A JavaScript REST API

Internet Applications, ID1354

Contents

Section

Server-Side Rendering (SSR), Loading the Entire Page

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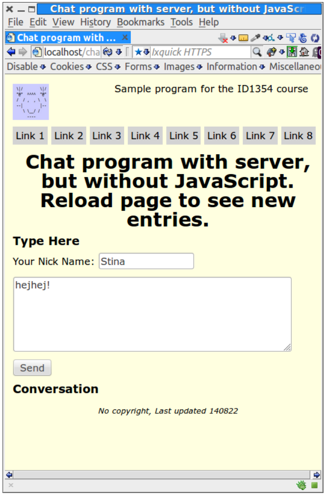
  - This is called server-side rendering, SSR.
- SSR might be appropriate if the entire page content really must change, but that is often not the case.

A Chat Example


Chat program with server, but without JavaScr
File Edit View History Bookmarks Tools Help
Chat program with ...
localhost/cha
Ixquick HTTPS
Disable Cookies CSS Forms Images Information Miscellaneo

Sample program for the ID1354 course

Link 1 Link 2 Link 3 Link 4 Link 5 Link 6 Link 7 Link 8

Chat program with server, but without JavaScript. Reload page to see new entries.

Type Here

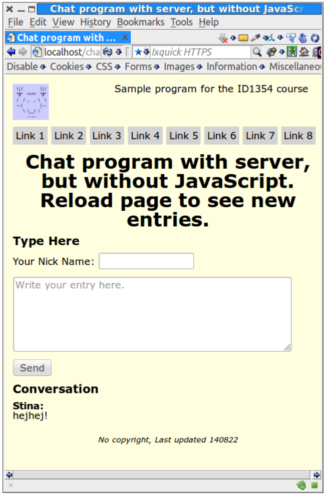
Your Nick Name: Stina

hejhej!

Send

Conversation

No copyright, Last updated 140822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Consider for example the sample chat application. All that happens when the user clicks **`Send`** is that the new entry is added, the rest of the page is untouched.

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- This course focuses on CSR.

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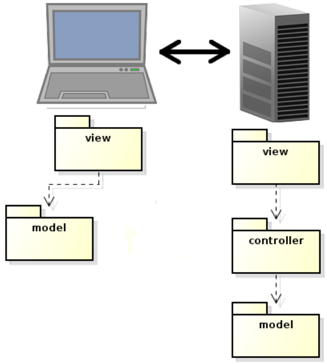
  - Fast rendering after the initial load.

Repetition: The MVVM Pattern



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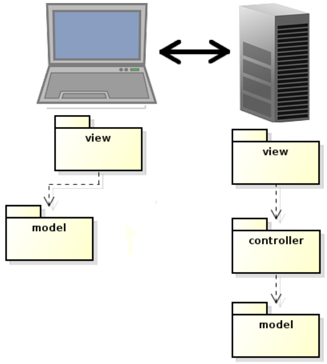

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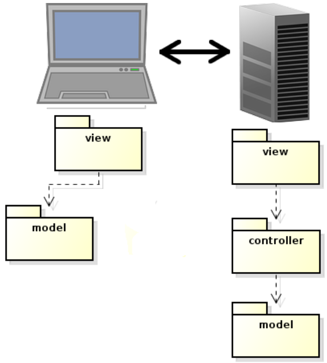

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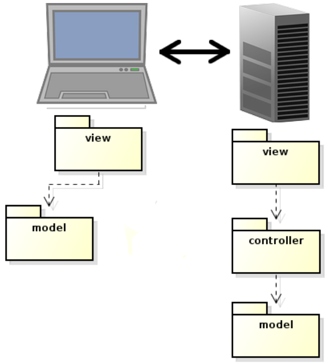

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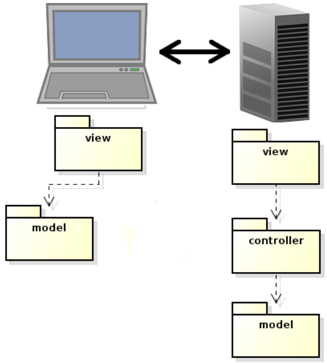

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- The browser view will reflect the viewmodel state, using the observer pattern.
- This is very useful for a CSR application.

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- The only thing specific for AJAX is a JavaScript object, called **`XMLHttpRequest`**, which is standardized by W3C.

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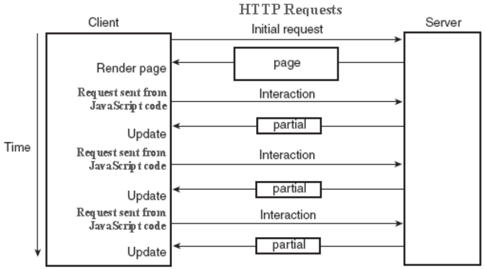

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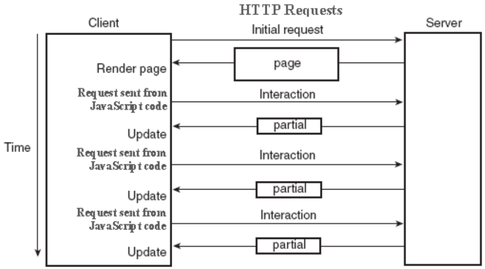

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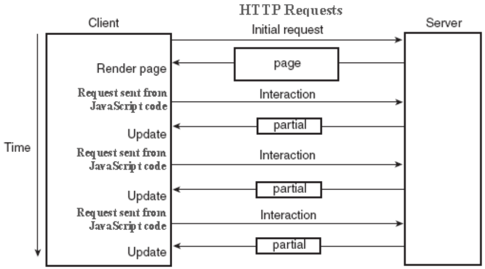

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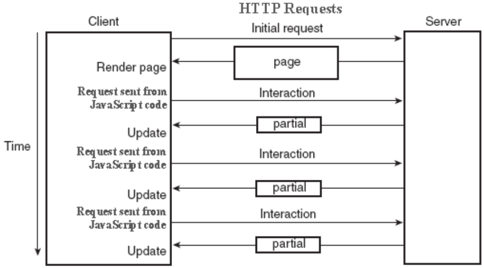

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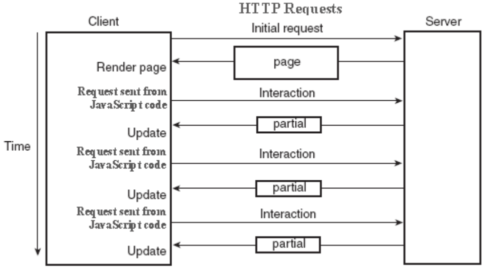

- Web page is loaded only on first request.
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- Returned data is available to JavaScript code, and is used to update the web page, by updating the DOM.

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- The server directs the request to the resource specified in the URL, just as when loading a HTML document.
- An AJAX request is normally handled by a program, for example written in JavaScript, which generates a response containing the new data.

Data Format

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- **J**ava**S**cript **O**bject **N**otation, JSON, is normally used since it is compact and easy to translate to JavaScript objects.

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  - Arrays are denoted with `[` and `]`:

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  - Data types are JavaScript types, for example string, **"abcd"**; integer, **`123`**; boolean, **`false`**

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  - For example, a HTTP GET call to the URL `my.server.com/message` tells the server to return all messages.
- The set of URLs and HTTP methods handled by the server is often called a REST API, or just an API.

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    - Hypermedia as the engine of application state, HATEOS or HATEOAS

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- Each resource must be addressable via a URI, which in the case of a web application means it must be reachable at a URL.
- This makes all resources linkable, references to resources can be embedded in for example documents or emails.

Addressable Resources, Contd

An example JSON document representing chat messages:

```
{
  "success": [
    {
      "id": 1,
      "msg": "hi Stina",
      "deletedAt": null,
      "author": "http://localhost:7777/user/2"
    },
    {
      "id": 2,
      "msg": "hi Nisse",
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      "author": "http://localhost:7777/user/1"
    }
  ]
}
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    - No problems with duplicate message delivery when using HTTP idempotent methods.

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- The representation is in the HTTP body, the format could be for example JSON.
- The format is specified with the content-type HTTP header, for example application/json.
- Different clients can use different formats.

Stateless Communication

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- Means that, if the application has more than one server, any server can serve any request from any client.

Hypermedia as the Engine of Application State, HATEOAS

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- Since all resources are addressable, links to them can be embedded in representations, see the example on the Addressable Resources slide above.
- This, together with the Constrained Interface and Representation-Oriented principles, leads to object graphs in message bodies.

HATEOAS, Cont'd

- Consider an HTTP body consisting of a chat message:

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  - All objects have the methods **`get`**, **`post`**, **`put`** and **`delete`**.
- This is object-oriented HTTP.

Section

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  - Serve static files (html, css, images, etc).
  - Make security checks, for example if the user is logged in, before handling a request.
- Thus, it is mandatory to use a web application framework in order to not write infrastructure code.

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- Very widely used and very actively maintained.

Install Express

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- Add express to the **`dependencies`** object in **`package.json`**

  ```
  "express": "^4.17.1"
  ```

  `^4.17.1` means any 4.x version bigger than 4.17.1, which is the current version when this presentation is written.

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  ```
  "express": "^4.17.1"
  ```

  `^4.17.1` means any 4.x version bigger than 4.17.1, which is the current version when this presentation is written.
- Install by executing the command **`npm install`** in the project root, the directory where **`package.json`** is located.

The First Express App

```
1 const express = require('express');
2 const app = express();
3 const port = 8001;
4
5 app.get('/', (req, res) =>
6   res.send('Server is up'));
7
8 app.listen(port, () =>
9   console.log(`Server running at ${port}!`));
```

- Line 1 loads express.

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```

- Line 1 loads express.
- Line 2 creates an express application.
- The call to **`app.get`** on line 5 tells express that an HTTP GET request to the path **`/`** shall execute the callback function **`(req, res)=> res.send('Server is up')`**

The First Express App, Cont’d

```
1  const express = require('express');
2  const app = express();
3  const port = 8001;
4
5  app.get('/', (req, res) =>
6    res.send('Server is up'));
7
8  app.listen(port, () =>
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```

- Line 6 calls the method **`send`** in the **`res`** object.

The First Express App, Cont'd

```
1  const express = require('express');
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3  const port = 8001;
4
5  app.get('/', (req, res) =>
6    res.send('Server is up'));
7
8  app.listen(port, () =>
9    console.log(`Server running at ${port}!`));
```

- Line 6 calls the method **`send`** in the **`res`** object.
- The **`res`** object represents the HTTP response, the **`send`** method sends an HTTP response containing only the specified string.

The First Express App, Cont'd

```
1 const express = require('express');
2 const app = express();
3 const port = 8001;
4
5 app.get('/', (req, res) =>
6   res.send('Server is up'));
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8 app.listen(port, () =>
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```

- The call to **`app.listen`** on line 8 makes the server listen for http requests on the specified port.

The First Express App, Cont'd

```
1  const express = require('express');
2  const app = express();
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4
5  app.get('/', (req, res) =>
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8  app.listen(port, () =>
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```

- The call to **`app.listen`** on line 8 makes the server listen for http requests on the specified port.
- The callback function on line 9 is executed when the server has started.

A Word About Nodemon

- nodemon is a utility that monitors the files in a web application and restarts the application if any file changes.

A Word About Nodemon

- nodemon is a utility that monitors the files in a web application and restarts the application if any file changes.
- In **`package.json`**, the server is started by executing

  ```
  nodemon.js ./scripts/server
  ```

- Installation is as usual with npm, add nodemon to the dependency section in **`package.json`** and execute **`npm install`**.

The Express Objects

- The express framework consists of the four objects **`application`**, **`request`**, **`response`** and **`router`**.

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The Express Objects

- The express framework consists of the four objects **`application`**, **`request`**, **`response`** and **`router`**.
    - Application represents the entire app, and is used to route HTTP requests to JavaScript functions.
    - Request represents the HTTP request, and is used to get information about the request.
    - Response represents the HTTP response, and is used to send a response.
    - Router is like a mini-application, which can contain its own HTTP request to JavaScript function mappings. The entire router object is mapped to a URL by the **`application`** object.

The `Application` Object, Routing

- We have seen how a HTTP GET was mapped to the root, `/`, by calling

```
app.get('/', (req, res) => //handle request)
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The `Application` Object, Routing

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```
app.get('/', (req, res) => //handle request)
```

- Any request using HTTP GET, POST, PUT or DELETE, can be mapped to any URL in the same way.
- For example, a POST request is mapped to the URL **`/abc/def`** by calling

```
app.post('/abc/def', (req, res) => // ...)
```

The **`Application`** Object, Middleware

- A middleware function performs some action before a request is passed to its request handling function.

The **`Application`** Object, Middleware

- A middleware function performs some action before a request is passed to its request handling function.
- Typically used for non-functional requirements, for example logging or security.

The **Application** Object, Middleware, Cont'd

```
app.use((req, res, next) => {
  console.log(
      neq Date().toLocaleTimeString() + ': ' +
      req.method + ' ' + req.originalUrl +
      ' from ' + req.ip
  );
  next();
});
```

- A middleware function is registered by calling **app.use**. The example above registers a function that logs all HTTP requests.

The **Application** Object, Middleware, Cont'd

```
1 app.use((req, res, next) => {
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- A middleware function is registered by calling **`app.use`**. The example above registers a function that logs all HTTP requests.
- Note the call to **`next()`** on line 7. That is when the request handling function (or next middleware function) is invoked.

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```

- A middleware function is registered by calling **`app.use`**. The example above registers a function that logs all HTTP requests.
- Note the call to **`next()`** on line 7. That is when the request handling function (or next middleware function) is invoked.
- Without a call to **`next`**, the request handling is terminated when the middleware function returns.

The **`Request`** Object, Parameters

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The **Request** Object, Parameters

- The **request** object is used to get information about the request.
- The logging middleware function above illustrated how to get for example the HTTP method and the URL of the request.
- When writing a REST API, it is common to include a resource id as a part of the URL. An HTTP GET to the URL **/user/2** means to read the suer with id 2.
- To extract such a parameter, the **request** object is used as below.

```
app.get('/user/:id', (req, res) =>
  res.send('The id is ' + req.params.id));
```

The **Request** Object, Body

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The **Request** Object, Body

- When the user is uploading a new state of a resource, for example by creating a new message in a chat, that new state might be in the request body.
- Neither node itself, nor express, parses body data. We need an npm package that handles the parsing.
- The sample application uses the package **`body-parser`**, as illustrated on the next slide.

The **Request** Object, Body, Cont'd

```
1  const bodyParser = require('body-parser');
2  app.use(bodyParser.json());
3
4  app.post('/msg', (req, res) =>
5    res.send('The body is ' + req.body.msg));
```

- Line one loads the body-parser package.

The `Request` Object, Body, Cont'd

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1  const bodyParser = require('body-parser');
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5    res.send('The body is ' + req.body.msg));
```

- Line one loads the body-parser package.
- Line two registers a middleware function that can parse bodies in JSON format. The parser will add the parsed objects to the express **`request`** object.

The **Request** Object, Body, Cont'd

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```

- Line one loads the body-parser package.
- Line two registers a middleware function that can parse bodies in JSON format. The parser will add the parsed objects to the express **request** object.
- If the request body contained an variable named **msg**, that object is contained in the parameter **req.body.msg**, on line five.

The **Response** Object

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  - The default status code is 200 (OK).
- The HTTP status code can be changed by calling **res.status**.
- If the response has no body, terminate the response by calling **end**.

```
app.get('/', //status is 404, body is empty
  (req, res) => res.status(404).end());
app.get('/', //status is 200, body is empty
  (req, res) => res.end());
```

The **Response** Object, Cont'd

- If the body shall be in JSON format, as is normally the case in a REST API, use the method **json** instead of **send**.

```
app.get('/',
        (req, res) =>
           res.json({param1: 'abc123'}));
```

- If the name of a JSON object property can not be hardcoded, use square bracket notation for a computed property name.

```
const propName = 'param1';
app.get('/',
        (req, res) =>
          res.json({[propName]: 'abc123'}));
```

The **Router** Object

```
const express = require('express');

const msgApi = express.Router();
msgApi.get('/:id', (req, res) =>
  res.send('returning msg ' + req.params.id)
);
msgApi.delete('/:id', (req, res) =>
  res.send('deleted msg ' + req.params.id)
);

app.use('/msg', msgApi);
```

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- A router can be considered a mini-application, containing only middleware and request handlers.
- Can make the code easier to read, by grouping related request handlers.
- The example above creates an API for message handling on lines 3-9, and adds the API to the application on line 11.

Section

Cookies

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- This is often solved with cookies.
- A cookie is a name/value pair passed between browser and server in the HTTP header.
- A cookie is only passed to the server from which it originated.

Cookies and REST

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- How to handle authentication in a REST API has been debated a lot.
- The problem is that if there shall be no state stored on the server, then all state, including proof of authentication, must be included in each request.
  - Including the user's credentials in each request brings a security risk, since then the credentials must be managed by the client.
  - There is good overview of this problem at `http://cryto.net/~joepie91/blog/2016/06/13/stop-using-jwt-for-sessions/`

Cookies and REST, Cont'd

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- The client must then include that token in the `Authorization` HTTP header of each request.
- However, also a cookie is passed as an HTTP request header. Therefore, it is not worse, from a REST point of view, to pass the token in a cookie. Using a cookie facilitates client side handling.

Cookies and REST, Cont'd

- An often used compromise is to return a token identifying the user to a client that has authenticated.
- The client must then include that token in the `Authorization` HTTP header of each request.
- However, also a cookie is passed as an HTTP request header. Therefore, it is not worse, from a REST point of view, to pass the token in a cookie. Using a cookie facilitates client side handling.
  - This solution is very common, and is also used in the course.

Cookies and REST, Cont’d

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Cookies and REST, Cont'd

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- We could also argue that we have better control over the "session" handling, we are for example free to choose format of the token.

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- In reply, we can claim that we are now free to place the token also in the `Authorization` header, which is required in some cases.
- We could also argue that we have better control over the "session" handling, we are for example free to choose format of the token.
- And so the debate continues...

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- **`name`** and **`value`** is the cookie's name/value pair.
- **`expire`** tells the instant in time when the cookie expires. Setting it to zero creates a session cookie, which means it should be discarded when the browser is closed.
  - However, web browsers may use session restoring, which means session state, including cookies, is not discarded.

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  - Registers a middleware function that retrieves all cookies in the HTTP request and stores them in the object `request.cookies`.
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To Retrieve a Cookie

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  - Registers a middleware function that retrieves all cookies in the HTTP request and stores them in the object `request.cookies`.
- The following code registers the `cookie-parser` middleware.

```
const cookieParser =
  require('cookie-parser');
app.use(cookieParser());
```

- The following code retrieves the cookies with the name **`cookieName`**.

```
const theCookie = req.cookies.cookieName;
```

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- If many servers set the same third party cookie, the third party server can track the user’s surfing.
- Typically used for marketing.
- There are many other ways, beside cookies, to identify a user for tracking purposes.
  - Flash, Silverlight and HTML5 storages
  - HTML5 canvas painting
  - content of caches and cache tags like Last-Modified or ETag
  - social networks
  - fingerprinting mechanisms like supported ciphersuites, DNS content, HTTP headers, plugins and fonts, clock drift, CPU and GPU benchmarks, network level information, user behavior

The EU Cookie Law

A person shall not store or gain access to information stored, in the terminal equipment of a subscriber or user unless the requirements of paragraph (2) are met.

(2) The requirements are that the subscriber or user of that terminal equipment

1. is provided with clear and comprehensive information about the purposes of the storage of, or access to, that information; and
2. has given their consent.

Exceptions To The Law

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- The cookie is for the sole purpose of carrying out the transmission of a communication over an electronic communications network.
    - Not relevant here.
- The cookie is strictly necessary for the provision of an information society service requested by the subscriber or user.
    - Applies to for example shopping baskets and authentication in an internet bank.

General Data Protection Regulation, GDPR

A data subject's (user's) personal data may be handled **only** if one of the following conditions apply. (From `https://gdpr.eu/what-is-gdpr/`)

- The data subject gave you specific, unambiguous consent to process the data. (e.g. **They have opted in to your marketing email list**.)

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- Processing is necessary to execute or to prepare to enter into a contract to which the data subject is a party. (e.g. **You need to do a background check before leasing property to a prospective tenant**.)
- You need to process it to comply with a legal obligation of yours. (e.g. **You receive an order from the court in your jurisdiction**.)

General Data Protection Regulation, GDPR, Cont'd

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- You need to process the data to **save somebody's life**. (e.g. Well, you'll probably know when this one applies.)
- Processing is necessary to perform a task in the public interest or to carry out some official function. (e.g. **You're a private garbage collection company**.)

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A data subject's (user's) personal may be handled **only** if one of the following conditions apply. (Text from `https://gdpr.eu/what-is-gdpr/`)

- You need to process the data to **save somebody's life**. (e.g. Well, you'll probably know when this one applies.)
- Processing is necessary to perform a task in the public interest or to carry out some official function. (e.g. **You're a private garbage collection company**.)
- You have a legitimate interest to process someone's personal data. This is the most flexible lawful basis, though the "fundamental rights and freedoms of the data subject" always override your interests.

General Data Protection Regulation, GDPR, Cont'd

A data subject's (user's) consent to handle their private data (first condition above) must follow these rules. (Text from `https://gdpr.eu/what-is-gdpr/`)

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Do Not Track Specification

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Question 1

Section

- Client-Side Instead of Server-Side Rendering
- A REST API
- The framework Express.js
- Cookies
- HTTP Sessions
- Authentication
- Scopes
- Other Npm Packages in the Chat Application
- Architecture

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  - Creates and maintains a session tracking id (Unique ID, UID), for each visitor, and sets a cookie containing that id.
  - Uses the same session id to identify a user's session data on the server.

No Sessions in a REST API

- As explained in the sections on a REST API and on cookies, we shall not use sessions because REST requires the app to be stateless.

Section

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- Once a user is authenticated, it is necessary to recognize requests from that particular user. Otherwise, the user would have to authenticate at each request.
- Authenticating at each request brings a security risk, because then the password must somehow be managed by the client.

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- JWT guarantees integrity, the content of a JWT can not be altered without revealing that it is altered.
- It is common solve the problem of recognizing an authenticated user by placing a JWT in a cookie.

The Anatomy of a JWT

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- The signature is computed by a signing algorithm, and is based on the header, the payload, and a secret known only to the issuer and to those verifying the JWT.
- To verify that the content of a JWT has not been altered, the signature is re-calculated and compared to the signature in the JWT.

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  - iat means issued at and tells when the JWT was created.
  - exp means expiration time and defines a time after which the JWT must not be accepted.

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- A JWT is created with the **`sign`** method, as below.

```
const jwt = require('jsonwebtoken');

const jwtToken = jwt.sign(
  {id: user.id, username: user.username},
  'this is the secret used to sign the JWT',
  {
    expiresIn: '30 minutes',
  }
);
```

To Read a JWT

- A JWT is read with the **`verify`** method, as below.

```
const jwt = require('jsonwebtoken');

const cookieContent = req.cookies.chatAuth;
const JWTPayload = jwt.verify(
  cookieContent,
  'this is the secret used to sign the JWT'
);
```

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- To releave the user of having to log in again and again, the user's real login expiry time is stored in the database. If the JWT expires, but the logout period in the database has not expired, a new JWT is created without forcing the user to re-login.
- This also makes it possible to log out the user programmatically, by setting the user's database status to **`not logged in`**.

But Isn't That an HTTP Session?

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- "Sure, but now we can ...", see the discussion on REST authentication above.

Section

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- The scope of an object in a web application can be a tricky issue, since the application executes an HTTP request, send an HTTP response, and then stops executing.
- When it starts from the beginning with the next request, what remains of objects that were created during the previous request handling?
- An advantage of a REST application like the sample application, is that it has just two scopes, that are easy to understand.

Application Scope

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  - Session scope objects live during one HTTP session, and are shared by all requests from all windows of the same browser on the same computer.
  - Tab scope objects live during the existence of one browser tab in one HTTP session, and are shared by all request from that tab.

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- Chains of exceptions, using a **`cause`** property the same way the **`rootCause`** property is used in Java.
- Different levels of information, by adding an **`info`** property which may contain an object with additional information about the exception.

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  - An environment variable is a named value, set in the operating system, that can be read by a processes on the computer.
  - All operating systems handle environment variables.

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- Most important, it helps avoid leakage of secrets. If a password is present in source code, there is a big risk it is revealed when the source code is made public.
- It is independent of languages and frameworks.
- Configuration is clearly separated from the app itself.

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- The env var settings should be managed by some product completely independent of the app.

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- This way there is no config at all in the source code, but unfortunately it is the app itself that creates environment variables.

Configuration With Dotenv-Safe, Cont'd

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  - **`.env.example`** now serves as documentation, illustrating which variables must be set.

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- Copy `.env` to a file called `.env.example`, but do not include the value of any setting in that file.
    - `.env.example` now serves as documentation, illustrating which variables must be set.
    - Also, `dotenv-safe` will check that all variables in `.env.example` are set in `.env`, and throw an exception if some setting is forgotten.

Reading an Env Var

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- **`ENV_VAR_NAME`** shall be the name of the env var.

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  - To make express deliver files in the directory **`public`**, include the statement below.

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  - Note that **`public`** is now the root directory for the server's static files. An HTTP get request for **`/abc/def.png`** will make the server look for the file **`public/abc/def.png`**

Section

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- All configuration files
  - **`.env`** and **`.env.example`** for settings used in our own code
  - **`package.json`** and **`package-lock.json`** for settings needed by npm.
  - It might be a better structure to place config files in a separate directory, **`config`**, but it is not obvious how to make npm look for **`package.json`** in another directory.

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        - It could be argued that login is behavior that should be placed in a class **`User`** in the model.

Layers, Cont’d

- There are the following layers, continued.
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Layers, Cont'd

- There are the following layers, continued.
  - Integration is responsible only for calling the datastore, since there are no other external systems.
  - Data contains a very simple datastore, consisting only of two arrays. It will be replaced by a real database later in the course.

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    - The only class in **`auth`** is **`Authorization`**, which forms a procedural api (no state, only static methods).
  - util, containing general utility classes, which in this case means only **`Logger`**.
  - It is convention to place the file **`server`**, which starts the entire application, directly in the source code root, which is **`src`** in this application.

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- A DAO shall be located in the integration layer.
- It shall not call any other layer, except the `data` layer, but can of course use DTOs.
- It shall not contain business logic.
- Its public interface meets the needs of client objects in controller and model, and is independent of the database.

DAO Example

```
class ChatDAO {
  findUserByUsername(username) {
    // Database-related code.
  }

  findUserById(id) {
    // Database-related code.
  }

  updateUser(user) {
    // Database-related code.
  }

  createMsg(msg, author) {
    // Database-related code.
  }

  findAllNotDeletedMsgs() {
    // Database-related code.
  }

  deleteMsg(id) {
    // Database-related code.
  }
}
```

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- DAO provides high cohesion since all database access code is collected in the DAO, instead of being mixed with other code.
- DAO provides encapsulation since no object outside the DAO will know the design of the database or database calls.
- It decouples other layers from the database, since the public interface of the DAO is adapted to the need of other layers, not to the database.

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- For clarity, try to be consistent. Use either classes, function objects, or no objects at all. Try not to mix.
- The sample application is an effort to use classes as much as possible, at almost any cost.
  - Increases cohesion and, only to some extent since class support is poor, reduces coupling and improves encapsulation.

Classes or no Classes?, Cont'd

- Create one file for each class, to improve readability and cohesion.

Classes or no Classes?, Cont'd

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- Where classes can not be used, it is still important that all code in the same file together performs only one task, which must have high cohesion.

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    - Just like the **`main`** method in a Java program, it shall be as short as possible.
    - It loads all required packages and all endpoints in the REST API.
    - When loading is done, it makes the server listen for requests.

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- In order to still use the advantages of classes in the api layer, **`MsgApi`** and **`UserApi`** are classes with a method, **`registerHandlers`**, which defines the anonymous request handling functions.
- Next question is, who calls **`registerHandlers`** in all api classes? It is not the task of **`server`** to know the internals of the **`api`** layer.

Request Handlers, Cont'd

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- Note that, with the statement below, **`server`** requires the **`api`** directory, not any class in that directory.

```
const reqHandlerLoader = require('./api');
```

Request Handlers, Cont’d

- To encapsulate the request handling classes (**`MsgApi`** and **`UserApi`**), the file **`index`** is created in **`api`**.
- Note that, with the statement below, **`server`** requires the **`api`** directory, not any class in that directory.

```
const reqHandlerLoader = require('./api');
```

- Requireing a directory means that the **`index.js`** file in that directory is executed.

Request Handlers, Cont'd

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Request Handlers, Cont'd

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- In the sample app, **MsgApi** and **UserApi** are passed explicitly to **RequestHandlerLoader**, with the statements below.

```
const loader = new RequestHandlerLoader();
loader.addRequestHandler(new UserApi());
loader.addRequestHandler(new MsgApi());
```

Request Handlers, Cont'd

- **`index`** defines a class, **`RequestHandlerLoader`**, whose task is to call **`registerHandlers`** in all classes defining request handling functions.
- In the sample app, **`MsgApi`** and **`UserApi`** are passed explicitly to **`RequestHandlerLoader`**, with the statements below.

```
const loader = new RequestHandlerLoader();
loader.addRequestHandler(new UserApi());
loader.addRequestHandler(new MsgApi());
```

- The code would be more flexible, but slightly more complicated, if **`RequestHandlerLoader`** instead listed all classes in the **`api`** directory, and assumed that for example all classes with names ending in **`Api`** contained request handling functions.