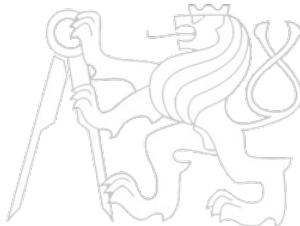


# Middleware Architectures 2

## Lecture 3: Security

doc. Ing. Tomáš Vitvar, Ph.D.

tomas@vitvar.com • @TomasVitvar • https://vitvar.com



Czech Technical University in Prague

Faculty of Information Technologies • Software and Web Engineering • https://vitvar.com/lectures



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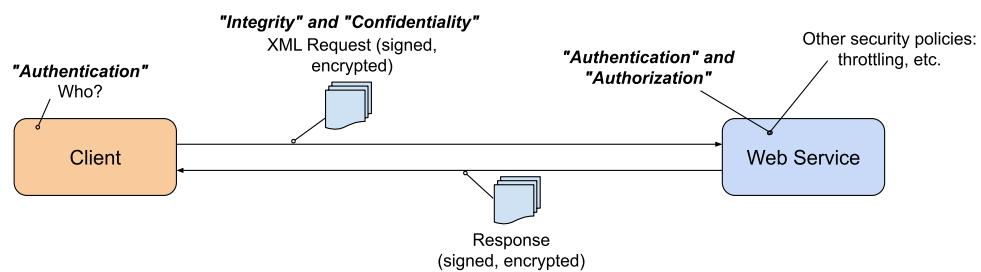
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## Overview

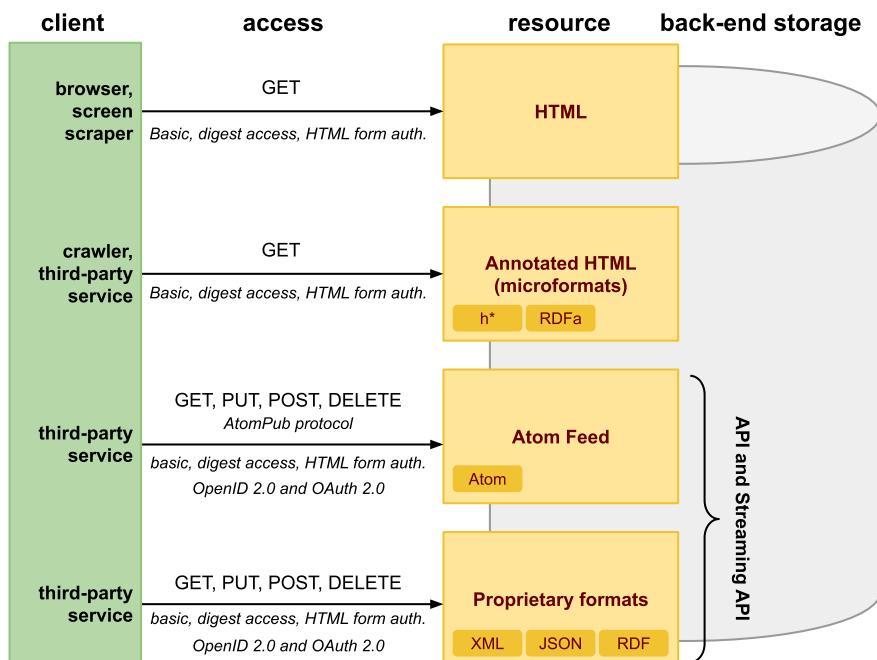
- Security Concepts
- Transport Level Security
- JSON Web Token
- OAuth 2.0
- OpenID

# Web Service Security Concepts

- Securing the client-server communication
  - *Message-level security*
  - *Transport-level security*
- Ensure
  - *Authentication* – verify a client's identity
  - *Authorization* – rights to access resources
  - *Message Confidentiality* – keep message content secret
  - *Message Integrity* – message content does not change during transmission
  - *Non-repudiation* – proof of integrity and origin of data



# Data on the Web



# Authentication and Authorization

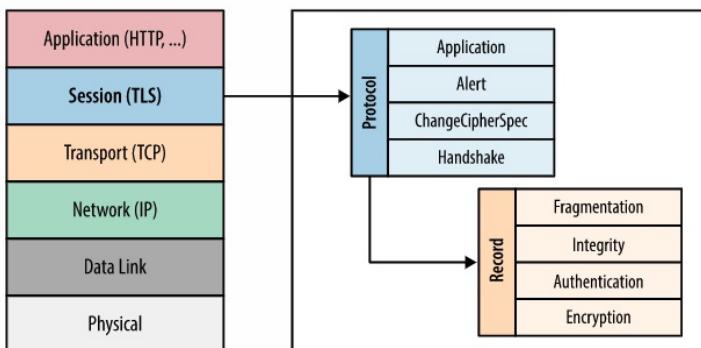
- Authentication
  - *verification of user's identity*
- Authorization
  - *verification that a user has rights to access a resource*
- Standard: HTTP authentication
  - *HTTP defines several main options*
    - *Basic Access Authentication*
    - *Digest Access Authentication*
    - *Bearer tokens to access OAuth 2.0-protected resources*
    - *Mutual authentication using password-based when server knows the user's encrypted password*
  - *Basic and Digest are defined in*
    - *RFC 2616: Hypertext Transfer Protocol – HTTP/1.1*
    - *RFC 2617: HTTP Authentication: Basic and Digest Access Authentication*
- Custom/proprietary: use of cookies

# Overview

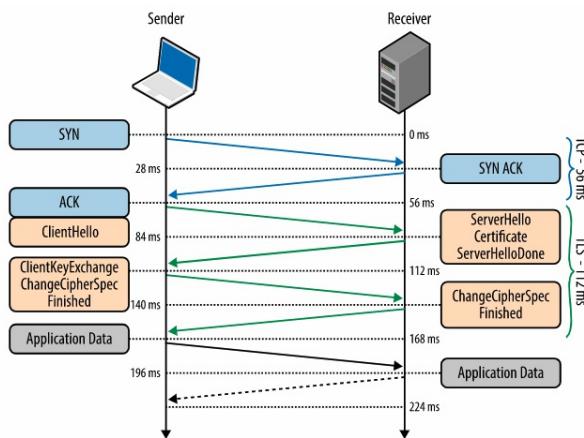
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# Overview

- SSL and TLS
  - SSL and TLS is used interchangeably
  - SSL 3.0 developed by Netscape
  - IETF standardization of SSL 3.0 is TLS 1.0
    - TLS 1.0 is upgrade of SSL 3.0
  - Due to security flaws in TLS 1.0, TLS 1.1 and TLS 1.2 were created
- TLS layer



## TLS Handshake Protocol



- TLS Handshake
  - 56 ms: ClientHello, TLS protocol version, list of ciphersuites, TLS options
  - 84 ms: ServerHello, TLS protocol version, ciphersuite, certificate
  - 112 ms: RSA or Diffie-Hellman key exchange
  - 140 ms: Message integrity checks, sends encrypted "Finished" message
  - 168 ms: Decrypts the message, app data can be sent

## TLS and Proxy Servers

- TLS Offloading
  - *Inbound TLS connection, plain outbound connection*
  - *Proxy can inspect messages*
- TLS Bridging
  - *Inbound TLS connection, new outbound TLS connection*
  - *Proxy can inspect messages*
- End-to-End TLS (TLS pass-through)
  - *TLS connection is passed-through the proxy*
  - *Proxy cannot inspect messages*
- Load balancer
  - *Can use TLS offloading or TLS bridging*
  - *Can use TLS pass-through with help of Server Name Indication (SNI)*

## Overview

- Security Concepts
- Transport Level Security
- JSON Web Token
- OAuth 2.0
- OpenID

## Overview

- JSON Web Token (JWT)
  - *Open standard (RFC 7519)*
  - *Mechanism to securely transmit information between parties as a JSON object.*
  - *Can be verified and trusted as it is digitally signed.*
- Basic concepts
  - *Compact*
    - *has a small size*
    - *can be transmitted via a URL, POST, HTTP header.*
  - *Self-contained*
    - *payload contains all required user information.*

## Use of JWT

- Authentication
  - *After user logs in, following requests contain JWT token.*
  - *Single Sign On widely uses JWT nowadays*
- Information Exchange
  - *Signature ensures senders are who they say they are.*
  - *Message integrity – signature calculated using the header and the payload.*

## JWT Structure

<header>.<payload>.<signature>

- Header

- Contains two parts, the type of the token (JWT) and the hashing algorithm being used (e.g. HMAC, SHA256, RSA).

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

- Payload

- Contains the claims, i.e. statements about an entity (e.g. user).
  - Can be registered, public and private
  - Registered and public should be defined in *IANA JSON Web Token Registry*

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

## JWT Structure (Cont.)

- Signature

- Signed encoded header, encoded payload and a secret.
  - For example, signature using HMAC SHA256 algorithm

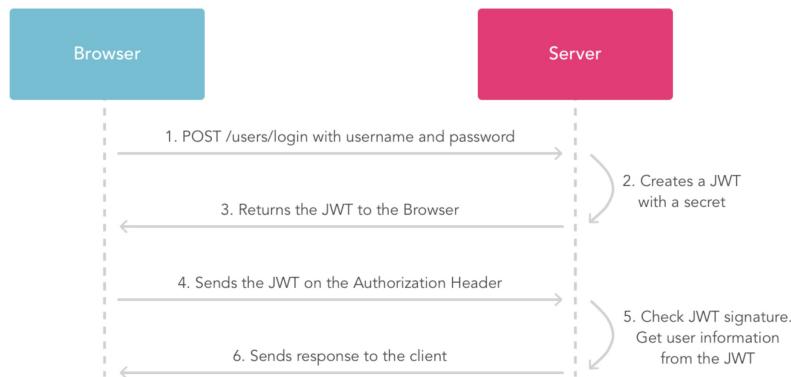
```
HMACSHA256(  
  base64UrlEncode(header) + "." +  
  base64UrlEncode(payload),  
  secret)
```

- Example

- JWT is a three Base64-URL strings separated by dots

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.  
eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4  
gRG9lIiwiwaXNTb2NpYWwiOnRydWV9.  
4pcPyMD09o1PSyXnrXCjTwXyr4BsezdI1AVTmud2fU4
```

# How to use JWT



1. User sends username and password
2. Server verifies user, creates JWT token with a secret and a expiration time
3. Server sends JWT token back to the Browser
4. Browser sends JWT token on subsequent interations

## Notes

- Authorization header does not behave the same as cookies!
- JWT should not contain secrets (passwords) as it can be read (on the client or if non-https connection is used)

# Expiration and revocation

- **Expiration**
  - Tokens should be valid for a limited time
  - Use **exp** claim
    - Timestamp of the token expiration
    - Token should be checked on every request
- **Revocation**
  - Tokens (access tokens) usually stored in memory
  - Tokens should be refreshed using refresh tokens
    - Refresh tokens are stored in the DB
    - When you need to revoke access tokens stored them in the DB
    - You can expire all tokens by changing the secret on the server

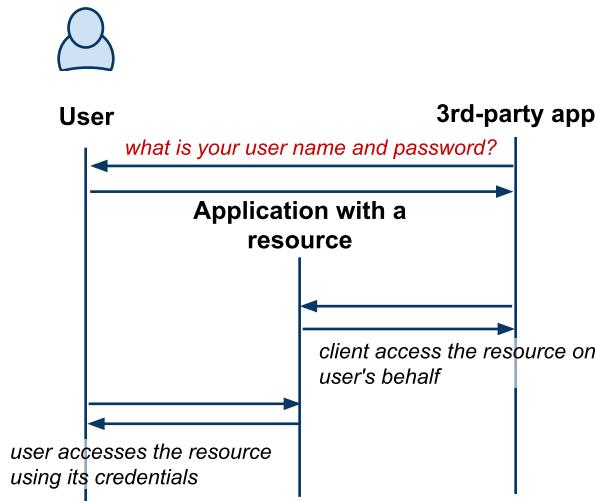
## Overview

- Security Concepts
- Transport Level Security
- JSON Web Token
- OAuth 2.0
  - Client-side Web Apps
  - Server-side Web Apps
- OpenID

## Motivation

- Cloud Computing – Software as a Service
  - Users utilize apps in clouds
    - they access **resources** via Web browsers
    - they store their data in the cloud
    - Google Docs, Contacts, etc.
  - The trend is that SaaS are open
    - can be extended by 3rd-party developers through APIs
    - attract more users ⇒ increases value of apps
  - Apps extensions need to have an access to users' data
- Need for a new mechanism to access resources
  - Users can grant access to third-party apps without exposing their users' credentials

## When there is no OAuth



- Users must share their credentials with the 3rd-party app
- Users cannot control what and how long the app can access resources
- Users must trust the app
  - *In case of misuse, users can only change their passwords*

## OAuth 2.0 Protocol

- OAuth Objectives
  - *users can grant access to third-party applications*
  - *users can revoke access any time*
  - *supports:*
    - *client-side web apps (implicit grant)*,
    - *server-side apps (authorization code)*, and
    - *native (desktop) apps (authorization code)*
- History
  - *Initiated by Google, Twitter, Yahoo!*
  - *Different, non-standard protocols first: ClientLogin, AuthSub*
  - *OAuth 1.0 – first standard, security problems, quite complex*
  - *OAuth 2.0 – new version, not backward compatible with 1.0*
- Specifications and adoption
  - *OAuth 2.0 Protocol* ↗
  - *OAuth 2.0 Google Support* ↗

## Terminology

- **Client**
  - a third-party app accessing resources owned by **resource owner**
- **Resource Owner** (also user)
  - a person that owns a resource stored in the **resource server**
- **Authorization and Token Endpoints**
  - endpoints provided by an **authorization server** through which a **resource owner** authorizes requests.
- **Resource Server**
  - an app that stores resources owned by a **resource owner**
  - For example, contacts in Google Contacts
- **Authorization Code**
  - a code that a **client** uses to request **access tokens** to access resources
- **Access Token**
  - a code that a **client** uses to access resources

## Overview

- Security Concepts
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- OAuth 2.0
  - *Client-side Web Apps*
  - *Server-side Web Apps*
- OpenID

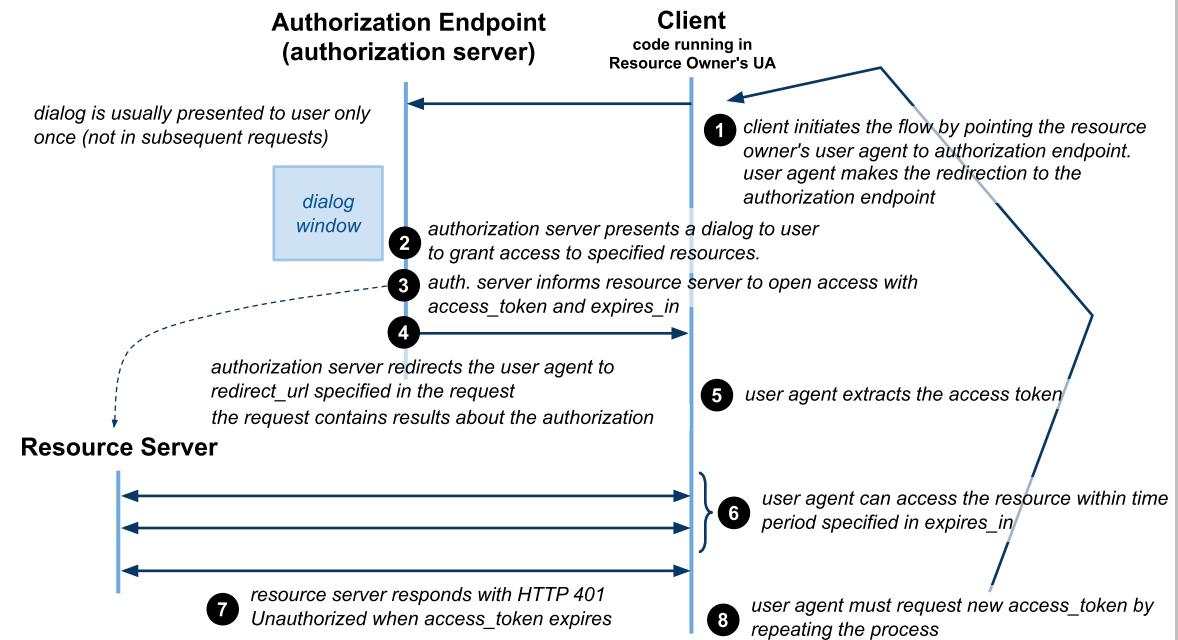
## Client-side Web Apps

- Simplified version of OAuth 2.0 protocol
  - *JavaScript/AJAX apps running in a browser*
  - *Apps that cannot easily "remember" app state*
  - *limited number of interactions*
- Architecture
  - *User-agent processes a javascript/HTML code from the client*
  - *No need of authorization code*
- Basic Steps
  - *A client redirects a user agent to the authorization endpoint*
  - *A resource owner grants an access to the client*  
→ or he/she rejects the request
  - *Authorization server provides an **access\_token** to the client*
  - *Client access the resource with the **access\_token***
  - *When the token expires, client requests a new token*

## Demo – List of Contacts

- Display your Google contacts
  - *this demo requests authorization from you to access your Google contacts using client-side OAuth 2.0 protocol and then displays the contacts below. In order to transfer **access\_token** from authorization window, it stores the **access\_token** in a cookie.*
  - **access\_token**
  - *Show contacts or revoke access*

# Client-side Web Apps Protocol



## Redirection – Step 1

- Methods and Parameters
  - **Methods:** `GET` or `POST`
  - **example authorization endpoint url (Google):**  
`https://accounts.google.com/o/oauth2/auth`
  - **query string parameters or application/x-www-form-urlencoded**
    - `client_id` – *id of the client that was previously registered*
    - `redirect_uri` – *an URI that auth. server will redirect to when user grants/rejects*
    - `scope` – *string identifying resources/services to be accessed*
    - `response_type` – *type of the response (token or code)*
    - `state (optional)` – *state between request and redirect*
  - **Example**

```
1 | https://accounts.google.com/o/oauth2/auth?
2 | client_id=621535099260.apps.googleusercontent.com&
3 | redirect_uri=http://w20.vitvar.com/examples/oauth/callback.html&
4 | scope=https://www.googleapis.com/auth/feedburner.readonly&
5 | response_type=token
```

## Callback – steps 4 and 5

- Resource owner grants the access
  - authorization server calls back **redirect\_uri**
  - client parses URL in JavaScript (Step 5)
    - extracts **access\_token** and **expires\_in** (by using `window.location.hash`)
  - Example:

```
1 | https://w20.vitvar.com/examples/oauth/callback.html#
2 | access_token=1/QbZfgDNsnd&
3 | expires_in=4301
```

- Resource owner rejects the access
  - authorization server calls back **redirect\_uri** with query string parameter **error=access\_denied**
  - Example:

```
1 | http://w20.vitvar.com/examples/oauth/callback.html?
2 | error=access_denied
```

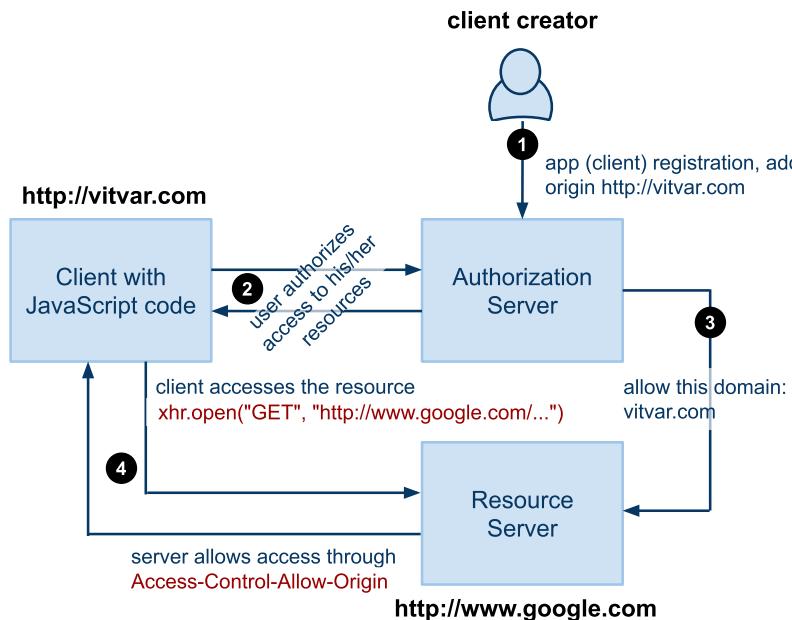
## Accessing Resources – Step 6

- Request
  - client can access resources defined by **scope**
  - resources' URIs defined in a particular documentation
  - Example Google Contacts
    - to access all users' contacts stored in Google
    - scope is <https://www.google.com/m8/feeds>
  - Query string parameter **oauth\_token**

```
1 | curl https://www.google.com/m8/feeds/contacts/default/full?
2 |   oauth_token=1/dERFd34Sf
```
  - HTTP Header **Authorization**

```
1 | curl -H "Authorization: OAuth 1/dERFd34Sf"
2 |   https://www.google.com/m8/feeds/contacts/default/full
```
  - The client can do any allowed operations on the resource
- Response
  - Success – **200 OK**
  - Error – **401 Unauthorized** when token expires or the client hasn't performed the authorization request.

# Cross-Origin Resource Sharing



– see *Same Origin and Cross-Origin* for details

## Example Application Registration

Screenshot of the Google API Access page for the client `vitvar.com search`:

**API Access**  
To prevent abuse, Google places limits on API requests. Using a valid OAuth token or API key allows you to exceed anonymous limits by connecting requests back to your project.

**Authorized API Access**  
OAuth allows users to share specific data with you (for example, contact lists) while keeping their usernames, passwords, and other information private. [Learn more](#)

**Branding information**  
The following information is shown to users whenever you request access to their private data.

Product name:	w20-test
Google account:	t.vitvar@gmail.com

[Edit branding information...](#)

**Client ID for web applications**

Client ID:	621535099260.apps.googleusercontent.com	<a href="#">Edit settings...</a>
Client secret:	RxWM917Sv-7cyfWMW7KhNV9R	<a href="#">Reset client secret...</a>
Redirect URIs:	<code>http://vitvar.com/examples/oauth/callback.html</code>	
JavaScript origins:	<code>http://example.org</code>	

[Create another client ID...](#)

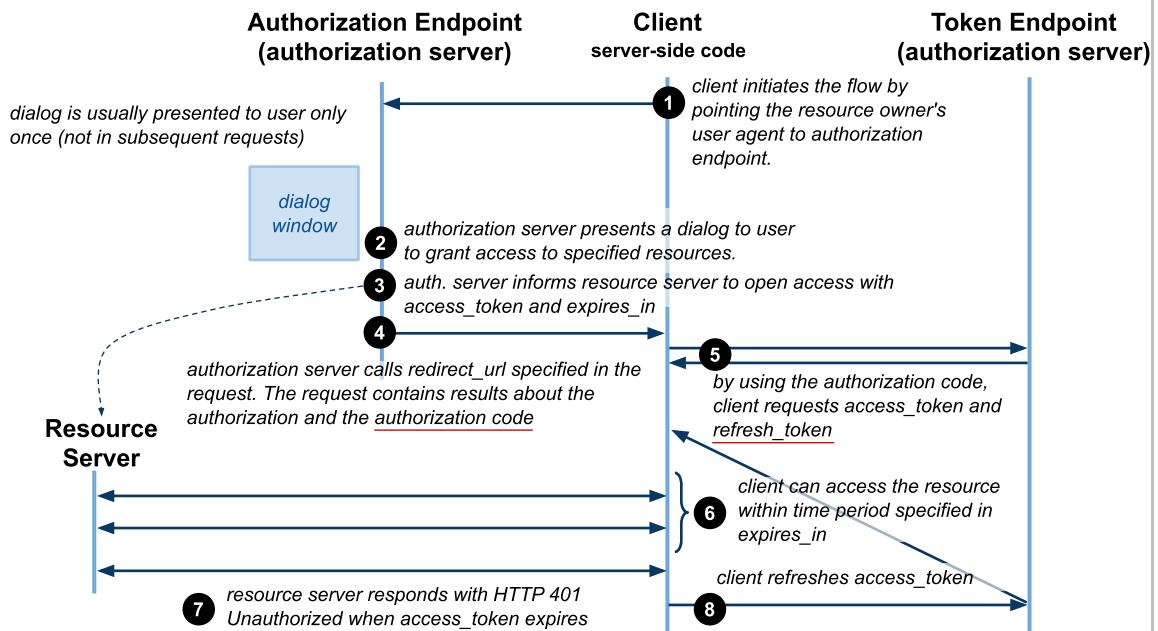
# Overview

- Security Concepts
- Transport Level Security
- JSON Web Token
- OAuth 2.0
  - *Client-side Web Apps*
  - *Server-side Web Apps*
- OpenID

## Server-side Web Apps

- Additional interactions
  - *server-side code (any language), the app can maintain the state*
  - *additional interactions, authorization code*
- Architecture
  - *Client at a server requests, remembers and refresh access tokens*
- Basic steps
  - *Client redirects user agent to the authorization endpoint*
  - *Resource owner grants access to the client or rejects the request*
  - *Authorization server provides **authorization code** to the client*
  - *Client requests **access** and **refresh tokens** from the auth. server*
  - *Client access the resource with the access token*
  - *When the token expires, client refreshes a token with refresh token*
- Advantages
  - *Access tokens not visible to clients, they are stored at the server*
  - *more secure, clients need to authenticate before they can get tokens*

# Server-side Web Apps Protocol



## Redirection – Step 1

- Methods and Parameters
  - same as for client-side app, except `response_type` must be `code`
- Example

```
1 https://accounts.google.com/o/oauth2/auth?
2 client_id=621535099260.apps.googleusercontent.com&
3 redirect_uri=http://w20.vitvar.com/examples/oauth/callback.html&
4 scope=https://www.google.com/m8/feeds&
5 response_type=code
```

## Callback + Access Token Request – steps 4, 5

- Callback
  - authorization server calls back `redirect_uri`
  - client gets the `code` and requests `access_token`
  - example (resource owner grants access):  
`http://w20.vitvar.com/examples/oauth/callback.html?code=4/P7...`
  - when user rejects → same as client-side access
- Access token request
  - `POST` request to token endpoint  
→ example Google token endpoint:  
`https://accounts.google.com/o/oauth2/token`

```
1 POST /o/oauth2/token HTTP/1.1
2 Host: accounts.google.com
3 Content-Type: application/x-www-form-urlencoded
4
5 code=4/P7q7W91a-oMsCeLvIaQm6bTrgtp6&
6 client_id=621535099260.apps.googleusercontent.com&
7 client_secret=XTHhXh1S2UggvyWGwDk1EjXB&
8 redirect_uri=http://w20.vitvar.com/examples/oauth/callback.html&
9 grant_type=authorization_code
```

## Access Token (cont.)

- Access token response
  - Token endpoint responds with `access_token` and `refresh_token`
- Refreshing a token
  - `POST` request to the token endpoint with `grant_type=refresh_token` and the previously obtained value of `refresh_token`
- Accessing a resource is the same as in the client-side app

```
1 POST /o/oauth2/token HTTP/1.1
2 Host: accounts.google.com
3 Content-Type: application/x-www-form-urlencoded
4
5 client_id=21302922996.apps.googleusercontent.com&
6 client_secret=XTHhXh1S1UNgvyWGwDk1EjXB&
7 refresh_token=1/6BMFW9j53gdGImsixUH6kU5RsR4zwI9lUVX-tqf8JXQ&
8 grant_type=refresh_token
```

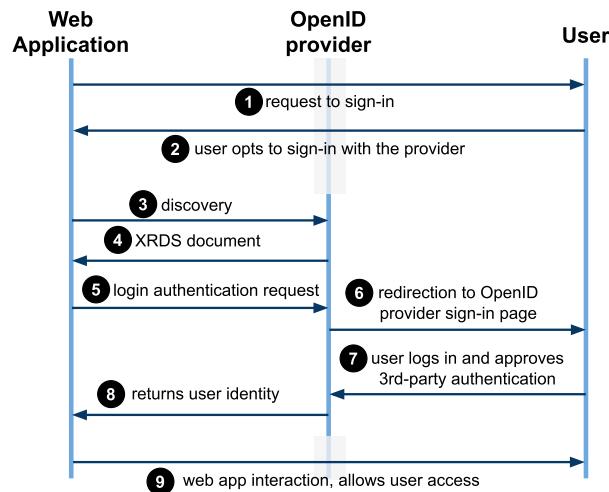
## Overview

- Security Concepts
- Transport Level Security
- JSON Web Token
- OAuth 2.0
- **OpenID**
  - *OpenID Connect*

## OpenID Protocol

- Motivation – many user accounts
  - *users need to maintain many accounts to access various services*
  - *multiple passwords problem*
- Objectives
  - *allows apps to utilize an OpenID provider*
    - *a third-party authentication service*
    - *federated login*
  - *users have one account with the OpenID provider and use it for apps that support the provider*
- OpenID providers
  - *it is a protocol, anybody can build a provider*
  - *Google, Yahoo!, Seznam.cz, etc.*
- Specification
  - *OpenID Protocol* [↗](#)

# Interaction Sequence



- Discovery – discovery of a service associated with a resource
- XRDS – eXtensible Resource Descriptor Sequence
  - *format for discovery result*
  - *developed to serve resource discovery for OpenID*
  - *Web app retrieves endpoint to send login authentication requests*

## Login Authentication Request – Step 5

- Example Google OpenID provider

```
1 | https://www.google.com/accounts/o8/id
2 | ?openid.ns=http://specs.openid.net/auth/2.0
3 | &openid.return_to=https://www.example.com/checkauth
4 | &openid.realm=http://www.example.com/
5 | &openid.assoc_handle=ABSmfpf6DNMw
6 | &openid.mode=checkid_setup
```

- Parameters
  - **ns** – protocol version (obtained from the XRDS)
  - **mode** – type of message or additional semantics (**checkid\_setup** indicates that interaction between the provider and the user is allowed during authentication)
  - **return\_to** – callback page the provider sends the result
  - **realm** – domain the user will trust, consistent with **return\_to**
  - **assoc\_handle** – "log in" for web app with openid provider

\* Not all fields shown, check the OpenID spec for the full list of fields and their values

## Login Authentication Response – Step 8

- User logs in successfully

```
1 | http://www.example.com/checkauth
2 | ?openid.ns=http://specs.openid.net/auth/2.0
3 | &openid.mode=id_res
4 | &openid.return_to=http://www.example.com:8080/checkauth
5 | &openid.assoc_handle=ABSmfpf6DNMw
6 | &openid.identity=https://www.google.com/accounts/o8/id?id=ACyQatiscWvwqs4UQV_l
```

- Web app will use **identity** to identify user in the application
  - response is also signed using a list of fields in the response (not shown in the listing)

- User cancels

```
1 | http://www.example.com/checkauth
2 | ?openid.mode=cancel
3 | &openid.ns=http://specs.openid.net/auth/2.0
```

\* Not all fields shown, check the OpenID spec for the full list of fields and their values

## Overview

- Security Concepts
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  - *OpenID Connect*

# OpenID Connect (OIDC)

- Simple identity layer on top of the OAuth 2.0 protocol
  - Authorization Server to verify identity of users
  - Clients can obtain basic profile information about users
- OIDC vs OpenID
  - OIDC does many of the same tasks as OpenID 2.0
  - API-friendly
    - can be used by native and mobile applications
  - Robust signing and encryption mechanisms
  - Native integration with OAuth 2.0.
- Defined by OpenID open standard
  - *OpenID Connect*

## Interaction sequence

