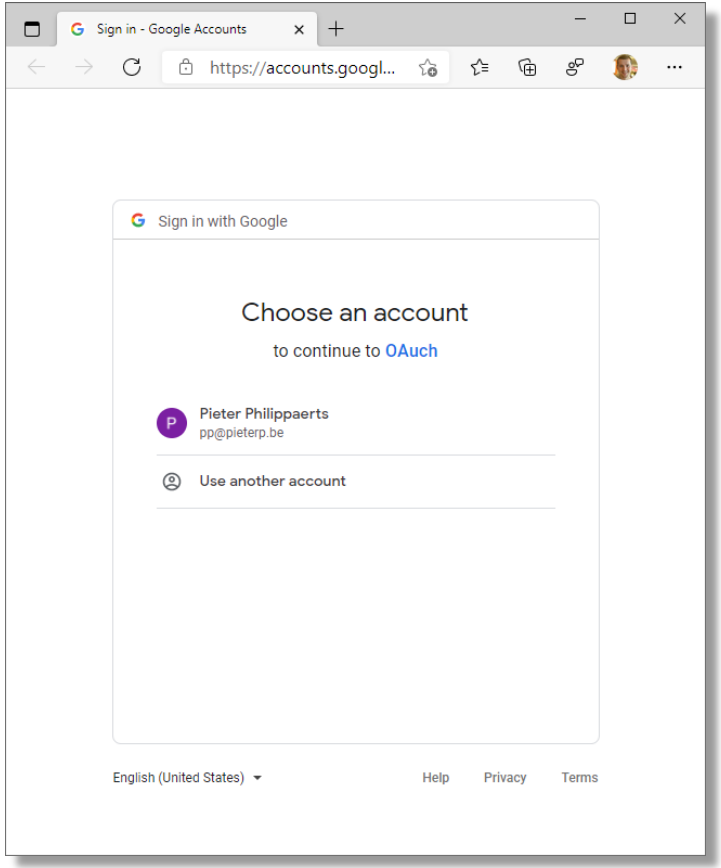
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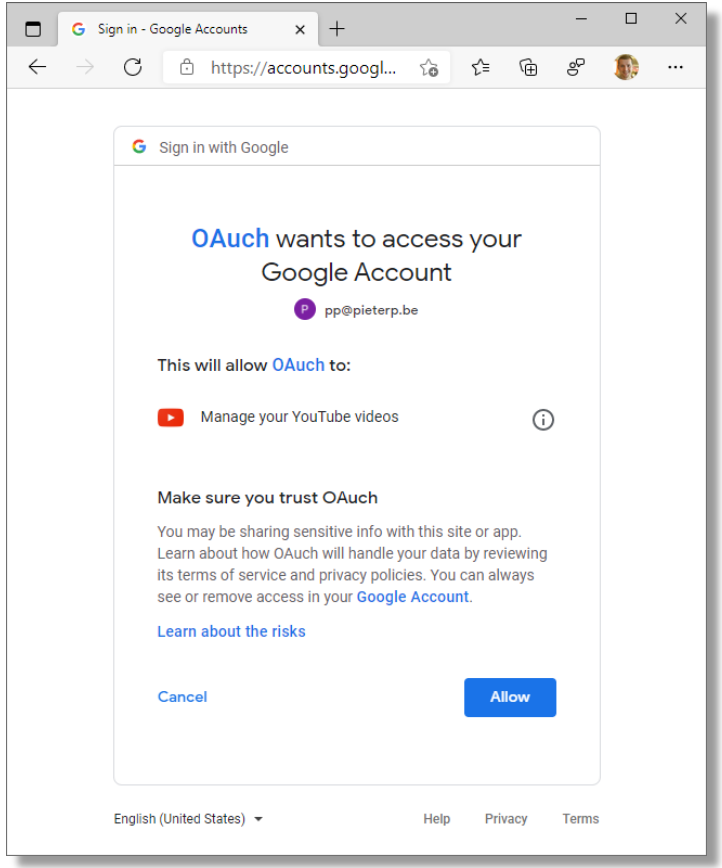
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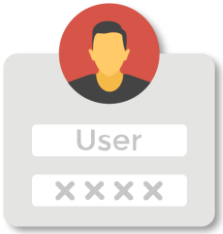
# Use Cases

Web-server apps

Browser-based apps

Mobile apps




Username/Password access

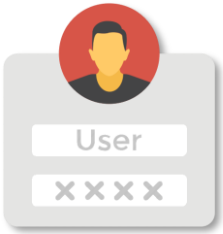
Application access

# Use Cases – Grant Types


**Web-server apps**
`authorization code`

**Browser-based apps**
`implicit`

**Mobile apps**
`implicit`



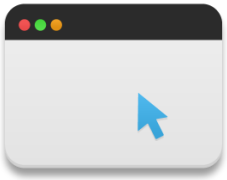

**Username/Password access**
`password`

**Application access**
`client credentials`

# OAuth 2.0 Roles

**Resource Owner**
“the user”

**User-Agent**
“the browser”



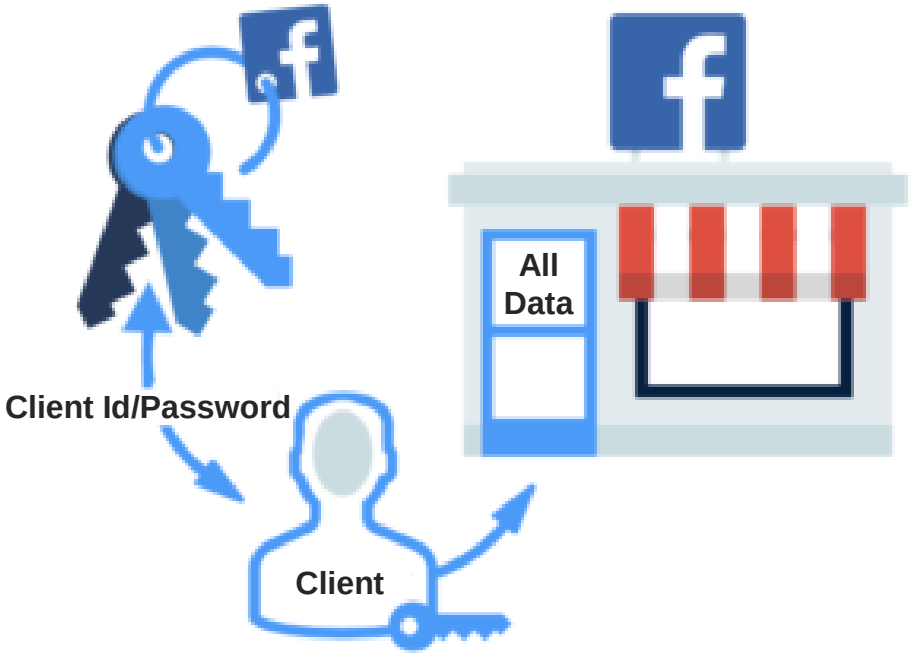
**Client**
“the app”


**Resource Server**
“the API”

**Authorization Server**

# OAuth 2.0 Grant Types

# Client Credentials Grant




https://blog.oauth.io/oauth2-flow-grant-types-in-pictures/

# Client Credentials Grant

**REQUEST**

```
POST /token HTTP/1.1
Host: server.example.com
Authorization: Basic czZCaGRSa3F0MzpnWDFmQmF0M2JW
Content-Type: application/x-www-form-urlencoded

grant_type=client_credentials
```

Client ID & Password

**RESPONSE**

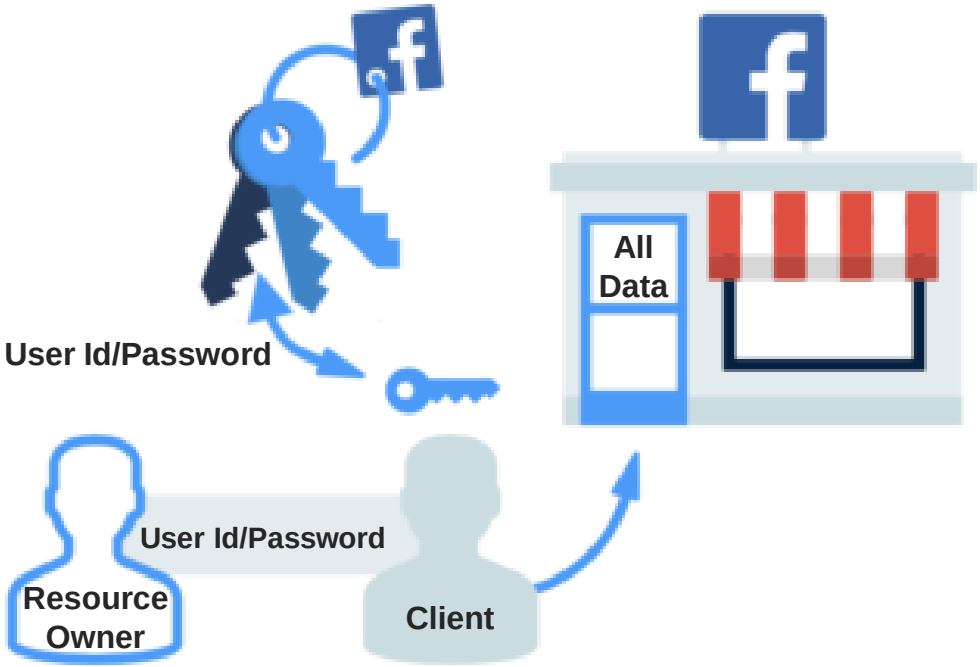
```
HTTP/1.1 200 OK
Content-Type: application/json;charset=UTF-8
Cache-Control: no-store
Pragma: no-cache

{
  "access_token":"2YotnFZFEjr1zCsicMWpAA",
  "token_type":"Bearer",
  "expires_in":3600
}
```

# Client Credentials Grant

- Easy ✓
- Secure ✓
- Wide use case support ✗


# Use the Client Credentials flow for Machine-to-machine authorization

# Password Grant




https://blog.oauth.io/oauth2-flow-grant-types-in-pictures/

# Password Grant

**REQUEST**

```
POST /token HTTP/1.1
Host: server.example.com
Authorization: Basic czZCaGRSa3F0MzpnWDFmQmF0M2JW
Content-Type: application/x-www-form-urlencoded

grant_type=password&username=johndoe&password=A3ddj3w
```

Client ID & Password

Resource Owner Username & Password

**RESPONSE**

```
HTTP/1.1 200 OK
Content-Type: application/json;charset=UTF-8
Cache-Control: no-store
Pragma: no-cache

{
  "access_token":"2YotnFZFEjr1zCsicMWpAA",
  "token_type":"example",
  "expires_in":3600,
  "refresh_token":"tGzv3JOkF0XG5Qx2TlKWIA",
}
```

# Password Grant

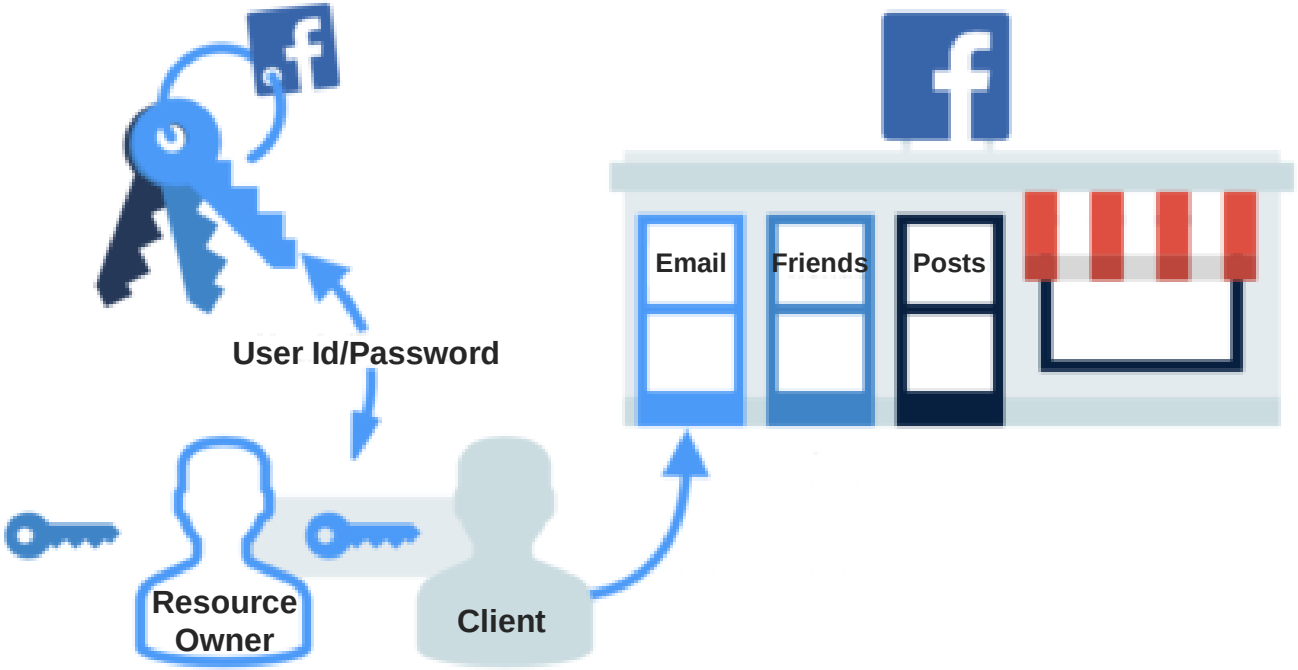
- Easy ✓
- Wide use case support ✓
- Secure ✗

# Password Grant Threats

- Threat #1: Exposes the username and password
- Threat #2: No mechanism to limit scope
- Threat #3: Trains users that it's okay to enter password in more than one place
- Threat #4: Difficult (or impossible) to add multifactor or passwordless authentication (WebCrypto, WebAuthn)


# Do not use the Password grant

# Implicit Grant

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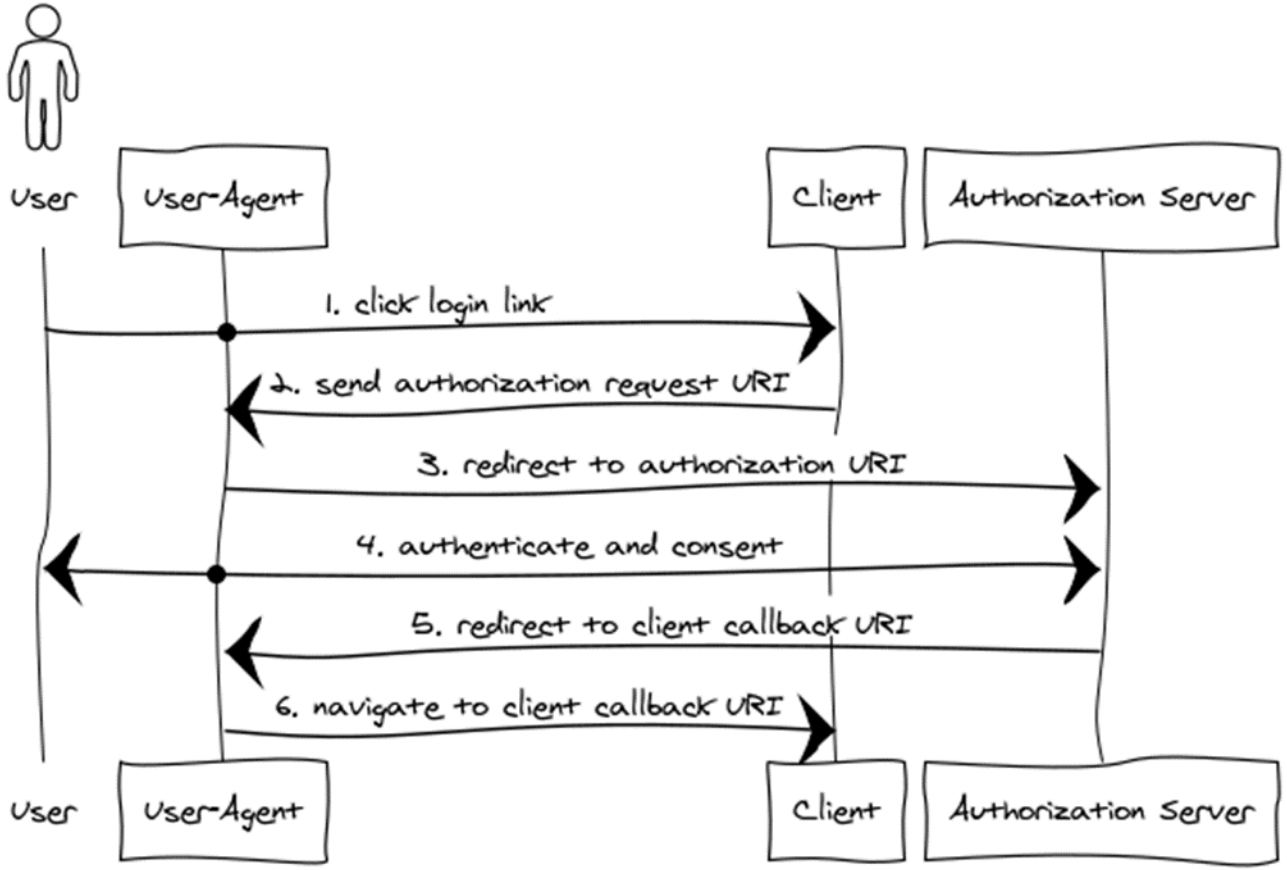
# Implicit Grant

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# Implicit Grant

**REQUEST**

```
GET /authorize?response_type=token&client_id=s6BhdRkqt3&state=xyz
      &redirect_uri=https%3A%2F%2Fclient%2Eexample%2Ecom%2Fcb HTTP/1.1
Host: server.example.com
```

- response_type **token**
- client_id **s6BhdRkqt3**
- state **xyz**
- redirect_uri **https://client.example.com/cb**

# Implicit Grant

**REQUEST**

```
GET /authorize?response_type=token&client_id=s6BhdRkqt3&state=xyz
      &redirect_uri=https%3A%2F%2Fclient%2Eexample%2Ecom%2Fcb HTTP/1.1
Host: server.example.com
```

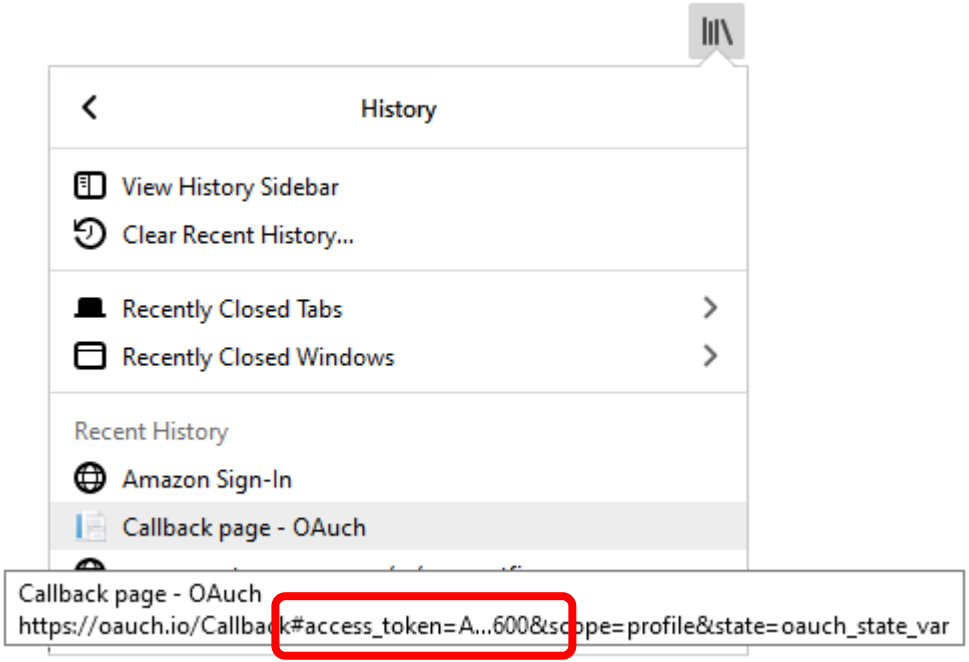
**RESPONSE**

```
HTTP/1.1 302 Found
Location: http://example.com/cb#access_token=2YotnFZFEjr1zCsicMWpAA
          &state=xyz&token_type=bearer&expires_in=3600
```

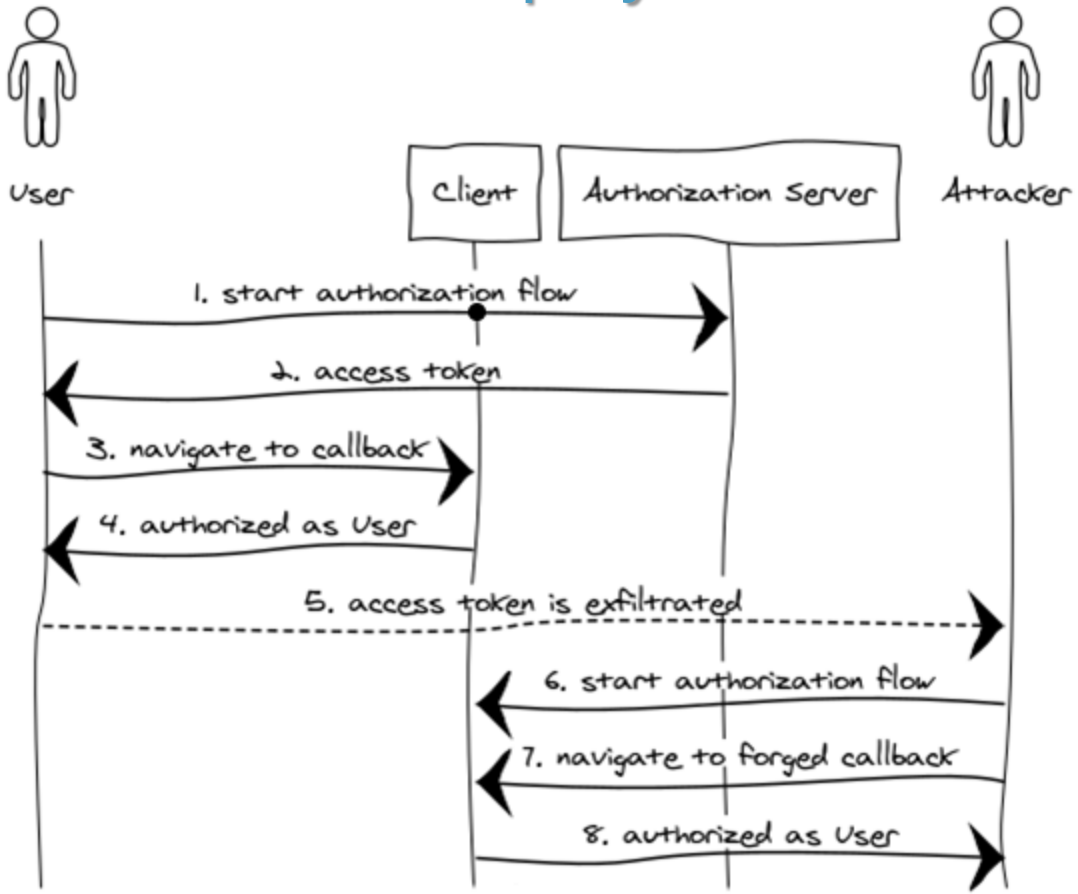
# Implicit Grant

- Easy ?
- Wide use case support ✓
- Secure
  - Username and password are not exposed ✓
  - Scope can be limited ✓
  - User always uses official authorization page ✓
  - Possible to add multi-factor or passwordless authentication ✓
  - But…

# Threat #1: Access token leakage



# Threat #2: Access token replay

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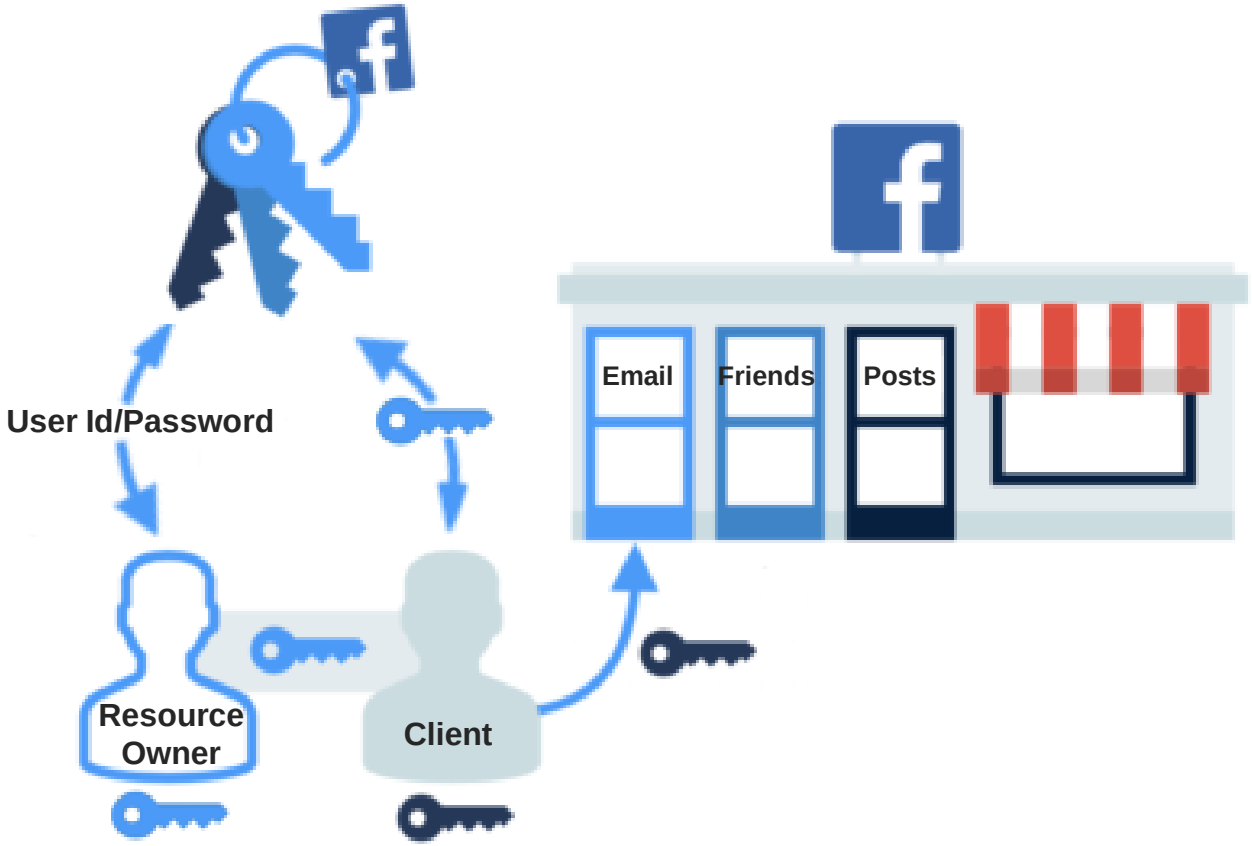
# Additional Shortcoming

- Tokens cannot be (cryptographically) bound to a client
  - Clients are not authenticated


# Do not use the Implicit grant

# Authorization Code Grant

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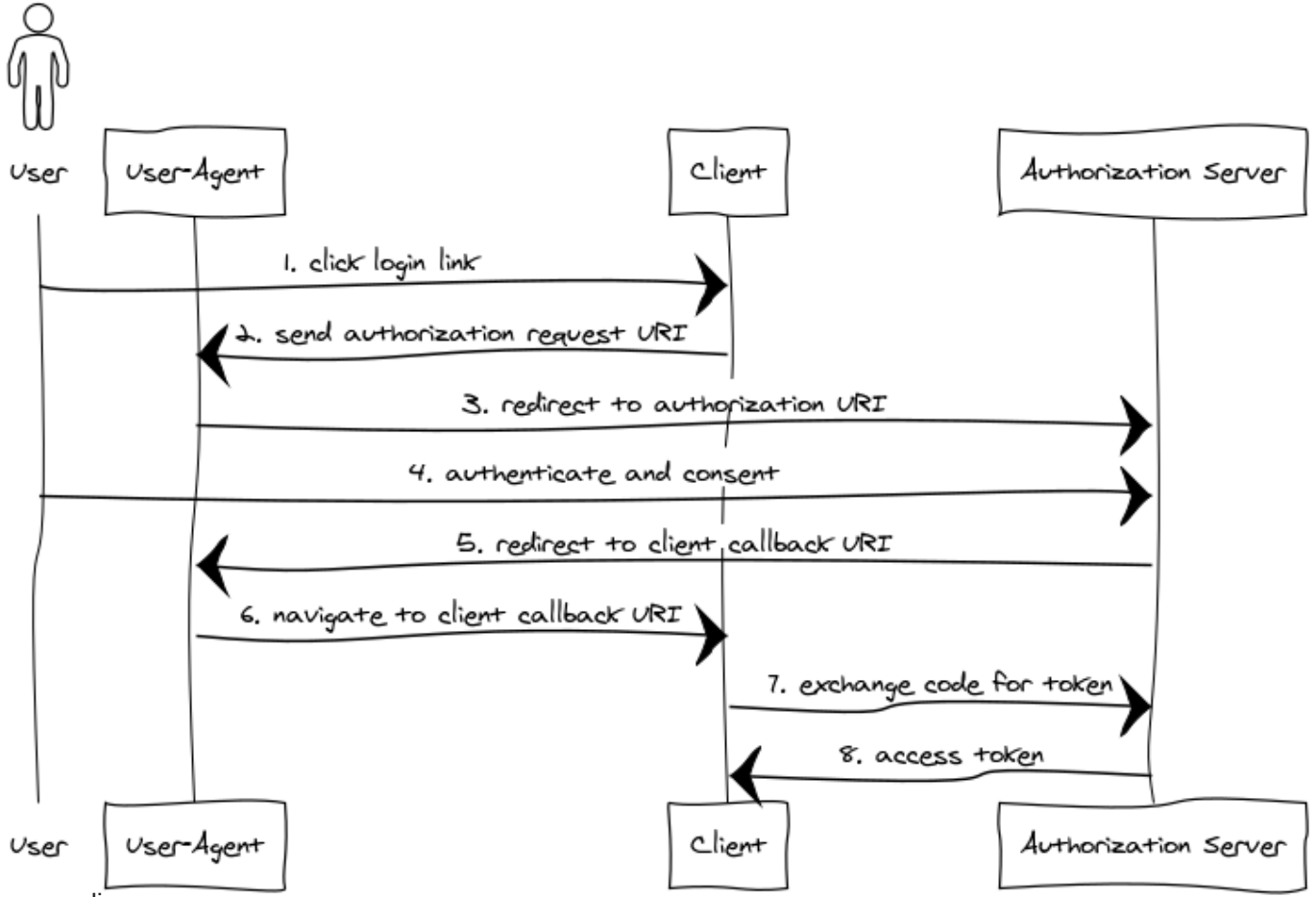
# Authorization Code Grant

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# Authorization Code Grant

**REQUEST**

```
GET /authorize?response_type=code&client_id=s6BhdRkqt3&state=xyz
    &redirect_uri=https%3A%2F%2Fclient%2Eexample%2Ecom%2Fcb HTTP/1.1
Host: server.example.com
```

**RESPONSE**

```
HTTP/1.1 302 Found
Location: https://client.example.com/cb?code=SplxlOBeZQQYbYS6WxSbIA
&state=xyz
```

# Authorization Code Grant

**REQUEST**

```
POST /token HTTP/1.1
Host: server.example.com
Authorization: Basic czZCaGRSa3F0MzpnWDFmQmF0M2JW
Content-Type: application/x-www-form-urlencoded

grant_type=authorization_code&code=SplxlOBeZQQYbYS6WxSbIA
&redirect_uri=https%3A%2F%2Fclient%2Eexample%2Ecom%2Fcb
```

**RESPONSE**

```
HTTP/1.1 200 OK
Content-Type: application/json;charset=UTF-8
Cache-Control: no-store
Pragma: no-cache

{
  "access_token":"2YotnFZFEjr1zCsicMWpAA",
  "token_type":"bearer",
  "expires_in":3600,
  "refresh_token":"tGzv3JOkF0XG5Qx2TlKWIA",
}
```

# Authorization Code Grant

- Easy ✗
- Wide use case support ✓
- Secure
  - All the benefits of the implicit flow ✓
  - Access tokens are not leaked ✓
  - Authorization codes cannot be replayed ✓
  - But…

# Threat #1: Insufficient Redirect URI Validation

- Some implementations allow redirect URI patterns
  - `https://*.benign.site/*`
  - Matches with `https://attacker.site/.benign.site/`

**REQUEST**

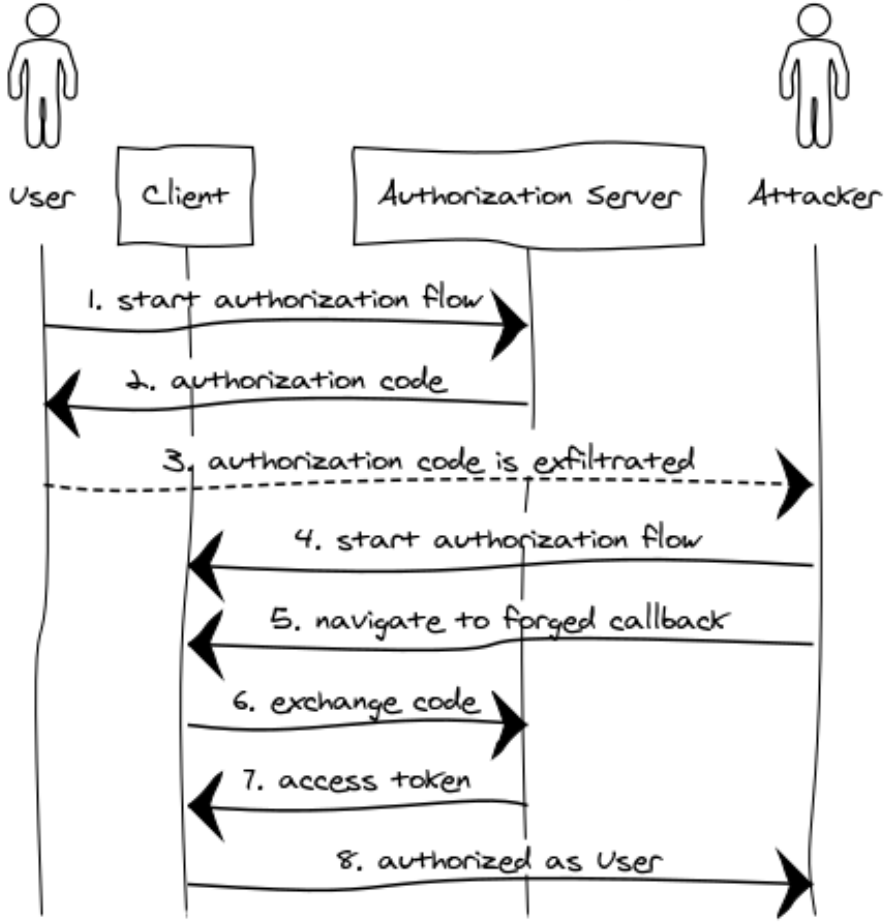
```
GET /authorize?response_type=code&client_id=s6BhdRkqt3&state=9ad67f13
     &redirect_uri=https%3A%2F%2Fattacker.site%2F.benign.site%2F
     HTTP/1.1
Host: server.somesite.example
```

# Threat #1: Insufficient Redirect URI Validation

- Other problems exist (e.g. open redirectors, …)

- Always exactly match Redirect URIs with the registered values

# Threat #2: Authorization Code Injection



# Proof Key for Code Exchange (PKCE)

- Bind an authorization code to a client's session
  - Client generates a random secret per authorization request
  - Client sends the hashed secret in the authorization request
  - When it exchanges the authorization code for an access token, it also sends the secret
    - The server can hash and compare the two hashes

# Proof Key for Code Exchange (PKCE)

**REQUEST**

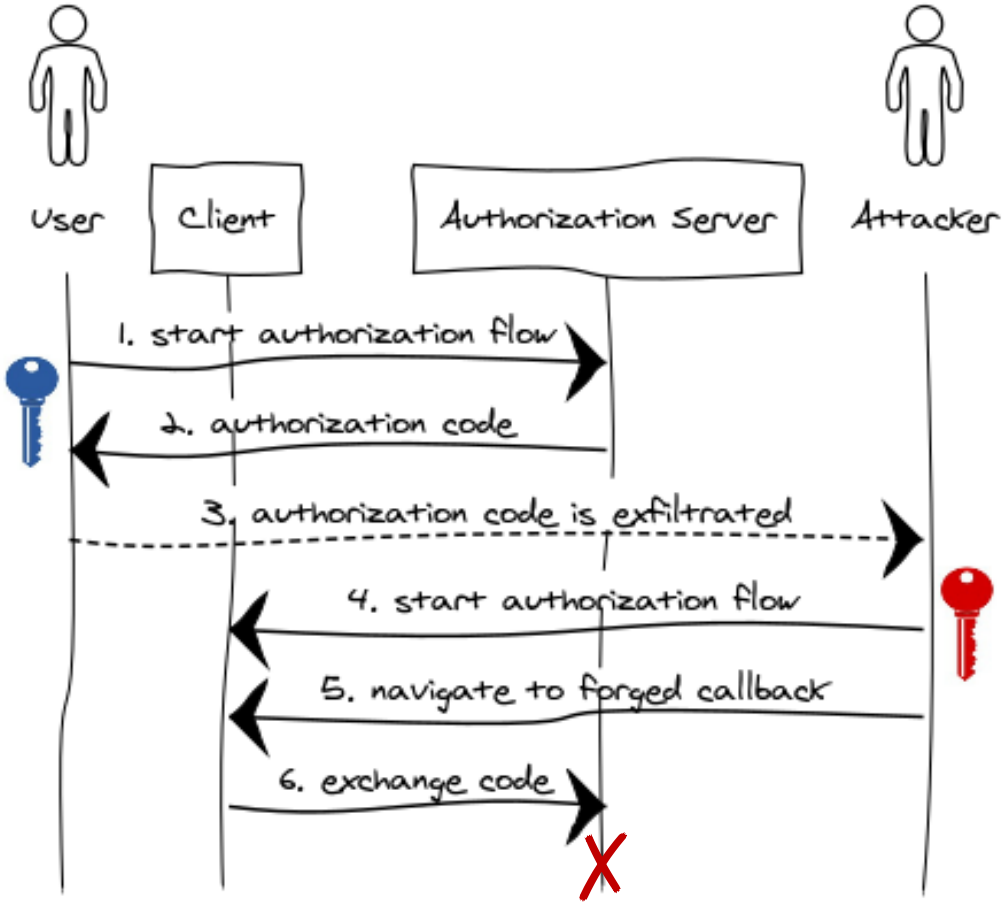
```
GET /authorize?response_type=code&client_id=s6BhdRkqt3&state=xyz
    &redirect_uri=https%3A%2F%2Fclient%2Eexample%2Ecom%2Fcb
    &code_challenge=rLGaLy…5Z5Dc&code_challenge_method=S256 HTTP/1.1
Host: server.example.com
```

**REQUEST**

```
POST /token HTTP/1.1
Host: server.example.com
Authorization: Basic czZCaGRSa3F0MzpnWDFmQmF0M2JW
Content-Type: application/x-www-form-urlencoded

grant_type=authorization_code&code=SplxlOBeZQQYbYS6WxSbIA
&redirect_uri=https%3A%2F%2Fclient%2Eexample%2Ecom%2Fcb
&code_verifier=8WBGM8cbVT…bRzqts370
```

# Threat: Authorization Code Injection



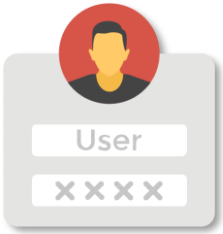

# Use Authorization Code grant + PKCE when a user is involved

# Use Cases – Grant Types

**Web-server apps**
`authorization code + PKCE`

**Browser-based apps**
~~`implicit`~~ `authorization code + PKCE`

**Mobile apps**
~~`implicit`~~ `authorization code + PKCE`




~~**Username/Password access**~~
~~`password`~~

**Application access**
`client credentials`

# More Best Practices


- Clients *should* use Mutual TLS
  - Replaces *client secret*
  - Enables sender-constrained tokens

# More Best Practices


- Clients *must not* pass access tokens in a URI query parameter
  - `https://myapi.com/posts/all?access_token=avGt23F8fWb`

# More Best Practices


- Refresh tokens must either be sender-constrained or one-time use
  - Use refresh token rotation

# Conclusion

- OAuth 2.0 is about **delegation**
  - Clients can ask permission to access protected resources on a resource owner's (user's) behalf
- OAuth 2.0 is a secure protocol ***if used correctly***
  - Most servers and clients do not follow the best practices


# Thank you!

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