Web Application Security

Outline

1. Token based Token based Authentication & Authorization (JWT)
2. Authorization for Next.js & React
3. Delegated Authentication (OpenID Connect)
4. Delegated Authorization (OAuth2)

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)

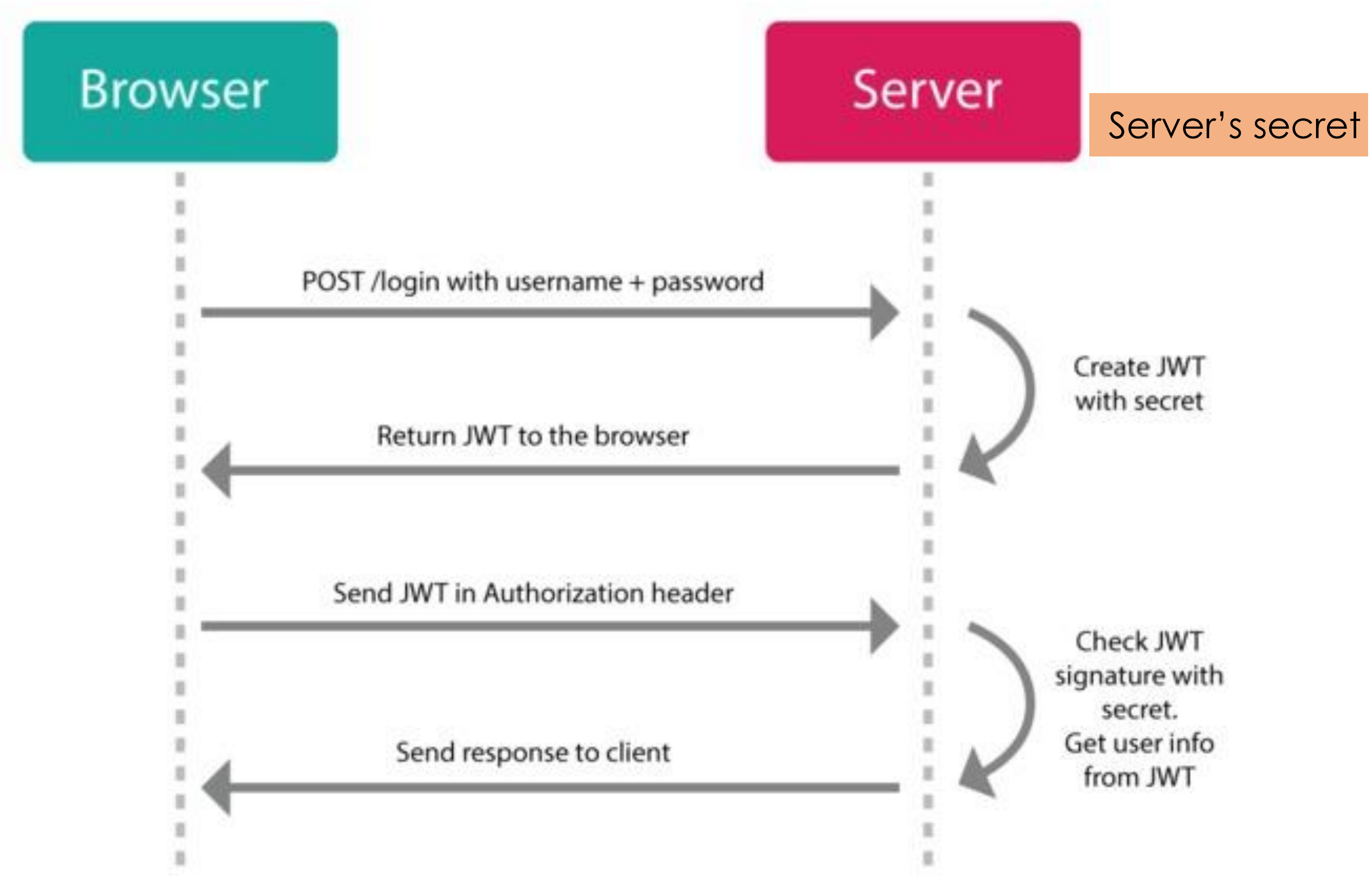
Token based Authentication & Authorization

JWT

Token based Authentication & Authorization

- After a successful authentication a **JSON Web Token (JWT)** is issued by the server and communicated to the client
- JWT token is a signed json object that contains:
  - Claims (i.e., information about *issuer* and the *user*)
  - Signature (encrypted hash for tamper proof & authenticity)
  - An expiration time
- Client must send JWT in an **HTTP authorization header** with subsequent Web API requests
- Web API (i.e., a resource) **validates** the received token and makes authorization decisions (typically based on the user’s **role**)

JSON Web Token (JWT)

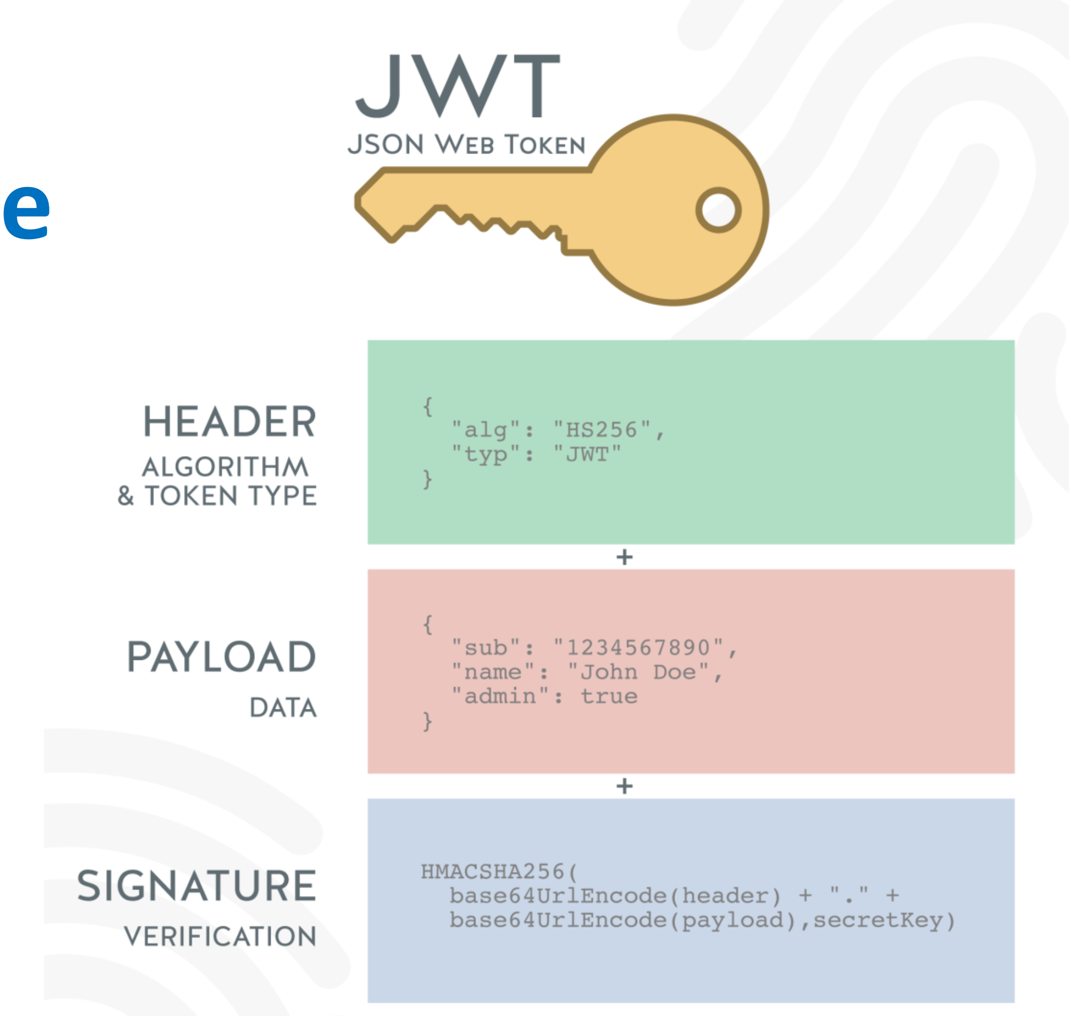

Browser
Server
Server's secret
POST /login with username + password
Create JWT with secret
Return JWT to the browser
Send JWT in Authorization header
Check JWT signature with secret. Get user info from JWT
Send response to client

- Every request to a Web API must include a **JWT**
- Web API checks that the JWT token is valid
- Web API 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 SPA, Web APIs, and mobile apps
  - The token is stored on the client-side
  - The claims in a JWT are encoded as a **JSON** object that contains information 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)
```

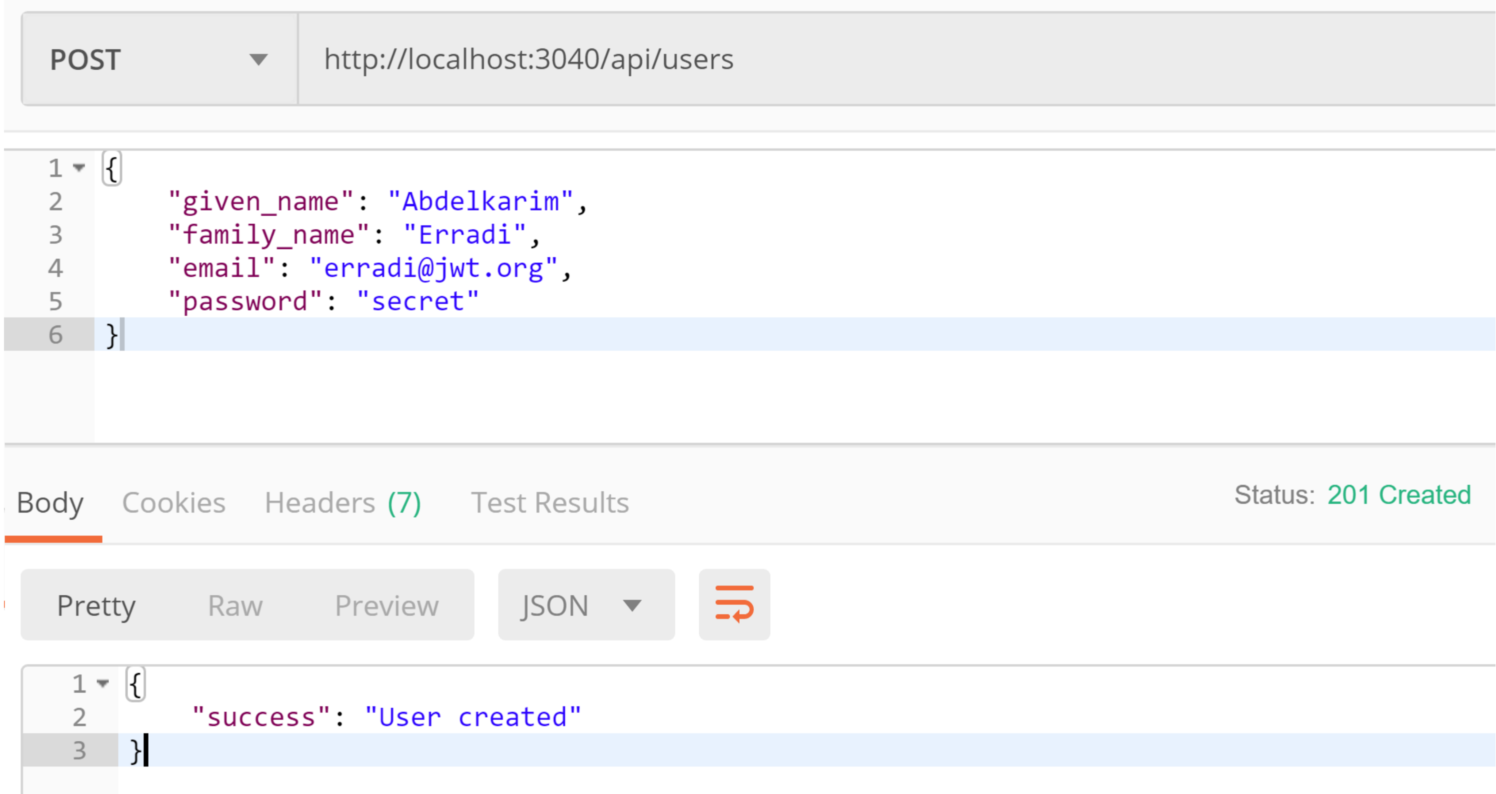
```
eyJhbGciOiJub25lIn0.eyJpc3MiOiJqb2UiLA0KICJleHAiOjEzMD.4MTkzODAsDQogImh0dHA6Ly9leGFt
```

Header **Payload** **Signature**

Sign-Up Example

- Sign up @ http://localhost:3040/api/users

Try it with Postman



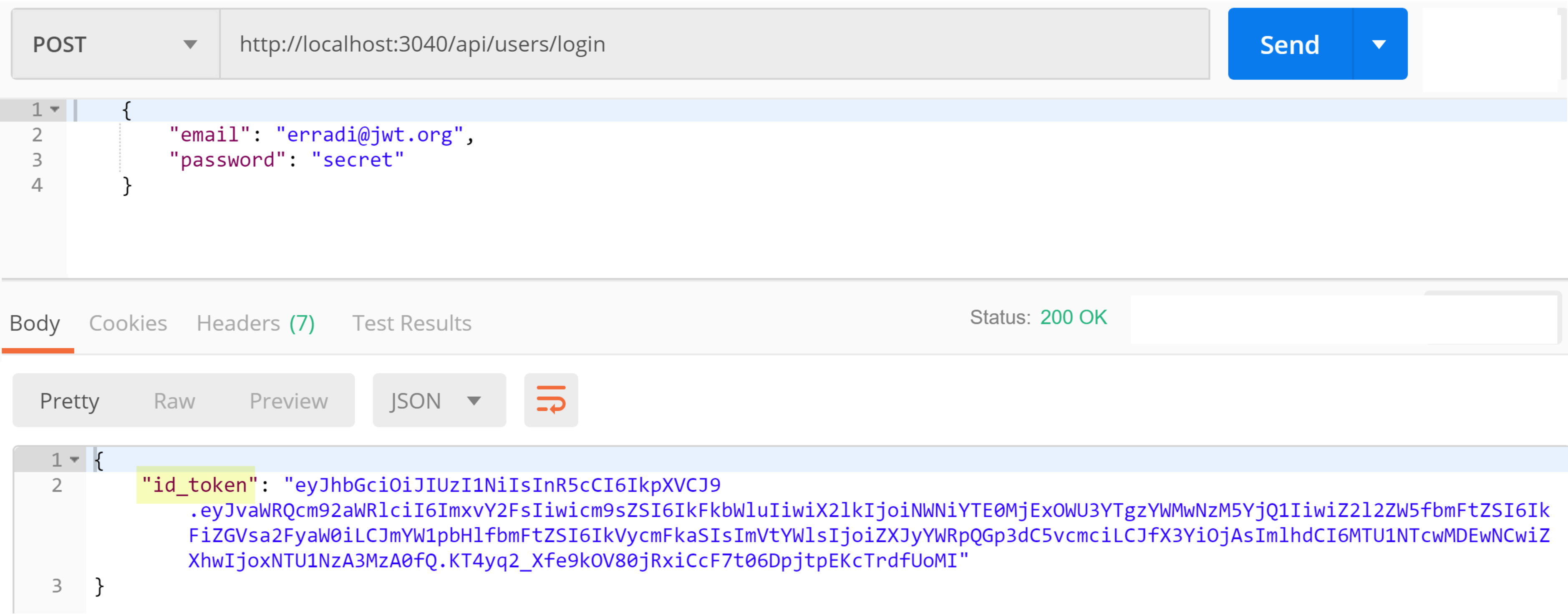
```
{
    "given_name": "Abdelkarim",
    "family_name": "Erradi",
    "email": "erradi@jwt.org",
    "password": "secret"
}
```

Status: 201 Created

```
{
    "success": "User created"
}
```

Successful Login to get JWT

- Sign in @ http://localhost:3040/api/users/login

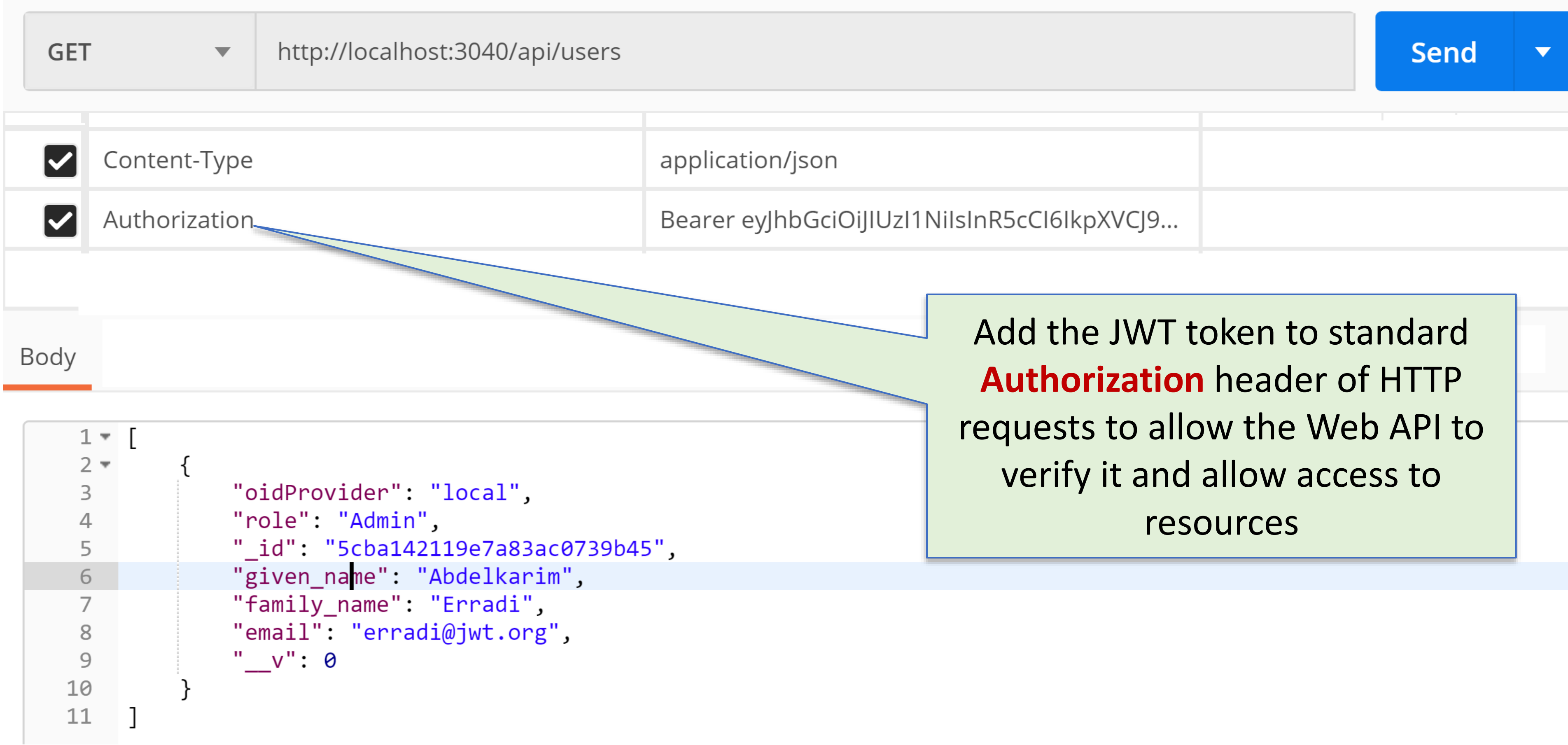


```
{
    "email": "erradi@jwt.org",
    "password": "secret"
}
```

```
{
    "id_token": "eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9
        .eyJvaWRQcm92aWRlciI6ImxvY2FsIiwicm9sZSI6IkFkbWluIiwiX2lkIjoiNWNiYTE0MjExOWU3YTgzYWMwNzM5YjQ1IiwiZ2l2ZW5fbmFtZSI6Ik
        FiZGVsa2FyaW0iLCJmYW1pbHlfbmFtZSI6IkVycmFkaSIsImVtYWlsIjoiZXJyYWRpQGp3dC5vcmciLCJfX3YiOjAsImlhdCI6MTU1NTcwMDEwNCwiZ
        XhwIjoxNTU1NzA3MzA0fQ.KT4yq2_Xfe9kOV80jRxiCcF7t06DpjtpEKcTrdfUoMI"
}
```

Use JWT to Access Protected Resource

- Get users http://localhost:3040/api/users



http://localhost:3040/api/users

☑	Content-Type	application/json
☑	Authorization	Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...

```
[
    {
        "oidProvider": "local",
        "role": "Admin",
        "_id": "5cba142119e7a83ac0739b45",
        "given_name": "Abdelkarim",
        "family_name": "Erradi",
        "email": "erradi@jwt.org",
        "__v": 0
    }
]
```

Add the JWT token to standard **Authorization** header of HTTP requests to allow the Web API to verify it and allow access to resources

Storing JWT in Browser Local Storage

Local Storage allows storing a set of name value pairs directly accessible with **client-side** JavaScript

- **Store**

```
localStorage.id_token = "eyJhbnR5cCI…."
```

- **Retrieve**

```
Console.log(localStorage.id_token)
```

- **Remove**

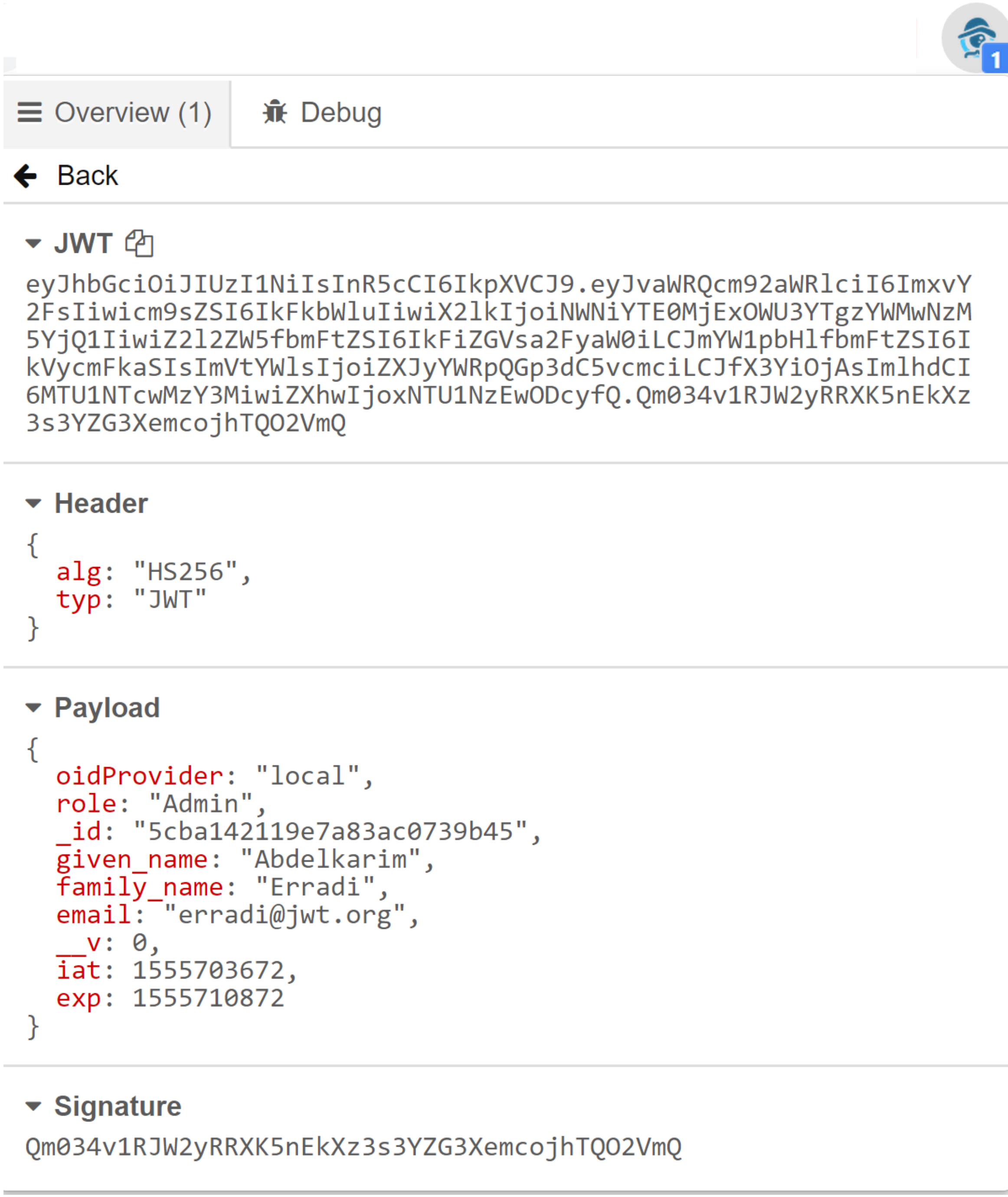
```
delete localStorage.id_token
```

- **Remove all saved data**

```
  localStorage.clear();
```

https://chrome.google.com/webstore/detail/jwt-analyzer-inspector/henclmbnehmcpbjgipaajbggekefngob

JWT Inspector is a chrome extension that lets you **decode** and **inspect** JWT in requests, and local storage



JWT

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJvaWRQcm92aWRlciI6ImxvY
2FsIiwicm9sZSI6IkFkbWluIiwiX2lkIjoiNWNiYTE0MjExOWU3YTgzYWMwNzM
5YjQ1IiwiZ2l2ZW5fbmFtZSI6IkFiZGVsa2FyaW0iLCJmYW1pbHlfbmFtZSI6I
kVycmFkaSIsImVtYWlsIjoiZXJyYWRpQGp3dC5vcmciLCJfX3YiOjAsImlhdCI
6MTU1NTcwMzY3MiwiZXhwIjoxNTU1NzEwODcyfQ.Qm034v1RJW2yRRXK5nEkXz
3s3YZG3XemcojhTQO2VmQ
```

Header

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

Payload

```
{
  oidProvider: "local",
  role: "Admin",
  _id: "5cba142119e7a83ac0739b45",
  given_name: "Abdelkarim",
  family_name: "Erradi",
  email: "erradi@jwt.org",
  __v: 0,
  iat: 1555703672,
  exp: 1555710872
}
```

Signature

```
Qm034v1RJW2yRRXK5nEkXz3s3YZG3XemcojhTQO2VmQ
```

401 vs. 403

- ***401 Unauthorized***

- Should be returned in case of failed authentication

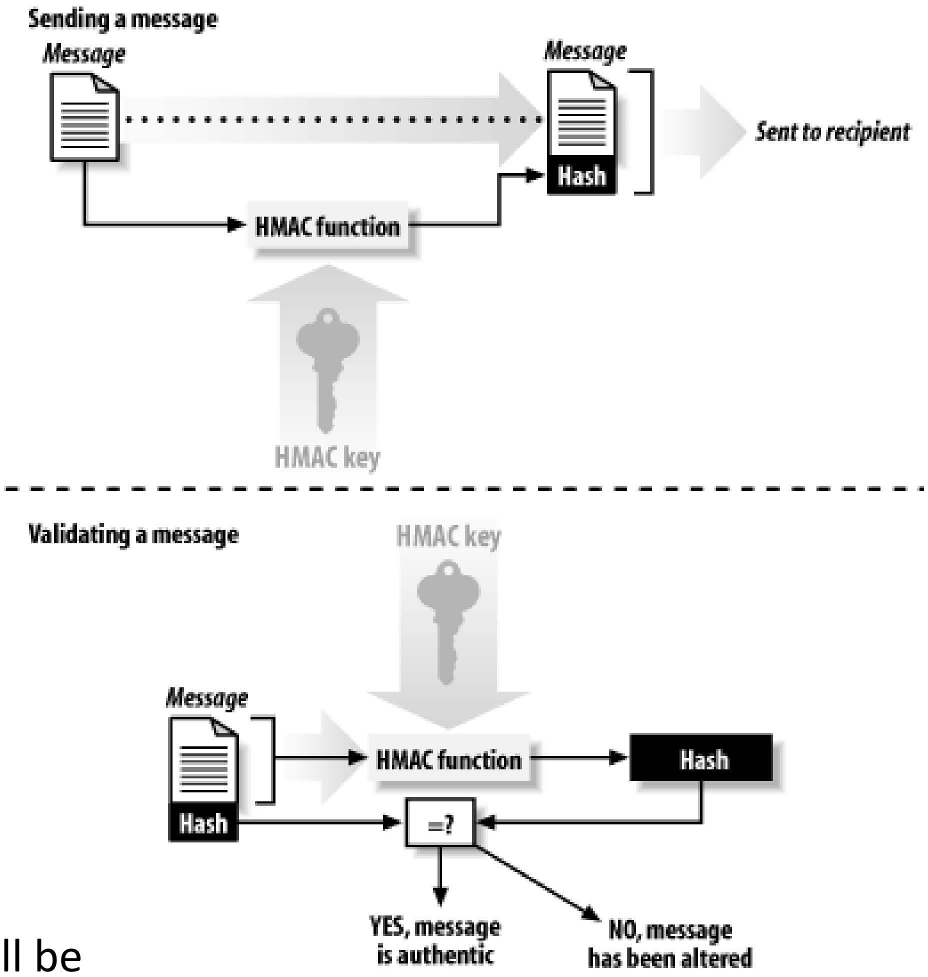
- ***403 Forbidden***

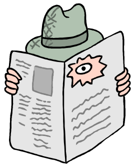
- Should be returned in case of failed authorization

- The user is authenticated but not authorized to perform the requested operation on the given resource

Hash-based Message Authentication Code (HMAC)

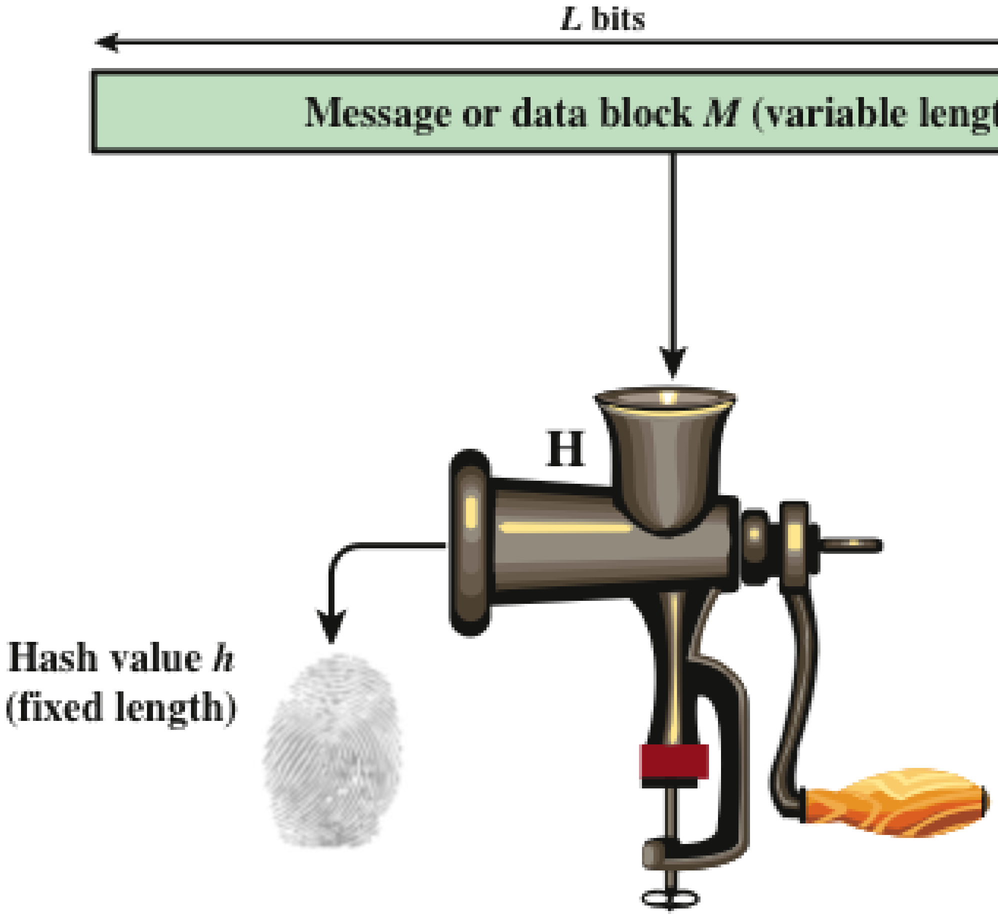
- **HMAC-SHA256** is often used for **signing JWT** to ensure its integrity
- HMAC-SHA256 is a *cryptographic hash function* that uses SHA256 hashing and **a *secret key*** *to generate a MAC (i.e., JWT signature)*
- The MAC is appended to the message sent
- MAC provides **message integrity**: Any manipulations of the message during transit will be detected by the receiver





An attacker who alters the message will be **unable** to alter the associated MAC value without knowledge of the secret key

Hashing



Hash functions are used to compute a digest of a message. It takes a variable size input, produce fixed size pseudorandom output

NextAuth.js

Authentication for Next.js

NextAuth.js

- **NextAuth.js** is a flexible, easy to use and open-source authentication library for Next.js
  - Support multiple providers such as Facebook, Google, Twitter, Github, … and the traditional email/password authentication
  - Supports passwordless sign in

NextAuth.js Programming Steps (1 of 2)

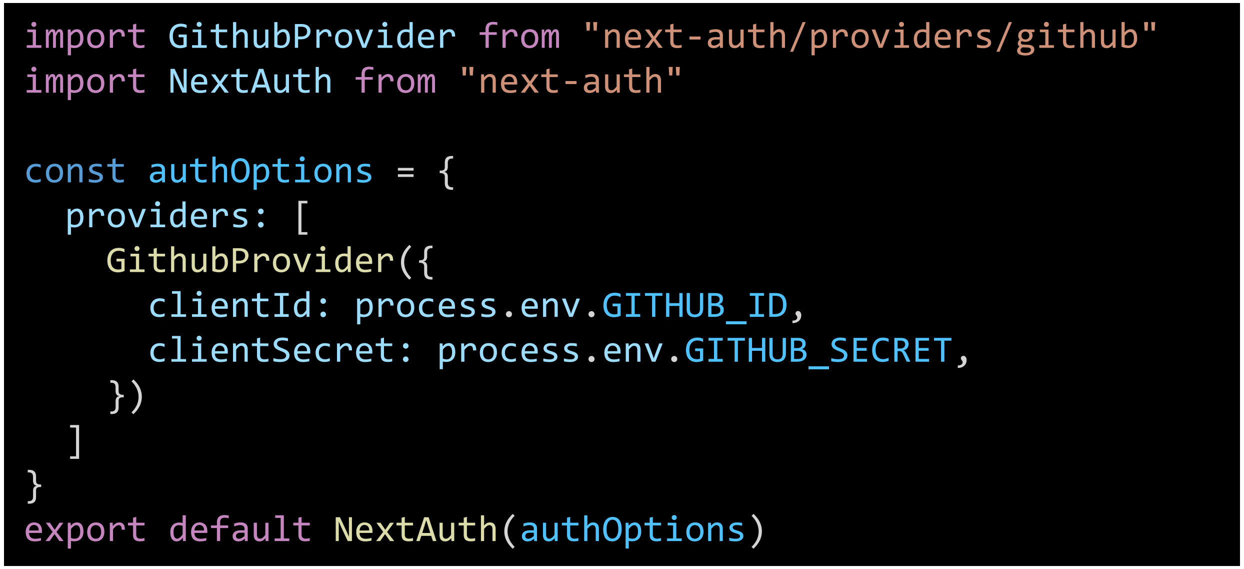
1. Install NextAuth.js **`npm install next-auth`**
2. Configure the Authentication Providers to be used such as GitHub, Google (more info):

- Create `[...nextauth].js` under `pages\api\auth`

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.local`** file in the root of the project

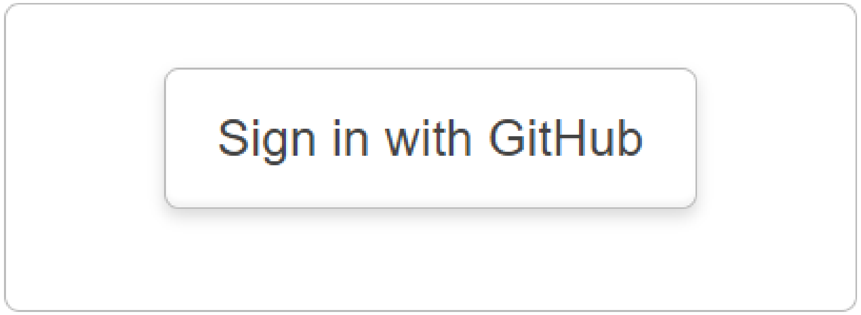


```
import GithubProvider from "next-auth/providers/github"
import NextAuth from "next-auth"

const authOptions = {
  providers: [
    GithubProvider({
      clientId: process.env.GITHUB_ID,
      clientSecret: process.env.GITHUB_SECRET,
    })
  ]
}
export default NextAuth(authOptions)
```

Auth Web API

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

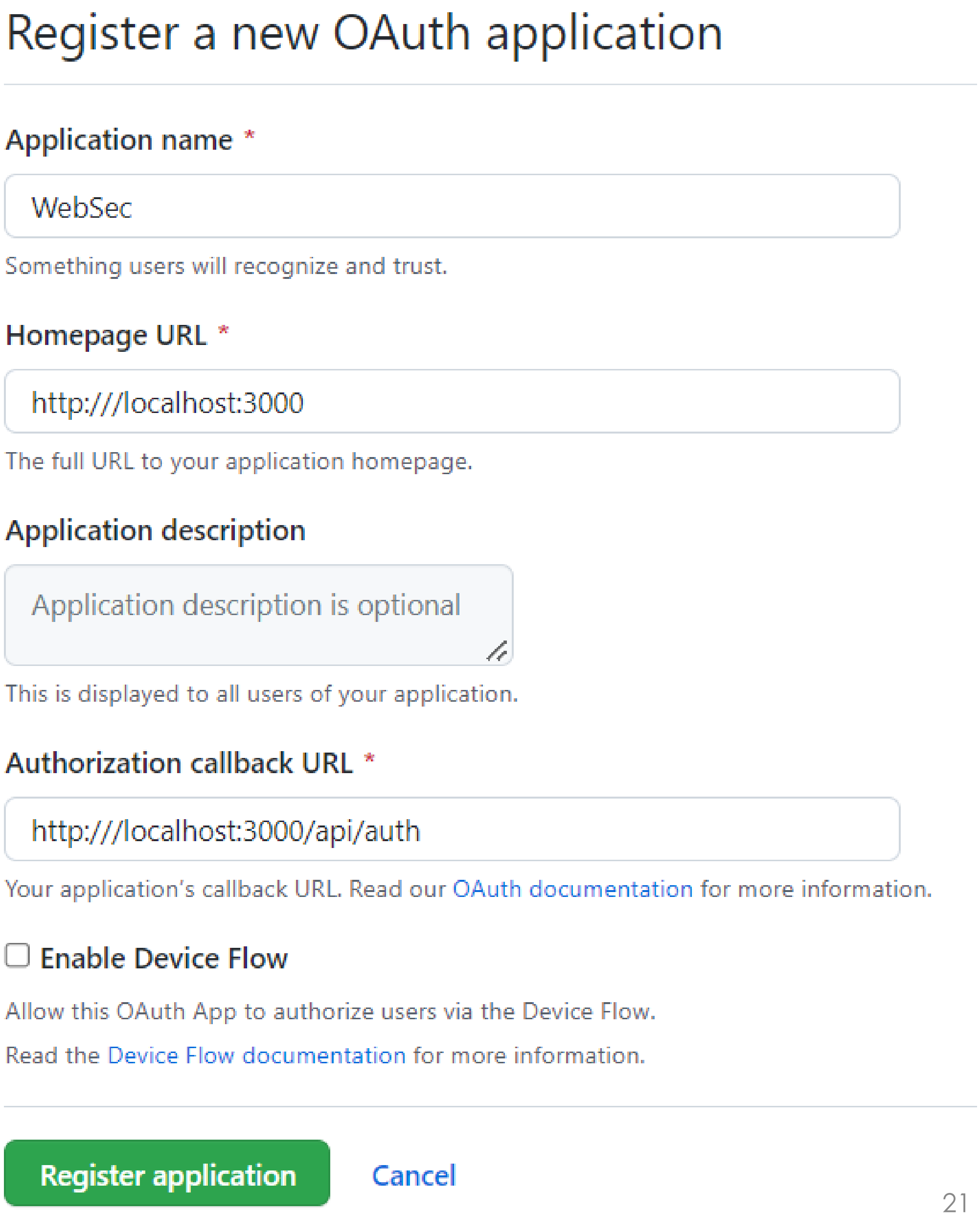


Create and Configure OAuth Client

- 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
  - session will return the user's details
- **`signIn`** and **`signOut`** functions can be used to perform the login and logout features in our app

Authorization
for Next.js & React

Node.js Middleware to Check Authorization

- Use route middleware function to check if the user is **authenticated** and **authorized** before handling their request

```
isAuthenticated(req, res, next) {
    let id_token = req.headers.authorization;
    console.log("received id_token: ", id_token);
    if (!id_token) {
        res.status(401).json({error: "Unauthorized. Missing JWT Token"});
        return;
    }
    try {
            id_token = id_token.split(" ")[1];
            //Decode and verify jwt token using the secret key
            const decodedToken = jwt.verify(id_token, keys.jwt.secret);
            //Assign the decoded token to the request to make the user details
            //available to the request handler
            req.user = decodedToken;
            console.log("decodedToken: ", decodedToken);
            next();
    } catch (e) {
        res.status(403).json({error: "Forbidden. Invalid JWT Token"});
    }
}
```

```
router.get('/users', isAuthenticated, async function (req, res) {
    if (req.user.role == 'Admin') {
        const users = await userRepository.getUsers();
        res.json(users);
    } else {
        res.status(403).json({ error: "Access denied" });
    }
});
```

React Protected Routes

- For protected React routes, we need to use a **Custom Route** function to check if the user

(1) is authenticated

(2) is authorized to access a particular route based on the user’s role

- See ***ProtectedRoute.js*** and ***App.js*** example

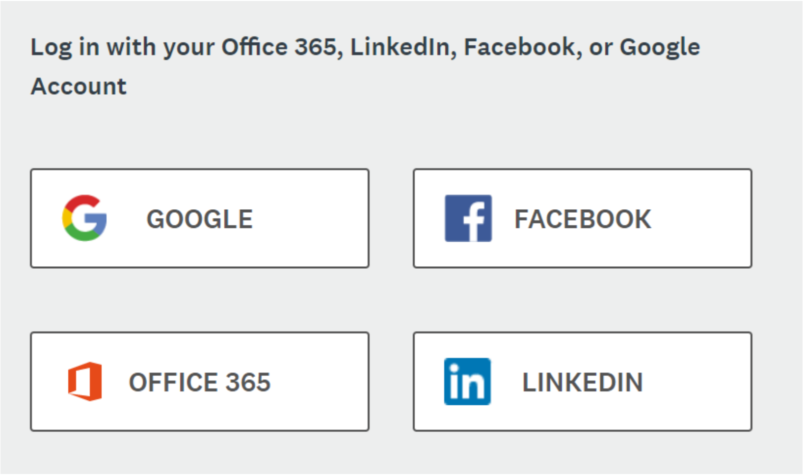
Delegated Authentication

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 **Identity 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
  - Examples: "Log in with Facebook"



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

OpenID Connect APIs

- Companies like Google, Facebook, Twitter, and GitHub offer OpenID Connect APIs:
  - Google Sign-in API
  - Facebook Login API
  - Twitter Login API
  - GitHub Apps/Integrations
  - OpenID Connect is standardized, but the API that these services provide are slightly different
  - You must read the documentation to understand how to connect via their API
- After the user logins, you will get the user profile such name, email, etc.

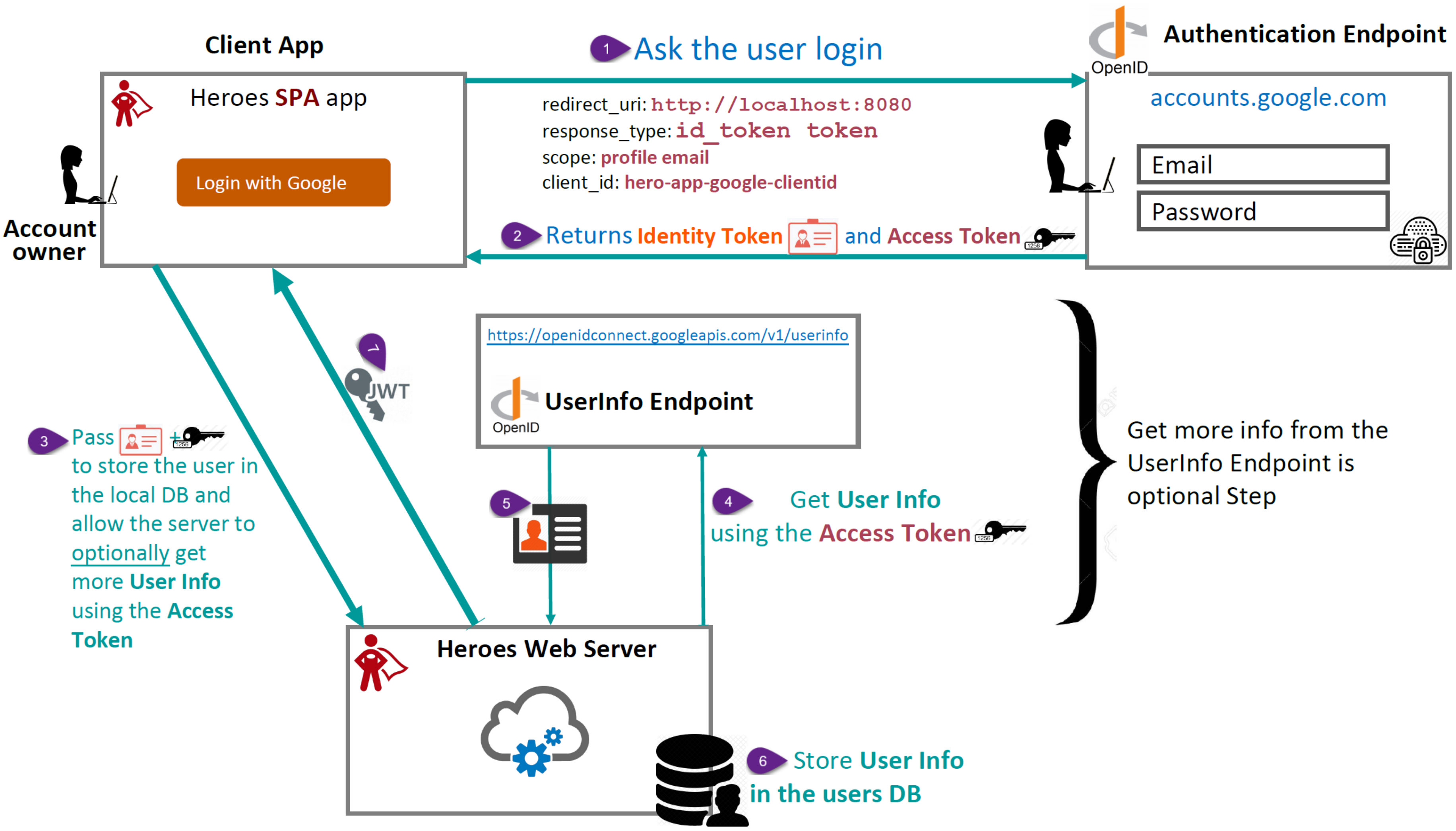
Register your App before using Google OpenID Connect

- To use Google OpenID Connect first create a project @ https://console.developers.google.com/apis
- Create OAuth clientId and clientSecret @

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

These steps are very similar for other services such as Twitter and Microsoft

OpenID Connect Authentication Flow



Client App

Heroes **SPA** app

Login with Google

Account owner

1 Ask the user login

redirect_uri: `http://localhost:8080`
response_type: `id_token token`
scope: **profile email**
client_id: **hero-app-google-clientid**

Authentication Endpoint

OpenID

accounts.google.com

Email

Password

2 Returns **Identity Token** and **Access Token**

7 JWT

https://openidconnect.googleapis.com/v1/userinfo

UserInfo Endpoint

OpenID

3 Pass + to store the user in the local DB and allow the server to optionally get more **User Info** using the **Access Token**

5

4 Get **User Info** using the **Access Token**

Get more info from the UserInfo Endpoint is optional Step

Heroes Web Server

6 Store **User Info** in the users DB

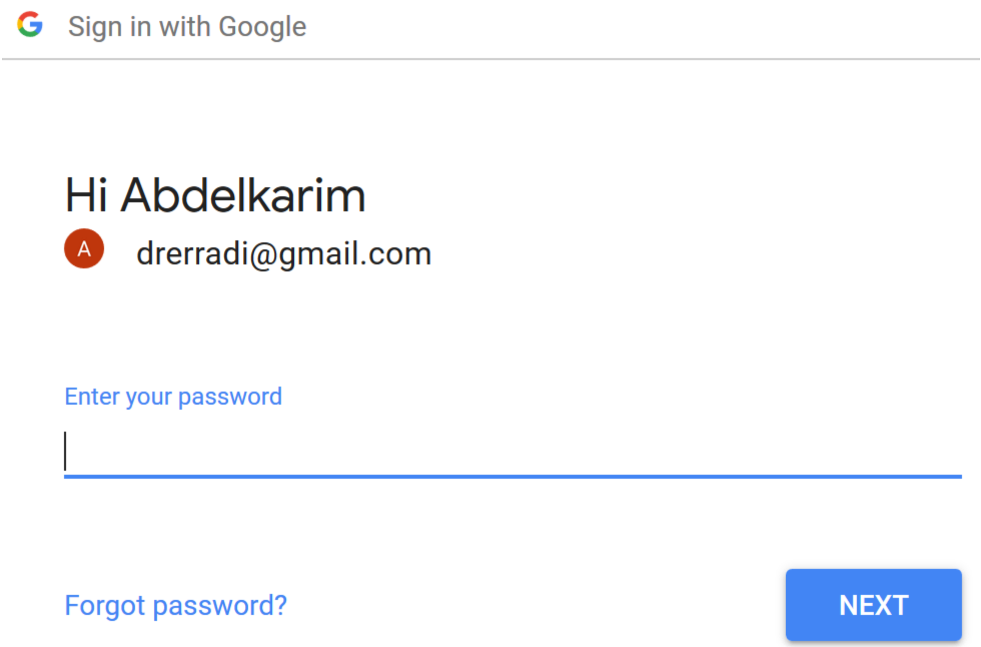
Authenticating via a SPA App

- **User** starts the flow by visiting a SPA App
- **Client** sends authentication request with ***profile*** scope via browser redirect to the **Authorization** endpoint
- **User** authenticates and consents to **Client** to access user's identity
- **ID Token** and **Access Token** is returned to **Client** via browser redirect
- **Client** optionally fetches additional user info with the **Access Token** from **UserInfo** endpoint

Authorization Request

- Ask the user to login via browser redirect to the Authentication Endpoint

https://accounts.google.com/o/oauth2/auth



Sign in with Google

Hi Abdelkarim

drerradi@gmail.com

Enter your password

- This will return an **Id Token** (has basic user info) and **Access Token** to the client to allow it to request further user's profile data from the UserInfo Endpoint

React GoogleLogin Parameters

Need to register and get **client_id** from https://console.developers.google.com/apis/credentials

```
<GoogleLogin
  clientId={googleClientId}
  onSuccess={handleGoogleResponse}
/>
```

After login, it returns:

- **id_token**: jwt of the authentication user
- **Access_token**: access-token to be able to access the UserInfo endpoint

Default scope:
profile email openid

Scope = what user info the client needs access to?

Scopes for Identify Claim Requests

- Scopes = what user info you can request access for?
- Standard scopes:

  `openid` – JWT representing logged-in user

  `profile` – Profile info

  `email` – Email address & verification status

  `address` – Postal address

  `phone` – Phone number & verification status

https://openid.net/specs/openid-connect-core-1_0.html#StandardClaims

ID Token

Example ID Token from Google

```
{
sub: "103784165006699511511",
iss: "accounts.google.com"
email: "drerradi@gmail.com",
email_verified: true,
family_name: "Erradi".
given_name: "Abdelkarim",
iat: 1555967854,
exp: 1555971454,
picture: "https://lh4.googleusercontent.com/K6npstA/s96-c/photo.jpg"
}
```

- JWT representing logged-in user
- Contains **standard** claims:

`sub` - User Identifier

`iss` - Issuer

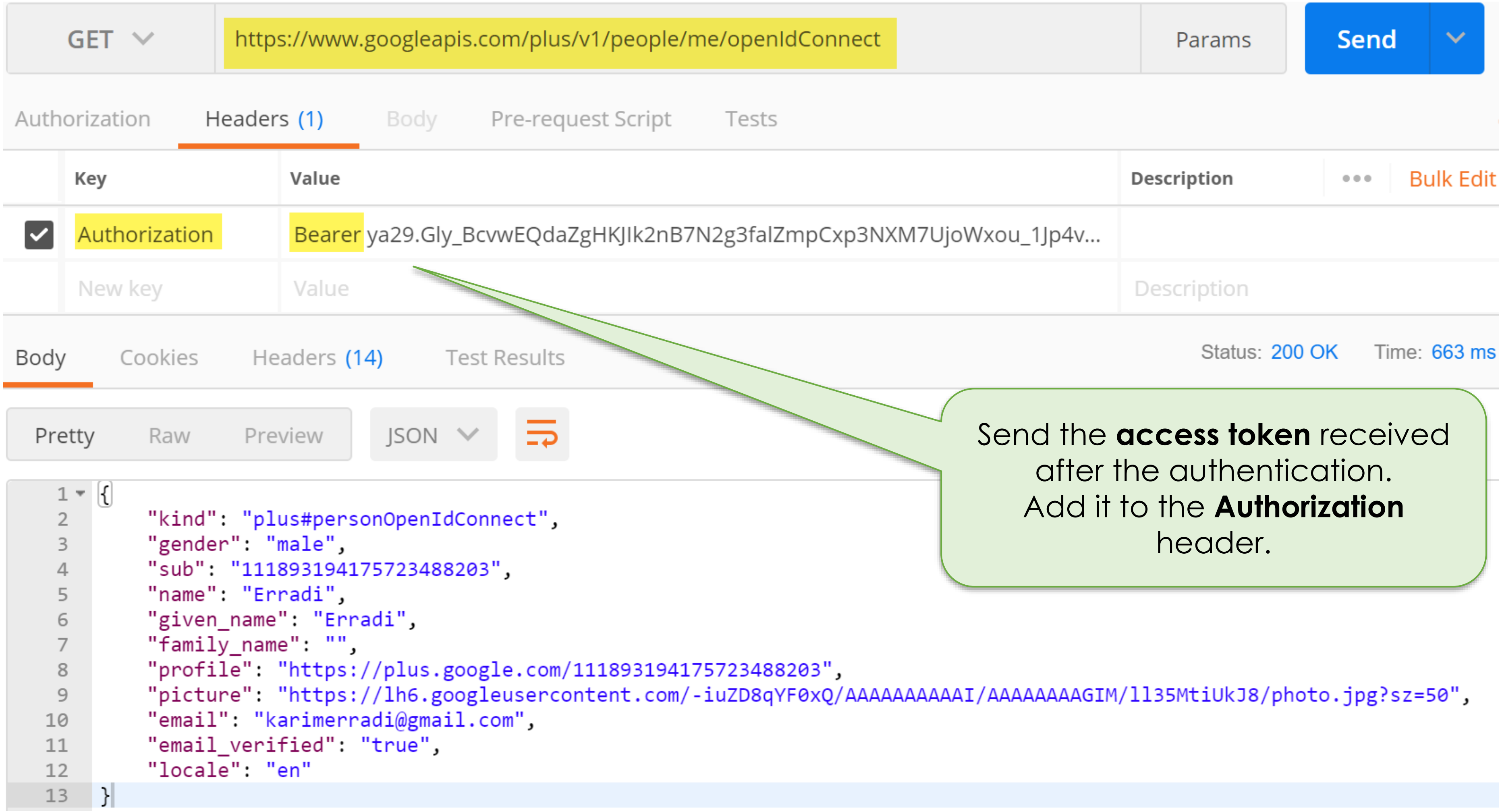
`iat` - Time token was issued

`exp` - Expiration time

…

Calling the UserInfo Endpoint

- Get the user's profile from the UserInfo Endpoint



	Key	Value	Description
☑	Authorization	Bearer ya29.Gly_BcvwEQdaZgHKJlk2nB7N2g3falZmpCxp3NXM7UjoWxou_1Jp4v...	
	New key	Value	Description

Status: 200 OK Time: 663 ms

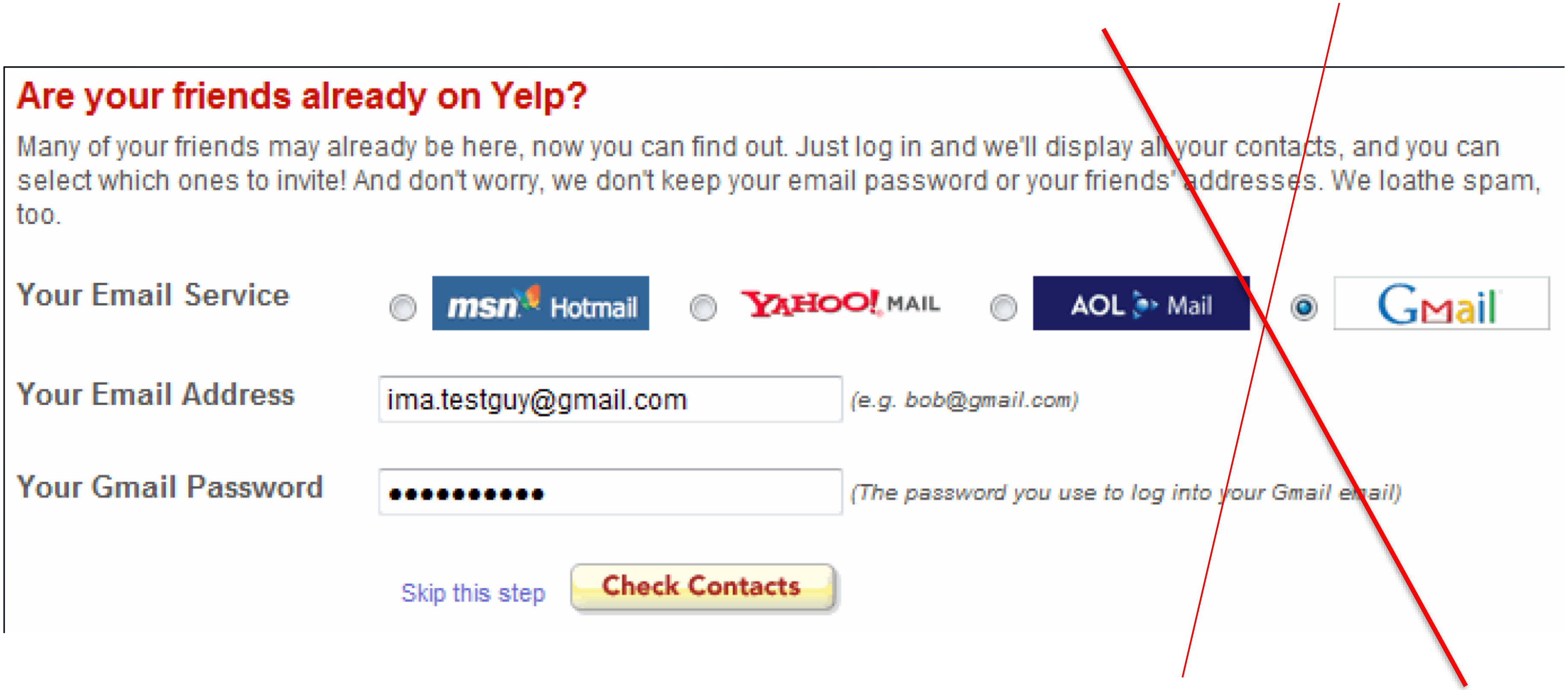
```
{
    "kind": "plus#personOpenIdConnect",
    "gender": "male",
    "sub": "111893194175723488203",
    "name": "Erradi",
    "given_name": "Erradi",
    "family_name": "",
    "profile": "https://plus.google.com/111893194175723488203",
    "picture": "https://lh6.googleusercontent.com/-iuZD8qYF0xQ/AAAAAAAAAAI/AAAAAAAAGIM/1l35MtiUkJ8/photo.jpg?sz=50",
    "email": "karimerradi@gmail.com",
    "email_verified": "true",
    "locale": "en"
}
```

Send the **access token** received after the authentication. Add it to the **Authorization** header.

Delegated Authorization

The delegated authorization problem

- How can I let a Web/Mobile App access my Data without giving it my password?
- Don't do it this way!



Are your friends already on Yelp?

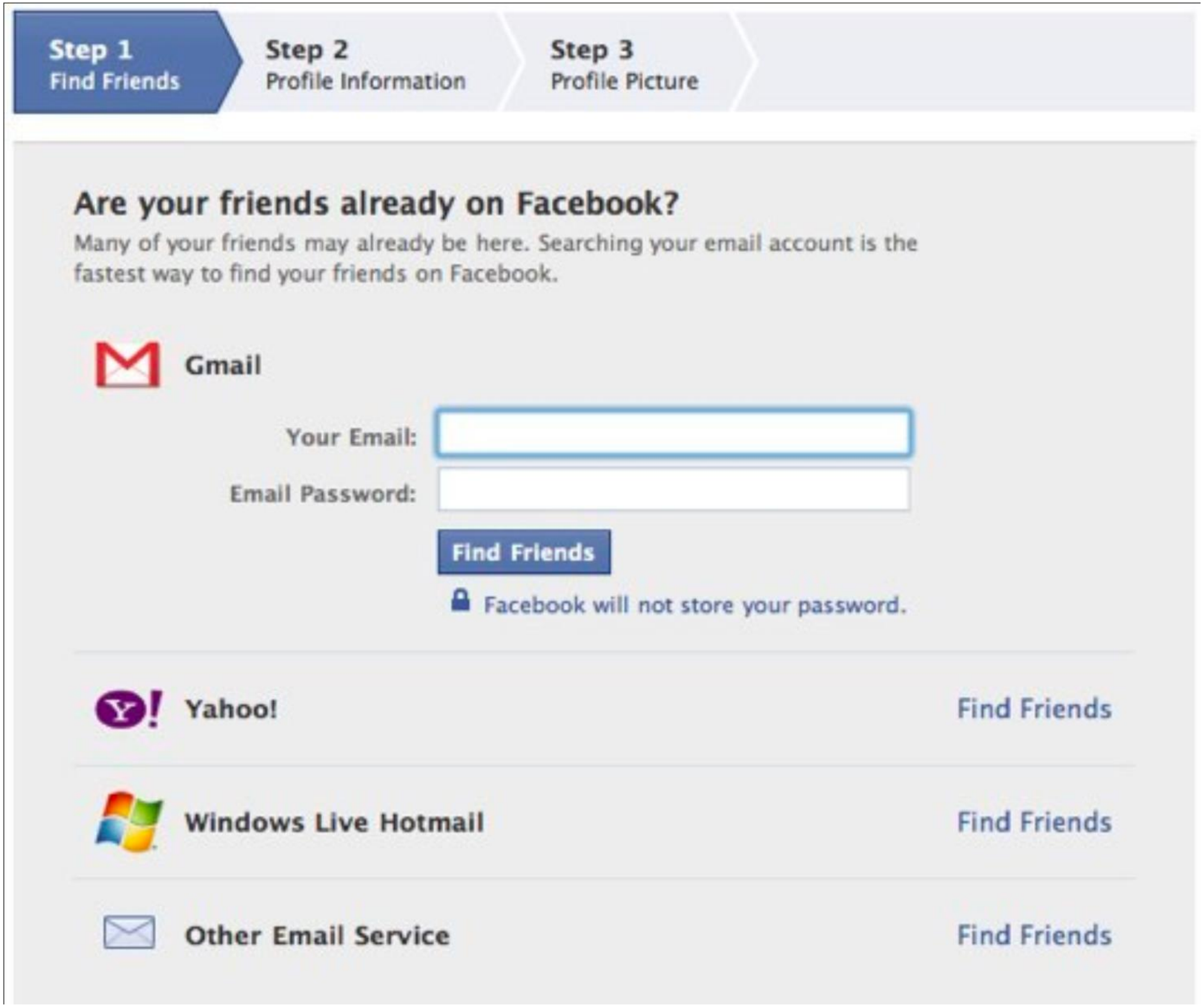
Many of your friends may already be here, now you can find out. Just log in and we'll display all your contacts, and you can select which ones to invite! And don't worry, we don't keep your email password or your friends' addresses. We loathe spam, too.

Your Email Service ○ msn Hotmail ○ YAHOO! MAIL ○ AOL Mail ● Gmail

Your Email Address ima.testguy@gmail.com (e.g. bob@gmail.com)

Your Gmail Password ●●●●●●●●●●● (The password you use to log into your Gmail email)

Facebook ~ 2010



Are your friends already on Facebook?

Many of your friends may already be here. Searching your email account is the fastest way to find your friends on Facebook.

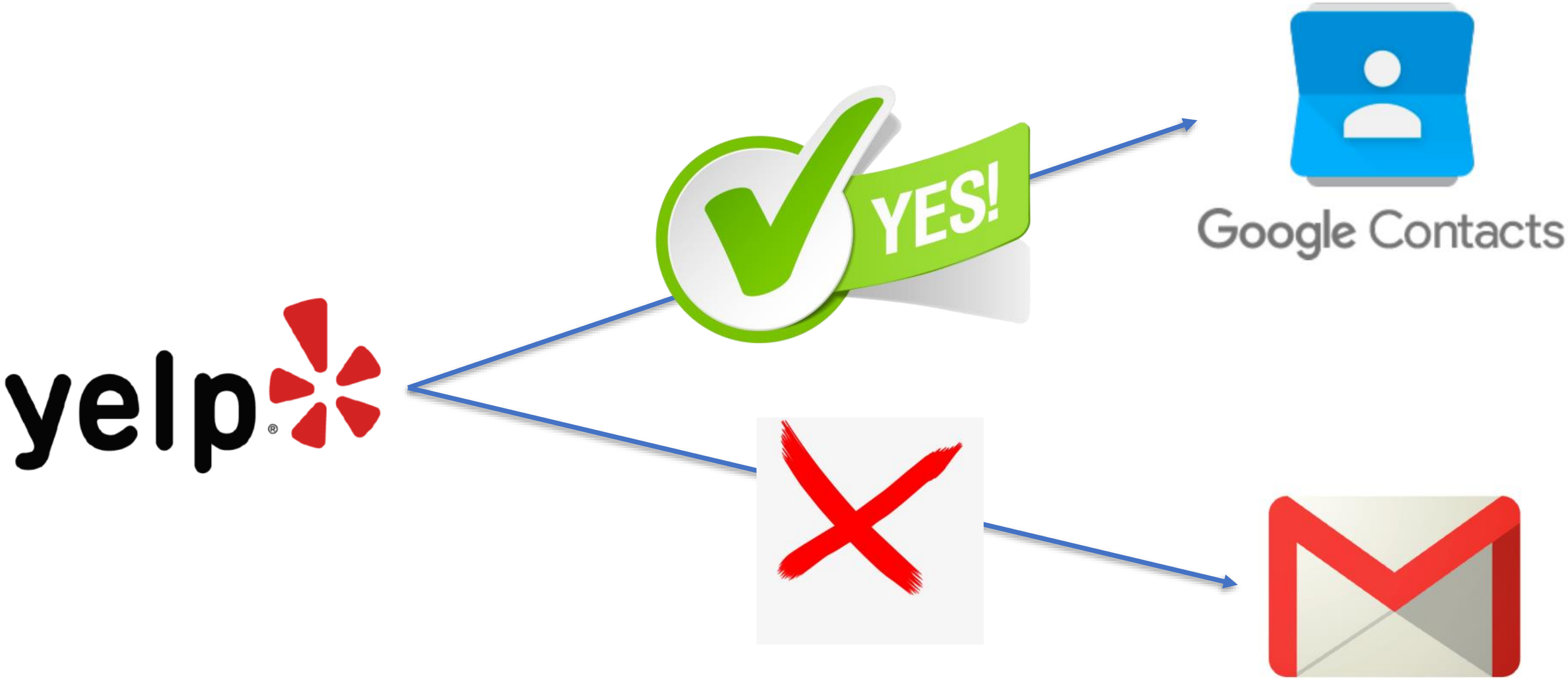
Gmail

Your Email:

Email Password:

Facebook will not store your password.

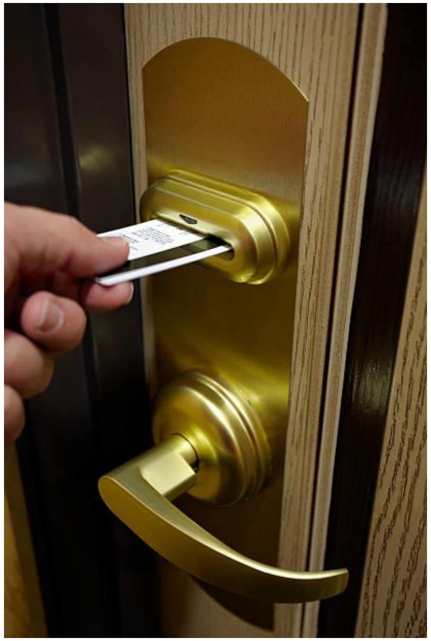
So... how can I let an app access my data without giving it my password?



Hotel Key Cards, but for Apps

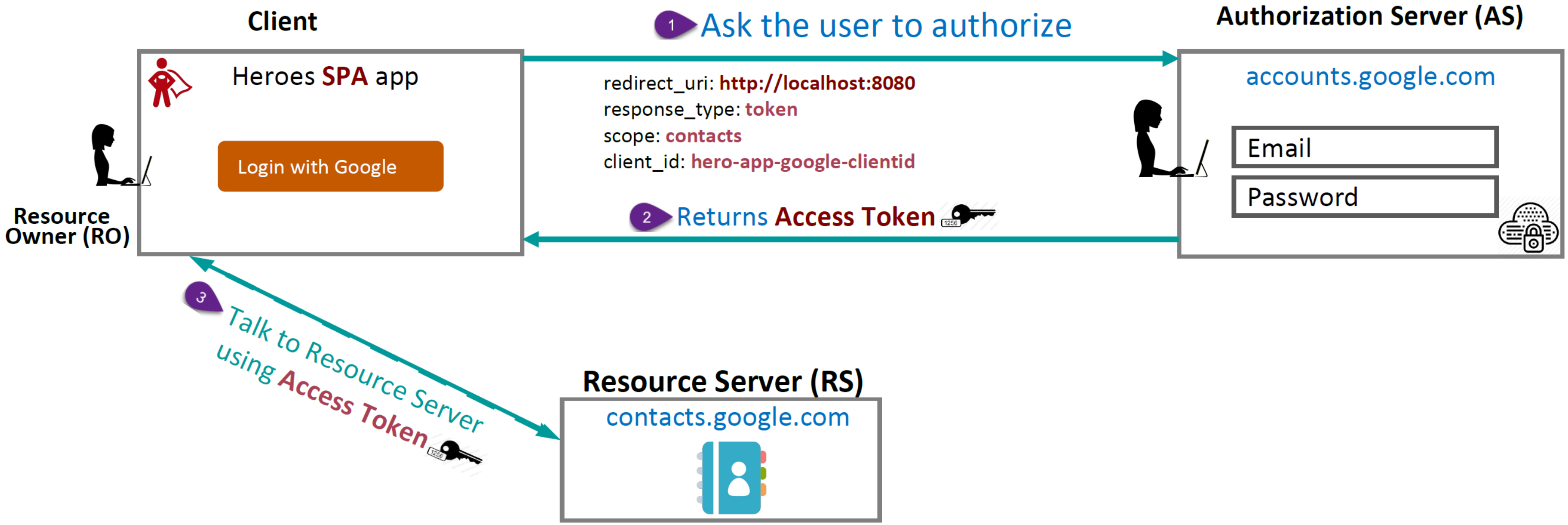
OAuth Authorization Server

Access Token



Resource (API)

OAuth Authorization Flow



Client

Heroes SPA app

Login with Google

Resource Owner (RO)

1 Ask the user to authorize

redirect_uri: http://localhost:8080
response_type: token
scope: contacts
client_id: hero-app-google-clientid

2 Returns Access Token

Authorization Server (AS)

accounts.google.com

Email

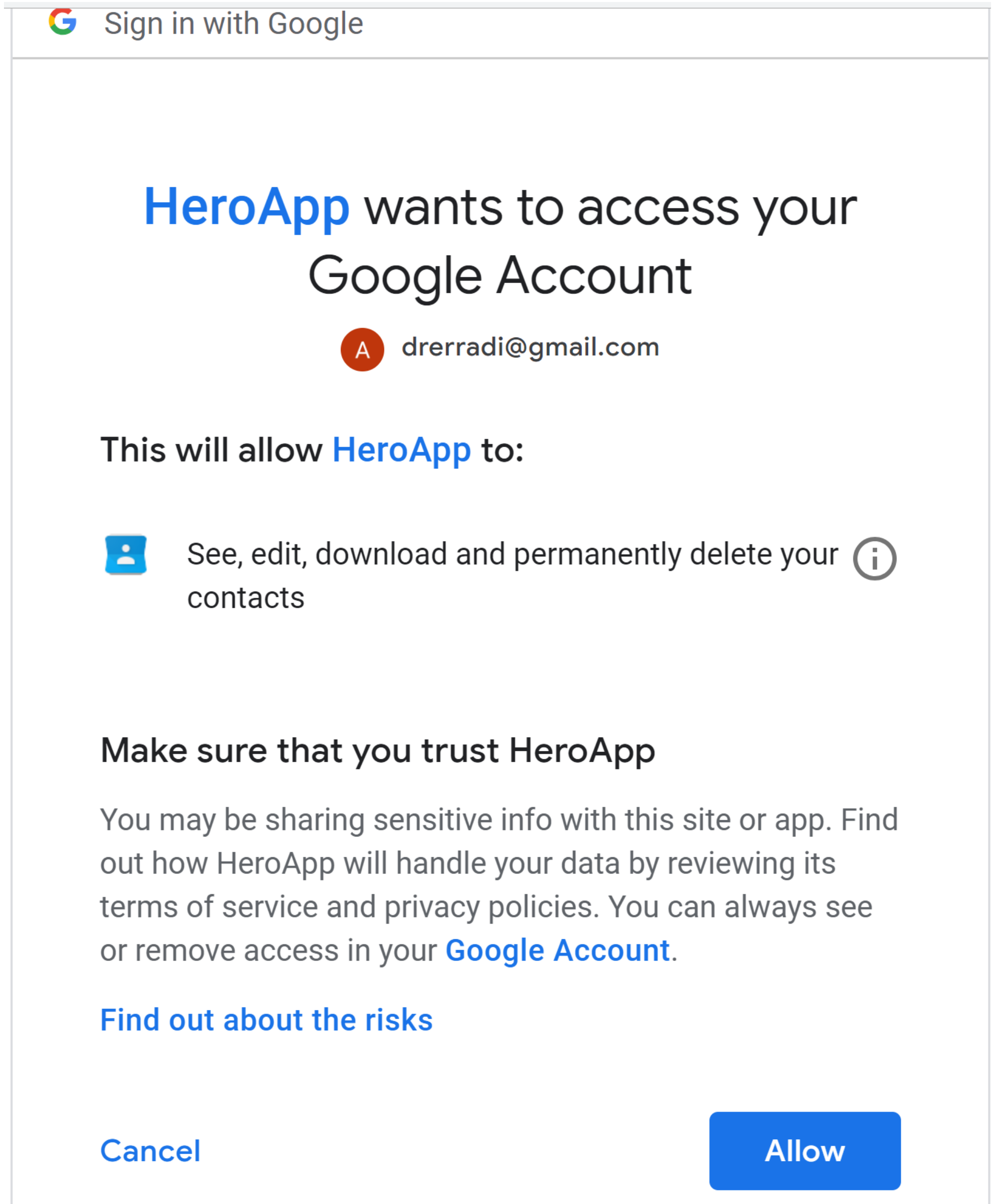
Password

3 Talk to Resource Server using Access Token

Resource Server (RS)

contacts.google.com

Google Example



Sign in with Google

HeroApp wants to access your Google Account

A drerradi@gmail.com

This will allow HeroApp to:

See, edit, download and permanently delete your contacts

Make sure that you trust HeroApp

You may be sharing sensitive info with this site or app. Find out how HeroApp will handle your data by reviewing its terms of service and privacy policies. You can always see or remove access in your Google Account.

Find out about the risks

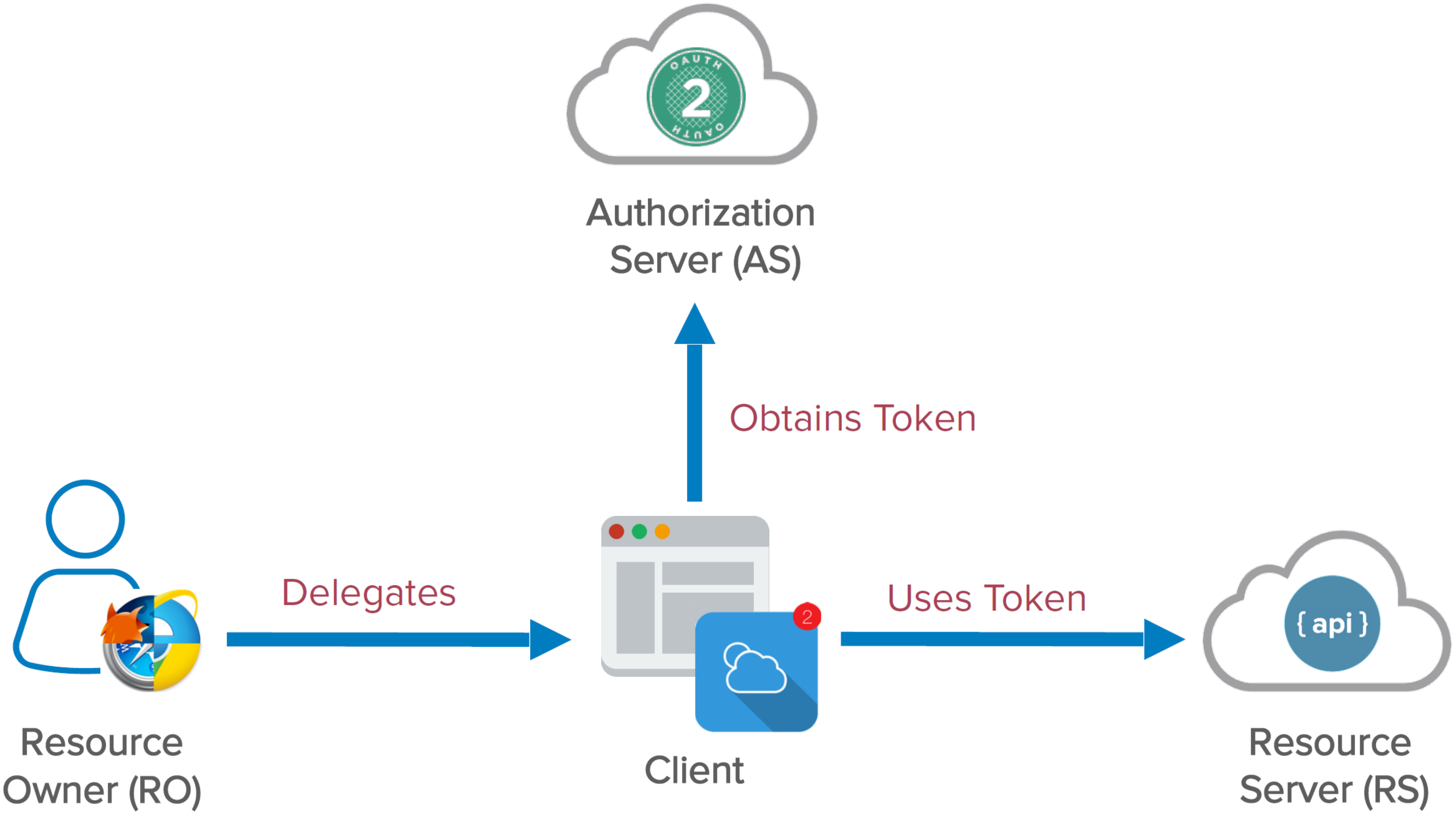
OAuth

- OAuth is used for **Delegation of Authorization** (i.e., Access Granting Protocol)
  - App gets the permission to access data on the user’s behalf

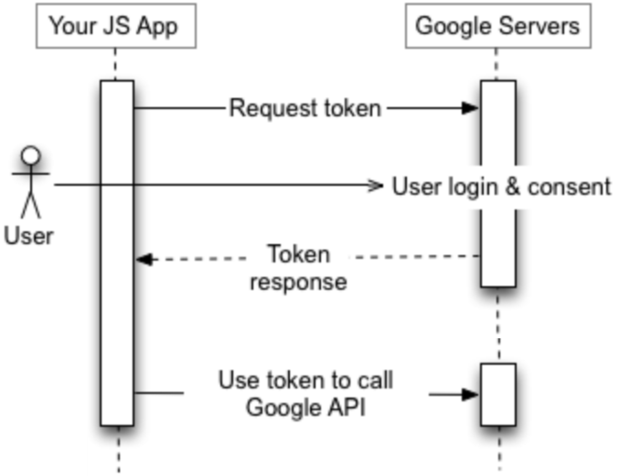
1. **App** requests authorization from **User**
2. **User** authorizes the **App**
3. **App** gets an **Access Token**
4. **App** uses **Access Token** to access the resource

Token is restricted to only access what the **User** authorized for the specific **App**

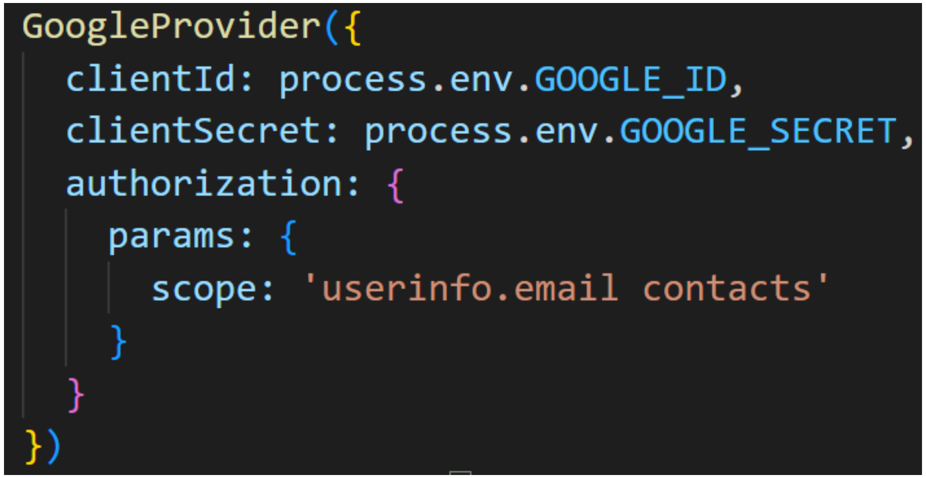
OAuth Actors



The client (app) needs to ask the user to authorize getting an *access token* which it can use when calling the API



First ask the user to Authorize



```
GoogleProvider({
  clientId: process.env.GOOGLE_ID,
  clientSecret: process.env.GOOGLE_SECRET,
  authorization: {
    params: {
      scope: 'userinfo.email contacts'
    }
  }
})
```

- User **Authenticates** and **Grants Authorization**,

This will return an **Access Token** to the client to allow it to access the protected resource (e.g., Google Contacts)

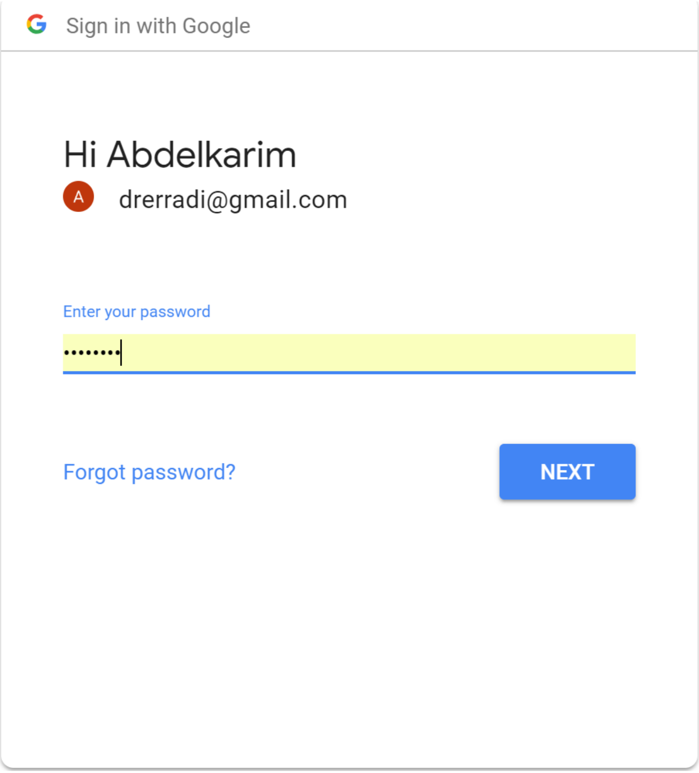
- **Google API Scopes**

https://developers.google.com/identity/protocols/googlescopes

- Before accessing any API (e.g., *Google People API*) you must **enable it** on your Google project @ https://console.developers.google.com/apis/library

User Authenticates and Grants Authorization

Authenticate & Grant Authorization



Sign in with Google

Hi Abdelkarim

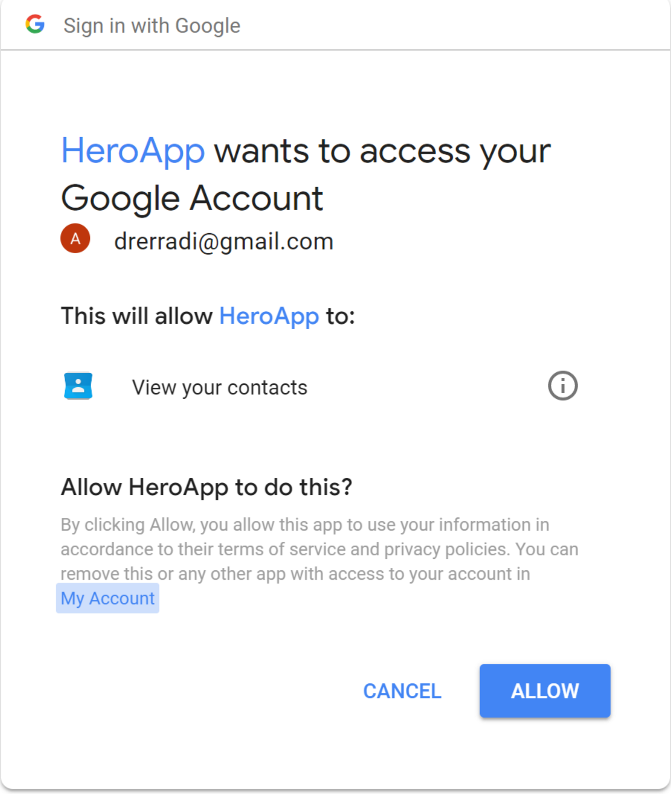
A drerradi@gmail.com

Enter your password

••••••••

Forgot password?

NEXT



Sign in with Google

HeroApp wants to access your Google Account

A drerradi@gmail.com

This will allow HeroApp to:

View your contacts

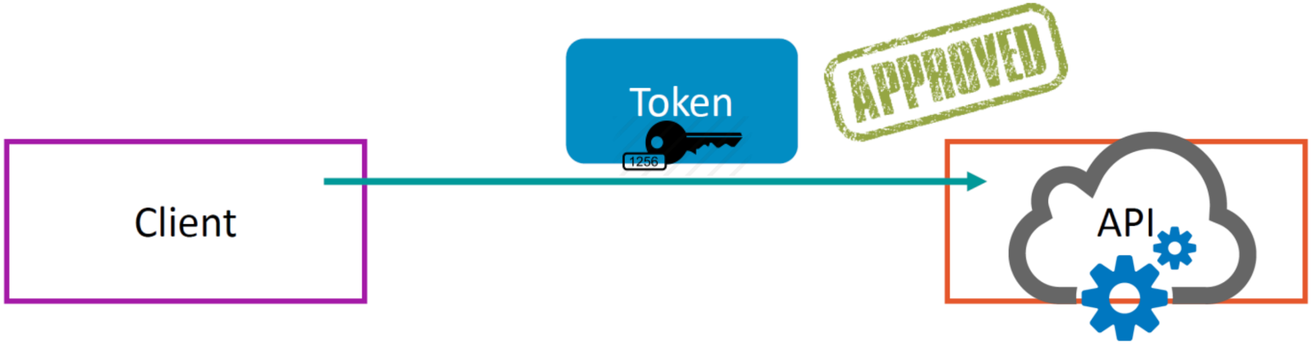
Allow HeroApp to do this?

By clicking Allow, you allow this app to use your information in accordance to their terms of service and privacy policies. You can remove this or any other app with access to your account in My Account

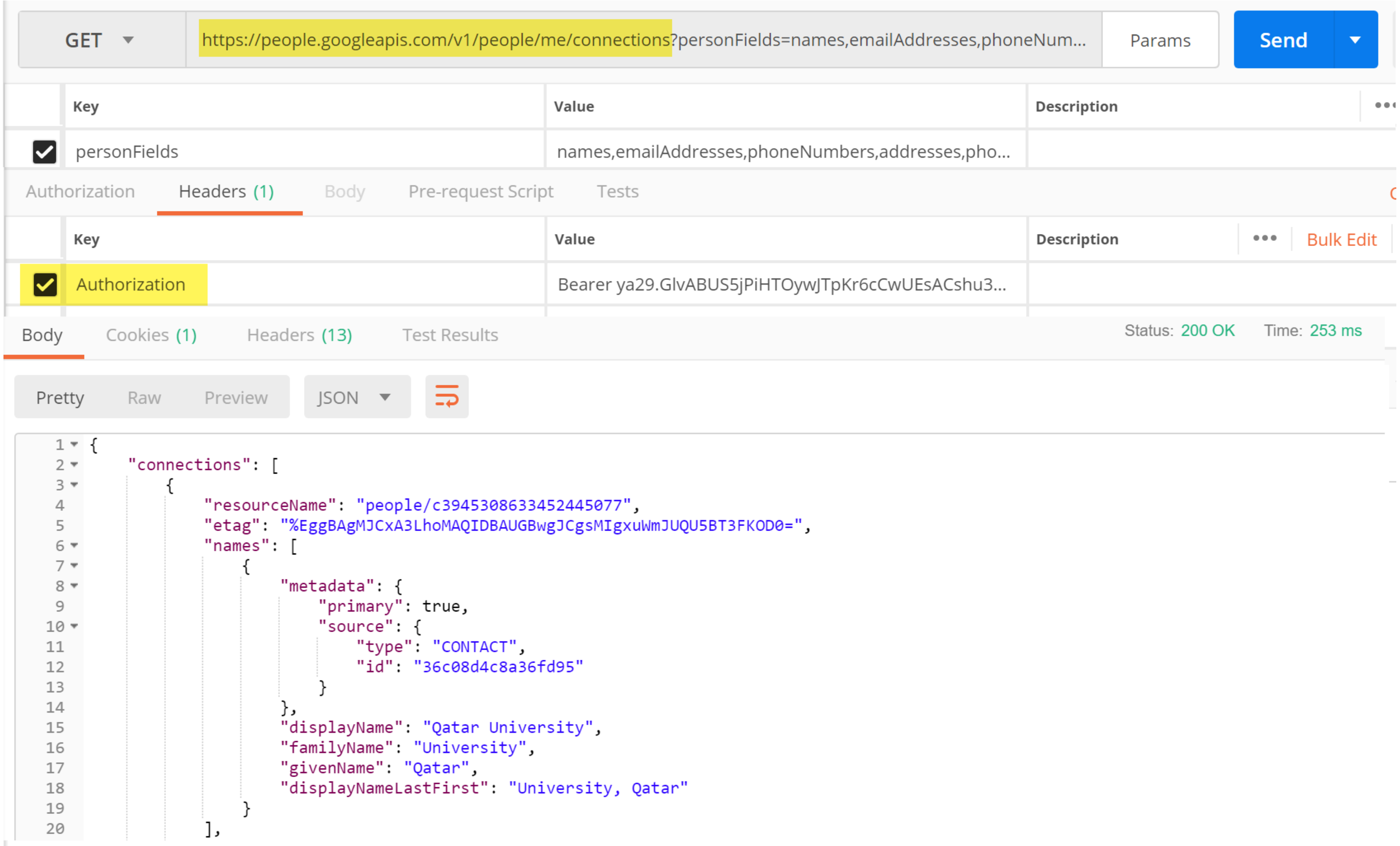
CANCEL ALLOW

Note that users can revoke the permission @ https://myaccount.google.com/permissions

Use the Access Token to access the Resource



- Validate token
- Grant access to the resource



https://people.googleapis.com/v1/people/me/connections?personFields=names,emailAddresses,phoneNum...

	Key	Value	Description
☑	personFields	names,emailAddresses,phoneNumbers,addresses,pho...	

	Key	Value	Description
☑	Authorization	Bearer ya29.GlvABUS5jPiHTOywJTpKr6cCwUEsACshu3...	

Status: 200 OK Time: 253 ms

```
{
    "connections": [
        {
            "resourceName": "people/c3945308633452445077",
            "etag": "%EggBAgMJCxA3LhoMAQIDBAUGBwgJCgsMIgxuWmJUQU5BT3FKOD0=",
            "names": [
                {
                    "metadata": {
                        "primary": true,
                        "source": {
                            "type": "CONTACT",
                            "id": "36c08d4c8a36fd95"
                        }
                    },
                    "displayName": "Qatar University",
                    "familyName": "University",
                    "givenName": "Qatar",
                    "displayNameLastFirst": "University, Qatar"
                }
            ],
```

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

- Use OAuth 2.0 for **Delegated Authorization**:
  - App gets the permission to access data on the user’s behalf

Resources

- JWT Handbook

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

- Authentication Survival Guide

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

- OAuth 2

https://www.oauth.com/

- Good resource to learn about JWT

https://jwt.io/

- RBAC

https://www.npmjs.com/package/easy-rbac

OAuth 2 and OpenID Connect Videos

- OAuth 2.0 and OpenID Connect (in plain English)

https://www.youtube.com/watch?v=996OiexHze0

- What the Heck is OpenID Connect?

https://www.youtube.com/watch?v=6ypYXxRPKgk

- How Google is using OAuth?

https://www.youtube.com/watch?v=fxRXLbgX53A