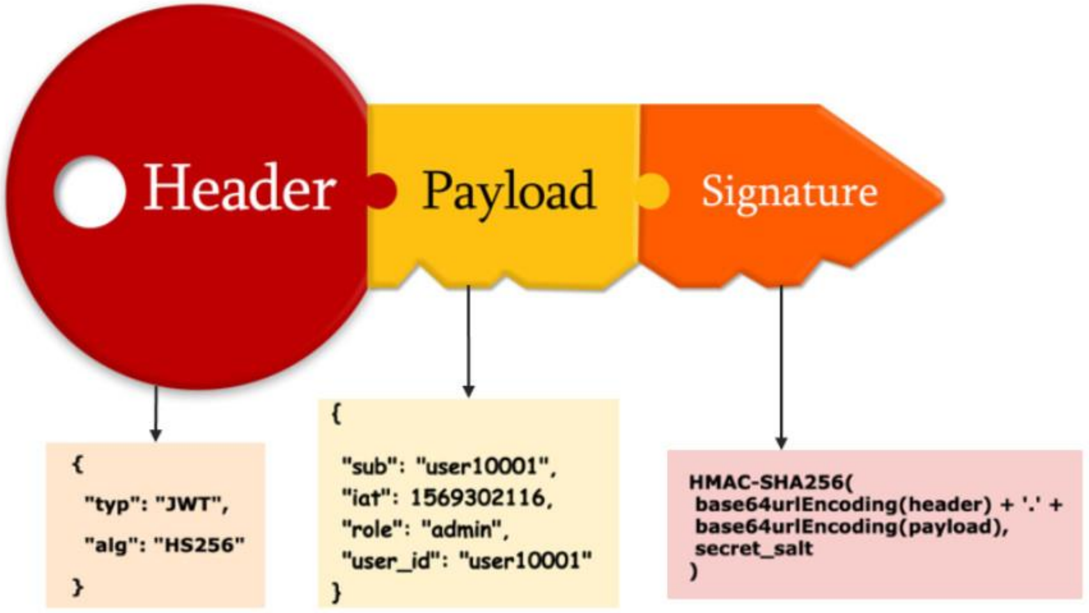
Web Application Security

Outline

Web Security Aspects

- **Authentication** (**Identity verification**):
  - Verify the identity of the user given the credentials received
  - Making sure the user is who he/she claims to be
- **Authorization**:
  - Determine if the user should be granted access to a particular resource/functionality.
- **Confidentiality**:
  - Encrypt sensitive data to prevent unauthorized access in transit or in storage
- **Data Integrality**:
  - Sign sensitive data to prevent the content from being tampered (e.g., changed in transit)

Token based Authentication & Authorization



```
{
  "typ": "JWT",
  "alg": "HS256"
}
```

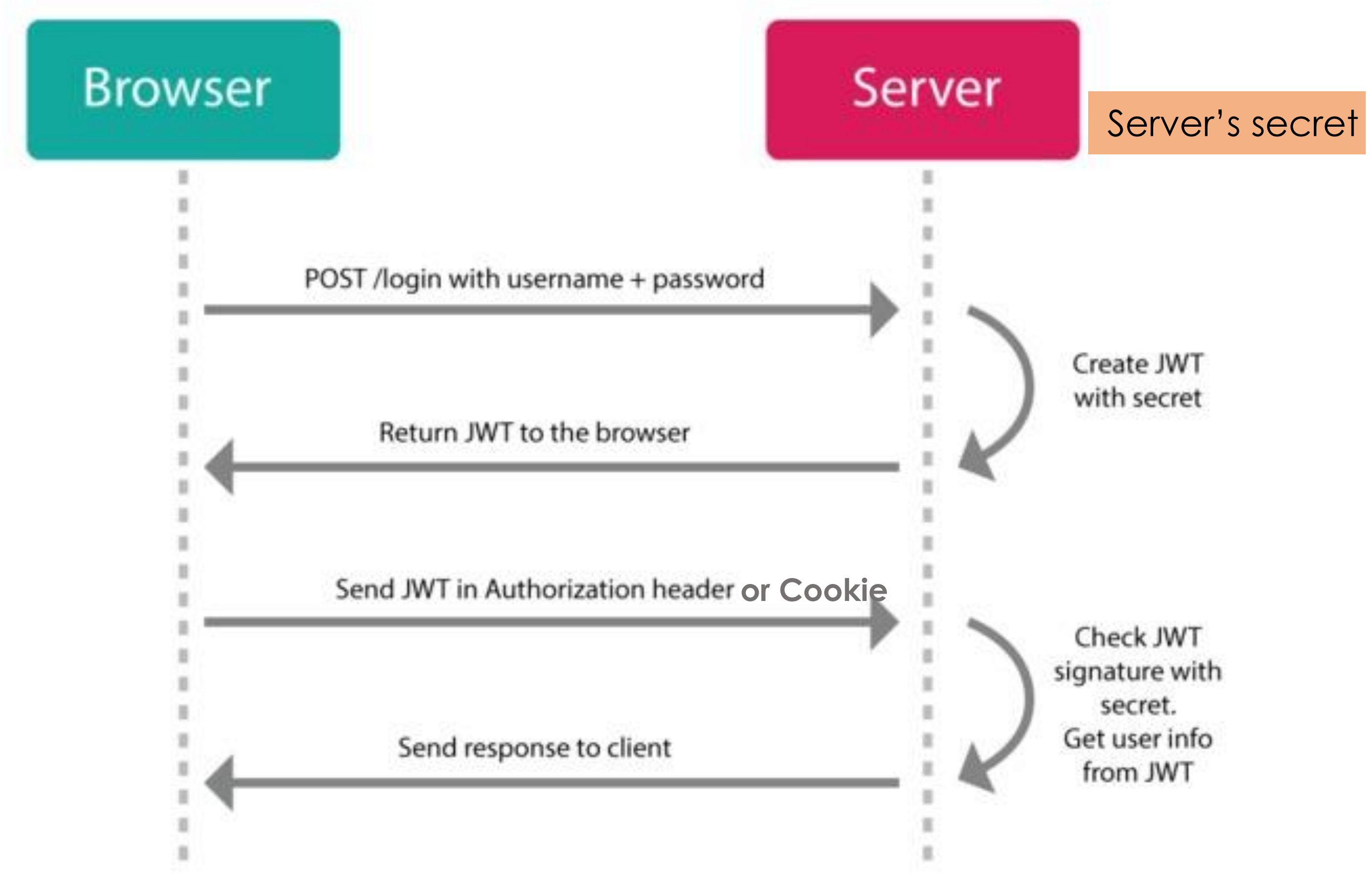
```
{
  "sub": "user10001",
  "iat": 1569302116,
  "role": "admin",
  "user_id": "user10001"
}
```

```
HMAC-SHA256(
 base64urlEncoding(header) + '.' +
 base64urlEncoding(payload),
 secret_salt
)
```

Token based Authentication & Authorization

- After a successful authentication a **JSON Web Token (JWT)** is issued by the server and communicated to the client
- **JWT** an open standard (RFC 7519) that represents the user's identity (user info & role) as a compact and signed string that can be easily transmitted between the client and server.
- JWT token is a **signed json object** that contains:
  - Claims (i.e., information about the *user* and *the issuer*)
  - Signature (encrypted hash for tamper proof & authenticity)
  - An expiration time
- Client must send JWT in an **HTTP authorization header** or in a **Cookie** with subsequent Web requests
- Web API/Page **validates** the received token and makes authorization decisions (typically based on the user’s **role**)

JSON Web Token (JWT)

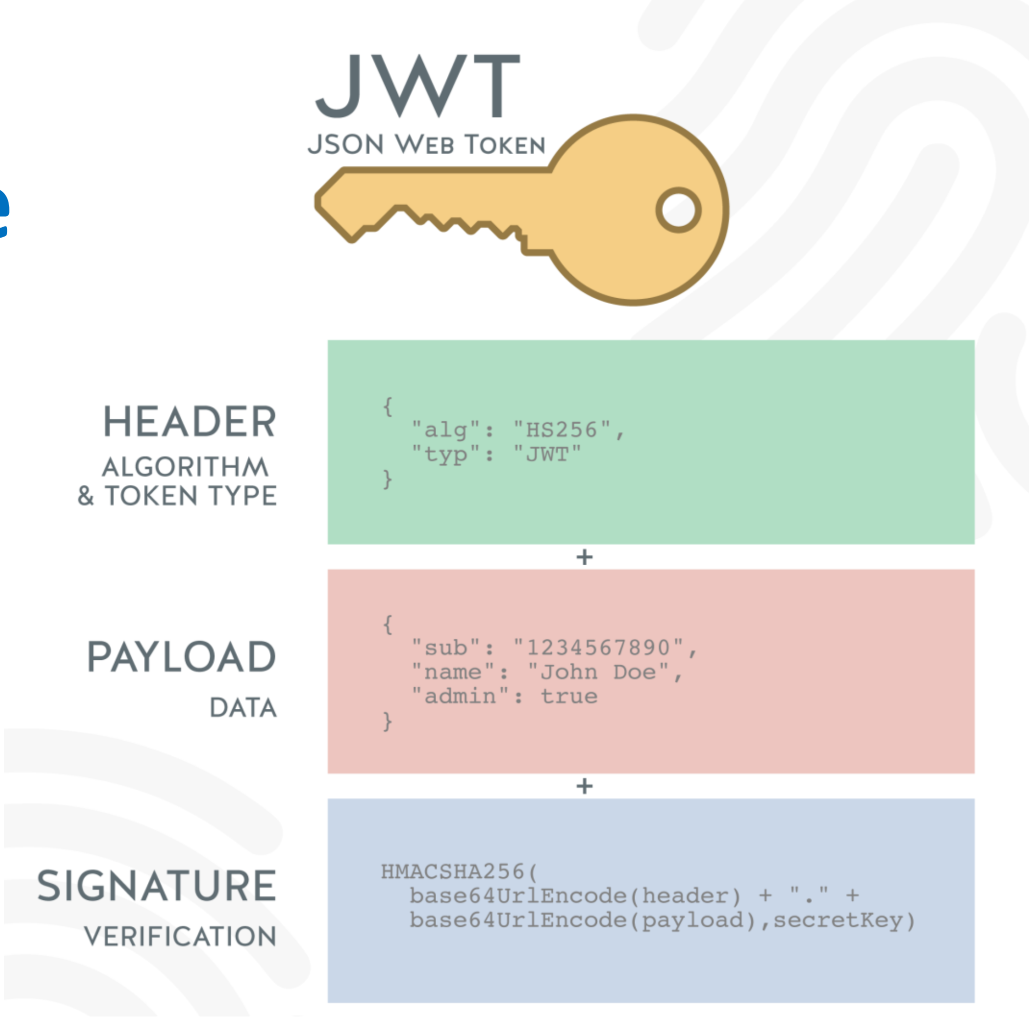

Browser
Server
Server's secret
POST /login with username + password
Create JWT with secret
Return JWT to the browser
Send JWT in Authorization header or Cookie
Check JWT signature with secret.
Get user info from JWT
Send response to client

- Every subsequent request to the server (either to Web API/page) must include a **JWT**
- Web API/Page checks that the received JWT token is valid
- Web API/Page uses info in the token (e.g., **role**) to make authorization decisions

Advantages of Token based Security

- A primary reason for using token-based authentication is that it is **stateless** and **scalable** authentication mechanism
  - It is suitable for Web Pages, Web APIs, and mobile apps
  - The token is stored on the client-side (e.g., in cookie or localStorage)
  - The claims (e.g., a user profile) in a JWT encode a **JSON** object that contains user information and role that is useful for making authorization decisions
  - JWT is a simple and widely useful security token format with libraries available in most programming languages
- Can be used for **Single Sign-On:**
  - Sharing the JWT between different applications

JWT Structure



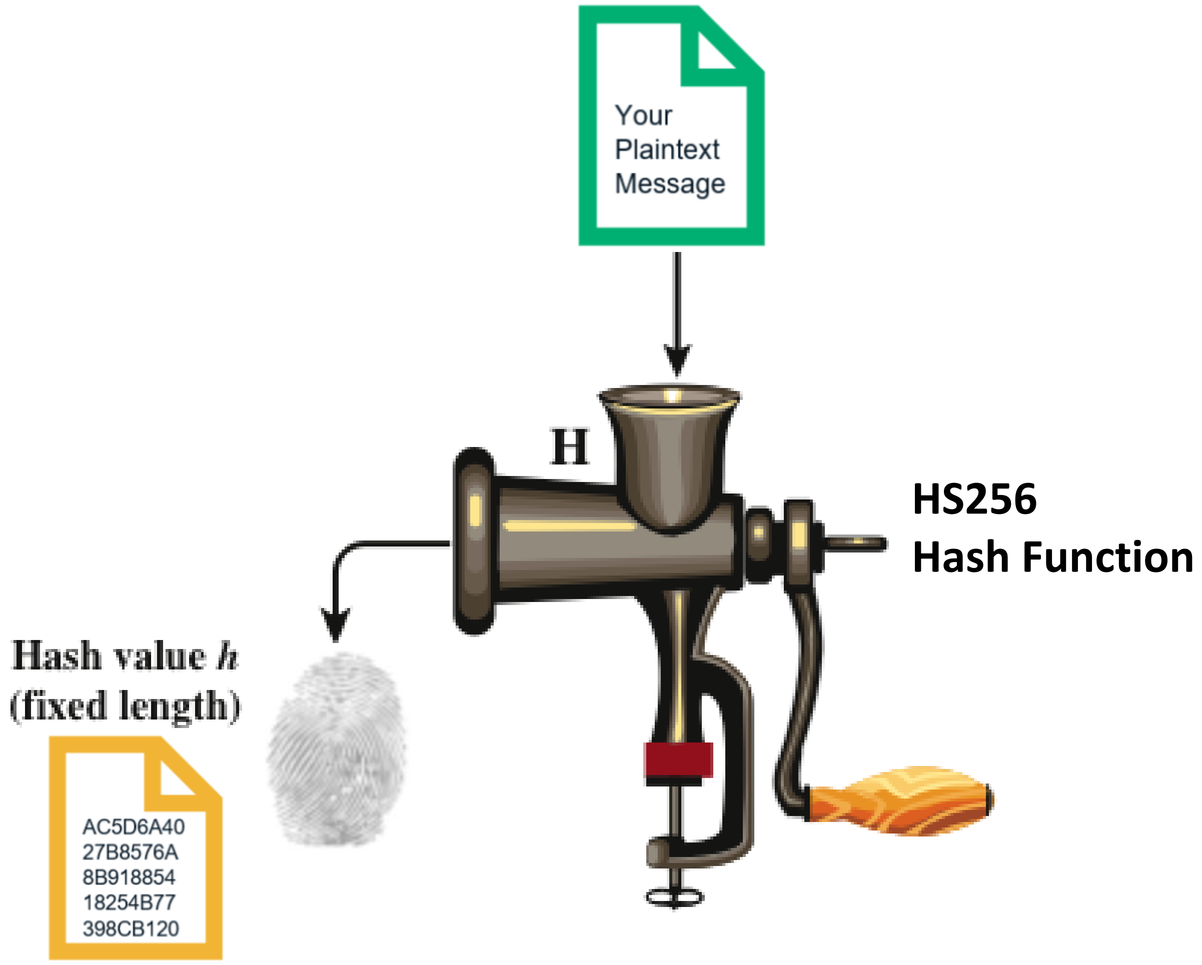
```
{
  "alg": "HS256",
  "typ": "JWT"
}
```

```
{
  "sub": "1234567890",
  "name": "John Doe",
  "admin": true
}
```

```
HMACSHA256(
  base64UrlEncode(header) + "." +
  base64UrlEncode(payload),secretKey)
```

$$\underbrace{\texttt{eyJhbGciOiJub25lIn0}}_{\textbf{Header}}.\underbrace{\texttt{eyJpc3MiOiJqb2UiLA0KICJleHAiOjEzMD}}_{\textbf{Payload}}.\underbrace{\texttt{4MTkzODAsDQogImh0dHA6Ly9leGFt}}_{\textbf{Signature}}$$

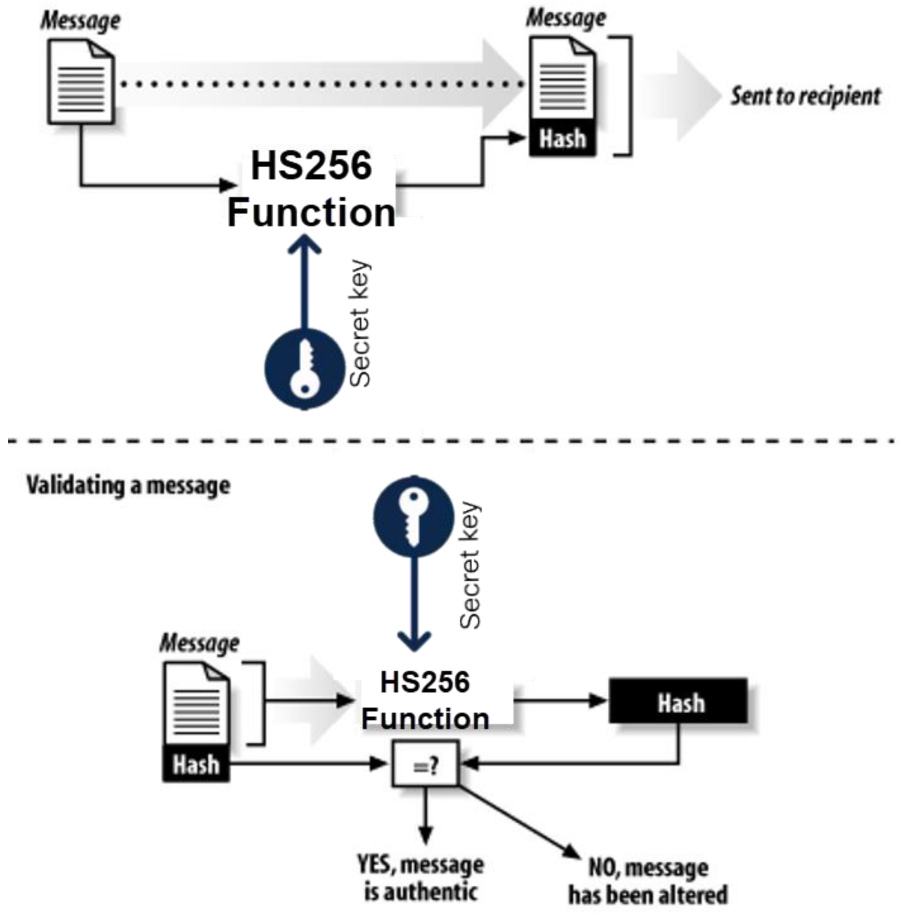
Hashing - Basic Idea

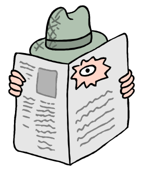


HS256 is a hashing function that takes a variable size input (e.g., user object as JSON text) and produces a signature (a fixed size pseudorandom string)

How JWT Signature is verified?

- **HMAC-SHA256** is often used for **signing JWT** to ensure its integrity
- It takes the **user object** + **a *secret key*** *as input and generates a Signature*
- The ***Signature*** is appended to the JWT
- The Signature provides **message integrity**: Any manipulation of the JWT will be detected by the receiver





An attacker who alters the **`id_token`** will be **unable** to alter the associated signature without knowledge of the secret key

Sign and Verify JWT

- jsonwebtoken library can be used to Sign and Verify JWT

```
import jwt from "jsonwebtoken"
export function signJwt(user, expiresIn = "1d") {
  // expiresIn is a string like "1h", "10h", "7d"
  const secretKey = process.env.JWT_SECRET_KEY
  const idToken = jwt.sign(user, secretKey, { expiresIn })
  return idToken
}
export function verifyJwt(idToken) {
  try {
    const secretKey = process.env.JWT_SECRET_KEY
    const user = jwt.verify(idToken, secretKey)
    return user
  } catch (error) {
    console.log(error)
    return null
  }
}
```

Example – Validating JWT received before returning the list of users

- Validating the JWT to ensure is authentic then checking that the user role is Admin before allow the user the get the list of users

```
import { getUsers } from "./users-repo"
import { verifyJwt } from "@/app/lib/jwt"

export async function GET(request) {
  const idToken = request.headers.get("authorization")
  if (!idToken) {
    return Response.json(
      { error: "🚫 Unauthorized - id token is missing" },
      { status: 401 })
  }

  const user = verifyJwt(idToken)
  if (!user) {
    return Response.json(
      { error: "🚫 Unauthorized - id token is invalid. },
      { status: 401 })
  }

  if (!user.role || user.role.toLowerCase() !== "admin") {
    return Response.json(
      { error: `⛔ Forbidden - Role should be Admin. Désolé ${user.name}!` },
      { status: 403 })
  }

  const users = await getUsers()
  return Response.json(users)
}
```

HTTP Status Code to Return in case failed Authentication / Authorization

- ***401 Unauthorized***

- Should be returned in case of failed authentication
- An access token is missing, expired, or invalid

- ***403 Forbidden***

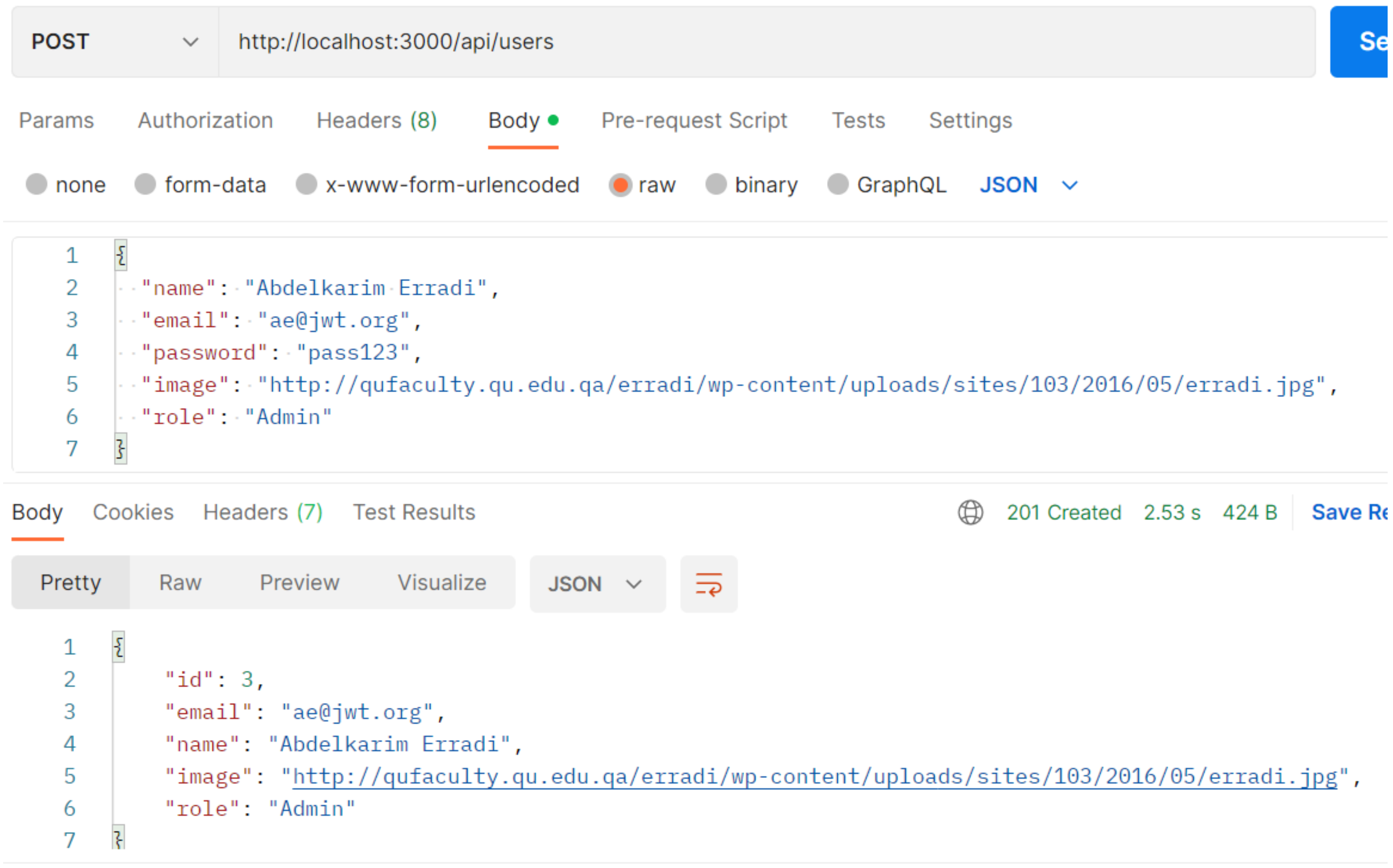
- Should be returned in case of failed authorization

- The user is authenticated (has a valid access token) but **NOT** authorized (i.e., does not have the permission or role) to perform the requested action

Sign-Up Example

- Sign up @ http://localhost:3000/api/users

Try it with Postman



POST http://localhost:3000/api/users

```
{
  "name": "Abdelkarim Erradi",
  "email": "ae@jwt.org",
  "password": "pass123",
  "image": "http://qufaculty.qu.edu.qa/erradi/wp-content/uploads/sites/103/2016/05/erradi.jpg",
  "role": "Admin"
}
```

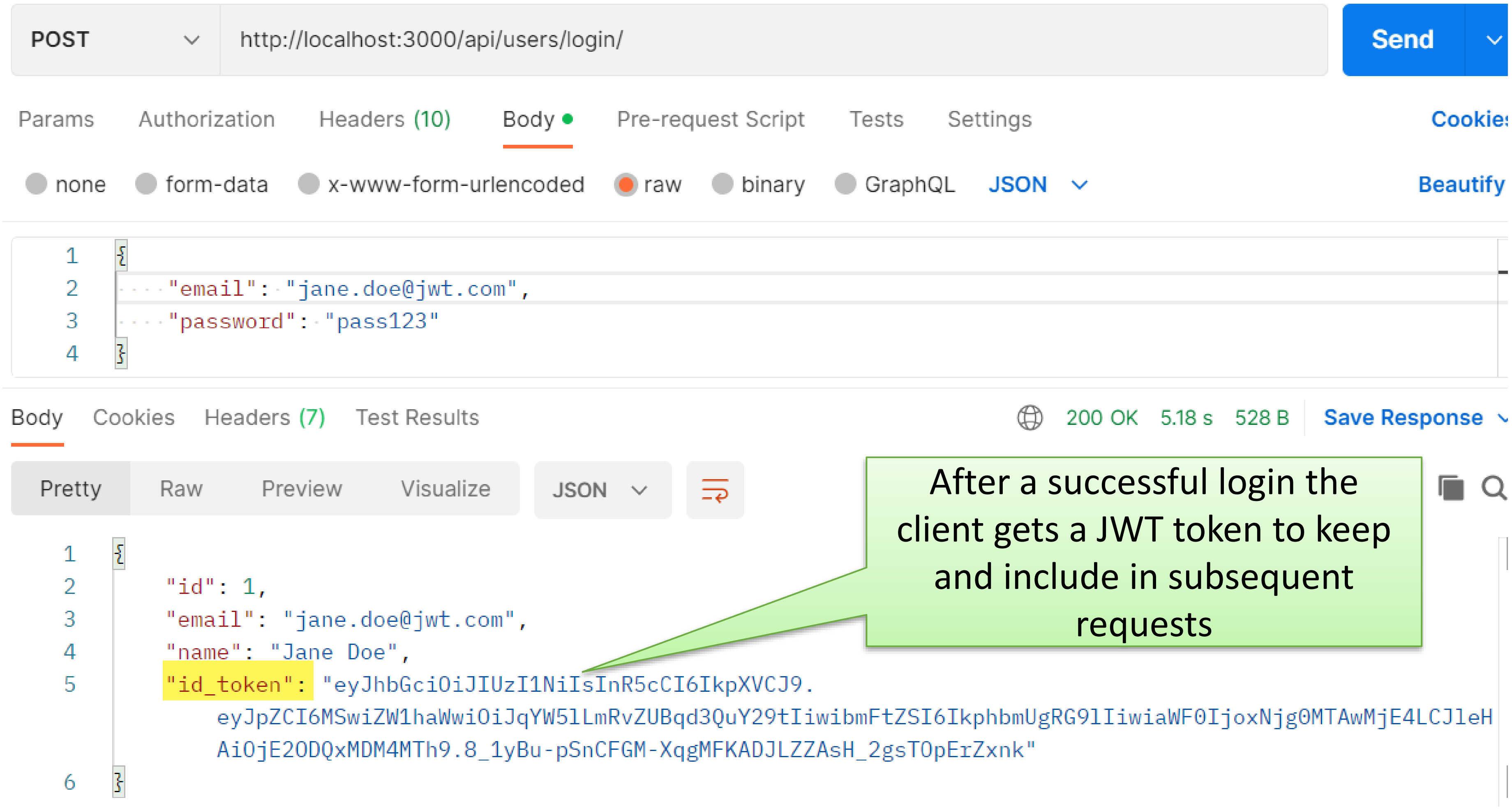
201 Created 2.53 s 424 B

Body: Pretty JSON

```
{
    "id": 3,
    "email": "ae@jwt.org",
    "name": "Abdelkarim Erradi",
    "image": "http://qufaculty.qu.edu.qa/erradi/wp-content/uploads/sites/103/2016/05/erradi.jpg",
    "role": "Admin"
}
```

Successful Login to get JWT

- Sign in @ http://localhost:3000/api/users/login



http://localhost:3000/api/users/login/

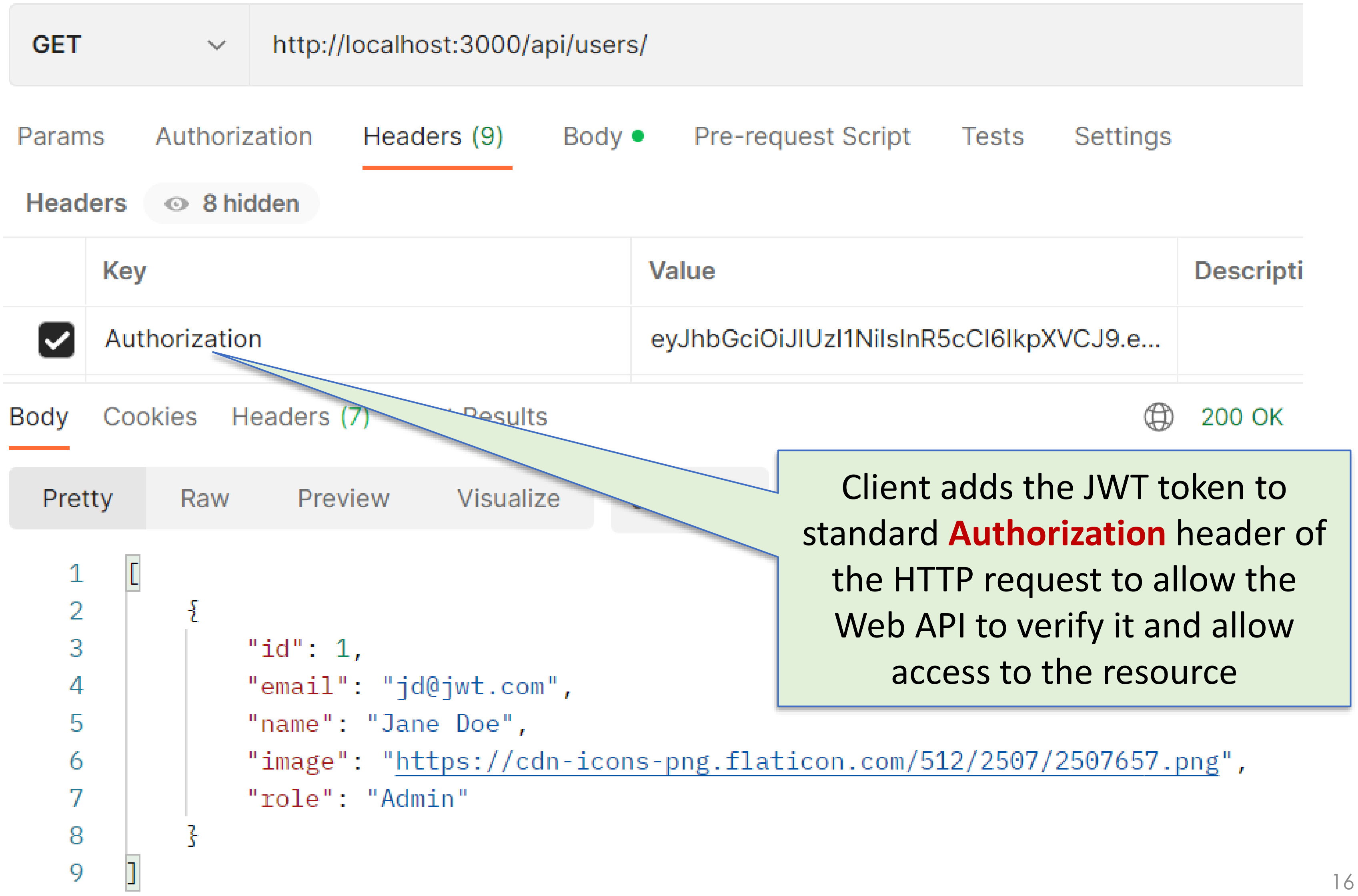
```
{
    "email": "jane.doe@jwt.com",
    "password": "pass123"
}
```

```
{
    "id": 1,
    "email": "jane.doe@jwt.com",
    "name": "Jane Doe",
    "id_token": "eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.
        eyJpZCI6MSwiZW1haWwiOiJqYW5lLmRvZUBqd3QuY29tIiwibmFtZSI6IkphbmUgRG9lIiwiaWF0IjoxNjg0MTAwMjE4LCJleH
        AiOjE2ODQxMDM4MTh9.8_1yBu-pSnCFGM-XqgMFKADJLZZAsH_2gsTOpErZxnk"
}
```

After a successful login the client gets a JWT token to keep and include in subsequent requests

Use JWT to Access Protected Web API Routes

- Get users http://localhost:3000/api/users



http://localhost:3000/api/users/

	Key	Value	Descripti
✓	Authorization	eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.e...	

```
[
    {
        "id": 1,
        "email": "jd@jwt.com",
        "name": "Jane Doe",
        "image": "https://cdn-icons-png.flaticon.com/512/2507/2507657.png",
        "role": "Admin"
    }
]
```

Client adds the JWT token to standard **Authorization** header of the HTTP request to allow the Web API to verify it and allow access to the resource

JWT for Web Pages

- For Web pages the JWT in returns to the client as a browser **Cookie**
  - A cookie is a **name-value** pair data sent by the server to the browser
  - It is **automatically** sent back to the server with subsequent requests
  - Only sent back to the **same domain** that set the cookie
  - Cookies are often used to remember information about the user such as JWT tokens or user preferences (e.g., preferred language and color theme)
- Read/write cookies using Next.js

```
import { cookies } from "next/headers"

// Save id_token in a cookie
cookies().set("id_token", user.id_token)

// Get id_token cookie
const idToken = cookies().get("id_token")?.value
```

Example of sending id_token cookie after successful login

- onSubmitHandler server action sends an id_token **cookie** after successful login. The cookie is set the expire after 1 week

```
async function onSubmitHandler(formData) {
  "use server"
  const { email, password } = Object.fromEntries(formData.entries())
  try {
    const user = await login(email, password)
    // Save id_token in a cookie
    const maxAge = 60 * 60 * 24 * 7 // 1 week
    cookies().set("id_token", user.id_token, { path: "/", maxAge })
    redirect("/")
  } catch (error) {
    errorMsg = error.message
    revalidatePath("/auth/login")
  }
}
```

Example of getting id_token from the incoming cookie and validating it

- The PostsPage gets the id_token from the incoming cookie and validating it before allowing the user to access their posts

```
export default async function PostsPage() {
  // Get id_token cookie
  const idToken = cookies().get("id_token")?.value
  console.log("UserPosts - id_token:", idToken)

  if (!idToken) {
    return <p>🚫 Unauthorized - id token is missing</p>
  }

  const user = verifyJwt(idToken)
  if (!user) {
    return <p>🚫 Unauthorized - id token is invalid</p>
  }
  const posts = await getPostsByAuthor(user.id)
...
```

Verifying id_token cookie in middleware.js

- Example of using `middleware.js` to redirect the user to the **login page** if they try to access **`/posts`** without a valid id_token token

```
export function middleware(req) {
  const idToken = req.cookies.get("id_token")?.value
  if (!idToken) {
   return Response.redirect("http://localhost:3000/auth/login")
  }
}
//This redirect rule only apply requests for /posts/:path*
export const config = {
  matcher: ["/posts/:path*"],
}
```

NextAuth.js

Authentication for Next.js

NextAuth.js

- **NextAuth.js** is a flexible, easy to use and open-source authentication library for Next.js. It supports
  - Traditional email/password authentication
  - Multiple identity providers such as Facebook, Google, Twitter, Github
  - Supports passwordless sign in

- Can be install using

```
npm install next-auth
```

NextAuth.js Programming Steps

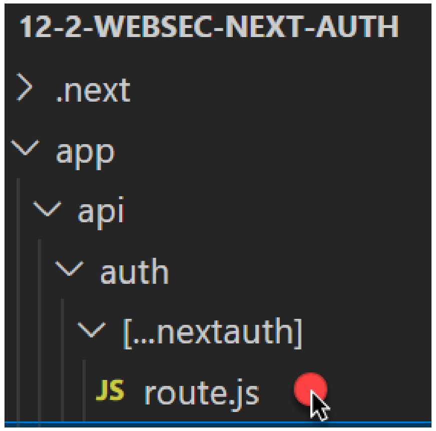
1. Create `[...nextauth]` subfolder under `app\api\auth`
2. Configure the **Authentication Providers** to be used such as GitHub, Google (more info):

- E.g., configure the Github provider with the **clientId** and the **secret**

Get them from https://github.com/settings/applications/new

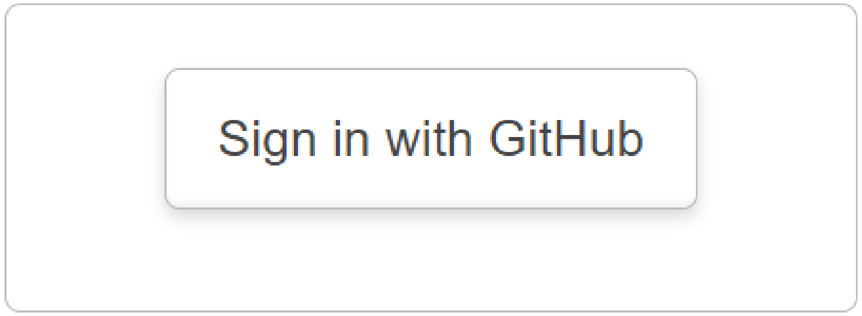
Enter them in the **`.env`** file in the project root folder

```
import NextAuth from "next-auth/next";
import GithubProvider from "next-auth/providers/github";
const handler = NextAuth({
  providers: [
    GithubProvider({
      clientId: process.env.GITHUB_ID,
      clientSecret: process.env.GITHUB_SECRET,
    }),
  ]});
// After configuring the next-auth handler, export it as
// GET and POST handlers for the /api/auth/[...nextauth] route
export { handler as GET, handler as POST };
```


```
12-2-WEBSEC-NEXT-AUTH
> .next
v app
  v api
    v auth
      v [...nextauth]
        JS route.js
```

Auth Web API

- Well, the magic has happened already. If we navigate to http://localhost:3000/api/auth/signin you should see this



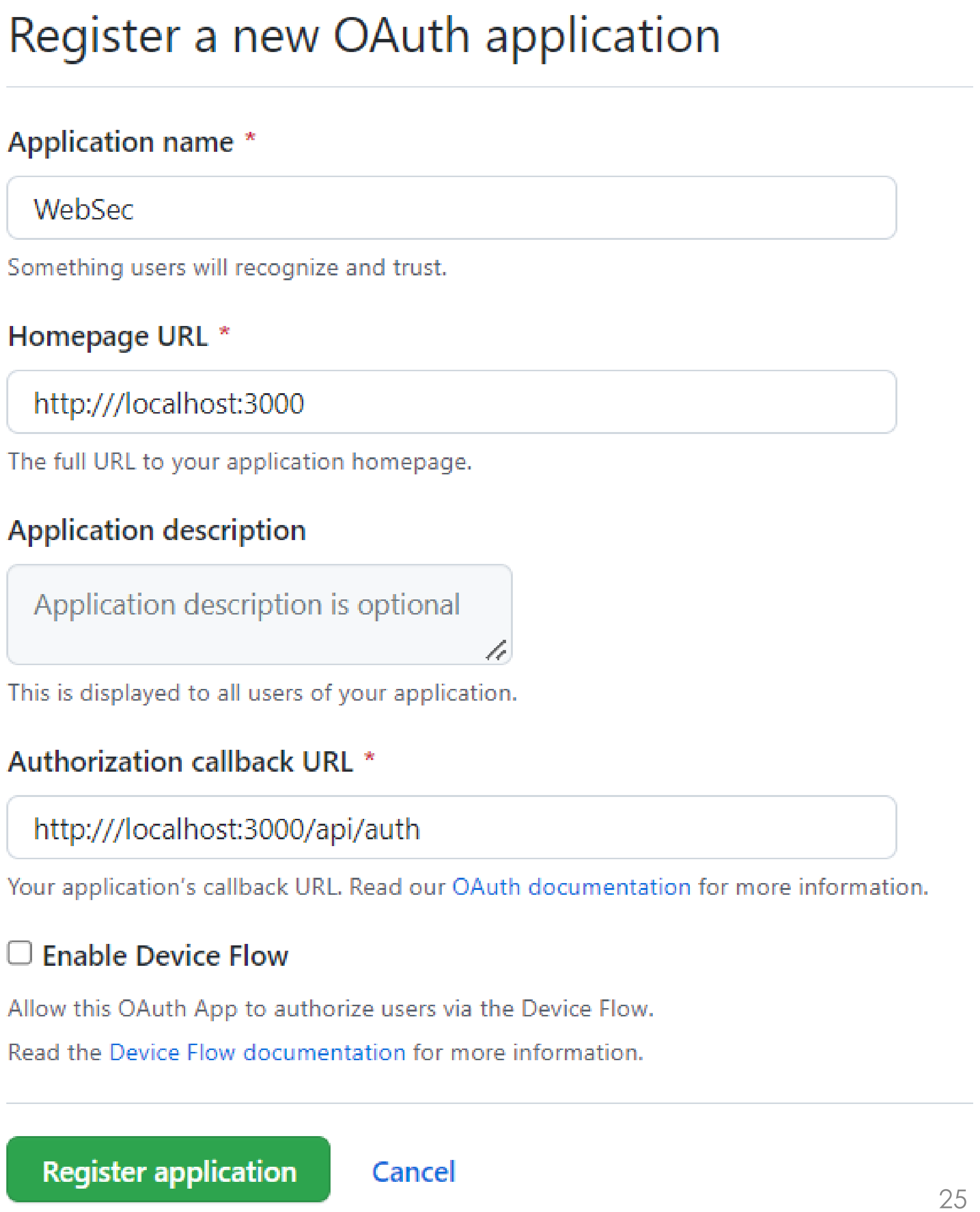
Create and Configure OAuth Client

- Add/Update GitHub OAuth Client https://github.com/settings/developers

- Add/Update Google OAuth Client

https://console.developers.google.com/apis/credentials

- Other Auth Providers provide similar UI to add and configure an OAuth Client (more info)



Register a new OAuth application

Application name *

WebSec

Something users will recognize and trust.

Homepage URL *

http:///localhost:3000

The full URL to your application homepage.

Application description

Application description is optional

This is displayed to all users of your application.

Authorization callback URL *

http:///localhost:3000/api/auth

Your application's callback URL. Read our OAuth documentation for more information.

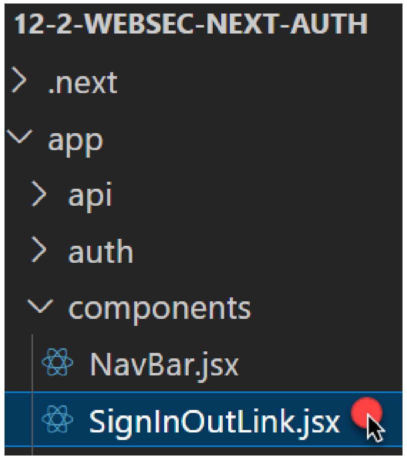
☐ Enable Device Flow

Allow this OAuth App to authorize users via the Device Flow.

Read the Device Flow documentation for more information.

NextAuth.js client-side API

- NextAuth.js has a client-side API to get the session data that contains the user info returned by the Auth Providers upon successful login
- NextAuth.js provides the **`useSession()`** React Hook, which can be used to check the user login status and return the user's details
- **`signIn`** and **`signOut`** functions can be used to perform the login and logout features in our app



```
12-2-WEBSEC-NEXT-AUTH
> .next
v app
  > api
  > auth
  v components
      NavBar.jsx
      SignInOutLink.jsx
```

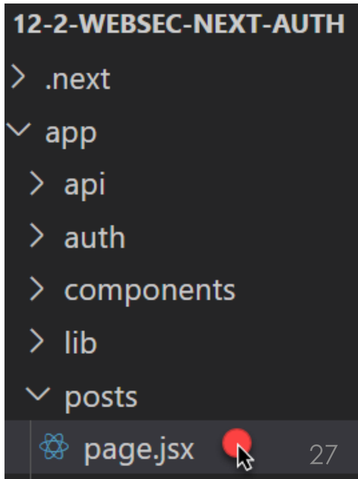
getServerSession

- `getServerSession` can be used to access the user info on the server-side
  - returns an object (containing the user info) if a session is valid and null if a session is invalid or has expired

```
import { getServerSession } from "next-auth/next"
import { authOptions } from "@/app/api/auth/[...nextauth]/route"

export default async function UserPosts() {
  const session = await getServerSession(authOptions)
  console.log("getServerSession:", session)

  let posts = []
  if (session) {
    const authorId = parseInt(session.user.id)
    posts = await getPostsByAuthor(authorId)
  }
...
```



Protecting app paths

- You can protect Web API / Pages via specifying the protected paths in **`middleware.js`** file placed at the app root folder
  - export a **`config`** object with a **`matcher`** to specify the paths to secure

```
export { default } from "next-auth/middleware"
export const config = {
  matcher: ["/posts/:path*"],
}
```

- Visiting **`/posts`** or nested routes (e.g., sub pages like `/posts/123`) will require **authentication**. If a user is not logged in the app will redirect them to the sign-in page

Delegated Authentication

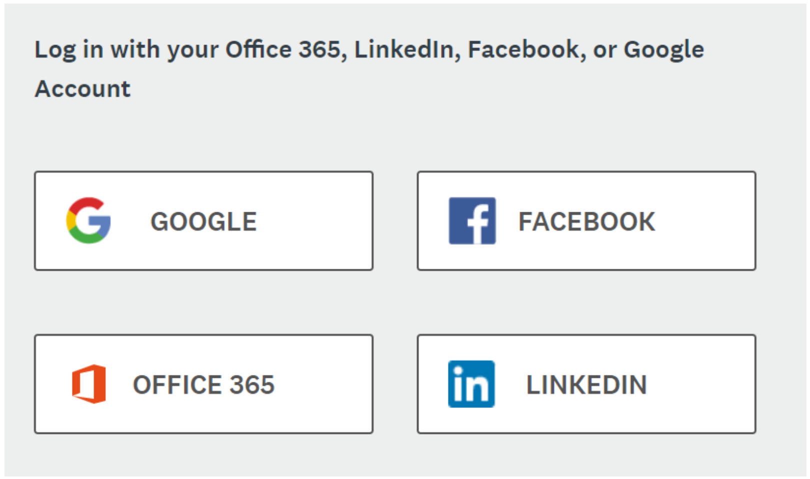
OpenID Connect

Authentication is hard

- Trying to write your own login system is difficult:
  - Need to save passwords securely
  - Provide recovery of forgotten passwords
  - Make sure users set a good password
  - Detect logins from suspecious locations or new devices
  - etc.
- Luckily, **you don't have to build your own authentication!**
- You can use **OpenID Connect** to delegate login to an **Authentication Provider** and get the user’s profile

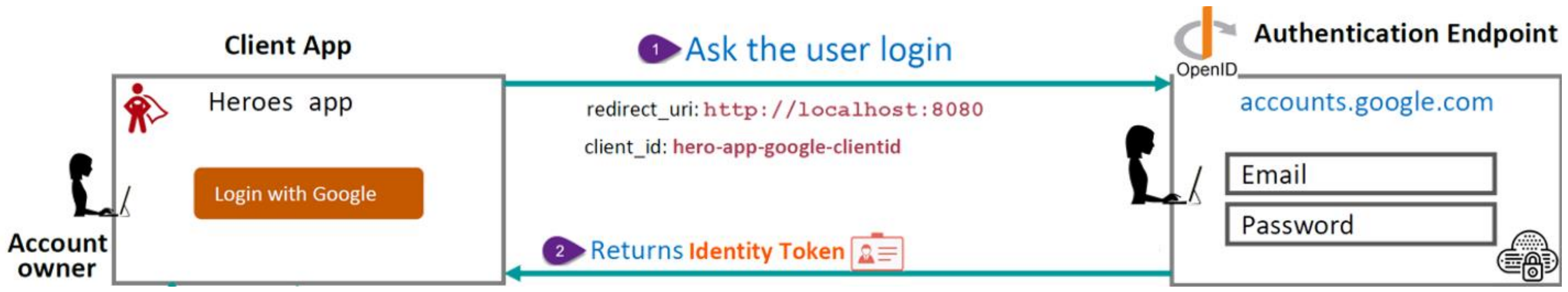
OpenID Connect

- **OpenID Connect** is a standard for user authentication
  - For users:
    - It allows a user to log into a website like AirBnB via some other service, like Google or Facebook
  - For developers:
    - It lets developers authenticate a user without having to implement log in
  - Example:



Log in with your Office 365, LinkedIn, Facebook, or Google Account

OpenID Connect Authentication Flow (simplified)



- **User** starts the flow by visiting the App
- **App** sends an authentication request via browser redirect to the **Authentication** endpoint
- **User** authenticates and consents to **App** to access user's identity
- **User Profile** is returned to **App** via browser redirect

Summary

- JWT is easy to create, transmit and validate to protect Web resources in a scalable way
- Use OpenID Connect for **Delegated Authentication**:
  - Delegate login to an **Identity Provider** and get the user's profile
- Next-Auth library makes implementing delegated authentication easier

Resources

- Next-Auth Getting Started

https://next-auth.js.org/getting-started/example

- JWT Handbook

https://auth0.com/resources/ebooks/jwt-handbook

- Authentication Survival Guide

https://auth0.com/resources/ebooks/authentication-survival-guide

- Good resource to learn about JWT

https://jwt.io/

- What is OpenID Connect?

https://www.youtube.com/watch?v=CHczpasUEIc