Web 2.0
Lecture 7: Security in REST

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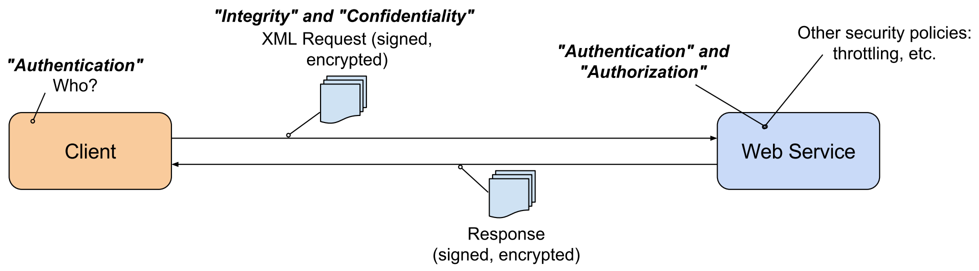
Humla v0.3

Overview

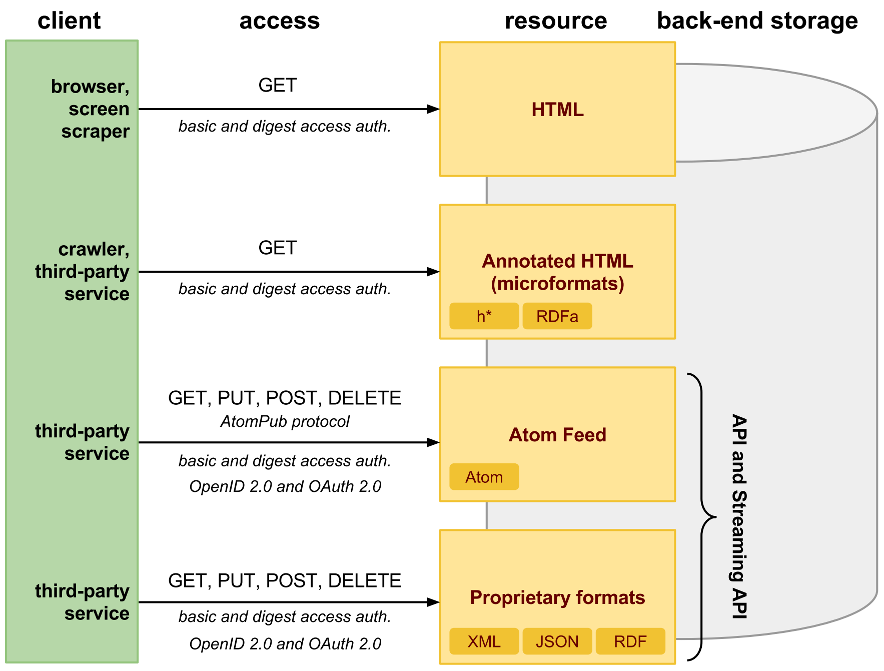
- Security Concepts
- Authentication and Authorization
- OAuth 2.0
- OpenID

Web Service Security Concepts

- Securing the client-server communcation
  - *Message-level security*
  - *Transport-level security*
- Ensure
  - *Authentication – verify a client's identity*
  - *Authorizaton – 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*


"Integrity" and "Confidentiality"
XML Request (signed, encrypted)
"Authentication"
Who?
"Authentication" and "Authorization"
Other security policies: throttling, etc.
Client
Web Service
Response (signed, encrypted)

Data on the Web



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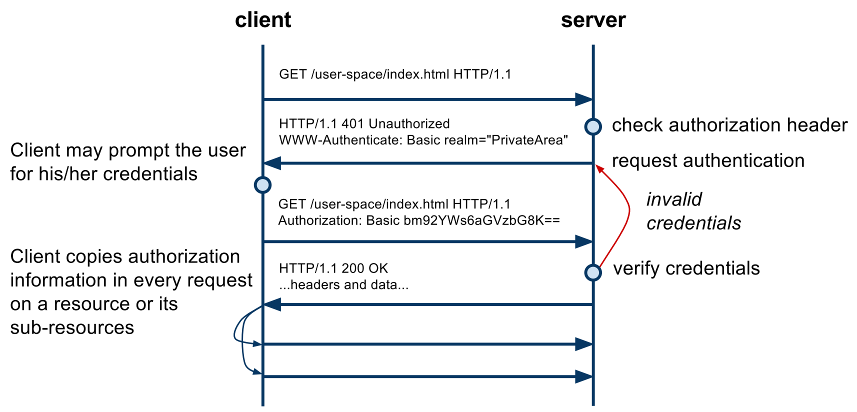
Authentication and Authorization

- 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


client
server
GET /user-space/index.html HTTP/1.1
check authorization header
HTTP/1.1 401 Unauthorized
WWW-Authenticate: Basic realm="PrivateArea"
request authentication
Client may prompt the user for his/her credentials
invalid credentials
GET /user-space/index.html HTTP/1.1
Authorization: Basic bm92YWs6aGVzbG8==
Client copies authorization information in every request on a resource or its sub-resources
HTTP/1.1 200 OK
...headers and data...
verify credentials

- 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`

```
# to encode in linux
echo "novak:heslo" | base64
> bm92YWs6aGVzbG8K

# and to decode
echo "bm92YWs6aGVzbG8K" | base64 -d # use capital "D" in OS X
> 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*

     ```
     > GET / HTTP/1.1
     ```

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

     ```
     < HTTP/1.1 401 Unauthorized
     < WWW-Authenticate: Digest realm="ProtectedArea",
       nonce="BbdQof3DBAA=a293ff3d724989371610f03015f2d23f3cd2c045",
       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*

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

Nonce and QoP

- Nonce
  - *A value to identify an interaction that should occur only once*
  - `nonce` *– generated by the server*
    - $\longrightarrow$ *may have a time period for which the nonce is valid*
    - $\longrightarrow$ *may be computed using client IP, ETag of the resource, etc.*
    - $\longrightarrow$ *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

```
HA1 = MD5(username:realm:password)
HA2 = MD5(method:digestURI)
response = MD5(HA1:nonce:HA2)
```

  - *with quality of protection (`qop=auth`)*

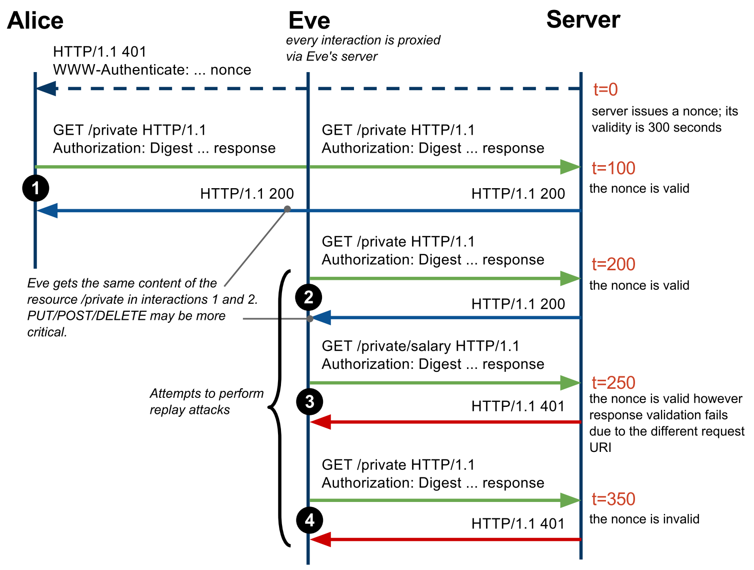
```
HA1 = MD5(username:realm:password)
HA2 = MD5(method:digestURI)
response = MD5(HA1:nonce:nonceCount:cnonce:qop:HA2)
```

  - *with quality of protection for message integrity (`qop=auth-int`)*
    → enables non-repudiation (i.e., proof of integrity and origin of data)

```
HA1 = MD5(username:realm:password)
HA2 = MD5(method:digestURI:MD5(payload))
response = MD5(HA1:nonce:nonceCount:cnonce:qop:HA2)
```

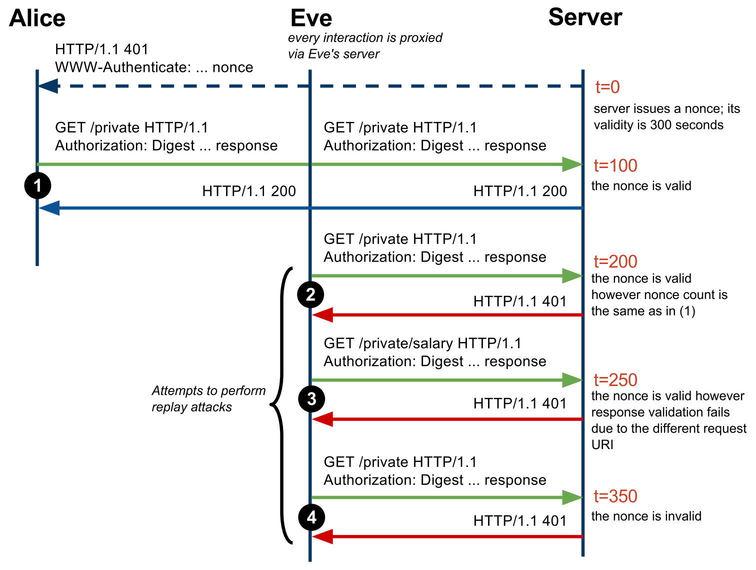
Replay Attack

- 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*


Alice
Eve
every interaction is proxied via Eve's server
Server
HTTP/1.1 401
WWW-Authenticate: ... nonce
t=0
server issues a nonce; its validity is 300 seconds
GET /private HTTP/1.1
Authorization: Digest ... response
GET /private HTTP/1.1
Authorization: Digest ... response
t=100
the nonce is valid
1
HTTP/1.1 200
HTTP/1.1 200
GET /private HTTP/1.1
Authorization: Digest ... response
t=200
the nonce is valid
Eve gets the same content of the resource /private in interactions 1 and 2. PUT/POST/DELETE may be more critical.
2
HTTP/1.1 200
GET /private/salary HTTP/1.1
Authorization: Digest ... response
t=250
the nonce is valid however response validation fails due to the different request URI
Attempts to perform replay attacks
3
HTTP/1.1 401
GET /private HTTP/1.1
Authorization: Digest ... response
t=350
the nonce is invalid
4
HTTP/1.1 401

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*



Alice
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Authorization: Digest ... response
GET /private HTTP/1.1
Authorization: Digest ... response
t=100
the nonce is valid
1
HTTP/1.1 200
HTTP/1.1 200
GET /private HTTP/1.1
Authorization: Digest ... response
t=200
the nonce is valid however nonce count is the same as in (1)
2
HTTP/1.1 401
GET /private/salary HTTP/1.1
Authorization: Digest ... response
Attempts to perform replay attacks
t=250
the nonce is valid however response validation fails due to the different request URI
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GET /private HTTP/1.1
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  - *Server-side Web Apps*
  - *OAuth 2.0 vs. OAuth 1.0*
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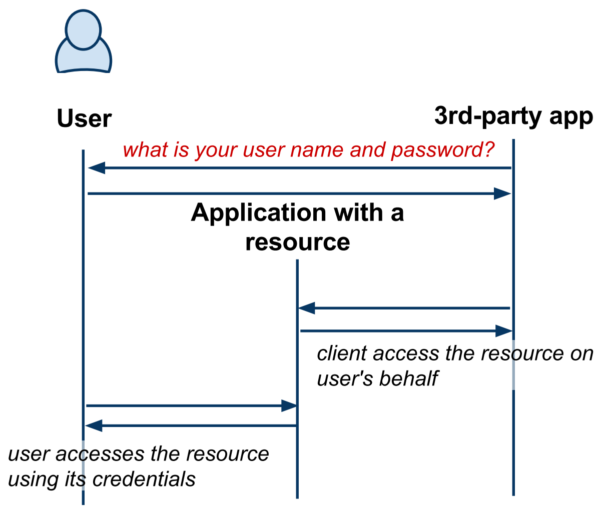
Motivation

- 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


User
3rd-party app
what is your user name and password?
Application with a resource
client access the resource on user's behalf
user accesses the resource using its credentials

- 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 compatibile 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*

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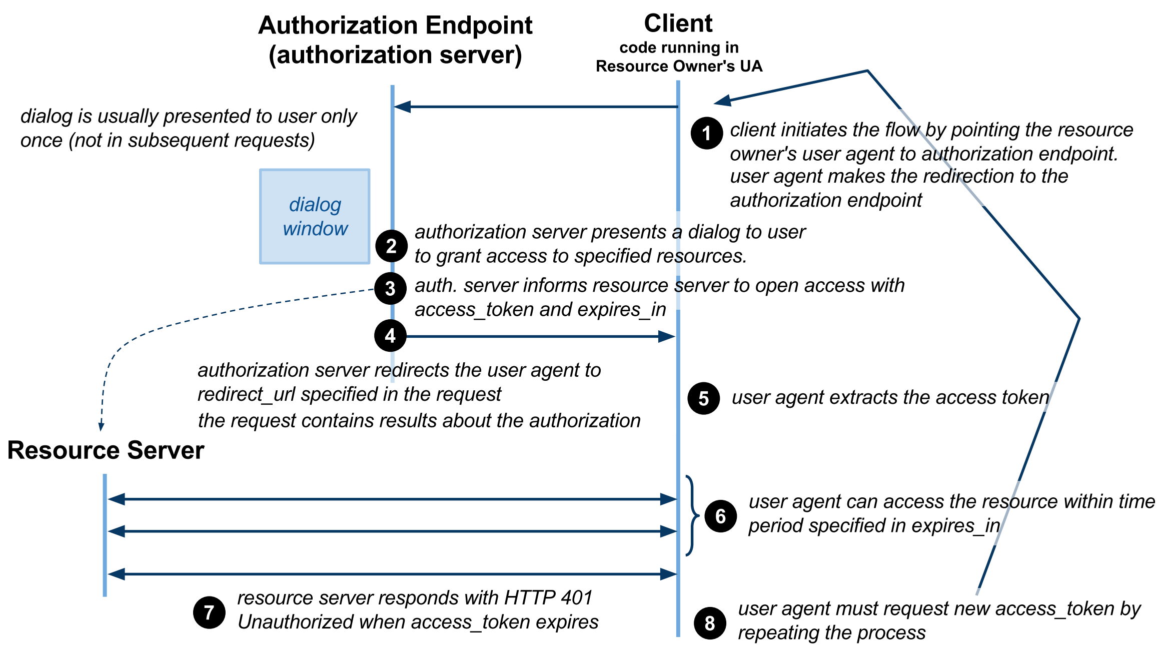
Client-side Web Apps

- 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


Authorization Endpoint (authorization server)
Client
code running in Resource Owner's UA
dialog is usually presented to user only once (not in subsequent requests)
dialog window
1 client initiates the flow by pointing the resource owner's user agent to authorization endpoint. user agent makes the redirection to the authorization endpoint
2 authorization server presents a dialog to user to grant access to specified resources.
3 auth. server informs resource server to open access with access_token and expires_in
4
authorization server redirects the user agent to redirect_url specified in the request
the request contains results about the authorization
5 user agent extracts the access token
Resource Server
6 user agent can access the resource within time period specified in expires_in
7 resource server responds with HTTP 401 Unauthorized when access_token expires
8 user agent must request new access_token by repeating the process

Redirection – Step 1

- Methods and Parameters
  - *Methods:* `GET` *or* `POST`
  - *example authorazation 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*

```
https://accounts.google.com/o/oauth2/auth?
client_id=621535099260.apps.googleusercontent.com&
redirect_uri=http://humla.vitvar.com/slides/w20/examples/oauth/callback.htm
scope=https://www.google.com/m8/feeds&
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:*

```
http://humla.vitvar.com/slides/w20/examples/oauth/callback.html#
access_token=1/QbZfgDNsnd&
expires_in=4301
```

- Resource owner rejects the access
  - *authorization server calls back* `redirect_uri` *with query string parameter* `error=access_denied`
  - *Example:*

```
hhttp://humla.vitvar.com/slides/w20/examples/oauth/callback.html?
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`

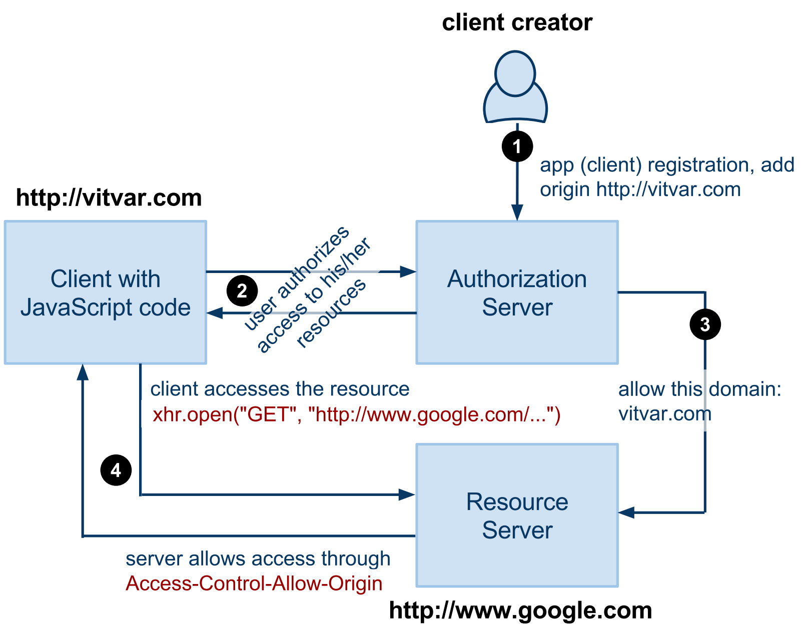
```
curl https://www.google.com/m8/feeds/contacts/default/full?
    oauth_token=1/dERFd34Sf
```

  – *HTTP Header* `Authorization`

```
curl -H "Authorization: OAuth 1/dERFd34Sf"
    https://www.google.com/m8/feeds/contacts/default/full
```

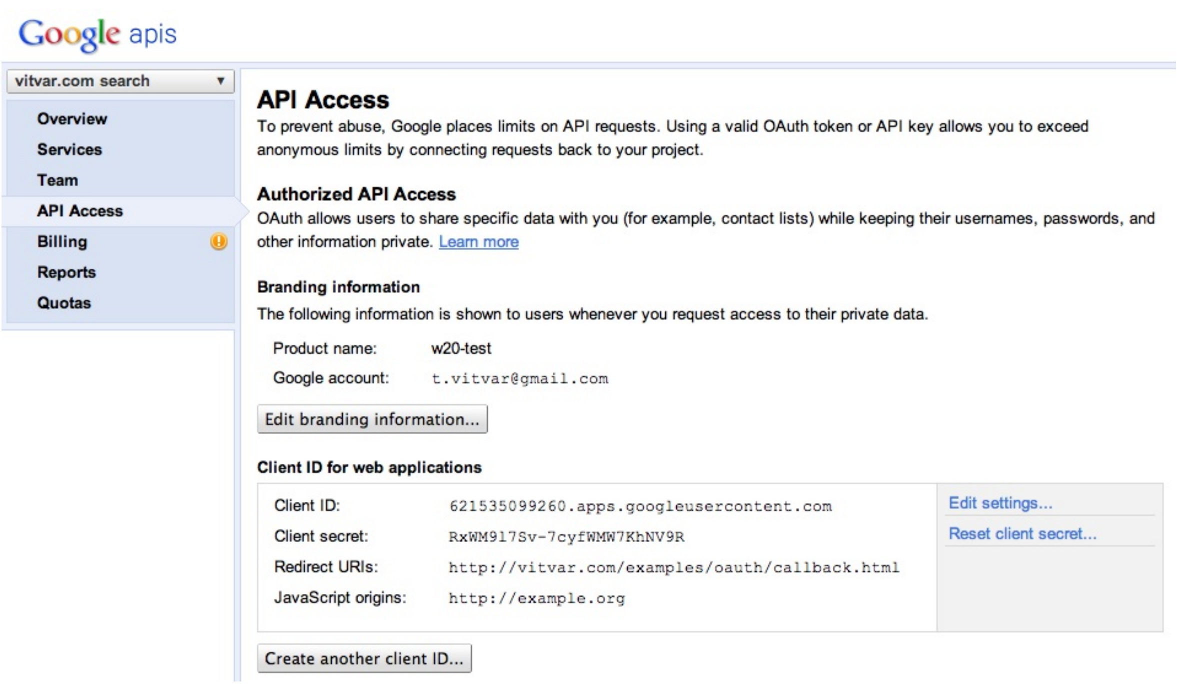
  – *The client can do any allowed operations on the resource*
- Response
  – *Success –* `200 OK`
  – *Error –* `401 Unauthorized` *when token expires or the client hasn't performed the authorization request.*

Cross-Origin Resource Sharing


client creator
1
app (client) registration, add origin http://vitvar.com
http://vitvar.com
Client with JavaScript code
2
user authorizes access to his/her resources
Authorization Server
3
allow this domain: vitvar.com
client accesses the resource
xhr.open("GET", "http://www.google.com/...")
4
Resource Server
server allows access through Access-Control-Allow-Origin
http://www.google.com

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

Example Application Registration



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

Client ID for web applications

Client ID:	621535099260.apps.googleusercontent.com
Client secret:	RxWM917Sv-7cyfWMW7KhNV9R
Redirect URIs:	http://vitvar.com/examples/oauth/callback.html
JavaScript origins:	http://example.org

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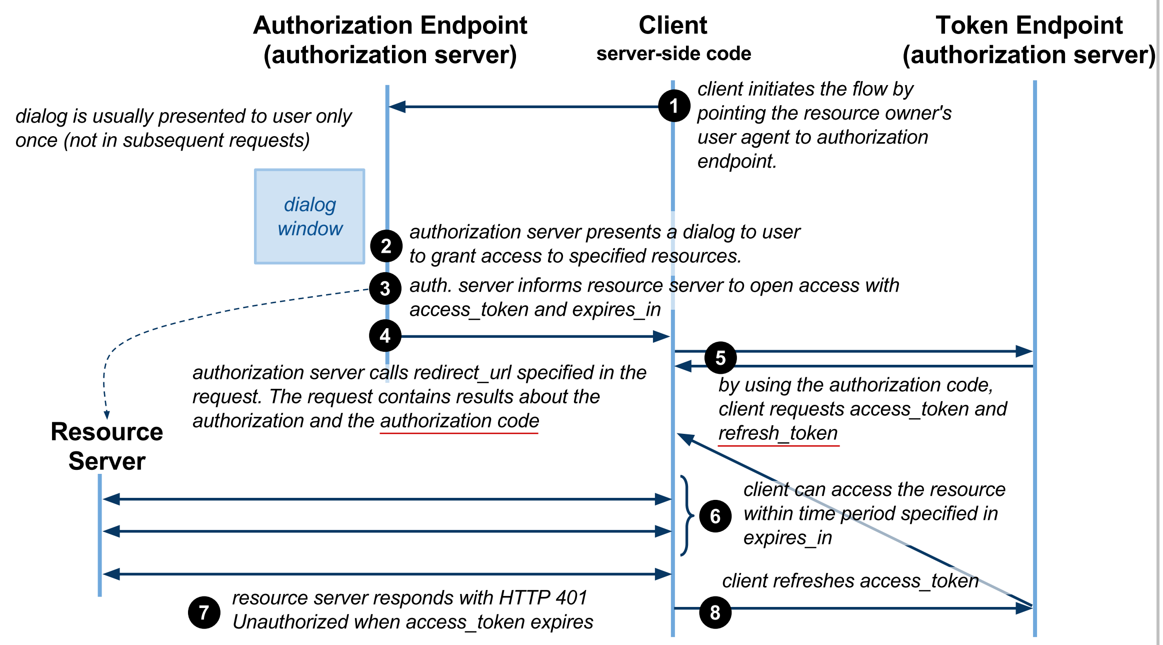
Server-side Web Apps

- 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


Authorization Endpoint (authorization server)
Client server-side code
Token Endpoint (authorization server)
dialog is usually presented to user only once (not in subsequent requests)
dialog window
1 client initiates the flow by pointing the resource owner's user agent to authorization endpoint.
2 authorization server presents a dialog to user to grant access to specified resources.
3 auth. server informs resource server to open access with access_token and expires_in
4 authorization server calls redirect_url specified in the request. The request contains results about the authorization and the authorization code
5 by using the authorization code, client requests access_token and refresh_token
Resource Server
6 client can access the resource within time period specified in expires_in
client refreshes access_token
7 resource server responds with HTTP 401 Unauthorized when access_token expires
8

Redirection – Step 1

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

```
https://accounts.google.com/o/oauth2/auth?
client_id=621535099260.apps.googleusercontent.com&
redirect_uri=http://humla.vitvar.com/slides/w20/examples/oauth/callback.html&
scope=https://www.google.com/m8/feeds&
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`

```
POST /o/oauth2/token HTTP/1.1
Host: accounts.google.com
Content-Type: application/x-www-form-urlencoded

code=4/P7q7W91a-oMsCeLvIaQm6bTrgtp6&
client_id=621535099260.apps.googleusercontent.com&
client_secret=XTHhXh1S2UggvyWGwDk1EjXB&
redirect_uri=http://humla.vitvar.com/slides/w20/examples/oauth/callback.htm
grant_type=authorization_code
```

Access Token (cont.)

- Access token response
  - *Token endpoint responds with* `access_token` *and* `refresh_token`

```
{ "access_token"   : "1/fFAGRNJru1FTz70BzhT3Zg",
  "expires_in"     : 3920,
  "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`

```
POST /o/oauth2/token HTTP/1.1
Host: accounts.google.com
Content-Type: application/x-www-form-urlencoded

client_id=21302922996.apps.googleusercontent.com&
client_secret=XTHhXh1SlUNgvyWGwDk1EjXB&
refresh_token=1/6BMfW9j53gdGImsixUH6kU5RsR4zwI9lUVX-tqf8JXQ&
grant_type=refresh_token
```

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

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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*

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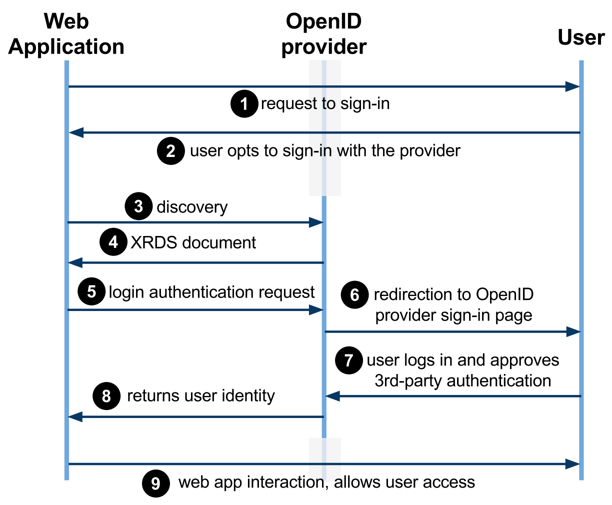
OpenID Protocol

- 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


Web Application
OpenID provider
User
1 request to sign-in
2 user opts to sign-in with the provider
3 discovery
4 XRDS document
5 login authentication request
6 redirection to OpenID provider sign-in page
7 user logs in and approves 3rd-party authentication
8 returns user identity
9 web app interaction, allows user access

- 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

```
https://www.google.com/accounts/o8/id
?openid.ns=http://specs.openid.net/auth/2.0
&openid.return_to=https://www.example.com/checkauth
&openid.realm=http://www.example.com/
&openid.assoc_handle=ABSmpf6DNMw
&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 logins successfully

```
http://www.example.com/checkauth
?openid.ns=http://specs.openid.net/auth/2.0
&openid.mode=id_res
&openid.return_to=http://www.example.com:8080/checkauth
&openid.assoc_handle=ABSmpf6DNMw
&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

```
http://www.example.com/checkauth
?openid.mode=cancel
&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*