

# Web 2.0

## Lecture 7: Security in REST

**doc. Ing. Tomáš Vitvar, Ph.D.**

tomas@vitvar.com • @TomasVitvar • <http://vitvar.com>



Czech Technical University in Prague

Faculty of Information Technologies • Software and Web Engineering • <http://vitvar.com/courses/w20>



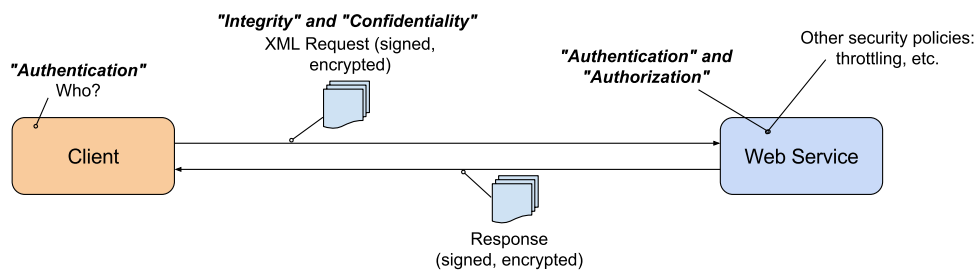
Modified: Wed Mar 22 2017, 13:52:19  
Humla v0.3

## Overview

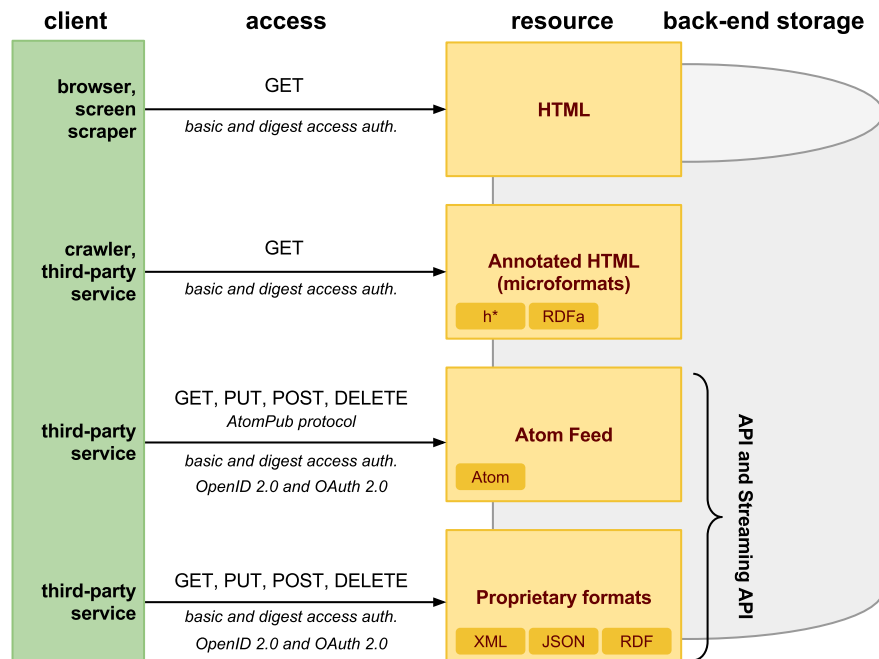
- **Security Concepts**
- Authentication and Authorization
- OAuth 2.0
- OpenID

## 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



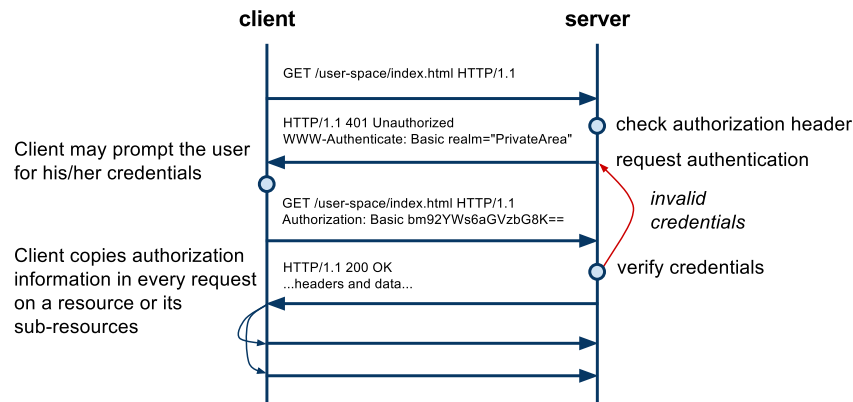
## Overview

- Security Concepts
- **Authentication and Authorization**
- OAuth 2.0
- OpenID

## 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 two options*
    - *Basic Access Authentication*
    - *Digest Access Authentication*
  - *They 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

# Basic Access Authentication



- Realm

- an identifier of the space on the server (~ a collection of resources and their sub-resources)
- A client may associate a valid credentials with realms such that it copies authorization information in requests for which server requires authentication (by **WWW-Authenticate** header)

# Basic Access Authentication – Credentials

- Credentials

- credentials are base64 encoded
- the format is: **username:password**

```
1 | # to encode in linux
2 | echo "novak:heslo" | base64
3 | > bm92YWw6aGVzOG8K
4 |
5 | # and to decode
6 | echo "bm92YWw6aGVzOG8K" | base64 -d # use capital "D" in OS X
7 | > novak:heslo
```

- Comments

- When SSL is not used, the password can be read
- An attacker can repeat interactions

# Digest Access Authentication

- RFC 2617 – Basic and Digest Access Authentication
  - No password between a client and a server but a hash value
  - Simple and advanced mechanisms (only server-generated nonce value – replay-attacks or with client-generated nonce value)

- Basic Steps

1. Client accesses a protected area

```
1 | > GET / HTTP/1.1
```

2. Server requests authentication with **WWW-Authenticate**

```
1 | < HTTP/1.1 401 Unauthorized
2 | < WWW-Authenticate: Digest realm="ProtectedArea",
3 |   nonce="BbdQof3DBAA=a293ff3d724989371610f03015f2d23f3cd2c045",
4 |   algorithm=MD5, domain="/", qop="auth"
```

3. Client calculates a response hash by using the realm, his/her username, the password, and the quality of protection (QoP) and requests the resource with **authorization** header

```
1 | > GET / HTTP/1.1
2 | > Authorization: Digest username="novak", realm="ProtectedArea",
3 |   nonce="BbdQof3DBAA=a293ff3d724989371610f03015f2d23f3cd2c045", uri="/",
4 |   algorithm=MD5, response="c4ea2293aeb318826d1e533f363efd90", qop=auth,
5 |   nc=00000001, cnonce="531ee8ba7f2a8fd1"
```

# Nonce and QoP

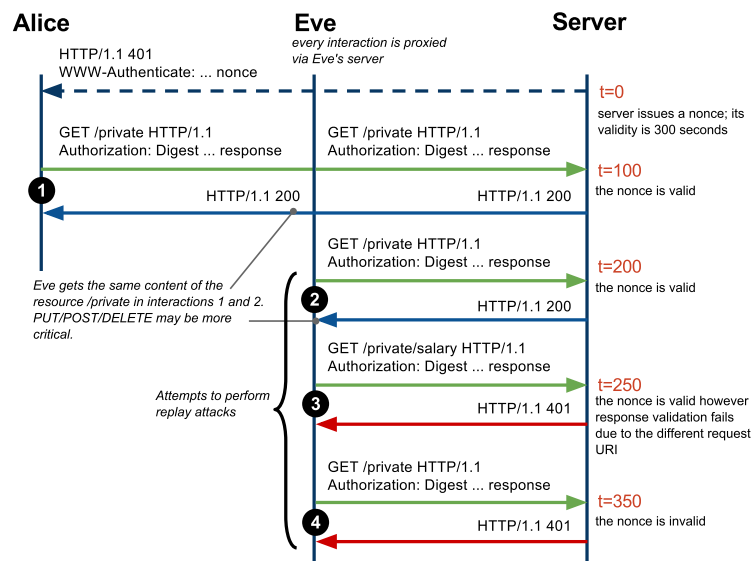
- Nonce
  - A value to identify an interaction that should occur only once
  - **nonce** – generated by the server
    - may have a time period for which the nonce is valid
    - may be computed using client IP, ETag of the resource, etc.
    - this limits chances for the replay attack.
  - **cnonce** – generated by the client
- QoP – quality of protection
  - Further improvements to prevent replay attacks and enables non-repudiation

## Algorithms

- Algorithm for **response** value of **authorization** header
  - No quality of protection (**qop** is missing or **qop=none**)
    - limits chances of replay-attacks
    - 1 | HA1 = MD5(username:realm:password)
    - 2 | HA2 = MD5(method:digestURI)
    - 3 | response = MD5(HA1:nonce:HA2)
  - with quality of protection (**qop=auth**)
    - 1 | HA1 = MD5(username:realm:password)
    - 2 | HA2 = MD5(method:digestURI)
    - 3 | response = MD5(HA1:nonce:nonceCount:cnonce:qop:HA2)
  - with quality of protection for message integrity (**qop=auth-int**)
    - enables non-repudiation (i.e., proof of integrity and origin of data)
    - 1 | HA1 = MD5(username:realm:password)
    - 2 | HA2 = MD5(method:digestURI:MD5(payload))
    - 3 | response = MD5(HA1:nonce:nonceCount:cnonce:qop:HA2)

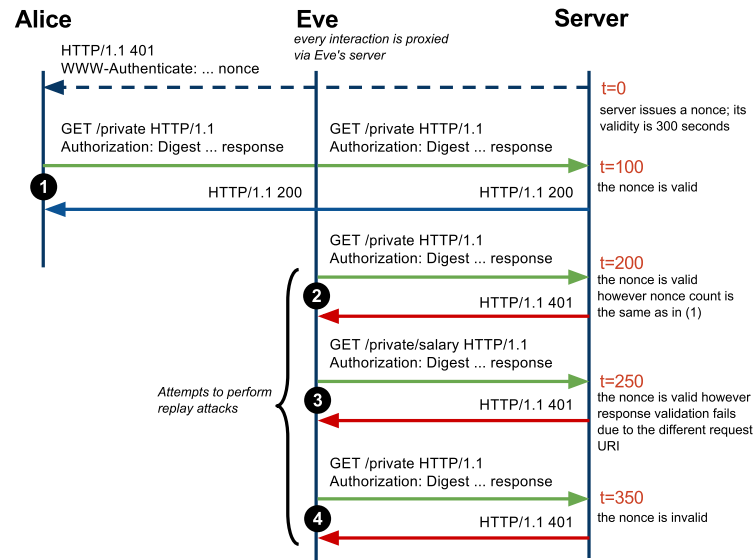
## Replay Attack

- Replay Attack Scenario (quality of protection is **none**)
  - The communication is not encrypted (i.e., no use of HTTPS)
  - Eve listens to the Alice's communication (e.g. on a proxy server)
  - Eve resends requests with headers from Alice's requests



## Replay Attack (Cont.)

- Replay Attack Scenario (quality of protection is **auth** or **auth-int**)
  - **nonceCount** should be incremented in every request to a response of the nonce value from the server



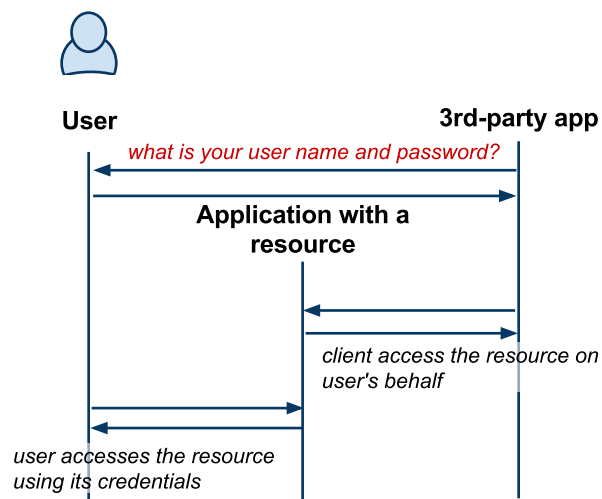
## Overview

- Security Concepts
- Authentication and Authorization
- **OAuth 2.0**
  - Client-side Web Apps
  - Server-side Web Apps
  - OAuth 2.0 vs. OAuth 1.0
- 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, PicasaWeb, 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** (e.g., pictures in Google PicasaWeb)*
- **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
- Authentication and Authorization
- OAuth 2.0
  - *Client-side Web Apps*
  - *Server-side Web Apps*
  - *OAuth 2.0 vs. OAuth 1.0*
- OpenID

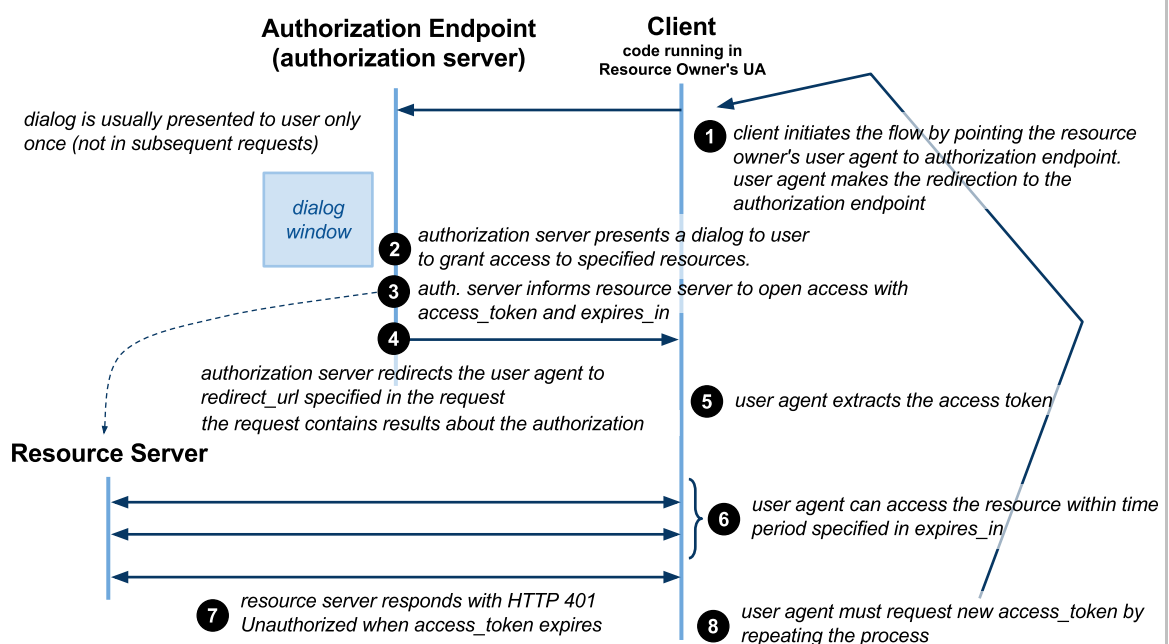
## Client-side Web Apps

- 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 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 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://humla.vitvar.com/slides/w20/examples/oauth/callback.htm  
4 | scope=https://www.google.com/m8/feeds&  
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 | http://humla.vitvar.com/slides/w20/examples/oauth/callback.html#  
2 | access_token=1/QbZfgDNsd&  
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://humla.vitvar.com/slides/w20/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`**

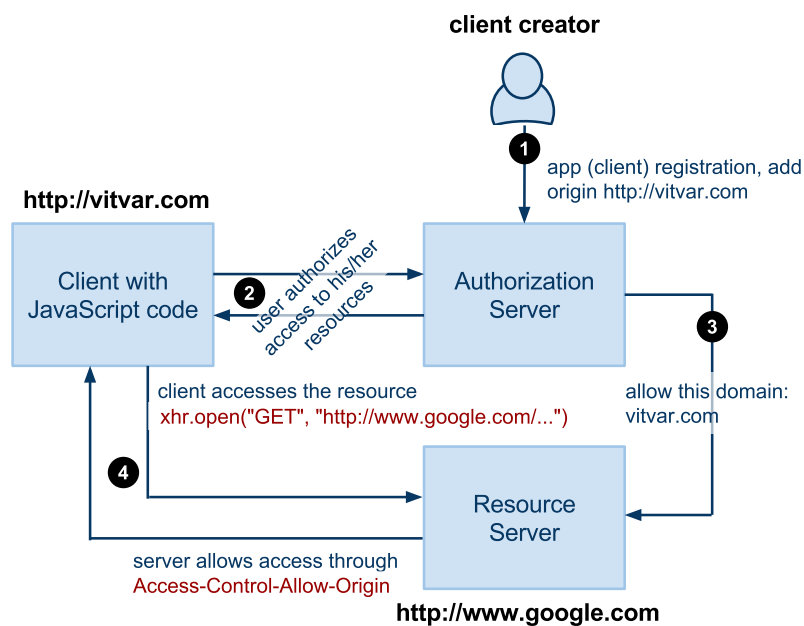
```
1 | curl https://www.google.com/m8/feeds/contacts/default/full?
2 |     oauth_token=1/dERFd34Sf
```
- HTTP Header **Authorization**

```
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

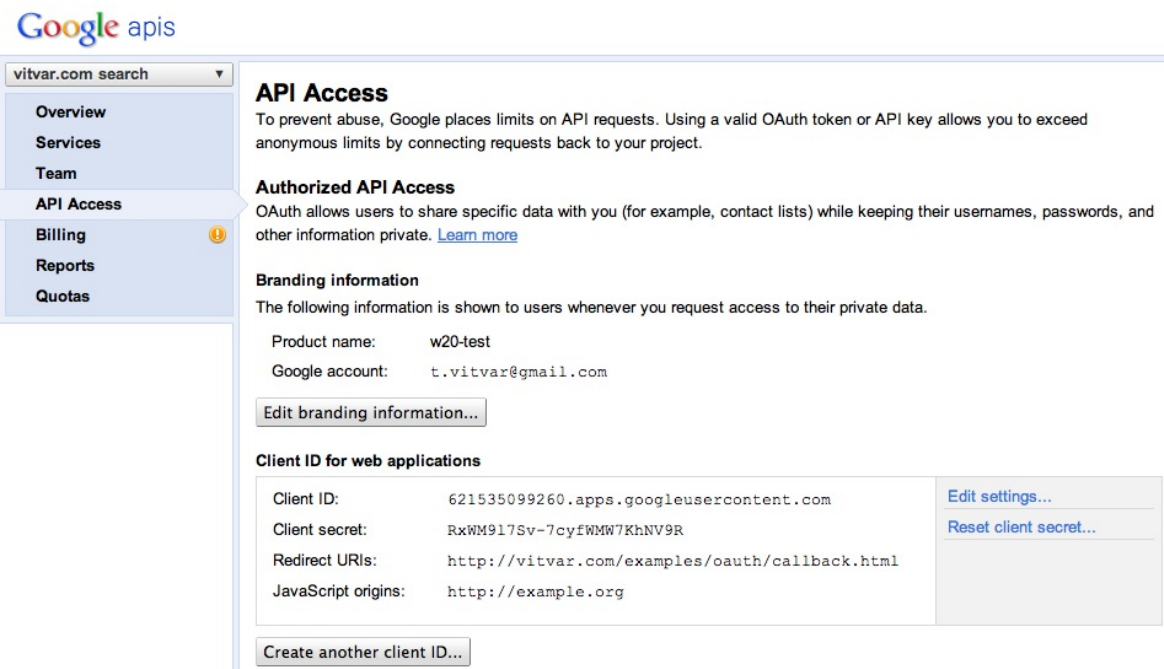
- Success – **200 OK**
- Error – **401 Unauthorized** when token expires or the client hasn't performed the authorization request.

## Cross-Origin Resource Sharing



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

# Example Application Registration



The screenshot shows the Google APIs console interface. On the left is a sidebar with navigation links: Overview, Services, Team, API Access (selected), Billing, Reports, and Quotas. The main content area is titled 'API Access' and contains the following sections:

- API Access**: A paragraph explaining that Google places limits on API requests and that using a valid OAuth token or API key allows exceeding these limits.
- Authorized API Access**: A paragraph explaining that OAuth allows sharing specific data while keeping usernames, passwords, and other information private, with a link to 'Learn more'.
- Branding information**: A paragraph stating that the following information is shown to users when requesting access to their private data. Below this, a table lists:
  - Product name: w20-test
  - Google account: t.vitvar@gmail.comA button 'Edit branding information...' is located below the table.
- Client ID for web applications**: A table with the following data:

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

A button 'Create another client ID...' is located below the table.

At the bottom of the page, the footer reads: 'Lecture 7: Security in REST, CTU Summer Semester 2016/2017, @TomasVitvar' on the left and '- 27 -' on the right.

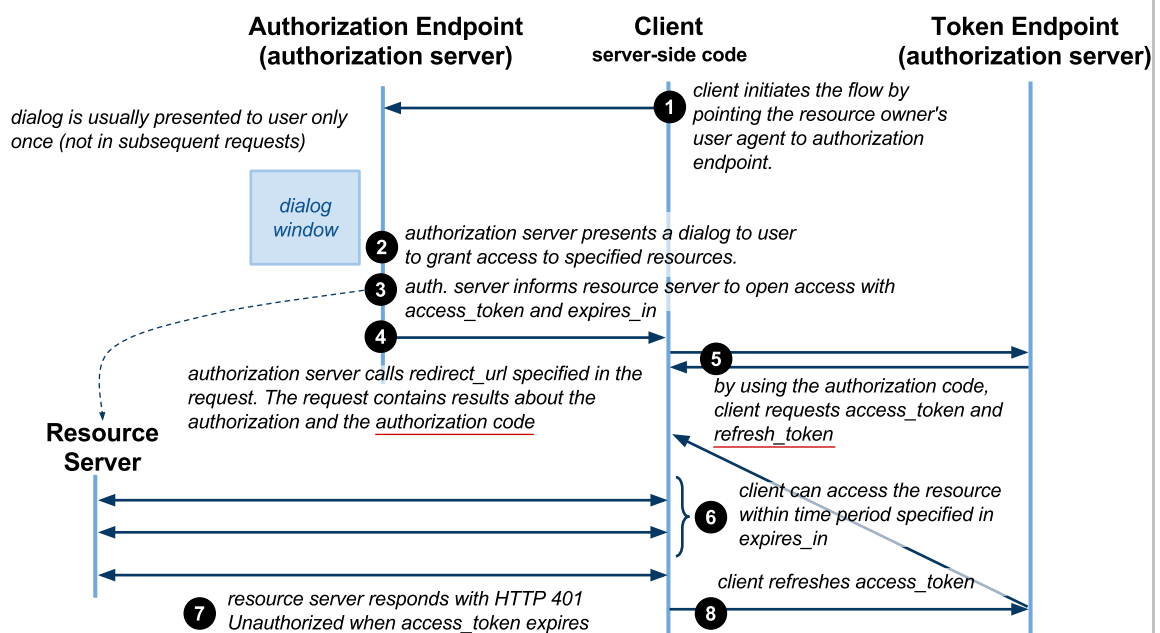
## Overview

- Security Concepts
- Authentication and Authorization
- OAuth 2.0
  - *Client-side Web Apps*
  - *Server-side Web Apps*
  - *OAuth 2.0 vs. OAuth 1.0*
- 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://humla.vitvar.com/slides/w20/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://humla.vitvar.com/slides/w20/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://humla.vitvar.com/slides/w20/examples/oauth/callback.htmr  
9 grant_type=authorization_code
```



## Access Token (cont.)

- Access token response

- *Token endpoint responds with **access\_token** and **refresh\_token***

```
1 { "access_token" : "1/ffAGRnJru1FTz70BzhT3Zg",  
2   "expires_in"   : 3920,  
3   "refresh_token" : "1/6BMfW9j53gdGimsixUH6kU5RsR4zwI9lUVX-tqf8JXQ" }
```

- Refreshing a token

- ***POST** request to the token endpoint with **grant\_type=refresh\_token** and the previously obtained value of **refresh\_token***

```
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=XTHhXh1SlUNgvyWgWdk1EjXB&  
7 refresh_token=1/6BMfW9j53gdGimsixUH6kU5RsR4zwI9lUVX-tqf8JXQ&  
8 grant_type=refresh_token
```

- Accessing a resource is the same as in the client-side app

## Overview

- Security Concepts
- Authentication and Authorization
- OAuth 2.0
  - *Client-side Web Apps*
  - *Server-side Web Apps*
  - ***OAuth 2.0 vs. OAuth 1.0***
- OpenID

## Why new version?

- OAuth 1.0 in brief
  - *security not based on SSL*
  - *client must sign every request using a defined algorithm*
    - *e.g., public-private key signatures by RSA*
  - *More complex to be implemented by clients*
    - *although client libraries exist*
  - *not suitable for JavaScript-based clients*
- OAuth 2.0 simplifies the process
  - *SSL is required for all communications to generate the token*
  - *Signatures are not required for the actual API calls once the token has been generated*
    - *SSL is also strongly recommended here*
  - *supports various clients including JavaScript and mobile*

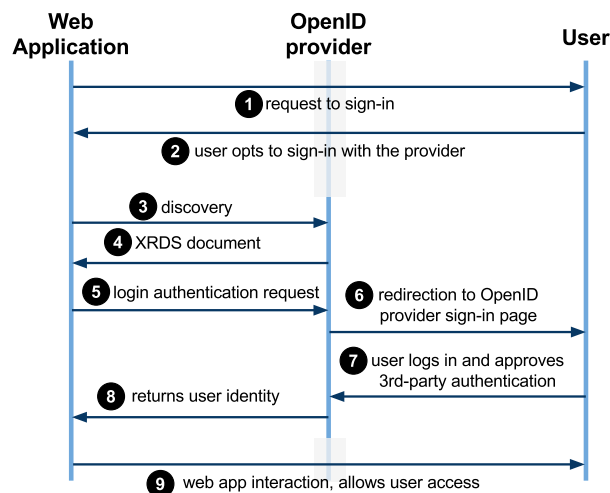
## Overview

- Security Concepts
- Authentication and Authorization
- OAuth 2.0
- **OpenID**

# 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=ABSmpf6DNMw
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=ABSmpf6DNMw
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*