# Lab 10: Tokens, Authorization and Docker

## Details

Aim: To provide a foundation around the usage of tokens for authorization. We will use your Ubuntu instance for this work, and aim to provide an introduction to Docker. Make sure you have created your GitHub account, as we will use the account details later in the lab.

## A JWT

**A.1** The JSON Web Token can be used to grant access rights. It is signed using a secret passphrase. Using node.js, create the following program (you need to use **npm install jwt-simple**):

var args = process.argv;

var sec='fff';

var pay="{ foo: \'bar\'}";

//if (args.length>1) pay=args[2];

//if (args.length>2) sec=args[3];

console.log("Message:\t",pay)

console.log("Passphrase:\t",sec)

var jwt = require('jwt-simple');

var payload = pay ;

var secret = sec;

// encode

var token = jwt.encode(payload, secret);

console.log("Token: ",token);

// decode

var decoded = jwt.decode(token, secret);

console.log("Decoded: ",decoded);

Repl.it: <https://repl.it/@billbuchanan/jwt>

**A.2** Now try different messages, but keep the secret the same:

How do the JSON Web Tokens change?

If we now keep the message the same, but change the secret, how do the JSON Web Tokens change?

There are different ways to encode the token (HS256, HS384, HS512 and RS256). We can add the encoding with:

jwt.encode(payload, secret, 'HS512')

What do HS256, HS364, HS512 and RS256 represent?

What is the difference between creating the signature with HMAC and RSA?

Try each of the hashing methods (HSXXX), and observe how the JWT changes:

Repl.it: <https://repl.it/@billbuchanan/jwt>

**A.3** Now, match the following parameters to the correct signing secret. For the following the message is “{ isa: 14321}”, and the signing keys used are either “napier”, “napier123”, “qwerty” or “fox123”:

eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.InsgaXNhOiAxNDMyMX0i.czeOHowkTpZQqG5pZneOlnpdBGMCnTLXaPImNmSr9w

**Secret:**

eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.InsgaXNhOiAxNDMyMX0i.WWR2-Wxw0Nm0Expix600cOltjnjhC7hCjOmHH2cPpJ4

**Secret:**

eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.InsgaXNhOiAxNDMyMX0i.uSXNmESTf\_NUk0QC8IJyPfsm\_QMu00UP6eIvOA3Dag4

**Secret:**

<https://repl.it/@billbuchanan/jwt2>

**A.4** The following JWT has been signed with the passphrase of “fox123”:

eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.IntcImlzc1wiOiBcImZyZWRcIixcInN1YmplY3RcIjpcImxvZ2luXCIsXCJkZXBhcnRtZW50XCI6IFwic2FsZXNcIixcImlhdFwiOiBcIjE1MjUxOTMzNzdcIixcImV4cFwiOiBcIjE1MjUyMzY1NzdcIn0i.4QpsBQ5HDbAjzv3EaMp0UQdCG-MnEanW7g8q9AUvOLU

Can you read the message with the wrong passphrase?

Can you determine the message?

When was the token issued, and when was its expiry time?

Repl.it: <https://repl.it/@billbuchanan/jwt3>

**A.5** The following JWT was signed with a three-character word [a-z]. Can you determine the secret phrase:

eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9.IntcImlzc1wiOiBcImZyZWRcIixcInN1YmplY3RcIjpcImxvZ2luXCIsXCJkZXBhcnRtZW50XCI6IFwic2FsZXNcIixcImlhdFwiOiBcIjE1MjUxOTMzNzdcIixcImV4cFwiOiBcIjE1MjUyMzY1NzdcIn0i.zyd0cy8p4xgpeoyOQ8G61xnA5Cmg5w095tNH9IWg9Wc

**A.6** The following JWT has a secret phrase of “napier”:

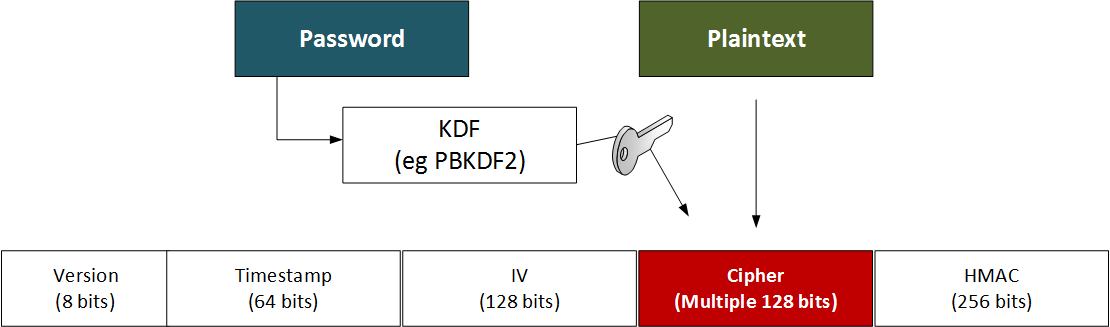
**eyJ0eXAiOiJKV1QiLCJhbGciOiJIUzI1NiJ9**.IntcImlzc1wiOiBcImZyZWRcIixcInN1YmplY3RcIjpcImxvZ2luXCIsXCJkZXBhcnRtZW50XCI6IFwic2FsZXNcIixcImlhdFwiOiBcIjE1MjUxOTMzNzdcIixcImV4cFwiOiBcIjE1MjUyMzY1NzdcIn0i**.G-cLzbqrTb\_daMusbJTEEi\_p-1cGC9\_Q2ONtGGXe65Q**

Did you decode it?

Now – one at a time – change one of the Base64 characters in the each of the fields (and which are separated by a ‘.’). What effect does it have on the ability to decode the token?

## B Fernet Tokens

**B.1** The Fernet token contains a timestamp, IV, cipher and HMAC signature. The cipher is generated by taking a password and the plaintext (Figure 1).



**Figure 1:** Fernet token

Enter the following program:

from cryptography.fernet import Fernet

from cryptography.hazmat.primitives import hashes

from cryptography.hazmat.backends import default\_backend

import sys

import binascii

import base64

password="hello"

val="hello world"

def get\_key(password):

digest = hashes.Hash(hashes.SHA256(), backend=default\_backend())

digest.update(password)

return base64.urlsafe\_b64encode(digest.finalize())

if (len(sys.argv)>1):

val=sys.argv[1]

if (len(sys.argv)>2):

password=str(sys.argv[2])

if (len(password)>1):

key = get\_key(password)

else:

key = Fernet.generate\_key()

print "Key: "+binascii.hexlify(bytearray(key))

cipher\_suite = Fernet(key)

cipher\_text = cipher\_suite.encrypt(val)

cipher=binascii.hexlify(bytearray(cipher\_text))

print "Cipher: "+cipher

print "\nVersion:\t"+cipher[0:2]

print "Time stamp:\t"+cipher[2:18]

print "IV:\t\t"+cipher[18:50]

print "HMAC:\t\t"+cipher[-64:]

plain\_text = cipher\_suite.decrypt(cipher\_text)

print "\nPlain text: "+plain\_text

For a message of “hello” and a password of “qwerty”, prove that you can decrypt the token.

Can you decrypt the token?

Generate several tokens, and outline the values which change on the token?

**B.2** The following Fernet token uses a password of “napier”.

Cipher: 6741414141414263706c6c645f707a5f2d6158394c3173623566354d366a6a636d575f5436307a737233764d5446484c634f622d6150794447486d55416a7839685a47496a477870367830455066657344725f376b676457584d38565747586e41773d3d

Version: 67

Time stamp: 4141414141426370

IV: 6c6c645f707a5f2d6158394c31736235

HMAC: 6a477870367830455066657344725f376b676457584d38565747586e41773d3d

Can you determine the message:

## C OAuth 2.0

OAuth 2.0 allows a user to gain an OAuth 2.0 token and then be granted rights onto other systems. One application is in federated ID login. In this case we will log into a system using a GitHub authorization. In this case GitHub will authorize our details, and redirect to a given page.

**C.1** First go to your GitHub account, and register your OAuth 2.0 application. Give it a name of (MyGit) and redirect to a Web site (such as <https://asecuritysite.com>). Figure 2 gives an overview of this. You will then generate a **Client ID** code and a **Client Secret** (Figure 3). Take a copy of these codes, as you will need it in the next part.

**C.2** We will now create a Flask program. In the following is an OAuth 2 method to create a federated ID login [1]. Enter the code:

from requests\_oauthlib import OAuth2Session

from flask import Flask, request, redirect, session, url\_for

from flask.json import jsonify

import os

app = Flask(\_\_name\_\_)

# This information is obtained upon registration of a new GitHub OAuth

# application here: https://github.com/settings/applications/new

client\_id = "<your client key>"

client\_secret = "<your client secret>"

authorization\_base\_url = 'https://github.com/login/oauth/authorize'

token\_url = 'https://github.com/login/oauth/access\_token'

@app.route("/")

def demo():

"""Step 1: User Authorization.

Redirect the user/resource owner to the OAuth provider (i.e. Github)

using an URL with a few key OAuth parameters.

"""

github = OAuth2Session(client\_id)

authorization\_url, state = github.authorization\_url(authorization\_base\_url)

# State is used to prevent CSRF, keep this for later.

session['oauth\_state'] = state

return redirect(authorization\_url)

# Step 2: User authorization, this happens on the provider.

@app.route("/callback", methods=["GET"])

def callback():

""" Step 3: Retrieving an access token.

The user has been redirected back from the provider to your registered

callback URL. With this redirection comes an authorization code included

in the redirect URL. We will use that to obtain an access token.

"""

github = OAuth2Session(client\_id, state=session['oauth\_state'])

token = github.fetch\_token(token\_url, client\_secret=client\_secret,

authorization\_response=request.url)

# At this point you can fetch protected resources but lets save

# the token and show how this is done from a persisted token

# in /profile.

session['oauth\_token'] = token

return redirect(url\_for('.profile'))

@app.route("/profile", methods=["GET"])

def profile():

"""Fetching a protected resource using an OAuth 2 token.

"""

github = OAuth2Session(client\_id, token=session['oauth\_token'])

return jsonify(github.get('https://api.github.com/user').json())

if \_\_name\_\_ == "\_\_main\_\_":

# This allows us to use a plain HTTP callback

os.environ['OAUTHLIB\_INSECURE\_TRANSPORT'] = "1"

app.secret\_key = os.urandom(24)

app.run(debug=True)

**C.3** Now add your Client ID and Client secret to the code, and run it:

napier@napier-virtual-machine:~/esecurity/unit10\_services/src$ python c02.py

\* Serving Flask app "c01" (lazy loading)

\* Environment: production

WARNING: Do not use the development server in a production environment.

Use a production WSGI server instead.

\* Debug mode: on

\* Running on **http://127.0.0.1:5000/** (Press CTRL+C to quit)

\* Restarting with stat

\* Debugger is active!

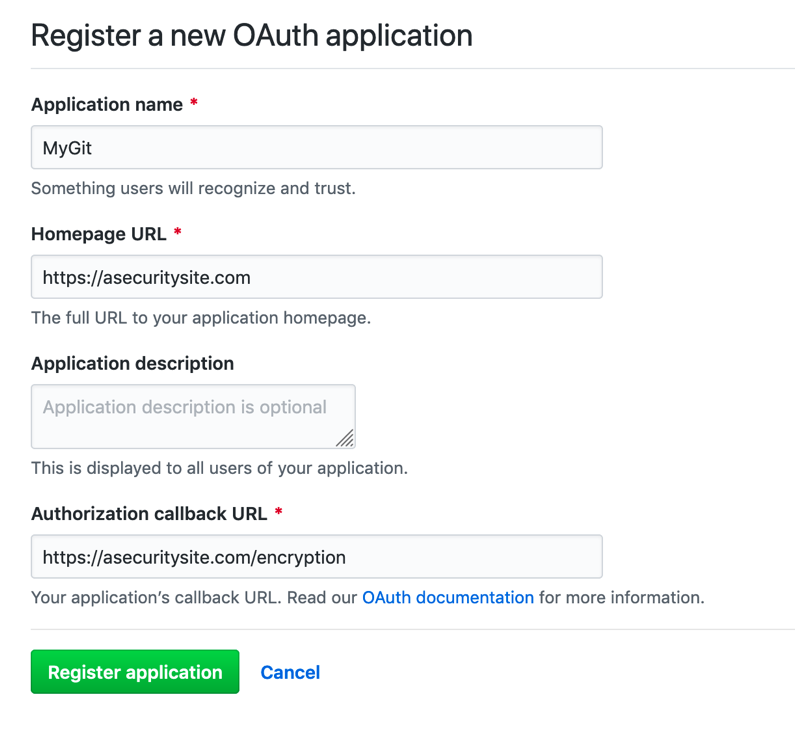
\* Debugger PIN: 118-069-597

**C.3** Now open up a browser, and connect to <http://127.0.0.1>. Next you should be faced with the GitHub login (Figure 4).

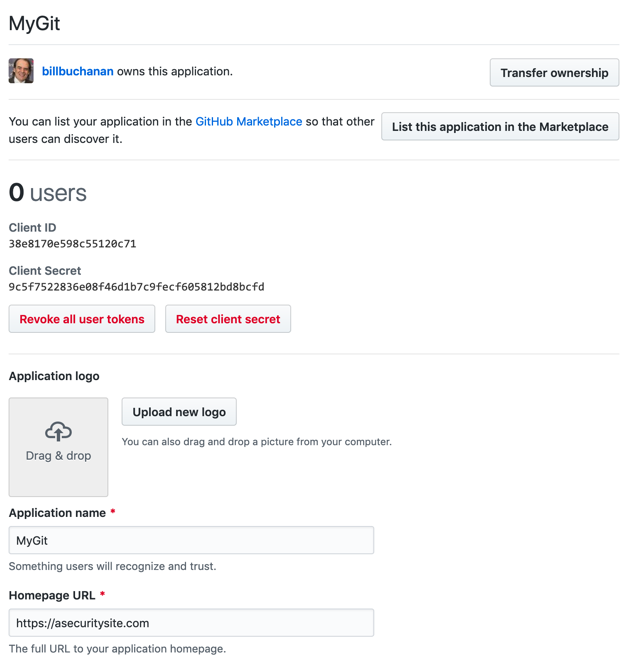
Are you able to login? What happened?

Quit from the browser, and now go back to <http://127.0.0.1:500>. What happens?

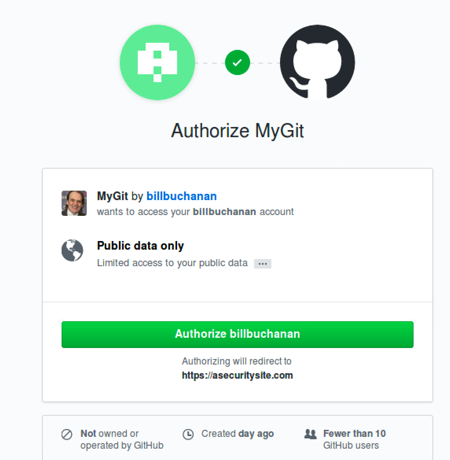
Now, clear the cache of the browser, and go back to <http://127.0.0.1:500>. What happens?



**Figure 2:** Registering an OAuth application



**Figure 3:** Generating Client ID and Client Secret



**Figure 4:** GitHub authorization

## D Introduction to Docker

**D.1** Docker is used to create a light-weight infrastructure for services. First we will install some of the pre-requisites:

sudo apt install apt-transport-https ca-certificates curl software-properties-common

curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -

sudo add-apt-repository "deb [arch=amd64] https://download.docker.com/linux/ubuntu bionic stable"

sudo apt update

apt-cache policy docker-ce

sudo apt install docker-ce

Now we will create a Docker instance for an SSH server.

mkdir docker\_sshd

cd docker\_sshd

Now create a file name “Dockerfile”, and add the following:

FROM ubuntu:16.04

RUN apt-get update && apt-get install -y openssh-server

RUN mkdir /var/run/sshd

RUN echo 'root:THEPASSWORDYOUCREATED' | chpasswd

RUN sed -i 's/PermitRootLogin prohibit-password/PermitRootLogin yes/' /etc/ssh/sshd\_config

# SSH login fix. Otherwise user is kicked off after login

RUN sed 's@session\s\*required\s\*pam\_loginuid.so@session optional pam\_loginuid.so@g' -i /etc/pam.d/sshd

ENV NOTVISIBLE "in users profile"

RUN echo "export VISIBLE=now" >> /etc/profile

EXPOSE 22

CMD ["/usr/sbin/sshd", "-D"]

Now build the docker file:

napier@napier-virtual-machine:~/Docker\_sshd$ docker build -t docker\_sshd .

Step 10/10 : CMD ["/usr/sbin/sshd", "-D"]

---> Running in 982e91d7a665

Removing intermediate container 982e91d7a665

---> e90cde8a95d3

Successfully built e90cde8a95d3

Successfully tagged **docker**\_sshd:latest

We can view the images that we have created with the “docker image ls” command:

napier@napier-virtual-machine:~/Docker\_sshd$ docker image ls

REPOSITORY TAG IMAGE ID CREATED SIZE

docker\_sshd latest e90cde8a95d3 4 minutes ago 196MB

friendlyhello latest 290382d66d7b 19 minutes ago 131MB

python 2.7-slim 48e3247f2a19 5 days ago 120MB

ethereum/solc stable 1b65904c442c 2 weeks ago 6.48MB

hello-world latest fce289e99eb9 3 months ago 1.84kB

ubuntu 16.04 b0ef3016420a 3 months ago

Which instances are installed?

Now log into your SSH server, and use the password defined in the Dockerfile. Create a new folder on your SSH server, and then create a file and add something to it:

napier@napier-virtual-machine:~/Docker\_sshd$ **docker run -d -P --name test\_sshd docker\_sshd**

2e1ee60deb3f44f2c4a6af5ebd0e32f9882ba4e03042f0eb30285f74e49ced39

napier@napier-virtual-machine:~/Docker\_sshd$ **docker port test\_sshd 22**

0.0.0.0:32769

napier@napier-virtual-machine:~/Docker\_sshd$ **ssh root@localhost -p 32769**

The authenticity of host '[localhost]:32769 ([127.0.0.1]:32769)' can't be established.

ECDSA key fingerprint is SHA256:WvbGw6gNNJzLksG87PWQ3yg+YvHBQc9PLFJl3wPOWnM.

Are you sure you want to continue connecting (yes/no)? **yes**

Warning: Permanently added '[localhost]:32769' (ECDSA) to the list of known hosts.

root@localhost's password: **<PASSWORD>**

Welcome to Ubuntu 16.04.5 LTS (GNU/Linux 4.4.0-142-generic x86\_64)

\* Documentation: https://help.ubuntu.com

\* Management: https://landscape.canonical.com

\* Support: https://ubuntu.com/advantage

The programs included with the Ubuntu system are free software;

the exact distribution terms for each program are described in the

individual files in /usr/share/doc/\*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by

applicable law.

root@2e1ee60deb3f:~# ls

root@2e1ee60deb3f:~# mkdir test

root@2e1ee60deb3f:~#

There are many options we can use with docker run:

--rm Remove container when it exits.

-d Runs docker container in the background so there is no output (also --detach)

--ip 10.10.10.10 Assign an IP address of 10.10.10.10.

-p 22:3000 Map port 22 to port 3000 (also --publish).

--name my\_c Give the container a unique name.

Now list the running containers:

napier@napier-virtual-machine:~/docker\_sshd$ **docker ps**

CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES

f0e1674e5c7a docker\_sshd "/usr/sbin/sshd -D" 3 minutes ago Up 3 minutes 0.0.0.0:32770->22/tcp test\_sshd

What information can you gain about your container from this listing?

What was the port number that we used to log into the SSH server?

By running “netstat” can you see the running port?

Now we will stop the container, and then remove it:

napier@napier-virtual-machine:~/Docker\_sshd$ docker container stop test\_sshd

test\_sshd

Can you now run the SSH container with Port 8888?

Did it run?

Finally, we will get rid of the docker container:

napier@napier-virtual-machine:~/Docker\_sshd$ **docker container rm test\_sshd**

napier@napier-virtual-machine:~/Docker\_sshd$ **docker image rm docker\_sshd**

Can you prove that the container does not exist?

Can you prove that the image does not exist?

## E Docker Setup for yml

**E.1** With Docker we can define a .yml file in order to create our instance. In the example we will use the code at [2] in order to setup OPA (Open Policy Authorization) for Web access rights. First create a folder named “docker\_opa”, and then create a file named “docker-compose.yml” in this folder. The contents will be:

version: '2'

services:

opa:

image: openpolicyagent/opa:0.10.5

ports:

- 8181:8181

# WARNING: OPA is NOT running with an authorization policy configured. This

# means that clients can read and write policies in OPA. If you are

# deploying OPA in an insecure environment, be sure to configure

# authentication and authorization on the daemon. See the Security page for

# details: https://www.openpolicyagent.org/docs/security.html.

command:

- "run"

- "--server"

- "--log-level=debug"

api\_server:

image: openpolicyagent/demo-restful-api:0.2

ports:

- 5000:5000

environment:

- OPA\_ADDR=http://opa:8181

- POLICY\_PATH=/v1/data/httpapi/authz

Next create the policy in the file “example.rego” (and which uses the Rego policy language), and add the following:

package httpapi.authz

# bob is alice's manager, and betty is charlie's.

subordinates = {"alice": [], "charlie": [], "bob": ["alice"], "betty": ["charlie"]}

# HTTP API request

import input

default allow = false

# Allow users to get their own salaries.

allow {

input.method = "GET"

input.path = ["finance", "salary", username]

input.user = username

}

# Allow managers to get their subordinates' salaries.

allow {

input.method = "GET"

input.path = ["finance", "salary", username]

subordinates[input.user][\_] = username

}

Now run docker-compose to run the Docker container:

napier@napier-virtual-machine:~$ **docker-compose -f docker-compose.yml up**

In another terminal, we can then update a policy on the container with:

napier@napier-virtual-machine:~$ curl -X PUT --data-binary @example.rego localhost:8181/v1/policies/example

Now check the policies:

napier@napier-virtual-machine:~$ **curl --user alice:password localhost:5000/finance/salary/alice**

Success: user alice is authorized

napier@napier-virtual-machine:~$ **curl --user bob:password localhost:5000/finance/salary/alice**

Success: user bob is authorized

napier@napier-virtual-machine:~$ **curl --user bob:password localhost:5000/finance/salary/charlie**

Error: user bob is not authorized to GET url /finance/salary/Charlie

Can you explain the operation of the policy, and, in this case, that Alice is authorized, but Bob is not?

Can you stop your container, and then run it on Port 8181?

## References

[1] <https://requests-oauthlib.readthedocs.io/en/latest/examples/real_world_example.html#real-example>

[2] https://www.openpolicyagent.org/docs/http-api-authorization.html