Security

Pillars of information security

- **Information security** has relied upon the following pillars:
  - Confidentiality – only allow access to data for which the user is permitted
  - Integrity – ensure data is not tampered or altered by unauthorized users
  - Availability – ensure systems and data are available to authorized users when they need it

Vulnerabilities

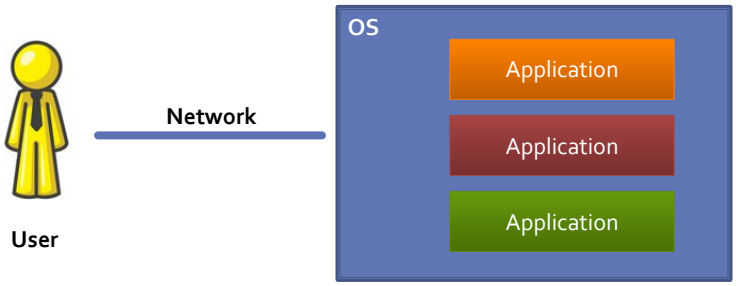
- Information systems are subject to **"security vulnerabilities"**
- A vulnerability allows to break one of the pillars.
- Generally a vulnerability is a bug or a misconfiguration that could be used by a malicious user (hacker) to break the system

Security attack

- a **security attack** is the action performed by a hacker to exploit a vulnerability
- most security attack are performed using:
  - direct network protocols (e.g. ssh, http)
  - emails
  - usb memory sticks
- In many cases the "human" plays a major role in the activation of a security problem (e.g. opening an email attachment)

Security attack

- What to attack?



Security attacks

- Many ways are available to compromise a system
  - via network
    - Buffer Overflow
    - Sniffing traffic
    - Man in the middle
    - …
  - via malware installation

Buffer Overflow

- aka Buffer Overrun
- a parameter has a larger size than the size of the destination buffer
- if the buffer is stored on the stack, part of the stack can be overwritten with arbitrary data
- it can lead to a segmentation fault or to the execution of malicious code
- it can happen only with low level languages as C or C++

Stack Buffer Overflow

- example:

```
void f(char* b) {
 char buffer[12];
 strcpy(buffer, b);
}
...
f("012345678901xxxxyyyy");
```

addr	Word (4 byte)
	buffer[0..3]
	buffer[4..7]
	buffer[8..11]
	FP
	IP

Stack Buffer Overflow

- Is it possible to inject assembler code to perform arbitrary actions, for example make a system call to execute /bin/sh
- The code is executed at the same security level as the running process
- **For this reason it is better to run a server process at the lowest possible security level (depending on the needs of the process)**

Buffer Overflow

- Buffer overflows can be avoided using high level languages (Java, go, python, php, …) or properly checking the access within array bounds.
- gcc makes a check of the stack integrity before returning from a function
- Buffer Overflow may affect also heap based buffers, in this case the function pointers if overwritten can lead to seg. fault or execution of arbitrary code.

Spoofing attack

- The attacker sniffs the packets travelling over the network, particularly for wifi connections
- In this way any unprotected connection can be analyzed and any personal information can be acquired (passwords, credit cards numbers, …)

Man in the middle attack

- An intermediary intercepts and modify the communication between two party
- **at network level**
  - the "Man" is on the local network or outside
  - e.g. DNS hijacking, the attacker changes the default DNS server with a DNS under control of the attacker, in this way every request can be controlled and possibly changed to another IP where a fake version of the same site is running and can acquire personal information
- **at system level**
  - the "Man" is a process running on the same computer (e.g. a malware)

Man in the middle

- Using https (TLS/SSL) with trusted certificates guarantee the identity of the server and client
- However a compromized web browser can still have access to any personal information

Malware

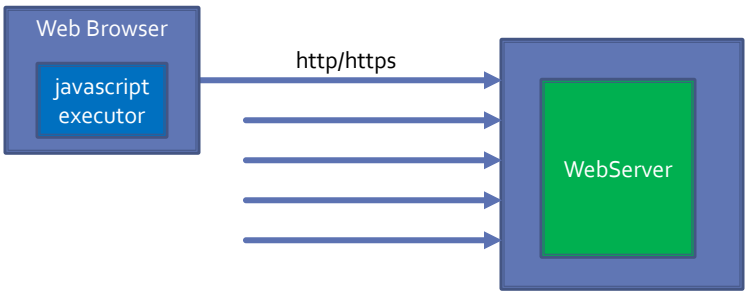
- Malicious software
  - **Virus** – a program that copies itself on other programs
  - **Trojan** – a "good" program that hides the installation of a malicious program
  - **Worm** – a program that transmit itself over the network
  - **Rootkit** – used to hide the presence of a malware on a system
  - **Spyware** – programs used to find personal information on the computer
  - **Backdoor** – a program allowing remote access to the computer
  - **Keylogger** – listen for the key pressed to identify passwords or credit card numbers
  - **Ransomware** – encrypts files on the computer and asks for a ransom
  - …

Our focus

- We will focus on the development of web applications without security vulnerabilities that can be used to:
  - access to unauthorized information or
  - get complete access to a system.

Web Application Security

- a web server or application server responds to web requests performed by external users using the HTTP/HTTPS protocol



Deny of Service

- One of the easiest way to compromise a web application is the **DenyOfService** (DoS) attack, flood the server with requests in order to not allow legitimate requests
- Breaks the **Availability** pillar

Distributed Deny of Service (DDoS)

- If all attack traffic is from a single source it can be easily blocked, if requests are coming from many different machines it is more difficult to identify that an attack is running
- The attacker gets "access" to thousands of machines and coordinate the attack to a server

botnet

- a network of compromized computers (e.g. via trojans) that can be used for DDoS or spam sending
- all controlled by a botmaster
- can have size of millions of computers

POST DoS

- Another possibility is to make POST requests that provide a very big payload very slowly thus keeping active the socket connection for a long time, in this way the server can quickly exaust the available sockets and block the access to the system.

Common Web App attacks

- SQL injection
- Session hijack
- javascript injection

SQL injection

- Based on a vulnerability of SQL query code
- Example PHP

```
$user = $_GET['user'];
$pwd = $_GET['pwd'];
$query= "SELECT * FROM users WHERE user='$user' AND passw='$pwd' "
```

- if the request is

  http://.../login.php?user=me&pwd=x'OR'1

- the query becomes:

  SELECT * FROM users WHERE user='me' AND passw='x'OR'1'

  that selects all users

SQL injection

- is very dangerous
  - *in 2002 a hacker found that Guess.com was vulnerable to SQL injection attack, allowing to get 200 000 credit cards numbers.*
- How to avoid?
  - use escaping functions that escape special characters as ' or " or use prepared statements that replace placeholders with parameters value
  - example:

```
$user=mysql_real_escape($_GET['user']);
$pwd=mysql_real_escape($_GET['passw']);
```

Never store plain passwords

- never, Never, NEVER! store plain password on a database, store the HASH (MD5, SHA1) of the password
- if an hacker is able to access to the **users table** he will not have access to the plain password… that is typically used in many other sites…
- send the password in a POST request and never in a GET request (and send it on an https connection)
- GET requests may be logged in web server log files where the password will be visible…

WEB Application Session

- A web request is stateless
- cookies are used to store on the client a session identificator that is resent in the following requests
- This identifier is used to identify the session information of the specific user (stored on a file or DB)

Web Application Session

- Session is normally used when login is performed to store the user information and is used to perform all the following requests that normally fail if the user is not logged in.
- The session is kept until user logout or the session expires after a predefined period.

Web App Session Example

Client **Server**

Login request (user=jdoe, password=secret) →

← *reply with cookie SESSID=abd564s5*

Cookie SESSID=abd564s5 is stored on the web browser

request transaction list (SESSID=abd564s5) →

check if the session refers to a logged user and

← *sends the transaction list*

SESSION hijack

- If a maliciuos user is able to find the session id he will be able to perform any request the user is able to do…
- How?
  - Sniffing the network he will be able to find any session running on an unprotected network
  - using javascript injection (see after)
  - or using brute force attack to find a valid session identifier (can be feasible if the id length is limited)

html & javascript injection

- if a site allows to write **comments** and allows to **write full HTML** it will be subject to html & javascript injection
- if you write a comment like:

  hi!<script>alert('Injected!')</script>
- and a dialog displaying "Injected!" appears… the site is subject to javascript and html injections

html & javascript injection

- If the script is stored on a comment ANYONE that see the comment is vulnerable to javascript injection that for example can:
  - access to the session id and send to a server
  - run a javascript keylogger that sends all keys pressed to a server
  - modify the web page
  - change a form to be submitted (e.g. reduce the price of an order)

html & javascript injection

- The same can happen if a url query parameter is written back on the result page
- Example:
  - http://.../search?query=puppy
  - and the query value is written back on the page without modifications
  - then using something like:
    - ...query=puppy<script src='http://.../bad.js'></script>
  - the script will be executed in the web page
  - This link could be sent via email to a potential victim

html & javascript injection

- also html can be injected, for example an iframe can be used to substitute the login form.
- Is also called XSS cross-site scripting
- can be solved my escaping or removing some tags as <script>, <iframe>

NEVER trust the client

- never trust any validation done on the web browser (e.g. via javascript)
- redo all validations on the server
- the request may be done from a fake client that can send malicious requests to bypass the checks

NEVER trust the client

- Example
  - http://.../documents/add.php - adds a new document
  - http://..../documents/count.php - returns the count of documents
  - The button to add a new document is disabled if the count is 5
  - however the check on document count needs to be performed also on the server in add.php

Path traversal

- allow access to file system files
- Example (PHP but not only):

```
...
include($_GET['page']);
...
```

- used:
  - http://.../service.php?page=p1.php
- but it can be used like:
  - http://.../service.php?page=../../../../../../etc/passd

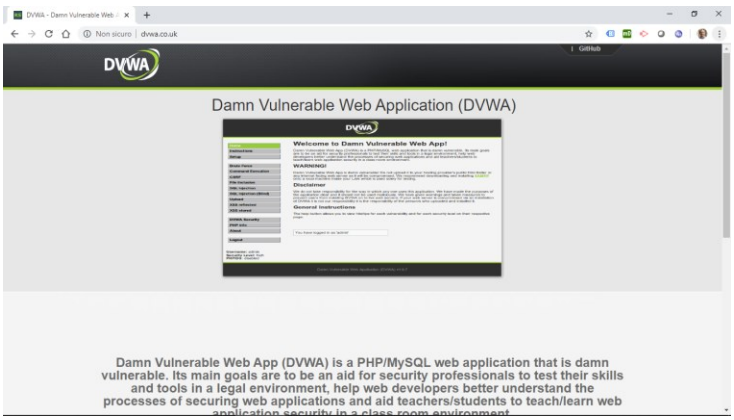
CSRF – Cross Site Resource Forgery

- Used to perform unintended action on a third party site (with an open session)
- Easily exploited when a GET request is used to modify state
- Example
  - Site A allows to change password with:
    - http://siteA/change-pwd?new=safepassword
  - SiteB (malicious)
    - <img src="http://siteA/change-pwd?new=abcd">
  - if an user with an active session on siteA visits siteB or receives an html email

CSRF

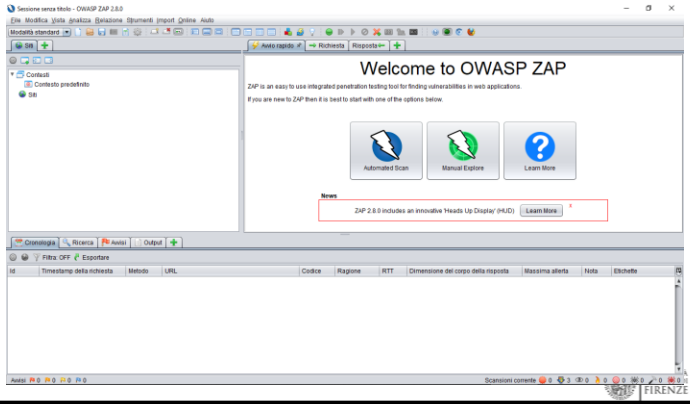
- How to avoid:
  - use POST requests to modify state, its more difficult to exploit
  - check the referer header
  - use a random token to identify that the call is coming from the legitimate site (the token is written in the page generating the call), when receiving the call the token is checked, can be a
    - per call token (problem with app open in more tabs)
    - per session token
    - **example:**
      - POST http://.../change-pwd?new=xyz&token=ads5a43t6ddgs53

http://www.dvwa.co.uk/



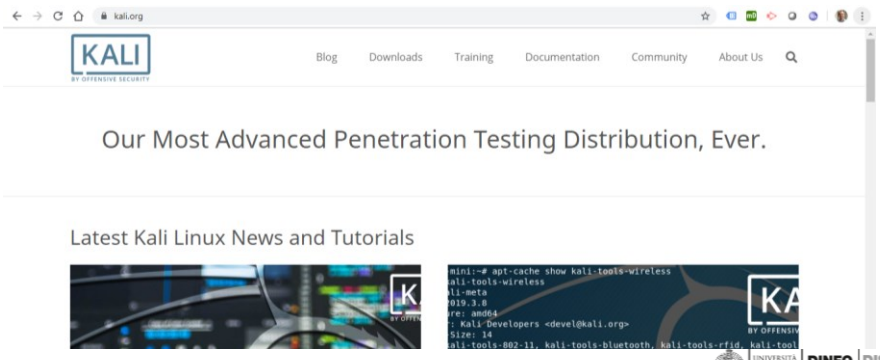
OWASP ZAP 2.8.0

- Application for WebApplication security testing



Kali Linux

- A linux distribution with MANY security analysis tools



OWASP Top10

- There are a lot of vulnerabilities
- Which are the most exploited?
- OWASP (open web application security project) classified in 2017 (and in 2013) the most frequently exploited vulnerabilities

Security by design

- When designing (web) applications follow the following principles :
  1. *Minimize attack surface area*
  2. *Establish secure defaults*
  3. *Principle of Least privilege*
  4. *Principle of Defense in depth*
  5. *Fail securely*
  6. *Don't trust services*
  7. *Separation of duties*
  8. *Avoid security by obscurity*
  9. *Keep security simple*
  10. *Fix security issues correctly*

source: OWASP (open web application security project) https://www.owasp.org

1. Minimize attack surface area

- Every feature that is added to an application adds a certain amount of risk to the overall application. The aim for secure development is **to reduce the overall risk by reducing the attack surface area.**
- For example, a web application implements online help with a search function. The search function may be vulnerable to SQL injection attacks.
  - If the help feature was limited to authorized users, the attack likelihood is reduced.
  - If the help feature's search function was gated through centralized data validation routines, the ability to perform SQL injection is dramatically reduced.
  - However, if the help feature was re-written to eliminate the search function (through better user interface, for example), this almost eliminates the attack surface area, even if the help feature was available to the Internet at large.

2. Establish secure defaults

- There are many ways to deliver an "out of the box" experience for users. **However, by default, the experience should be secure**, and it should be up to the user to reduce their security – if they are allowed.
- *For example*, by default, password aging and complexity should be enabled. Users might be allowed to turn these two features off to simplify their use of the application and increase their risk.

3. Principle of Least privilege

- The principle of least privilege recommends that **accounts have the least amount of privilege required to perform their business processes**. This encompasses user rights, resource permissions such as CPU limits, memory, network, and file system permissions.
- For example, if a middleware server only requires access to the network, read access to a database table, and the ability to write to a log, this describes all the permissions that should be granted. Under no circumstances should the middleware be granted administrative privileges.

4. Principle of Defense in depth

- The principle of defense in depth suggests that where one control would be reasonable, **more controls that approach risks in different fashions are better**. Controls, when used in depth, can make severe vulnerabilities extraordinarily difficult to exploit and thus unlikely to occur.
- With secure coding, this may take the form of tier-based validation, centralized auditing controls, and requiring users to be logged on all pages.
- For example, a flawed administrative interface is unlikely to be vulnerable to anonymous attack if it correctly gates access to production management networks, checks for administrative user authorization, and logs all access.

5. Fail securely

- Applications regularly fail to process transactions for many reasons. How they fail can determine if an application is secure or not.
- For example:

```
isAdmin = true;
try {
  codeWhichMayFail();
  isAdmin = isUserInRole( "Administrator" );
} catch (Exception ex) {
  log.write(ex.toString());
}
```

- If either *codeWhichMayFail()* or *isUserInRole* fails or throws an exception, the user is an admin by default. This is obviously a security risk.

6. Don't trust services

- Many organizations utilize the processing capabilities of third party partners, who more than likely have differing security policies and posture than you. It is unlikely that you can influence or control any external third party, whether they are home users or major suppliers or partners.
- Therefore, **implicit trust of externally run systems is not warranted**. All external systems should be treated in a similar fashion.
- For example, a loyalty program provider provides data that is used by Internet Banking, providing the number of reward points and a small list of potential redemption items. However, the data should be checked to ensure that it is safe to display to end users, and that the reward points are a positive number, and not improbably large.

7. Separation of duties

- A key fraud control is separation of duties. For example, someone who requests a computer cannot also sign for it, nor should they directly receive the computer. This prevents the user from requesting many computers, and claiming they never arrived.
- Certain roles have different levels of trust than normal users. In particular, administrators are different to normal users. In general, administrators should not be users of the application.
- For example, an administrator should be able to turn the system on or off, set password policy but shouldn't be able to log on to the storefront as a super privileged user, such as being able to "buy" goods on behalf of other users.

8. Avoid security by obscurity

- Security through obscurity is a weak security control, and nearly always fails when it is the only control. This is not to say that keeping secrets is a bad idea, it simply means that the security of key systems should not be reliant upon keeping details hidden.
- For example, the security of an application should not rely upon knowledge of the source code being kept secret. The security should rely upon many other factors, including reasonable password policies, defense in depth, business transaction limits, solid network architecture, and fraud and audit controls.
- A practical example is Linux. Linux's source code is widely available, and yet when properly secured, Linux is a hardy, secure and robust operating system.

9. Keep security simple

- Attack surface area and simplicity go hand in hand. Certain software engineering fads prefer overly complex approaches to what would otherwise be relatively straightforward and simple code.
- Developers should avoid the use of double negatives and complex architectures when a simpler approach would be faster and simpler.
- For example, although it might be fashionable to have a slew of singleton entity beans running on a separate middleware server, it is more secure and faster to simply use global variables with an appropriate mutex mechanism to protect against race conditions.

10. Fix security issues correctly

- Once a security issue has been identified, it is important to develop a test for it, and to understand the root cause of the issue. When design patterns are used, it is likely that the security issue is widespread amongst all code bases, so developing the right fix without introducing regressions is essential.
- For example, a user has found that they can see another user's balance by adjusting their cookie. The fix seems to be relatively straightforward, but as the cookie handling code is shared among all applications, a change to just one application will trickle through to all other applications. The fix must therefore be tested on all affected applications.

Public key infrastructure

Cryptography - Basics

- Symmetric key
  - the same key used by the sender and receiver
  - the parties need to share the same secret
- Problem:
  - how to share the key???

Cryptography - Basics

- Asymmetric key
  - public key
  - private key
  - message encrypted with the *public key* can be decrypted only with the *private key*
  - message encrypted with the *private key* can be decrypted with the corresponding *public key*

Example

- Bob wants to write a secure message for Alice
  - Alice sends her public key *pkA* to Bob
  - Bob encrypts the message with *pkA*
  - Alice decrypts the message using her private key
- Problems:
  - Bob can trust that pkA is really the public key of Alice?
  - Alice can trust that the message is really coming from Bob?
- Solution uses **Digital Signature**

Digital Signature

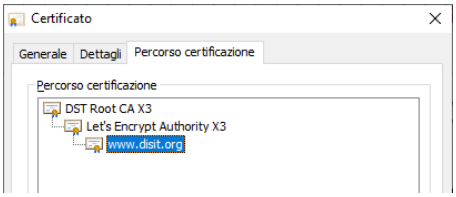
- how can we certify that a message is produced by X?
- X has private key *privKeyX* and public key *pubKeyX*
- ***signatureX(msg)*** = *enc(H(msg),privKeyX)*
  - *H() hash function*
- we send **msg** and **signatureX(msg)**
- how can the receiver verify that the message is really from X?
  - receive *msg*, *signX*
  - check if *dec(signX, pubKeyX) = H(msg)*
  - if it is true the message is really coming from X (unless the private key was compromized…)

Public key infrastructure

- A **Certification Authority** (CA) produces a digital certificate of the public key of someone, this certificate is signed with the private key of the CA
- The CA produces the certificate after an user identity verification made off-line
- There are some Root CAs public keys that are pre-installed on the OS or in the browser are ALWAYS TRUSTED

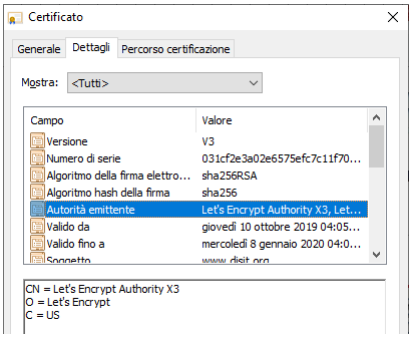
Public key infrastructure

- Mid level CAs:
  - generate certificates that are trustable only if using a Root CA public key we are able to verify the public key of the Mid level CA
- Certificates are used in the SSL/TLS protocol to trust a web server



Certificates

- Certificates contains the public key but also other information:



Certificates file formats

- Some file formats are used for storing and exchanging certificates e.g. der, cer, pem, p12
- X.509 is a standard for certificate representation

- in some cases a certificate file can contain also the private key, typically protected with a password, however in this case is ONLY for backup and should not be sent to anyone…

SSL/TLS Mutual authentication

- The SSL/TSL allows to require a certificate also for the client
- It guarantees to the server the identity of the client
- In this case the private key can be stored on a smart card but it needs a specific reader.
- the private key is stored inside the card and it is not accessible from outside.

Certificate Signing Request - CSR

- How to ask for a certificate to a CA?
  - private and public key are generated on the client
  - the CSR is built with the public key and other details of the certificate, then the CSR is signed using the private key and sent to the CA
  - the CA can check the CSR and produce the certificate when the identity check has been performed

Certificate Revocation List

- What happen when a private key is stolen?
  - the **certificate is revoked** thus certificate serial number and revocation date is put on the CRL of the CA (signed by the CA)
  - the client should check if the certificate to be validated is on the CRL of the CA

openssl

- an opensource tool for certificate generation
- command line tool for windows and linux
- **generate a self-signed certificate**
  - openssl req -newkey rsa:2048 -nodes -keyout key.pem -x509 -days 365 -out certificate.pem
- **review it**
  - openssl x509 -text -noout -in certificate.pem
- **generate a pkcs12 certificate**
  - openssl pkcs12 -inkey key.pem -in certificate.pem -export -out certificate.p12

openssl

- **generate a CSR**
  - openssl req -newkey rsa:2048 -nodes -keyout domain.key -out domain.csr
- **verify a CSR**
  - openssl req -text -noout -verify -in domain.csr

a simple CA with openssl

- **create CA private key**
  - openssl genrsa -out ca.key 2048
- **create CA certificate**
  - openssl req -new -x509 -key ca.key -out ca.crt
- **produce a certificate from a CSR**
  - openssl x509 -req -in domain.csr -CA ca.crt -CAkey ca.key -CAcreateserial -out domain.crt

Authentication & Authorization

App Authentication & Authorization

- Authentication
  - allows a user to access a service
  - based on:
    - something you know (e.g. password)
    - something you have (e.g. token generator)
    - something you are (e.g. fingerprint)
  - two factor authentication
- Authorization
  - allows an authenticated user to access a functionality or data (e.g. read only access)

Basic authentication

- HTTP "Authorization" header

  GET http://...

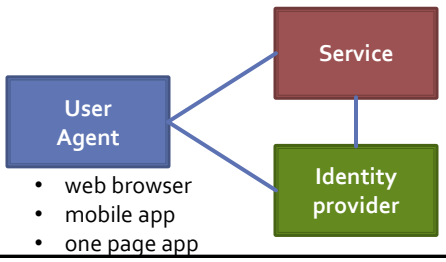
  Authorization: Basic **xyz**
- where xyz is base64 encode of "username:password"
- **Pro:** very simple and managed by the browser
- **Cons:** credentials can be easily sniffed on the network if connection is not encrypted

https mutual authentication

- Use SSL/TLS protocol
- client certificate installed on the browser used to identify the client
- the server receives the client certificate
- the certificate may be associated with a private key stored on a smart card

Authentication protocols

- provide authentication using a **common user identity source** (e.g. facebook, google, github)
- external services can use the user identities (and associated data) from big social media (or corporate user directory)
- the user should authenticate providing username and password to the identity provider and NOT to the service
- single sign-on, many services share the same IDP



- web browser
- mobile app
- one page app

Authentication protocols

- OAuth2.0 one of the most used authentication protocols for web applications
- standardized by IETF
- used by many big social networks (Facebook, google, twitter, github, …)

OAuth2.0

- Different cases:
  - web server application
    - browser client and application running on server side
  - one page app
    - application running on the browser, no specific server side code
  - mobile application
    - application running on mobile, no specific server side code

OAuth2.0 – web server app

- First step: register Client Application
  - client_id
  - client_secret
  - valid redirect_uri

OAuth2.0 – web server app

- web browser opens the url

  http://mysite.com/login
- which generates a random *state* string (saved in the session) and redirects to

  http://auth.server.com/auth?
  response_type=code&
  client_id=….&
  redirect_uri=…&
  scope=…&
  state=….

OAuth2.0 – web server app

- the auth server checks *client_id* and *redirect_uri*
- user can login (if not already done), user is requested permission for the app and if authentication succeeds and user give permission the auth server redirects to
  redirect_uri?code=…&state=…
- **code** is used to get an access token
- **state** is used to check that the call was performed by this site

OAuth2.0 – web server app

- the web app receives the code and state
- checks the state is the same as the one originally sent
- and uses the code to get an access token, making a server side request to

```
POST http://api.auth.server/auth
  grant_type=authorization_code&
  code=…&
  redirect_uri=…&
  client_id=…&
  client_secret=…
```

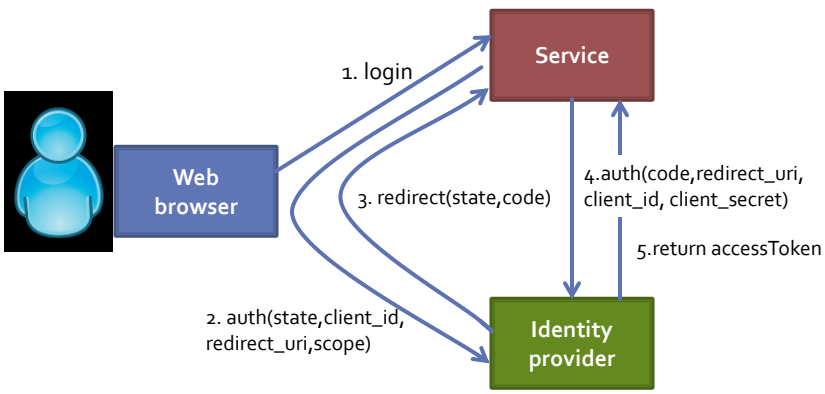
OAuth2.0 – web server app

- the web server app receives the access token

```
{
  "access_token":"RsT5OjbzRn430zqMLgV3Ia",
  "expires_in":3600
}
```

- The app can now make a request to the api to get information about the user

OAuth2.0 – web server app



OAuth2.0 – Single page App

- In this case the app is running on the web browser, the client secret cannot be used to get the access token

  POST http://api.auth.server/auth

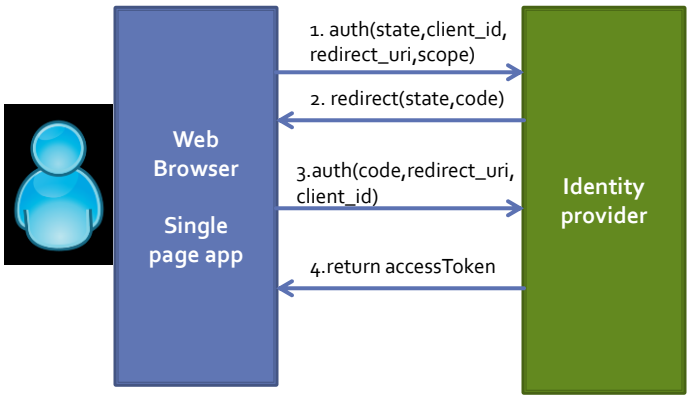
  grant_type=authorization_code&

  code=...&

  redirect_uri=...&

  client_id=...

OAuth2.0 – single page app



OAuth2.0 – mobile app

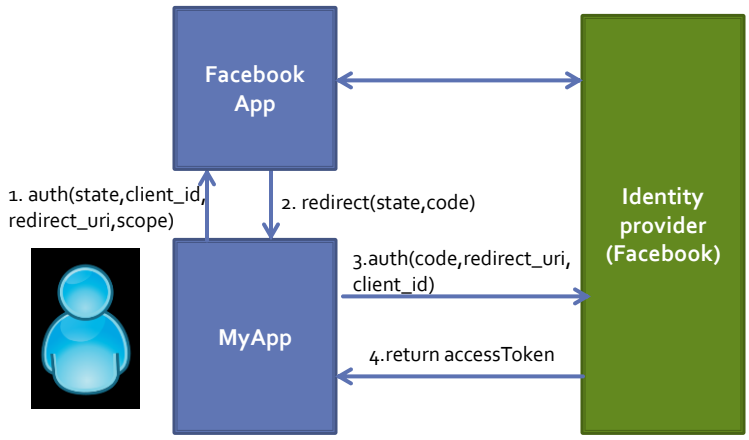
- Authentication made via fb app or browser
- Not using client_secret
- When made via fb app, custom urls are used to activate the app
  - fbauth2://authorize?
    response_type=code&
    client_id=…&
    redirect_uri=…&
    scope=…&
    state=…
  - the *redirect_uri* should activate the mobile app again

OAuth2.0 – mobile app

- the app will receive the **code** via redirect:
  - myapp://authorize?code=…&state=….
- and then use the **code** to get the access token

  POST http://api.auth.server/auth
  grant_type=authorization_code&
  code=…&
  redirect_uri=…&
  client_id=…
- however…

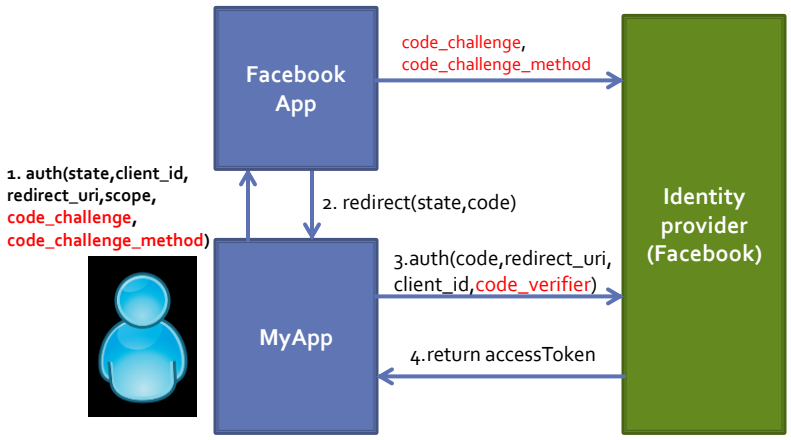
OAuth2.0 – mobile app



OAuth2.0 – mobile app

- A malicious app can register to be called on the same url scheme, in this way it gets the **code**, and then get an access token using the code.
- **Proof Key for Code Exchange PKCE Extension**
  1. The app generates a key
  2. the hash of the key is sent to the server
  3. and the key is sent when requesting the access token

OAuth2.0 – mobile app



OAuth2.0+PKCE – mobile app

- hash of key is sent with hash method

  fbauth2://authorize?
  response_type=code&
  client_id=...&
  redirect_uri=...&
  scope=...&
  state=...&
  code_challenge=...&
  code_challenge_method=S256

- the hash is sent to the authorization service

OAuth2.0+PKCE – mobile app

- then when requesting token the original key is sent:
  - POST https://api.authorization-server.com/token
    grant_type=authorization_code&
    code=...&
    redirect_uri=...&
    client_id=...&
    code_verifier=...
- the key received is hashed and compared with the previously sent hash

OAuth2.0 – implicit flow

- **implicit flow** allows to get directly the access token avoiding the intermediate code (faster authorization)
- It was originally introduced for single page apps
- But best practice suggests to use the code authorization also in this context and avoid implict flow.

OAuth2.0 - refresh token

- Once the access token is expired, the access token can be used to request another fresh access token
- Access tokens are typically of short duration (1-5 minutes)
- While refresh tokens have longer durations

openid connect (OIDC)

- extension of OAuth2.0 that use JWT (JSON WebToken)
- JWT tokens store the claims of the connected user

- Example of JWT:

eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4gRG9lIiwiaWF0IjoxNTE2MjM5MDIyfQ.SflKxwRJSMeKKF2QT4fwpMeJf36POk6yJV_adQssw5c

JSON Web Token

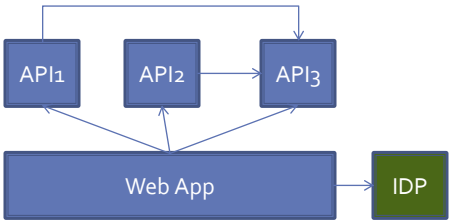
- header.payload.signature
  - header:
    base64({"alg":"HS256","typ":"JWT"})
  - payload:
    base64({"sub":"1234567890","name":"John Doe","iat":1516239022})
  - signature:
    - hashAlg(header+"."+payload,secret)
    - or signed with a private key, verifiable with a public key
- see http://jwt.io

JWT - claims

- The JSON payload contain some predefined attributes:
  - "iss": issuer
  - "sub": subject
  - "aud": audience
  - "exp": expiration time
  - "nbf": not before
  - "iat": issued at
  - "jti": JWT ID

JWT and authenticated APIs

- Once the app has obtained an access token for a user (using the authentication procedure) it can send the AT to APIs to perform services for an user
- APIs must check the signature, the temporal valididity and (if ok) get username and roles directly from the token and perform the action requested



JWT and authenticated API

- Access token can be sent in GET, POST or in the header:
  - Authorization: Bearer <access token>
- and should be sent always over a protected channel!
- If a malicious user is able to get an access token he can use any API with this token on behalf of the user… for this reason the token does not have a long duration.

SAML2.0

- Security Assertion Markup Language
- Is another authentication protocol, similar to OAuth2, it uses XML (much more verbose) to represent **assertions about a subject**

LDAP

- In business environments identities are managed in a central repository
- **Lightweight Directory Access Protocol** (LDAP) is an open, vendor-neutral, industry standard application protocol for accessing and maintaining distributed directory information services.
- *Active Directory* implements the LDAP protocol
- Specified by IETF

LDAP – direcory structure

- An entry consists of a set of attributes.
- An attribute has a name (an *attribute type* or *attribute description*) and one or more values. The attributes are defined in a *schema*.
- Each entry has a unique identifier: its *Distinguished Name* (DN). This consists of its *Relative Distinguished Name* (RDN), constructed from some attribute(s) in the entry, followed by the parent entry's DN.
- A DN may change over the lifetime of the entry, for instance, when entries are moved within a tree.
- The DNs build a hierarchy

LDAP – entry example

dn: cn=John Doe,dc=example,dc=com
cn: John Doe
givenName: John
sn: Doe
telephoneNumber: +1 888 555 6789
telephoneNumber: +1 888 555 1232
mail: john@example.com
manager: cn=Barbara Doe,dc=example,dc=com
objectClass: inetOrgPerson
objectClass: organizationalPerson
objectClass: person
objectClass: top

LDAP – operations

- LDAP provides the following operations:
  - BIND – to connect
  - ADD – add a new entry
  - DELETE – to remove an entry given its DN
  - MODIFY – to replace/add/remove some attributes
  - SEARCH – to search for entries

LDAP – search

- arguments:
  - **baseObject** the name of the base object entry (or possibly the root) relative to which the search is to be performed.
  - **scope** what elements below the baseObject to search. Can be *BaseObject* (search just the named entry, typically used to read one entry), *singleLevel* (entries immediately below the base DN), or *wholeSubtree* (the entire subtree starting at the base DN).
  - **filter** criteria to use in selecting elements within scope. For example, the filter ***(&(objectClass=person)(\|(givenName=John)(mail=john*)))*** will select "persons" with givenName John or email starting with john
  - **derefAliases** whether and how to follow alias entries (entries that refer to other entries),
  - **attributes** which attributes to return in result entries.
  - **sizeLimit**, **timeLimit** maximum number of entries to return, and maximum time to allow search to run.
  - **typesOnly** return attribute types only, not attribute values.

keycloak

- is an open source project for authentication management, providing:
  - integration of user identities from LDAP and Active Directory servers
  - OpenID Connect and SAML2.0 protocols
  - Social login
  - Single-Sign-On (SSO)
  - double factor authentication using One Time Password (OTP) with google authenticator app or Open OTP app
  - multi tentant configuration

Authorization

- application functionalities available to users on the basis of authorization level
- typically associating users with roles and roles with functionalities
- the application should enforce role checking and ensure it cannot be bypassed…