Software Architectures and Containers

Front-End, Back-End, APIs, Microservices

Virtualization, Containers, Docker, Cloud

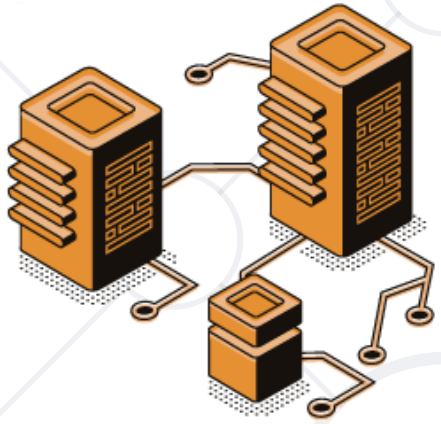

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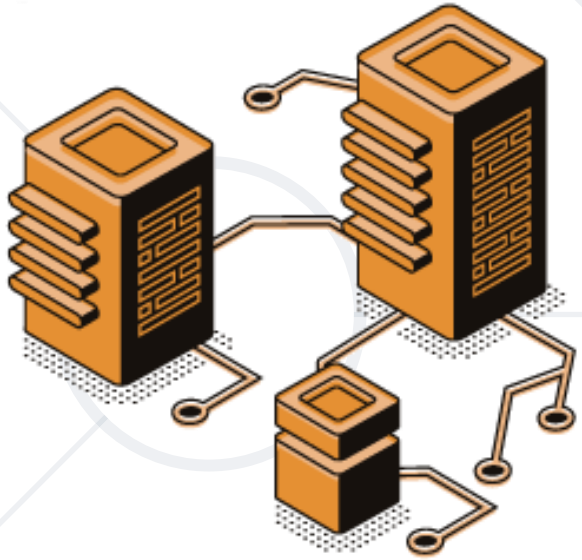
Table of Contents



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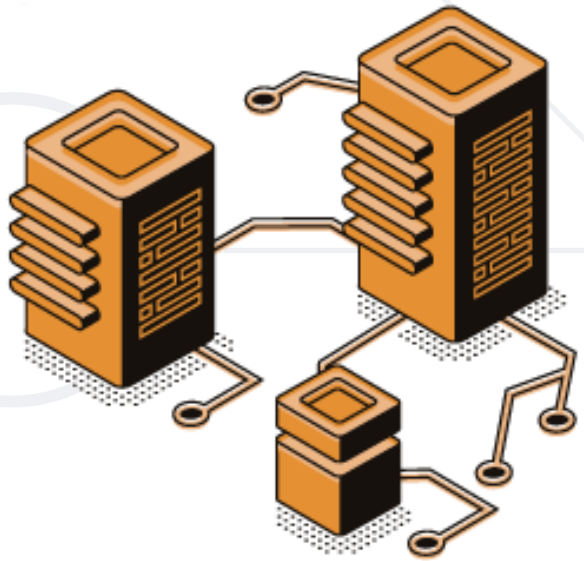
Software Architectures

Monolith, Client-Server, 3-Tier, Microservices

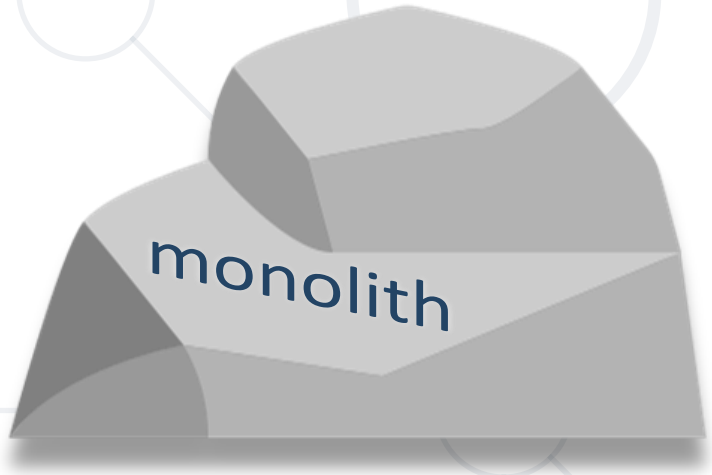
Software Architectures

- Software systems consist of **interconnected components** organized in certain structure called an **architecture**
- Concepts related to **software architectures**:
  - Monolith apps
  - Client-server model
  - Front-end and back-end
  - 3-tier and multi-tier architecture
  - SOA and microservices



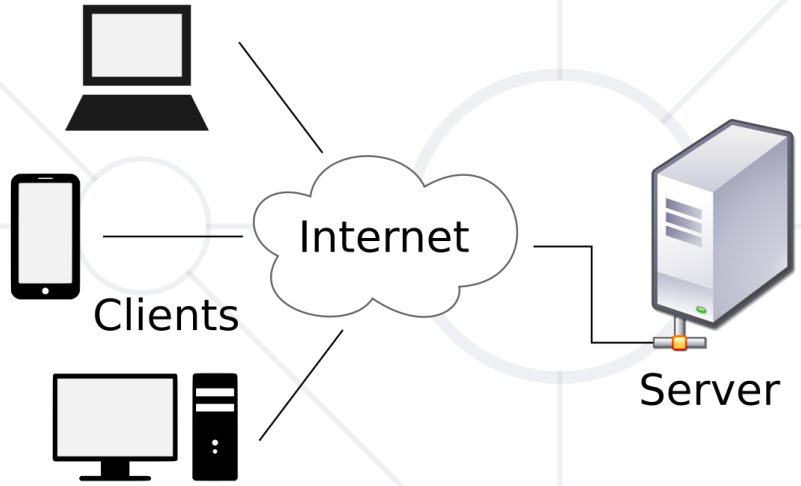
Monolith Apps

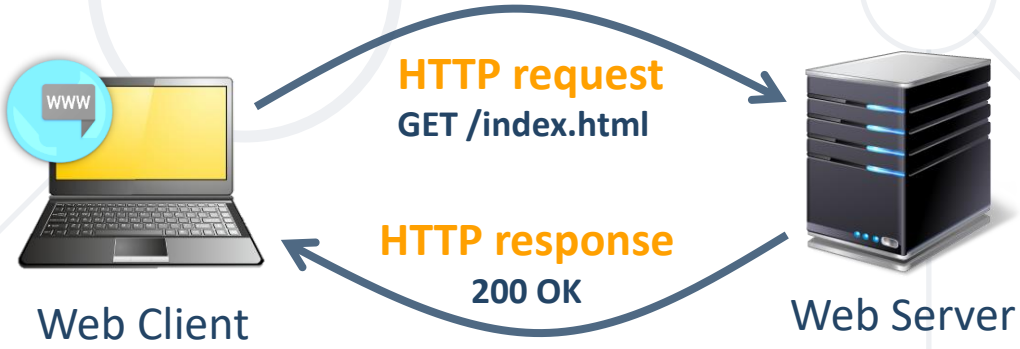
- **Monolith** apps
  - A **single application** holds its data, logic and user interface (UI)
  - **Single user** (no shared data access)
  - **Disconnected** from the Internet
  - App data is stored on the **local machine**
  - Examples:
    - A simple smartphone **game**
    - The **Notepad** text editor



The "Client-Server" Model

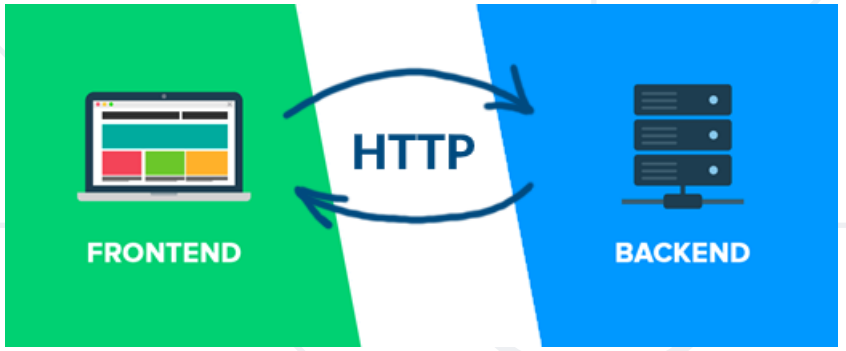
- The **client-server** architectural model
  - The **server** holds app data and logic and provides APIs to clients
  - The **clients** implement the UI (the **user interface**) and consume the server APIs
- Examples:
  - Web browser ↔ Web site
  - Email client ↔ Email server
  - Chat client ↔ Chat server





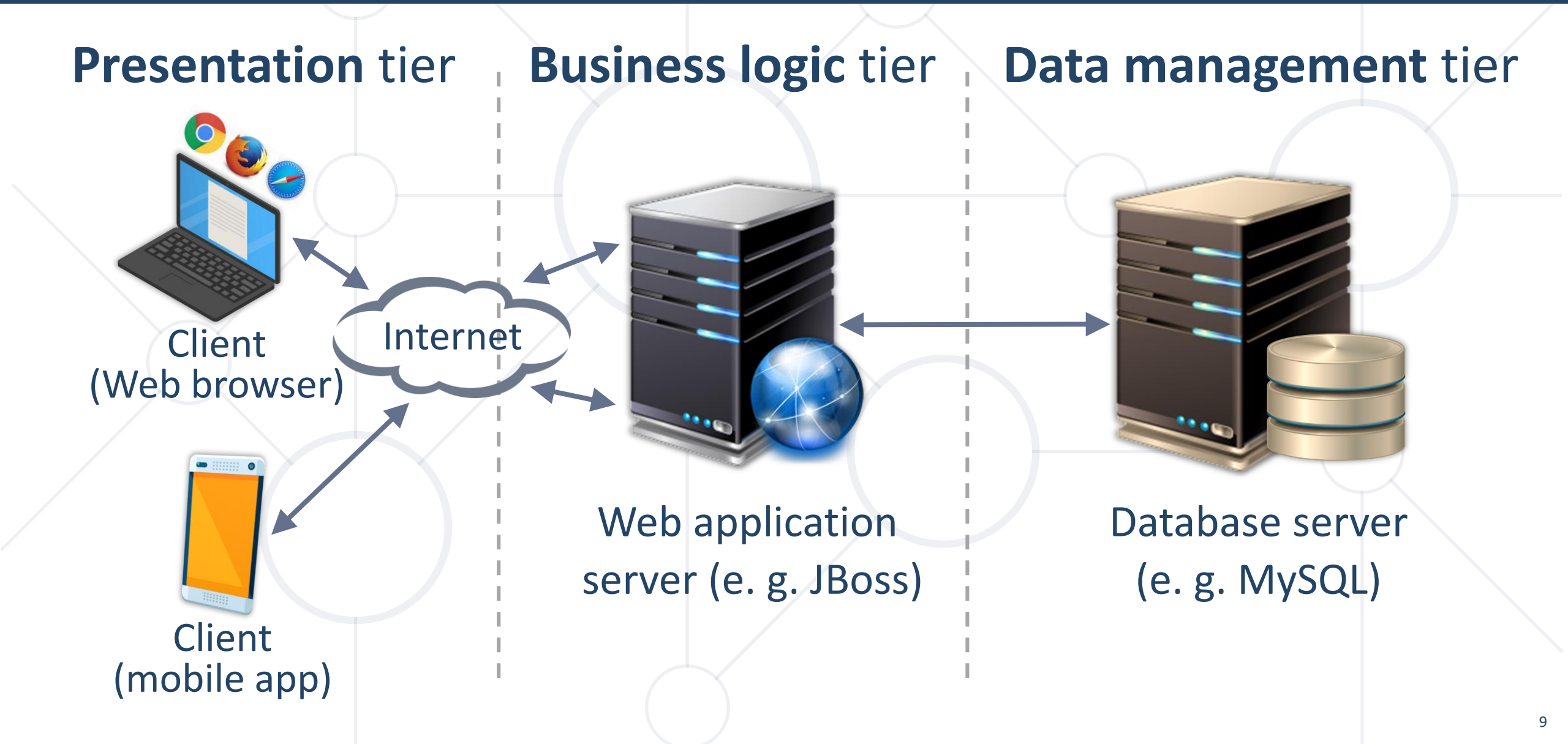
Front-End and Back-End

- **Front-end** and **back-end** separate the modern apps into **client-side** (UI) and **server-side** (data) components
- **Front-end** == client-side components (presentation layer)
  - Implement the **user interface** (UI)
- **Back-end** == server-side components (data and business logic APIs)
  - Implements **data storage and processing**

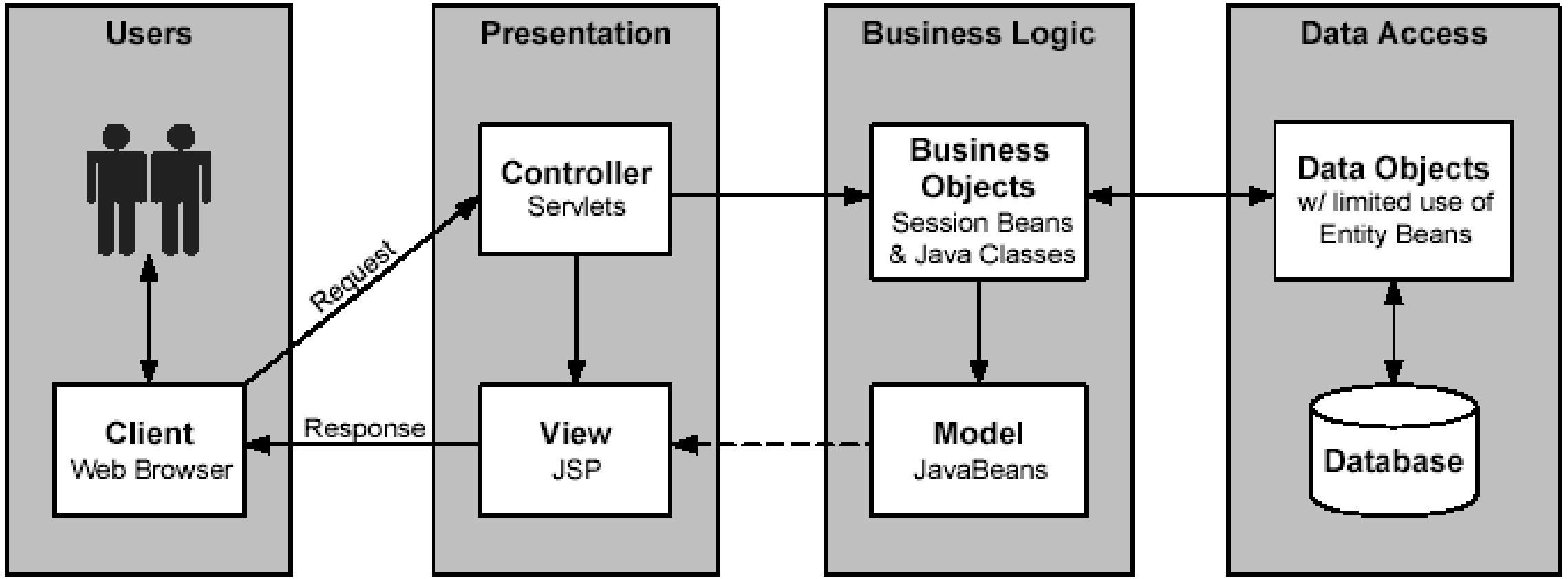


- **HTTP** connects front-end with back-end

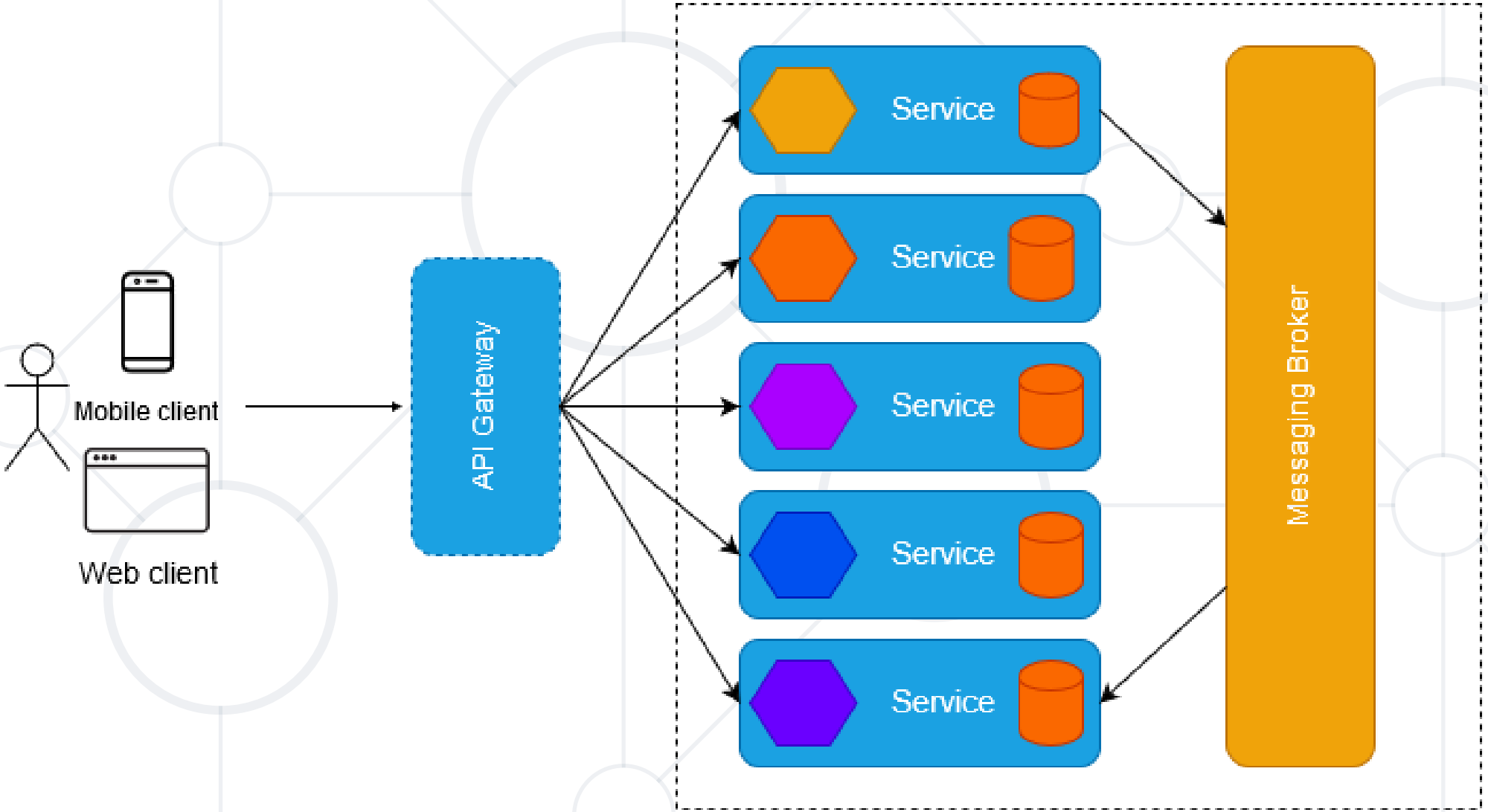
3-Tier Architecture / Multi Tier Architecture



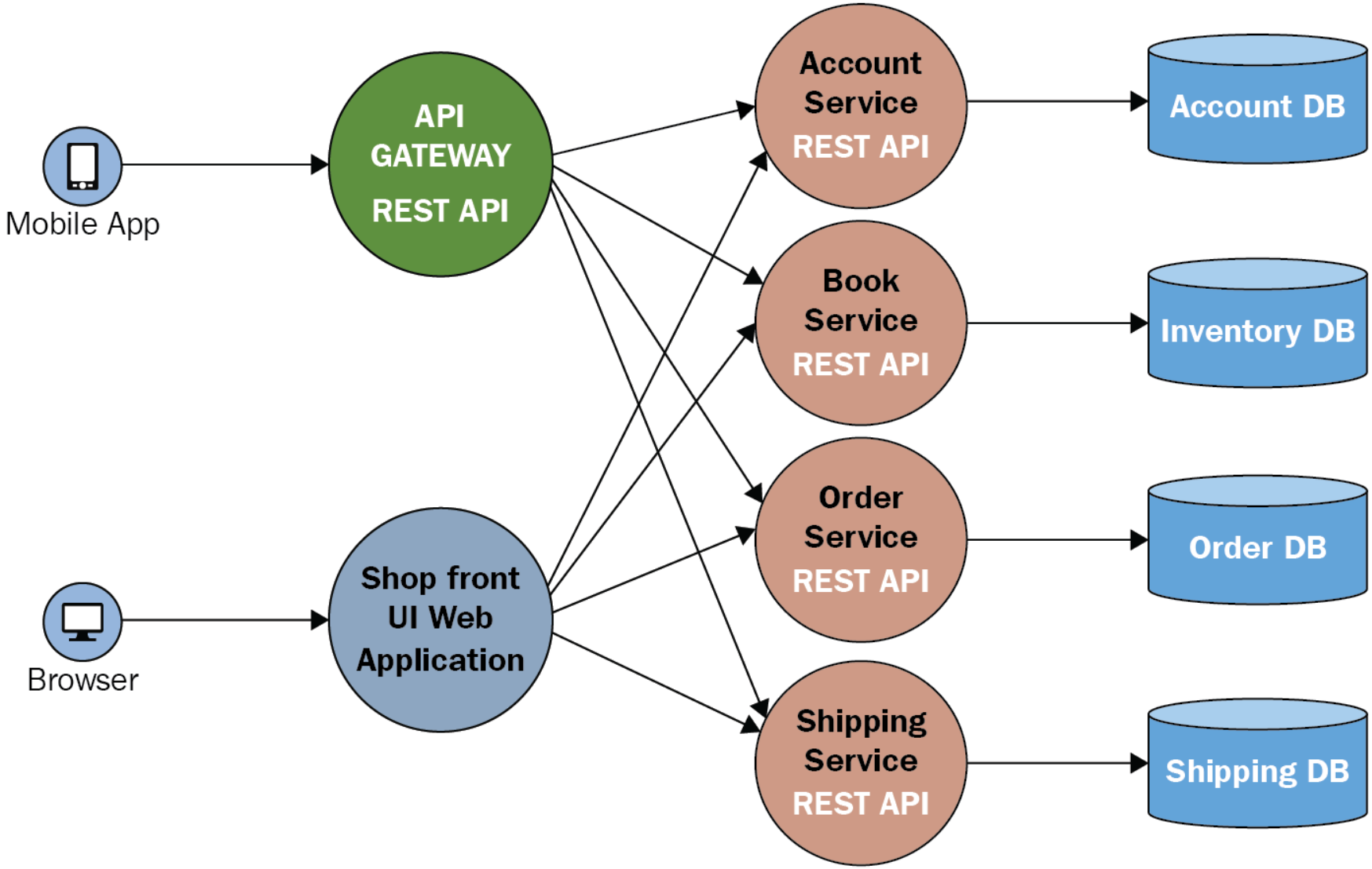
Multi-Tier Architecture – Example



Microservice Architecture



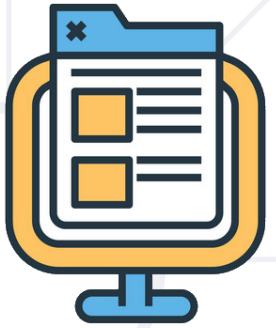
Microservice Architecture – Example



Front-End Concepts

HTML + CSS + JavaScript + JS Libraries

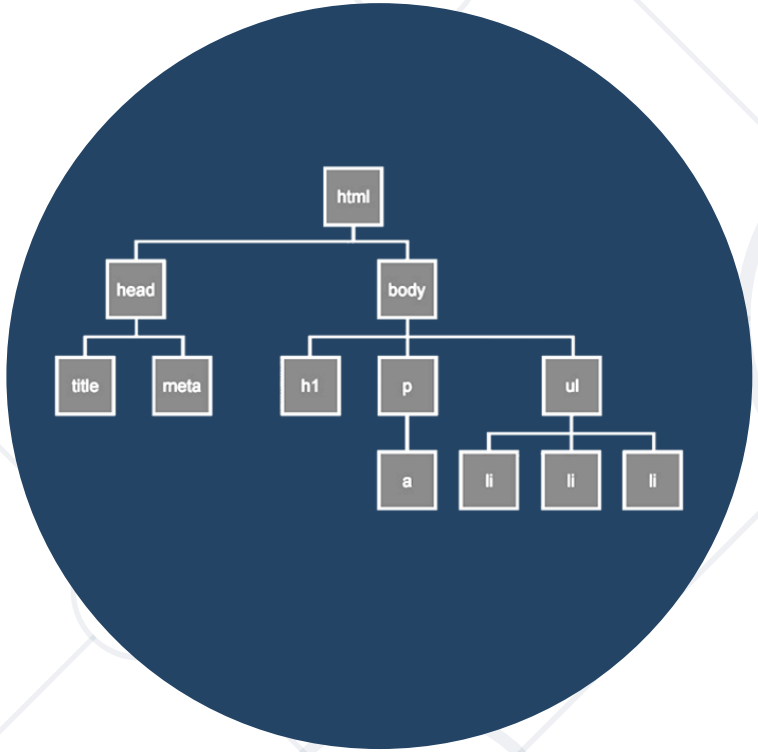
Front-End Technologies



- Front-end **technologies**
  - **Web front-end**: HTML + CSS + JavaScript + JS libraries
  - **Web front-end frameworks**: React, Angular, Vue, Flutter
  - **Desktop front-end**: XAML (Microsoft), UIKit (Apple)
  - **Mobile front-end**: Android UI, SwiftUI
  - **Hybrid mobile front-end**: React Native, Ionic
- **Front-end developers** deal with UI, UX and front-end technologies and frameworks

Web Front-End and DOM

- **Web front-end technologies** (see https://platform.html5.org)
  - HTML, CSS, JavaScript, DOM, AJAX
  - JS front-end frameworks (e.g. React, Angular, Vue)
- **DOM** (the Document Object Model)
  - **DOM** == a tree of UI and other elements
  - Documents in the Web browser are represented by a **DOM tree**
  - The **DOM API** allows changing the DOM from JS



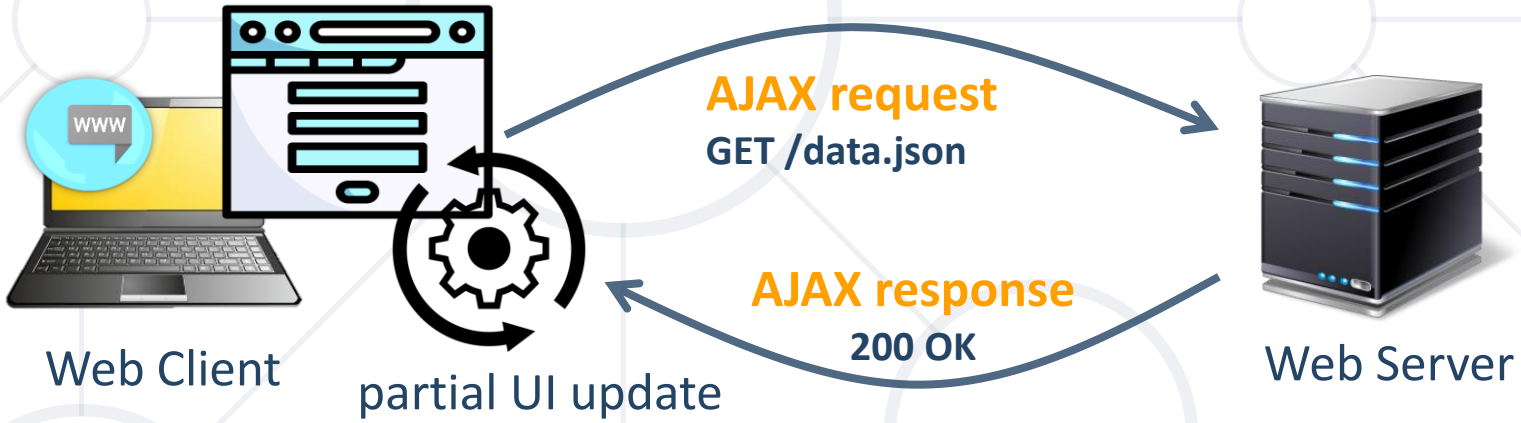
DOM Interaction

Live Demo

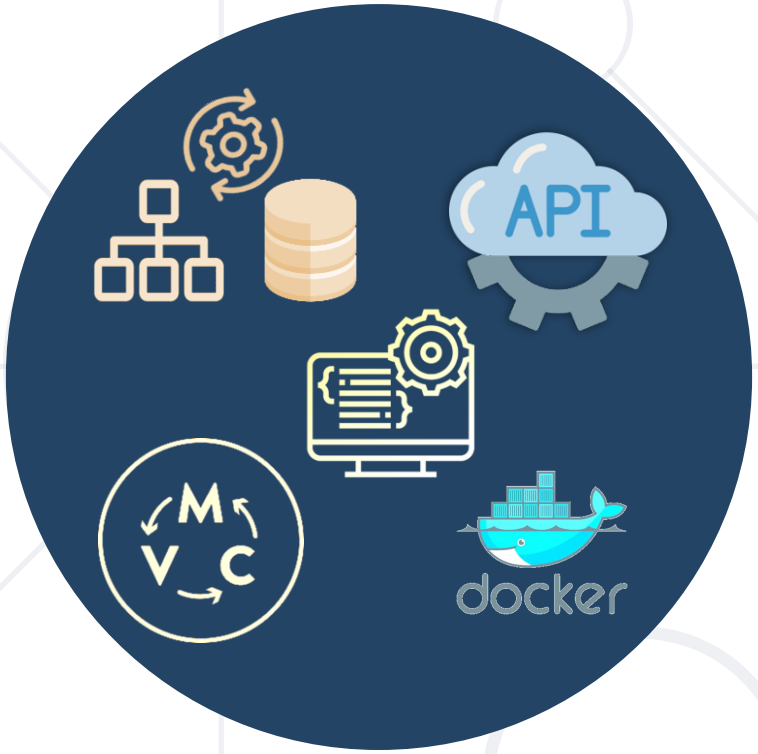
https://repl.it/@nakov/summator-js-dom

AJAX and RESTful APIs

- **AJAX** is a technology for **asynchronous** execution of **HTTP requests** from client-side JavaScript with **dynamic UI updates**



- **RESTful APIs** are HTTP-based Web services
  - The HTTP methods **GET**, **POST**, **PUT** and **DELETE** retrieve, create, modify and delete data



Back-End

Concepts and Technologies

Back-End Technologies

- **Back-end technologies** are about server-side programming
  - **Data management** technologies and **ORM frameworks**
  - Backend **Web frameworks** and **MVC** frameworks
  - **REST API** frameworks, **reactive** APIs, other services and APIs
  - **Microservices**, **containers** and **cloud**

- **Back-end developers** work on the server-side
  - They deal with the business logic, data processing, data storage, cloud services, APIs

Back-End Languages and Platforms

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- Back-end **technologies**: server-side frameworks and libraries
  - **C# / .NET back-end**: ASP.NET MVC, Web API, Entity Framework, …
  - **Java back-end**: Java EE, Spring MVC, Spring Data, Hibernate, …
  - **JavaScript back-end**: Node.js, Express.js / Meteor, MongoDB, …
  - **Python back-end**: Django / Flask, Django ORM / SQLAlchemy, …
  - **PHP back-end**: Apache, Laravel / Symfony, …

Databases

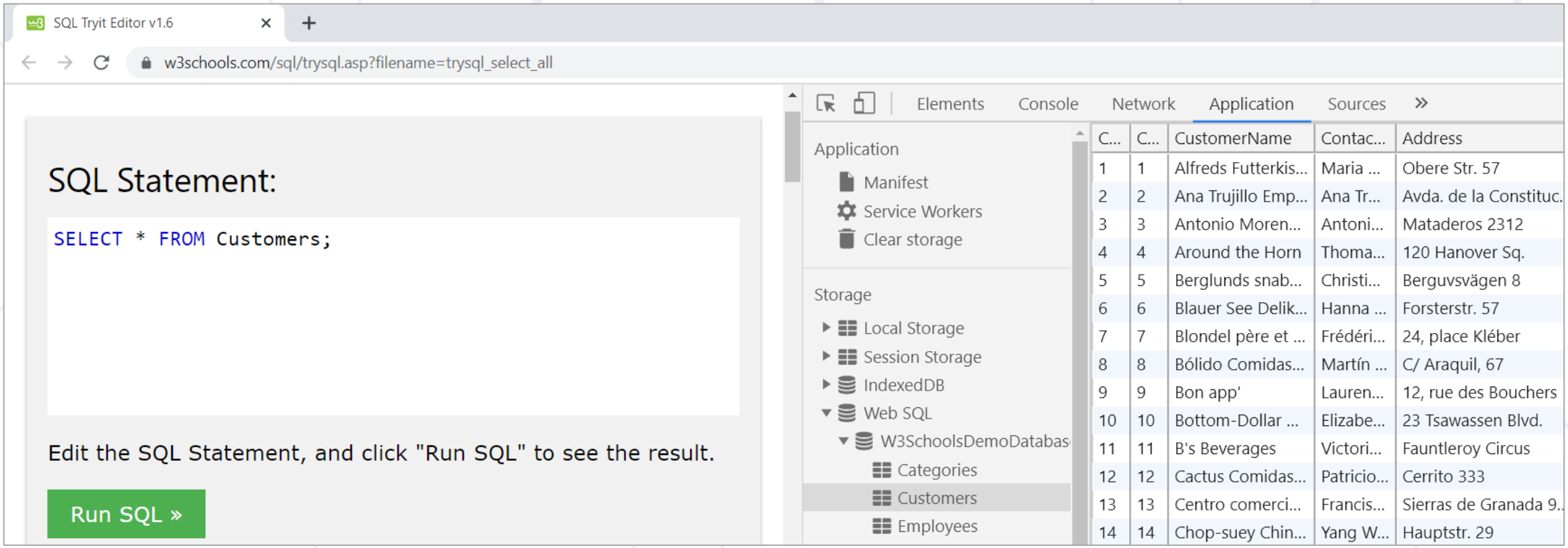
Relational Databases, SQL, NoSQL

Databases

- **Databases** hold and manage data in the back-end systems
- **Relational databases** (**RDBMS**)
  - Hold data in **tables** + **relationships**
  - Use the **SQL** language to query / modify data
  - Examples: MySQL, PostgreSQL, Web SQL in HTML5
- **NoSQL databases**
  - Hold collections of documents or key-value pairs
  - Examples: MongoDB, IndexedDB in HTML5

Web SQL – Example

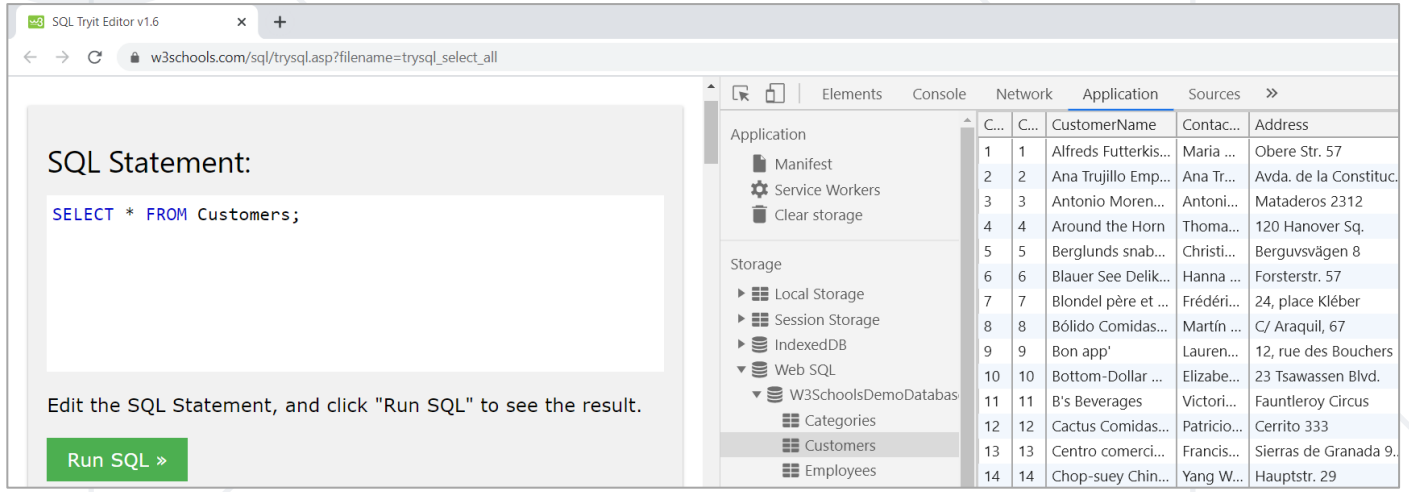
- **Web SQL** is a relational database, embedded the Web browsers
  - It is fully functional **RDBMS system**, runs at the **client-side**



Web SQL

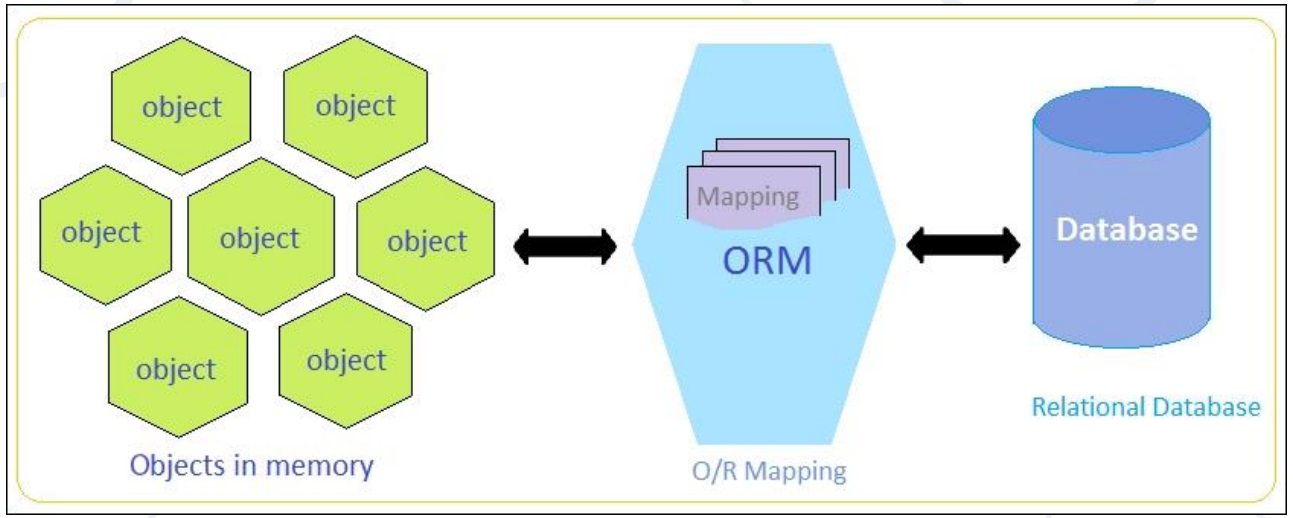
Live Demo

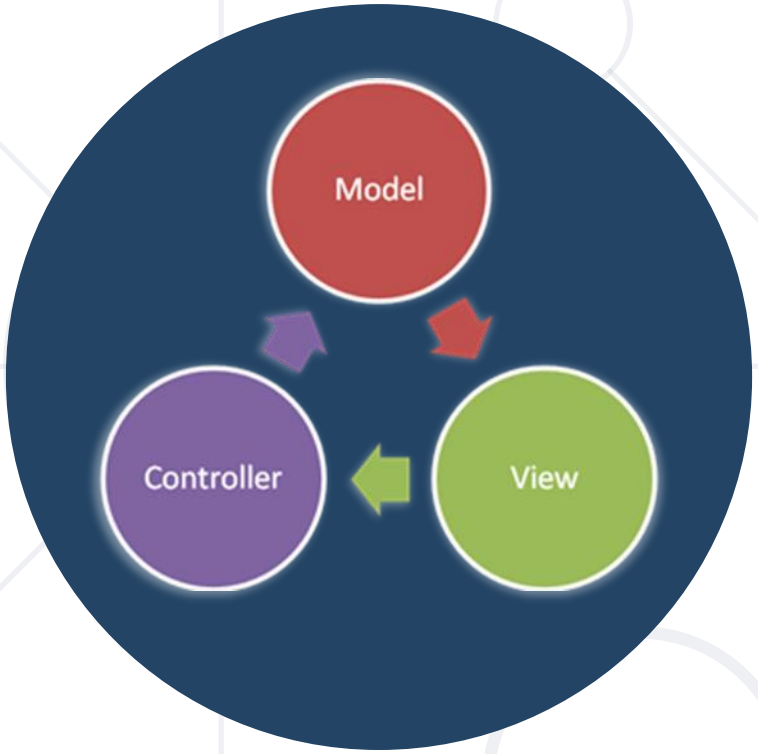
https://w3schools.com/sql/



ORM Frameworks

- **ORM frameworks** (object-relational mapping) allow persisting objects in relational database (by mapping classes to tables)
  - E.g. store JS objects in MySQL database
- Popular ORM frameworks:
  - **Entity Framework** (C#)
  - **Hibernate** (Java)
  - **Sequelize** (JavaScript)
  - **SQLAlchemy** (Python)





Back-End Frameworks

Model-View-Controller and MVC Frameworks

The Model-View-Controller (MVC) Pattern

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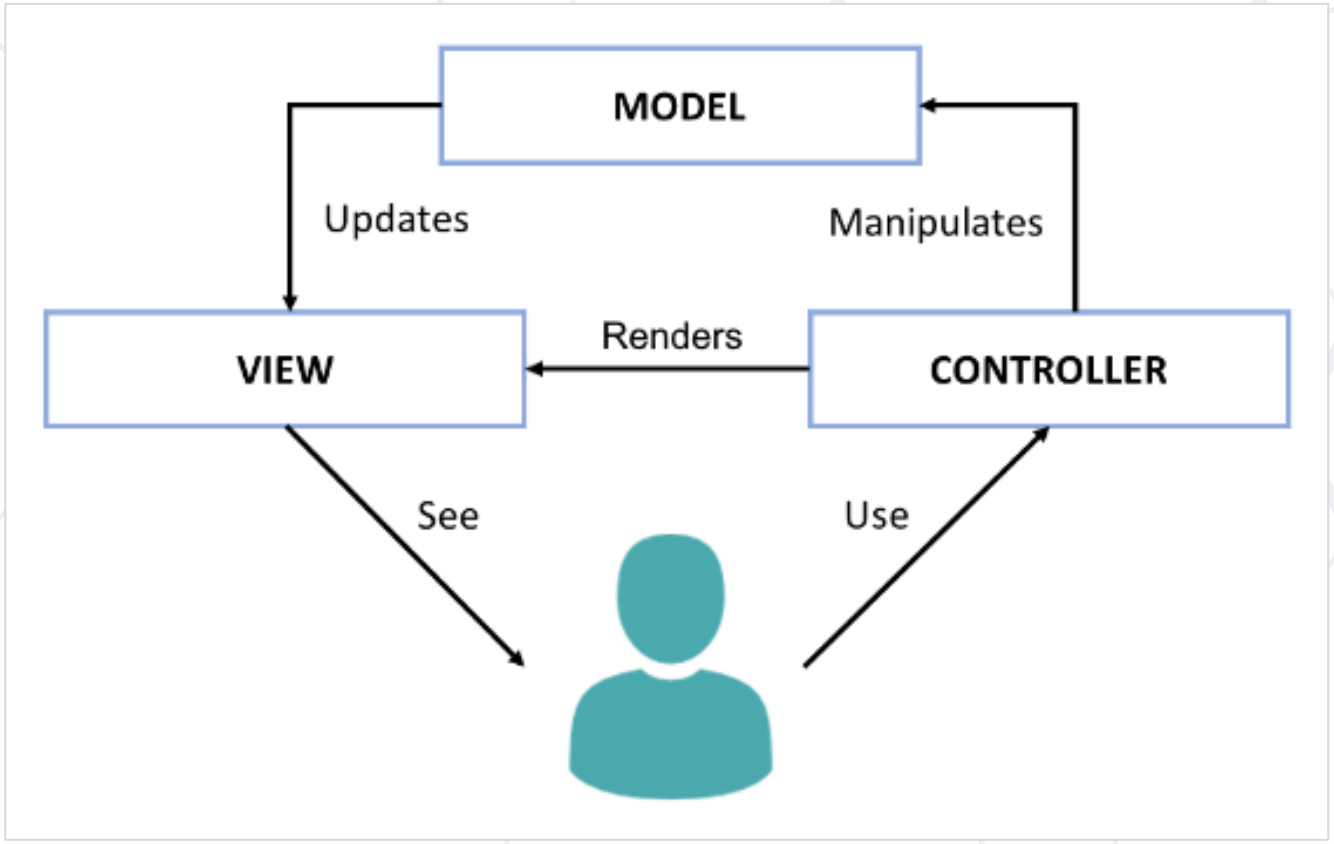
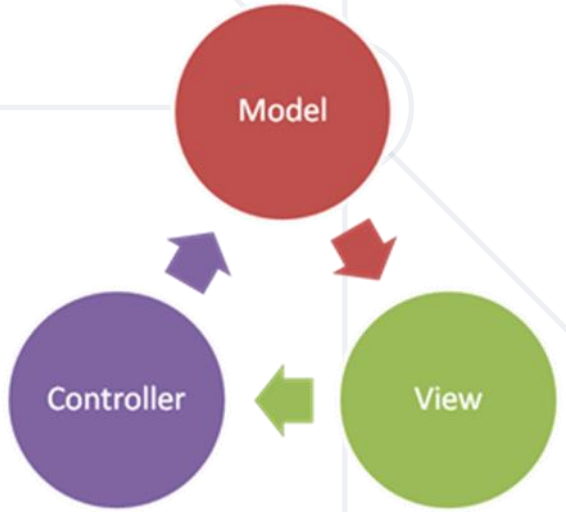
- The **Model-View-Controller** (**MVC**) pattern



- **Controller**
  - Handles user actions
  - Updates the model
  - Renders the view (UI)
- **Model**
  - Holds app data
- **View**
  - Displays the UI, based on the model data

Web MVC Frameworks

- **Web MVC frameworks** are used build Web applications
  - **Controllers** handle HTTP GET / POST and render a view
  - **Views** display HTML + CSS, based on the models
  - **Models** hold app data for views, prepared by controllers
- Examples of Web MVC frameworks:
  - **ASP.NET MVC** (C#), **Spring MVC** (Java), **Express** (JS), **Django** (Python), **Laravel** (PHP), **Ruby on Rails** (Ruby), **Revel** (Go), …



Back-End MVC App

Live Demo

https://repl.it/@nakov/MVC-express-pug-example

Web Services

Communication between Systems and Components

What is API?

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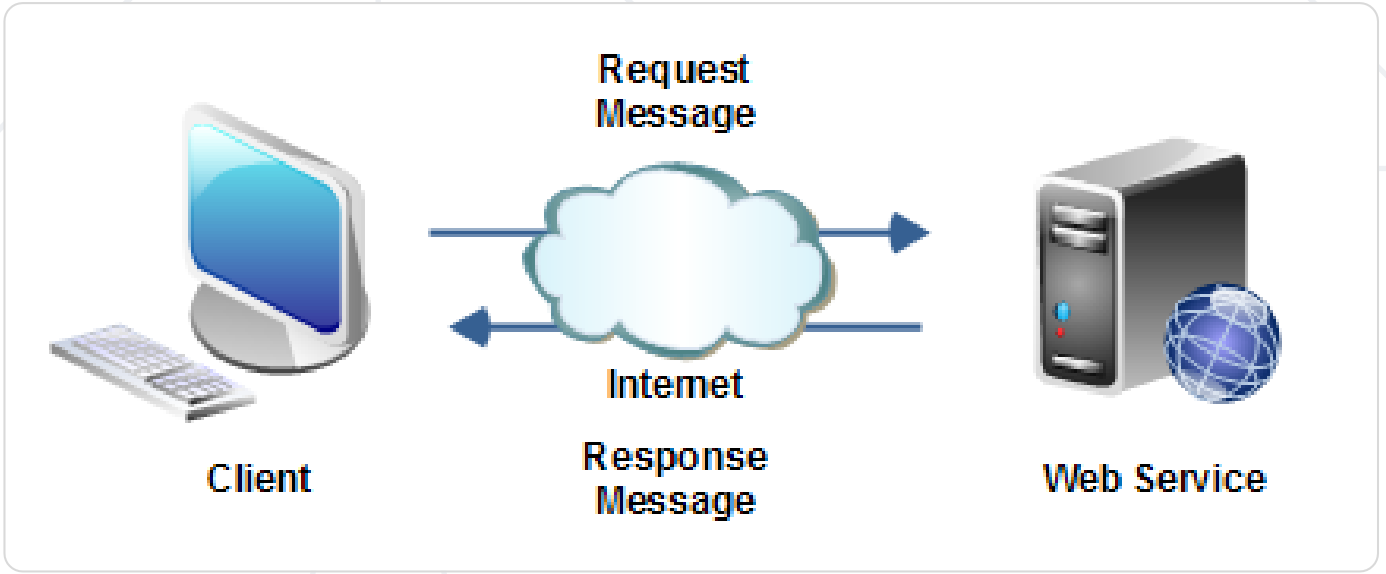
- API == Application Programming Interface
  - Programming interface, designed for communication between system components
  - Set of **functions** and **specifications** that software programs and components follow to talk to each other

- API **examples**:
  - **JDBC** – Java API for apps to talk with database servers
  - **Windows API** – Windows apps talk with Windows OS
  - **Web Audio API** – play audio in the Web browser with JS

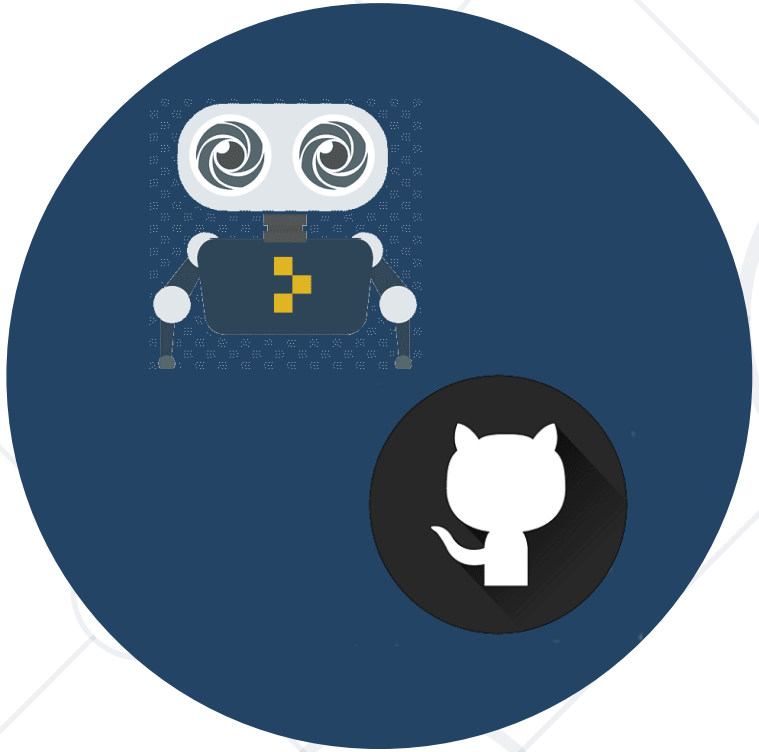
What is Web Service?

- **Web services** implement **communication** between software **systems** or **components** of over the **network**
  - Using standard **protocols**, such as HTTP, JSON and XML
  - Exchanging **messages**, holding data and operations



Web Services and APIs

- **Web services** expose **back-end APIs** over the **network**
  - May use different **protocols** and **data formats**: **HTTP**, **REST**, **GraphQL**, **gRPC**, **SOAP**, JSON-RPC, JSON, BSON, XML, YML, …
- **Web services** are hosted on a Web server (HTTP server)
  - Provide a set of functions, invokable from the Web (Web API)
- **RESTful APIs** is the most popular Web service standard
  - Uses **HTTP requests** (GET, POST, PUT, DELETE, …) to invoke remote functionals at the server-side



Running an API from a GitHub Repo in Repl.it

Live Demo

https://replit.com/@nakov/shorturl

Containers, Docker, Cloud

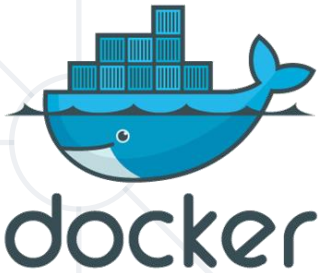
Virtualization, Cloud, Containers, Docker

Virtualization and Cloud

- **Virtualization** == running a **virtual machine** (VM) / virtual environment inside a physical hardware system
  - E.g. run Android VM or Linux inside a Windows host
  - Storage, memory, networking, desktops can also be virtual
- **Cloud** == computing resources, virtual machines, storage, platforms and software instances, available on demand
  - **IaaS** (infrastructure as a service) – virtual machines on demand
  - **PaaS** (platform as a service) – app deployment environments
  - **SaaS** (software as a service) – software instances, e.g. Office 365

Containers and Docker

- **Container image** == software, packaged with its dependencies, designed to run in a virtual environment (like Docker)
  - E.g. WordPress instance (Linux + PHP + Apache + WordPress)
  - Simplified installation, configuration and deployment
- **Docker** is the most popular containerization platform
  - Runs **containers** from local **image** or downloaded from the **Docker Hub** online repository
  - Open-source, runs on Linux, Windows, Mac



Docker – Example

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- Install **Docker** on your local computer
  - Or use the Docker online playground: https://labs.play-with-docker.com (with a free Docker Hub registration)
- Download and **run a Docker image** in a new container:

```
docker run -it -p 80:80 alexwhen/docker-2048:latest
```

- Open the exposed URL: http://localhost:8080
- View currently running Docker containers

```
docker ps
```

Play with Docker

Live Demo

https://labs.play-with-docker.com

What is Cloud?

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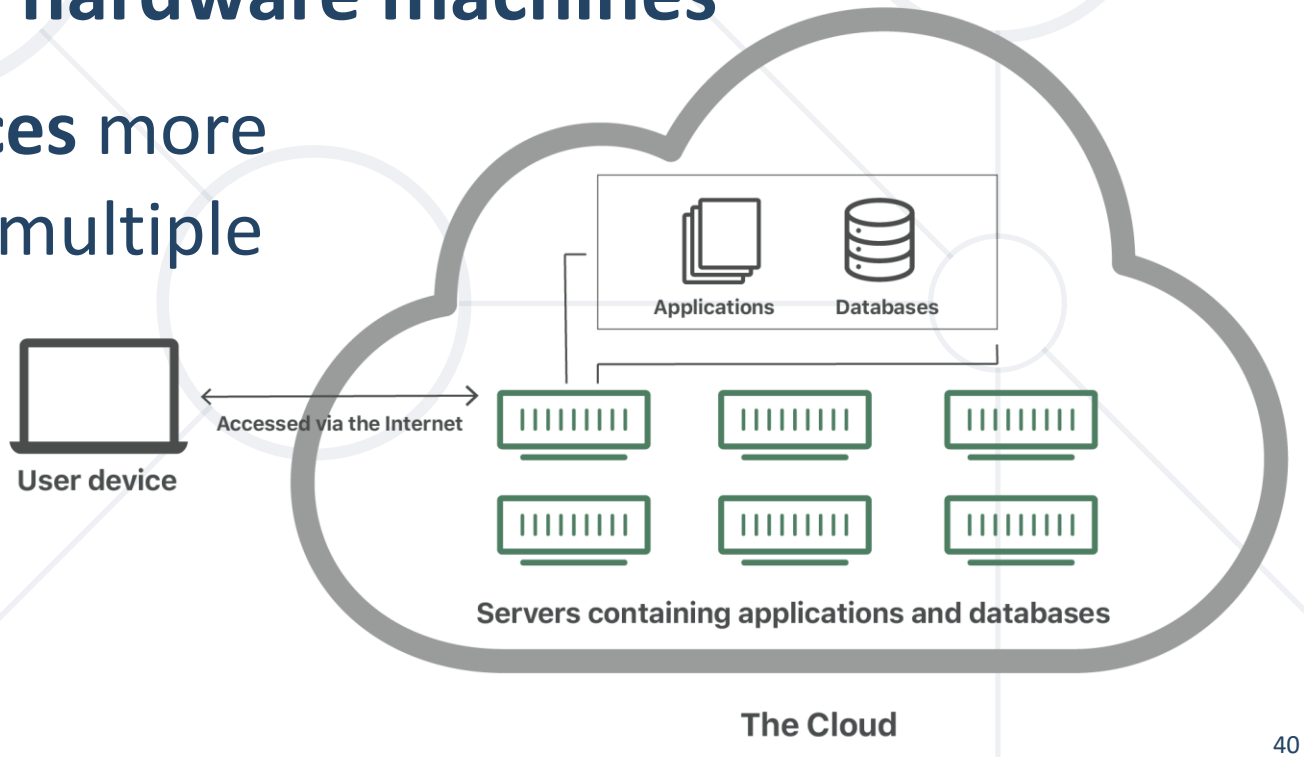
- **Cloud** is a **virtual space** (**software** and **services**) that runs on the **Internet**, instead of locally on your computer
- **Clouds** combine the computing power and resources of **multiple hardware machines**
  - **Share cloud resources** more efficiently between multiple users and apps
  - Save **costs**
  - Better **service**



How the Cloud Works?

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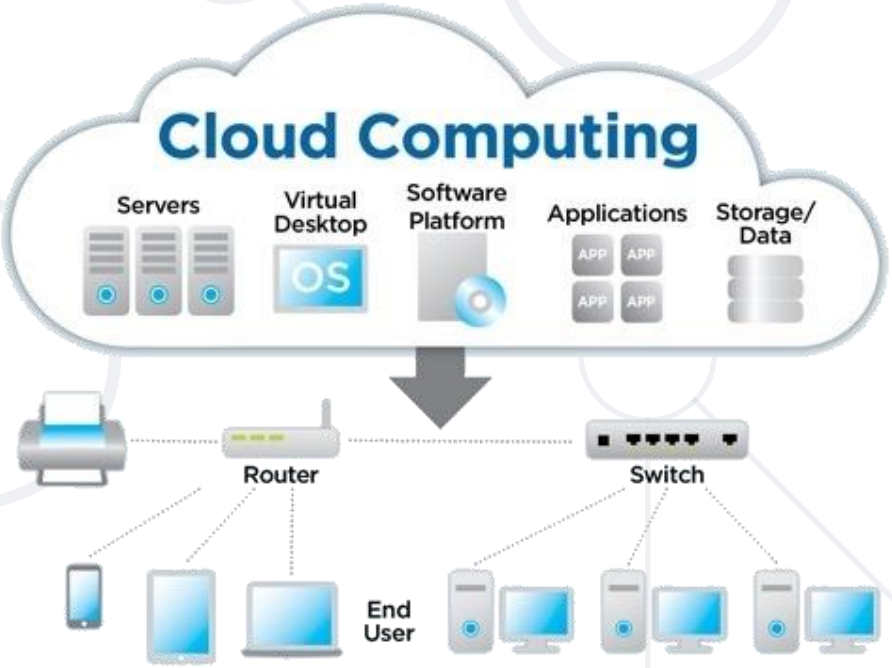
- In the **cloud** everyone consumes a **portion** of the **shared computing resources**
  - CPU, memory, storage, IO, networking, etc.
- If your **business is small**, you consume **less cloud resources**
  - If your business is growing, you consume more resources
- **Pay as you go**
  - Start for **free**, **pay** when you grow and need more resources



Microsoft Azure

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- Fast-growing **public cloud** from **Microsoft**
- Provides **rich PaaS platform**
  - Mainly for **.NET developers**
  - Provides also Java, PHP, Python, and Node.js APIs
  - **Databases**, **storage**, **mobile back-ends**, **CDN**, …

- Provides **IaaS cloud** (Windows and Linux VMs)

Azure for Students

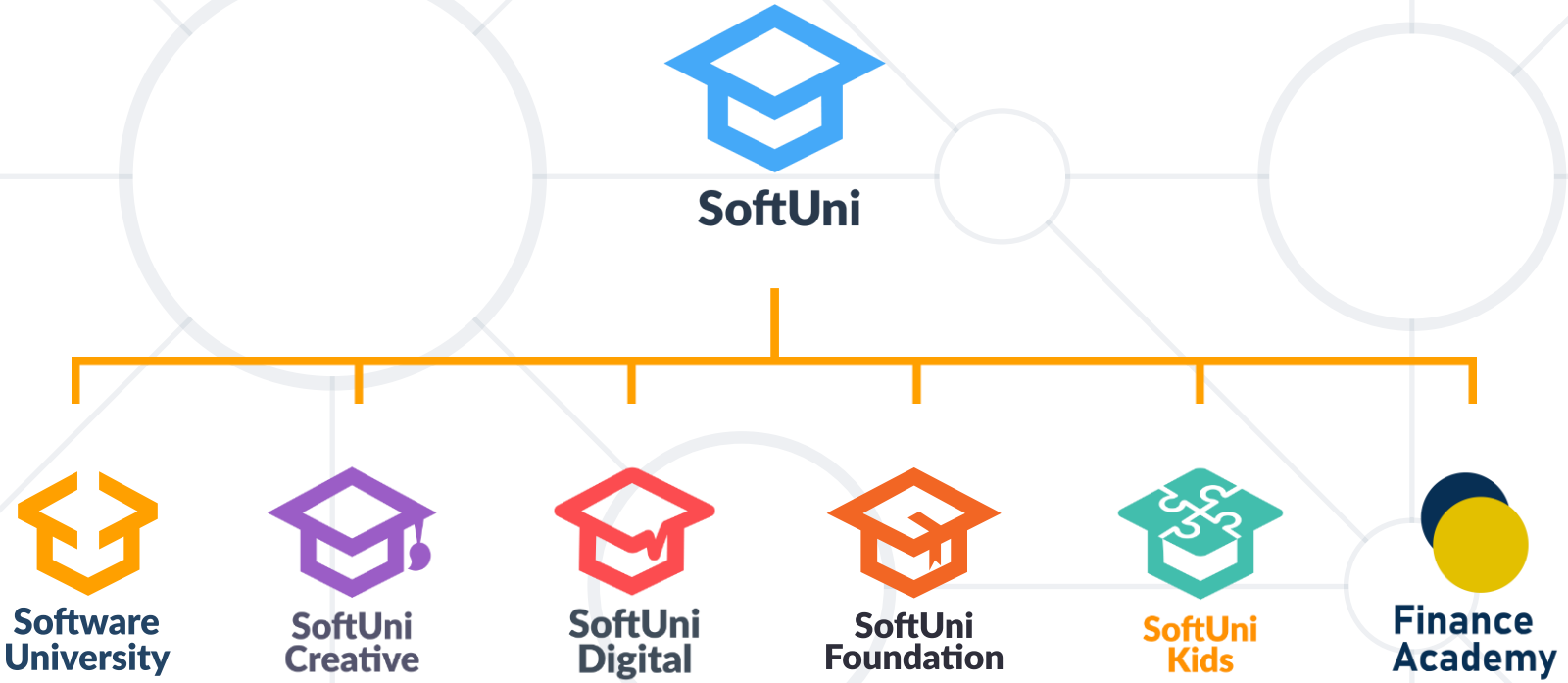
Live Demo

https://azure.microsoft.com/free/students/

Summary

- **Front-End**: client-side apps
  - HTML + CSS + JavaScript + AJAX
- **Back-End** == server-side apps and APIs
  - Back-end logic: databases, data processing, ORMs, APIs, Web APIs, MVC frameworks
- **Containers** and **Docker**
  - Run OS with preinstalled apps in a container
- **Cloud** == rental of computing resources

Questions?



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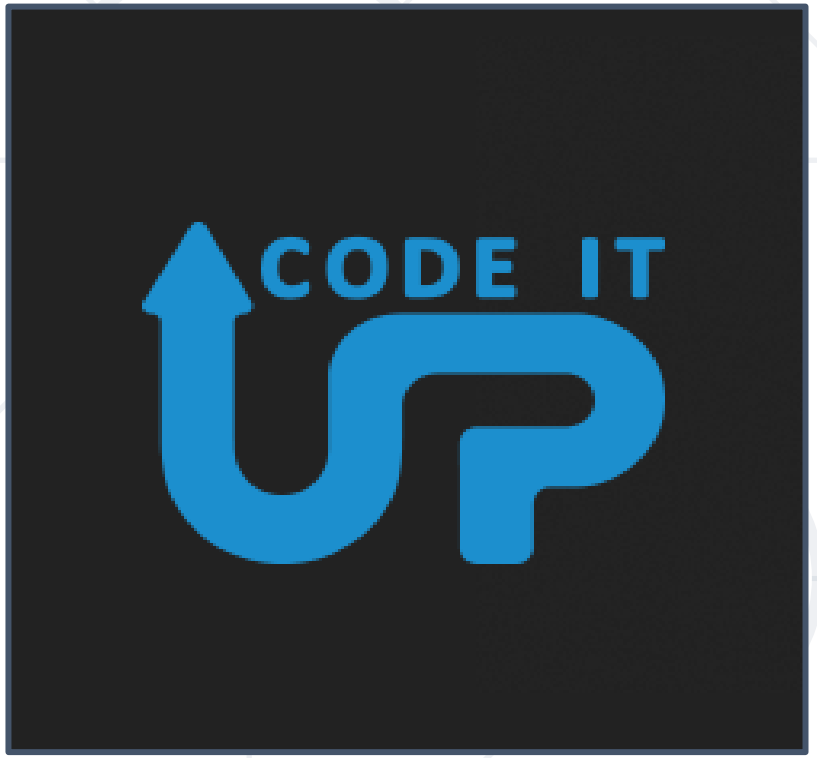

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