Organisatorisches

- 30.06.2019 (So) - Übungsabgabe
- 21.07.2019 (So) - Abgabe Projekte
- 23.07.2019 (Di) 10:00 - 13:00 Uhr – Abschlusspräsentationen

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Praktikum Mobile und Verteilte Systeme

Client Server Communication

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Sommersemester 2019

Today

Basics

1. Communication models
2. TCP and HTTP basics
3. RESTful API architectures
4. WebSockets
5. REST VS Websockets

6. Implementation for your Apps

Communication models – Client Server

Examples

- **Smartphones**
  Client: (Android) App
  Server: Webserver (e.g. Apache)
  Protocol: HTTP(S)

- **WWW**
  Client: Webbrowser (e.g Firefox)
  Server: Webserver (e.g. Apache)
  Protocol: HTTP(S)

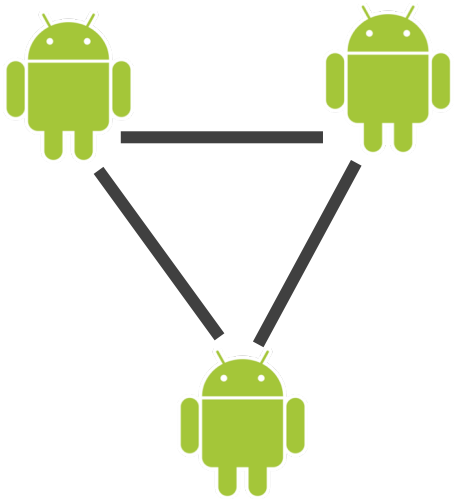
- **E-Mail**
  Client: Mailclient (e.g. Outlook)
  Server: Mailserver (e.g. MS Exchange)
  Protocol: POP, IMAP, SMTP, …

Communication models – P2P

Examples

- **Filesharing**
  Peer: BitTorrent-Client (e.g µTorrent)
  Protocol: BitTorrent

- **Cryptocurrency**
  Peer: Bitcoin-Wallet (e.g. Bitcoin Core)
  Protocol: Bitcoin-Protocol



ISO/OSI Model

ISO/OSI Layer		Protocol	Comment
7	Application-Layer	HTTP, IMAP, BitTorrent	Defined message format, e.g plain-text ASCII for HTTP
5-6	Session & Presentation		
4	Transport-Layer	TCP, UDP	Using a socket, we send & receive streams of bytes
1-3	Physical & Data Link & Network		

ISO/OSI - Firefox Example

What does an application like Firefox do?

1: It opens a connection to a server using a **socket** (IP and Port)
→ **TCP Transport** Layer **4**

2: It talks to the server in a certain protocol
→ **HTTP Application** Layer **7**

3: It receives the response, parses, and displays it

Low-level example

1: Open a TCP connection in Netcat („nc“ on Linux) or telnet (on Windows)

```
$ nc google.de 80
```

Opens a TCP socket and lets you send bytes to the recipient (Layer 4)
A socket can be opened using an IP (or hostname) and a port.

Bad Low-level example

2: Send useless bytes, e.g. „hello!“

```
nc google.de 80
hello!
HTTP/1.0 400 Bad Request
Content-Type: text/html; charset=UTF-8
Referrer-Policy: no-referrer
Content-Length: 1555
Date: Mon, 29 Apr 2019 12:30:17 GMT
```

We did not conform to the protocol, so the server closed the connection.

Good Low-level example

2: Conform to the protocol

```
$ nc google.de 80
GET / HTTP/1.1

HTTP/1.1 200 OK
Date: Mon, 29 Apr 2019 12:22:03 GMT
Expires: -1
Cache-Control: private, max-age=0
Content-Type: text/html; charset=ISO-8859-1
```

We receive the response code 200, OK!

Why do we need protocols like HTTP?

Layer 4 communication using sockets is protocol agnostic.

→ It has no concept of URLs, Methods, …

→ It only knows bytes

If we want „higher-logic“ (access documents, execute actions),

➔ we need a protocol on top

```
$ nc google.de 80
```

Socket is open. To netcat everything that follows is just bytes

```
GET / HTTP/1.1
```

HTTP Protocol: Method (e.g. GET) followed by URI (e.g. /) followed by Protocol-Version (e.g. HTTP/1.1)

```
HTTP/1.1 200 OK
Date: Mon, 29 Apr 2019 12:22:03 GMT
Expires: -1
Cache-Control: private, max-age=0
Content-Type: text/html; charset=ISO-8859-1
```

Structuring application access with REST

REST (Representational State Transfer)

- Defined by Roy T. Fielding
  - Dissertation: “Architectural Styles and the Design of Network-based Software Architectures“ (2000)
  - main author of HTTP/1.0 and HTTP/1.1
  - co-founder of the Apache HTTP server project (**httpd**)

Important:

- **REST is an architectural style, not a protocol!**
- REST is simply a way to structure things, it is not limited to HTTP

Important architectural principles of REST

1. Everything is a **resource**
2. Communicate **statelessly**
3. Use a **common interface** for all resources
4. Resources can have **multiple representations**

REST principles I: Everything is a resource

- **Every data element** of an application that should be accessible **is a resource** with it's own **unique URI**
- The resource is not an actual object or service itself, but rather **an abstract interface** for using it
- Using **human-readable URIs** is common (yet not obligatory)

```
http://example.com/customers/1234
http://example.com/orders/2013/1/12345
http://example.com/orders/2013/1
http://example.com/products/4554
http://example.com/products?color=green
http://example.com/processes/salary-increase
```

REST principles II: Communicate statelessly

- All application state should either
  - be **turned into resource state**
  - or be **managed at the client**

- All **requests should be independent** from earlier requests
  - messages are **self-contained**, including all necessary information

- Advantages:
  - **scalability**
  - **isolation of the client** against changes on the server

REST principles III: Use a common interface

- REST demands the usage of **simple, uniform interfaces** for all resources
- When implementing REST using HTTP, we make use of the **HTTP verbs** (GET, POST, etc.)
- With REST, these verbs are mapped to resource-specific semantics

```
class Resource {                        // analogy to oo-programming
  Resource(URI u);                      // URI
  Response get();                       // HTTP GET
  Response post(Request r);             // HTTP POST
  Response put(Request r);              // HTTP PUT
  Response delete();                    // HTTP DELETE
}
```

REST principles IV: Multiple representations

- Resources can have **multiple representations**
  - provide multiple representations of resources for different needs
  - ideally, at least one standard format should be provided

- The selection of data formats is done **using HTTP content negotiation**

```
GET /customers/1234 HTTP/1.1
Host: example.com
Accept: application/xml
```

```
GET /customers/1234 HTTP/1.1
Host: example.com
Accept: application/json
```

- Advantages:
  - Multiple representations can be consumed via the same interface

REST-conformant usage of HTTP methods

- **HTTP GET**
  - Used for accessing the requested resource without any side-effects. A resource must never be changed via a GET request (read-only)!
- **HTTP PUT**
  - Used for creating or updating a resource at a known URI.
- **HTTP DELETE**
  - Used for removing a resource.
- **GET**, **PUT** and **DELETE** must be implemented as idempotent methods
  - can be called repeatedly without leading to different results
- **HTTP POST**
  - Update an existing resource or create a new one (not idempotent)

A simple example of a RESTful web service

- Mapping of “normal” method names to RESTful resource interfaces

Normal method name	URI (RESTful resource)	HTTP method
listOrders	/orders	GET
addNewOrder	/orders	POST
addNewOrder	/orders/12344	PUT
getOrder	/orders/12344	GET
deleteOrder	/orders/12344	DELETE
listCustomers	/customers	GET
getCustomer	/customers/beck	GET
addCustomer	/customers	POST
addCustomer	/customers/beck	PUT
updateCustomer	/customers/ebert	PUT
…		

Advantages of the RESTful approach

- **Simplicity**
  - well known interfaces (URIs, HTTP methods), no new XML specification
- **Lightweightness**
  - short messages, little overhead
- **Multiple representations**
- **Security**
  - authentication and authorization can be done by the web server
- **Scalability (e.g., multi-device usage / multiple servers)**
- **Reliability (e.g., on restoring state / recovering)**
- **Caching**
- **Easy service orchestration** (via hyperlinks)
  - URIs define global namespace, no application boundaries

Example REST API Request

```
curl -v https://jsonplaceholder.typicode.com/posts/1
*   Trying 2606:4700:30::6812:24a3...
* Connected to jsonplaceholder.typicode.com (2606:4700:30::6812:24a3) port 443 (#0)
```

Curl is opening the Layer 4 TCP connection
(same as `nc jsonplaceholder.typicode.com 443` would do)

```
> GET /posts/1 HTTP/2
> Host: jsonplaceholder.typicode.com
> User-Agent: curl/7.54.0
> Accept: */*

…

< HTTP/2 200
< date: Thu, 02 May 2019 12:22:43 GMT
< content-type: application/json; charset=utf-8
…
{
  "userId": 1,
  "id": 1,
  …
}
```

shows data sent by curl (only if curl is run in verbose mode `-v`)
GET (default) the resource at **/posts/1**

shows HTTP Header data received from the server

Here starts the http response body. In this case the resource
In json format

REST ist not the solution to everything

- What if the server should notify the client?
  E.g.: Chat-Application, …
- What if we need to continously send and receive data?
  E.g.: Video-Conference
- What if we need to be as fast as possible (low overhead)?
  E.g.: Online-Games

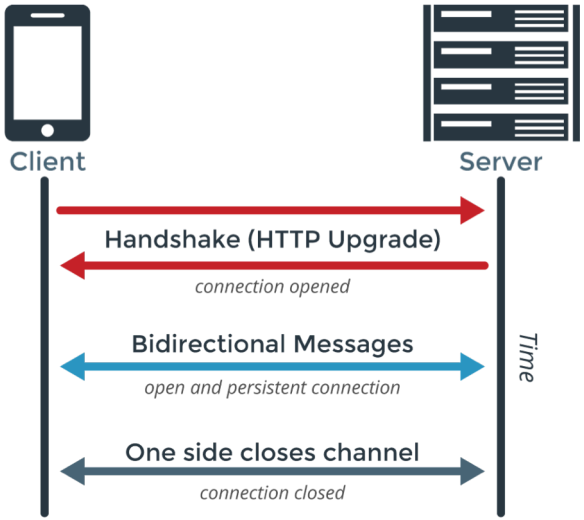
WebSockets for real-time communication

Open up a plain TCP socket connection as the solution?

→ Non-HTTP Communication is often blocked by Firewalls

→ You can‘t open a plain socket in your browser

➔ **WebSockets** for fast real-time communication between Server and Client



Source: https://www.pubnub.com/blog/2015-01-05-websockets-vs-rest-api-understanding-the-difference/

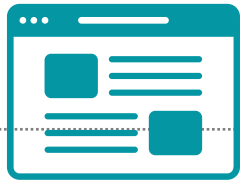
WebSockets

- TCP-based network protocol, standardized in 2011
- enables **bidirectional communication** between web applications and a WebSocket server
- **Client-server** as well as **Peer-to-peer** (P2P) usage is possible
- Server stays **always open** for communication and data may always be pushed to the client
- Good fit for high message frequencies, Ad hoc messaging and Fire-and-forget scenarios

Advantages of WebSockets

- **Two-Way communication**
  - Frequent updates **without regular polling**
  - no redundant creation of new TCP connections for every exchange
- **Lower overhead per message**
  - **TCP connection** is created only **once**
  - No need to send something like the HTTP-Header everytime
- **Stateful connections**
  - Without sending cookies or session Ids with every request
  - Server side handling of **complex application states** possible

When to use REST APIs



→ For retrieving single resources

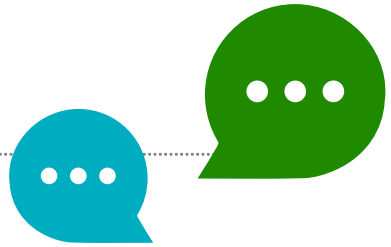
→ Stateless communication,
application state is handled on client side

→ No frequent updates needed

→ Idempotency enables **cachable** resources

→ Handling of **synchronized communication**

When to use WebSockets



→ **Fast, high frequent updates** needed with small payloads

→ Complex application state can be handled on server side

→ **Fire-and-forget** scenarios

→ Constantly **changing states** (e.g., game state)

→ Distribution of application state to **multiple clients**

Client-Server Implementation

Option 1

- Implement everything above Layer 4 yourself!

Option 2 

- Use one of the various frameworks or a programming language that provides out-of-the-box support.

Frameworks and BaaS

Frameworks

Backend As A Service

The Spring Framework

- Open-Source framework for Java and JavaEE development
- Probably the most widely used enterprise web framework
- Capable of WebSocket as well as RESTful communication
- Easy and fast server setup for client-server communication

Creating a Spring Server

Install an IDE for java programming: **IntelliJ**

- Download of the community version at:
  - https://www.jetbrains.com/idea/
- If you choose the version without JDK, make sure that the latest Java Runtime Environment (JRE) and Java Software Development Kit (JDK) are installed
  - http://openjdk.java.net
  - http://www.oracle.com/technetwork/java/javase/downloads/index.html
- JDK and JRE must be known to your machine‘s runtime environment
  - i.e. **JAVA_HOME environment variable must be set**

  On Debian based systems: **update-alternatives --display javac**

  Add the path (without /bin) shown in the following line to your ~/.bashrc then logout/login again
  Example:

  export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64
- Spring can use maven or gradle for build management
- Install gradle. On Debian based systems (Ubuntu etc.):
  - **sudo apt-get install gradle**

Gradle Build Manager

- Automated **dependency management** and **build automation**
- Based on *Apache Ant* and *Apache Maven*
- Uses *Groovy*-based domain-specific language (DSL)
- Dependency configuration within the `build.gradle` file e.g.:

```
buildscript {
    repositories {
        mavenCentral()
    }
    dependencies {
        classpath("org.springframework.boot:spring-boot-gradle-plugin:1.5.5.RELEASE")
    }
}
apply plugin: 'java'
apply plugin: 'org.springframework.boot'

jar {
    baseName = 'yourExampleApplication'
    version =  '0.1.0'
}
sourceCompatibility = 1.8
targetCompatibility = 1.8

dependencies {
    compile("org.springframework.boot:spring-boot-starter-web")
    testCompile('org.springframework.boot:spring-boot-starter-test')
}
```

WATCH YOUR build.gradle **CODE e.g. buildscript** must be the first function

Gradle Build Manager

- By default assumes **Maven directory structure** for **Java sources** and **resources**
- These directories are:
  - src/main/java
  - src/main/resources
  - src/test/java
  - src/test/resources
- Simplest build.gradle for a basic java project

```
apply plugin: 'java'
```

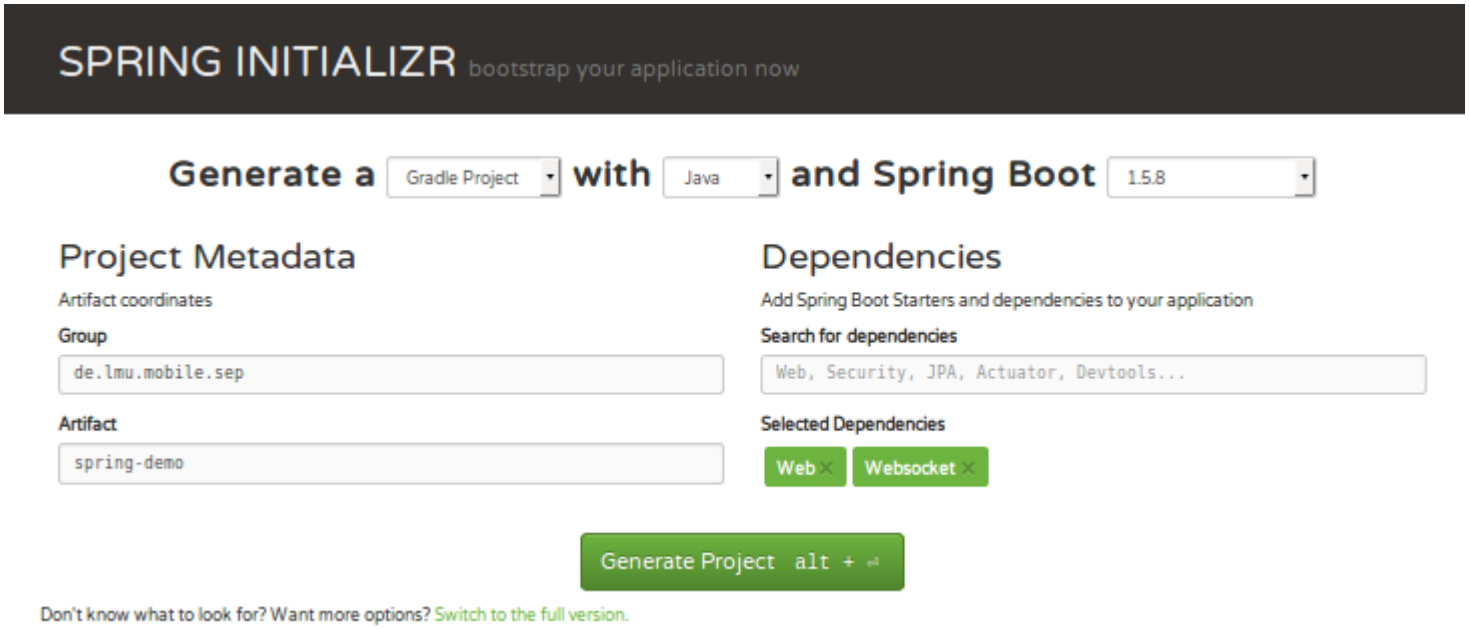
Running **gradle build** has the effect of:

```
> gradle build
:compileJava
:processResources
:classes
:jar
:assemble
:compileTestJava
:processTestResources
:testClasses
:test
:check
:build

BUILD SUCCESSFUL
```

Using the Spring framework

- Use the online tool https://start.spring.io/ to generate an empty spring boot project. You can use it to get started quickly instead of manually setting up your src/main/java folders, build.gradle etc.
- Choose the dependencies you want to use in your project.
  - **Required: Web** Optional: **WebSocket**
- Choose a Group name: Usually your company‘s domain & department Convention: reverse url style e.g. de.lmu.mobile.sep
- Choose an Artifact name (The name of your application)



Using the Spring framework

- Unpack the zip file
- Import the project into IntelliJ
  - Use „Import project from external model“: Gradle

- Tell IntelliJ which java SDK to use. Add the JDK which is available on your system.
- Now no more errors should be shown in IntelliJ
- Open the SpringDemoApplication in src/main/java/de/lmu/mobile/sep/springdemo

SpringDemoApplication.java

```
1   package de.lmu.mobile.sep.springdemo;
2
3   import org.springframework.boot.SpringApplication;
4   import org.springframework.boot.autoconfigure.SpringBootApplication;
5
6   @SpringBootApplication
7   public class SpringDemoApplication {
8
9       public static void main(String[] args) { SpringApplication.run(SpringDemoApplication.class, args); }
12  }
13
```

Start the application from IntelliJ – The server will listen on port 8080:
Run/Run ‚SpringDemoApplication‘
Or from the terminal: **gradle bootrun**
Or to build an executable, standalone jar to deploy on a server: **gradle build**

Using the Spring framework

SpringDemoApplication.java

```
1   package de.lmu.mobile.sep.springdemo;
2
3   import org.springframework.boot.SpringApplication;
4   import org.springframework.boot.autoconfigure.SpringBootApplication;
5
6   @SpringBootApplication
7   public class SpringDemoApplication {
8
9       public static void main(String[] args) { SpringApplication.run(SpringDemoApplication.class, args); }
12  }
13
```

- The class is marked for Spring as the launching class by using the annotation `@SpringBootApplication`
- Normally you don‘t need to add/modify anything else here
  - Other classes, controllers etc. are configured & started using annotations
- Spring uses Apache Tomcat by default as it‘s servlet/web server
- The used port is 8080 by default and optionally configurable within the *`application.properties`* file
  (create it if it doesn‘t exist in `/src/main/resources/`):

```
server.port = <port-number>
```

- You can now access the application at http://localhost:8080

REST with Spring

- Create a new class and annotate it with `@RestController`:

DemoController.java

```java
package de.lmu.mobile.sep.springdemo;

import org.springframework.web.bind.annotation.RequestMapping;
import org.springframework.web.bind.annotation.RequestParam;
import org.springframework.web.bind.annotation.RestController;

@RestController
public class DemoController{
    @RequestMapping("/hello")
    public String myHelloMethod(){
        return "Hello";
    }

    @RequestMapping("/hello2")
    public String myHelloMethod2(@RequestParam("a") String aParam, @RequestParam("b") int anotherParam){
        return "a: " + aParam + " b:" + (anotherParam+1);
    }
}
```

- `@RequestMapping` allows us to map a path to a specific REST resource
  - without specific request type definition, the annotated method is responsible for all incoming calls to the specified path (i.e., POST, GET, etc.)
  - HTTP methods may be routed to different java methods by adjusting the basic annotation (e.g., `@RequestMapping(method=GET, value="/hello")` for handling only GET requests)
- Due to the annotation, the REST controller runs automatically on application startup (no initialization within the main application is needed!)
- The REST interface is accessible via HTTP:
  - `http://localhost:8080/hello`
  - `http://localhost:8080/hello2?a=something&b=5`

REST with Spring

Automatic creation of JSON encoded resources from POJOs (plain-old-java-objects)

Spring can automatically serialize and deserialize java objects to json/xml etc.

- We can **return java objects** from the methods
- We can **receive serialized (json, etc.)** objects and spring automatically **deserializes** them into **java objects**

MyHelloObject.java

```java
package de.lmu.mobile.sep.springdemo;

public class MyHelloObject {

    private final String message;

    public MyHelloObject(String message) { this.message = message; }

    public String getMessage() {
        return message;
    }
}
```

DemoController.java

```java
package de.lmu.mobile.sep.springdemo;

import ...

@RestController
public class DemoController{

    private static final Logger logger = LoggerFactory.getLogger(DemoController.class);

    @RequestMapping("/hello-object")
    public MyHelloObject myHelloObjectMethod(){
        return new MyHelloObject("I am a java object");
    }

    @RequestMapping("/hello-receive-object")
    public MyHelloObject myHelloReceiveObjectMethod(@RequestParam("hello") MyHelloObject myObject){
        // write log
        logger.info("We received a "+myObject.getClass()+ " object with message "+myObject.getMessage());
        // echo it back to the client
        return myObject;
    }
}
```

- The returned object looks as follows: `{"message":"I am a java object"}`

WebSockets with Spring

- Check that the Spring libraries for websockets is included in build.gradle:

```
dependencies {
    …
    compile("org.springframework.boot:spring-boot-starter-websocket")
```

- Create a class which implements the WebSocketConfigurer

```
@Configuration
@EnableWebSocket
public class MyWebSocketConfigurer implements WebSocketConfigurer {

    @Override
    public void registerWebSocketHandlers(WebSocketHandlerRegistry registry) {
        //registry.addHandler(..) enables us to register a handler for a specific path
        WebSocketHandler handler = new MySocketHandler();
        registry.addHandler(handler, "/<pathname>" );
    }
}
```

- The annotations `@Configuration` and `@EnableWebSocket`:
  - indicate to Spring, that a web socket connection should be made available
  - ensure that our configurer class is launched automatically on server startup
- A `<pathname>` must be set at which the WebSocket connection is accessible
- Create and configure a Handler class for session and message handling

WebSockets with Spring

- Basically, we want our WebSocket handler to:
  - manage sessions (e.g. store incoming sessions, remove closed ones)
  - distribute messages among server and client sessions

```
public class MySocketHandler extends TextWebSocketHandler {

    private ArrayList<WebSocketSession> sessionQueue;

    @Override
    public void afterConnectionEstablished(WebSocketSession session) throws Exception {
        super.afterConnectionEstablished(session);
        // handle incoming sessions
    }

    @Override
    public void afterConnectionClosed(WebSocketSession session, CloseStatus status) throws Exception {
        super.afterConnectionClosed(session, status);
        // handle closed sessions
    }

    @Override
    public void handleMessage(WebSocketSession session, WebSocketMessage<?> message) throws Exception {
        super.handleMessage(session, message);
        // handle incoming messages, e.g., distribute them among target sessions
    }
}
```

Frameworks and BaaS

Frameworks

Backend As A Service

Node.js – Hello World

Once you have installed Node, let's try building our first web server. Create a file named "app.js", and paste the following code:

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

const hostname = '127.0.0.1';
const port = 3000;

const server = http.createServer((req, res) => {
  res.statusCode = 200;
  res.setHeader('Content-Type', 'text/plain');
  res.end('Hello World\n');
});

server.listen(port, hostname, () => {
  console.log(`Server running at http://${hostname}:${port}/`);
});
```

After that, run your web server using `node app.js`, visit http://localhost:3000, and you will see a message 'Hello World'

Node.js – Express Framework

```
var express = require('express');
var app = express();

app.get('/', function (req, res) {
  res.send('Hello World!');
});

app.listen(3000, function () {
  console.log('Example app listening on port 3000!');
});
```

Express Generator

- With the Express Generator, you can quickly bootstrap websites/-services.

```
$ npm install express-generator -g
```

```
$ express --view=pug myapp

   create : myapp
   create : myapp/package.json
   create : myapp/app.js
   create : myapp/public
   create : myapp/public/javascripts
   create : myapp/public/images
   create : myapp/routes
   create : myapp/routes/index.js
   create : myapp/routes/users.js
   create : myapp/public/stylesheets
   create : myapp/public/stylesheets/style.css
   create : myapp/views
   create : myapp/views/index.pug
   create : myapp/views/layout.pug
   create : myapp/views/error.pug
   create : myapp/bin
   create : myapp/bin/www
```

Express Routing

- RESTful routes can easily be created with Express

```
app.get('/', function (req, res) {
  res.send('Hello World!');
});
```

```
app.put('/user', function (req, res) {
  res.send('Got a PUT request at /user');
});
```

```
app.post('/', function (req, res) {
  res.send('Got a POST request');
});
```

```
app.delete('/user', function (req, res) {
  res.send('Got a DELETE request at /user');
});
```

Integrating socket.io

- Socket.IO is composed of two parts:
  - A server that integrates with the Node.JS HTTP Server: socket.io
  - A client library that loads on the browser side: socket.io-client

Server

```
var app = require('express')();
var http = require('http').Server(app);
var io = require('socket.io')(http);

app.get('/', function(req, res){
  res.sendFile(__dirname + '/index.html');
});

io.on('connection', function(socket){
  console.log('an user connected');
});

http.listen(3000, function(){
  console.log('listening on *:3000');
});
```

Integrating socket.io

Client – connect to socket

```
import com.github.nkzawa.socketio.client.IO;
import com.github.nkzawa.socketio.client.Socket;

private Socket mSocket;
{
    try {
        mSocket = IO.socket("http://chat.socket.io");
    } catch (URISyntaxException e) {}
}

@Override
public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    mSocket.connect();
}
```

Client send message

```
private EditText mInputMessageView;

private void attemptSend() {
    String message = mInputMessageView.getText().toString().trim();
    if (TextUtils.isEmpty(message)) {
        return;
    }

    mInputMessageView.setText("");
    mSocket.emit("new message", message);
}
```

Frameworks and BaaS

Frameworks

Backend As A Service

Google Firebase - BaaS

Authentication

Hosting

Cloud Storage

Cloud Firestore

Realtime Database

Cloud Functions

ML Kit BETA

Examples (1)

Authentication – Create a User

```
mAuth.createUserWithEmailAndPassword(email, password)
        .addOnCompleteListener(this, new OnCompleteListener<AuthResult>() {
            @Override
            public void onComplete(@NonNull Task<AuthResult> task) {
                if (task.isSuccessful()) {
                    // Sign in success, update UI with the signed-in user's information
                    Log.d(TAG, "createUserWithEmail:success");
                    FirebaseUser user = mAuth.getCurrentUser();
                    updateUI(user);
                } else {
                    // If sign in fails, display a message to the user.
                    Log.w(TAG, "createUserWithEmail:failure", task.getException());
                    Toast.makeText(EmailPasswordActivity.this, "Authentication failed.",
                            Toast.LENGTH_SHORT).show();
                    updateUI(null);
                }

                // ...
            }
        });
```

Examples (1)

Authentication – Sign in a User

```
mAuth.signInWithEmailAndPassword(email, password)
        .addOnCompleteListener(this, new OnCompleteListener<AuthResult>() {
            @Override
            public void onComplete(@NonNull Task<AuthResult> task) {
                if (task.isSuccessful()) {
                    // Sign in success, update UI with the signed-in user's information
                    Log.d(TAG, "signInWithEmail:success");
                    FirebaseUser user = mAuth.getCurrentUser();
                    updateUI(user);
                } else {
                    // If sign in fails, display a message to the user.
                    Log.w(TAG, "signInWithEmail:failure", task.getException());
                    Toast.makeText(EmailPasswordActivity.this, "Authentication failed.",
                            Toast.LENGTH_SHORT).show();
                    updateUI(null);
                }

                // ...
            }
        });
```

Documentation

Useful links

- Spring Documentation
  - https://docs.spring.io/spring-framework/docs/
  - https://spring.io/guides/gs/spring-boot/
- Spring REST Tutorial
  - https://spring.io/guides/gs/rest-service/
- Creating and configuring Gradle projects with IntelliJ
  - https://www.jetbrains.com/help/idea/gradle.html
- Spring Unit / Integration Testing
  - http://www.baeldung.com/integration-testing-in-spring
  - https://spring.io/guides/gs/testing-web/
  - https://joel-costigliola.github.io/assertj/

Useful links

- Node.js
  - https://nodejs.org/en/docs/
- ExpressJS
  - https://expressjs.com/de/4x/api.html
- Android Volley
  - https://developer.android.com/training/volley
- socket.io
  - https://socket.io/blog/native-socket-io-and-android/
- Firebase
  - https://firebase.google.com/docs/