

Software Development Concepts

Fundamental Concepts and Paradigms
in the Software Engineering Profession



SoftUni Team
Technical Trainers



SoftUni



Software University

<https://softuni.bg>

Table of Contents

- The 4 Skills of the Software Engineers
- Fundamental Software Engineering Concepts
 - Math Concepts in Software Development
 - Object-Oriented Programming (OOP)
 - Functional Programming (FP)
 - Data Structures and Algorithms
 - Component-Based Development and Event-Driven Programming
 - Asynchronous Programming and Promises
- Software Architectures, Front-End and Back-End



Have a Question?

sli.do

#fund-common



The 4 Skills of Software Engineers

- 4 main **groups of technical skills**:
 - **Coding skills** – 20%
 - **Algorithmic thinking** – 30%
 - Fundamental software development **concepts** – 25%
 - Programming languages and software **technologies** – 25%



Skill #1: Coding (20%)

- The skill to **write code**
 - Working with **commands**, IDE, variables, data and **calculations**, **conditional** statements, **loops**
 - Using **functions** (or methods) and **objects**
 - Working with **data structures** (arrays, lists, maps and others), libraries and APIs
- **Courses** at SoftUni: softuni.bg/curriculum
 - Programming Basics, Programming Fundamentals
- The programming language doesn't matter!



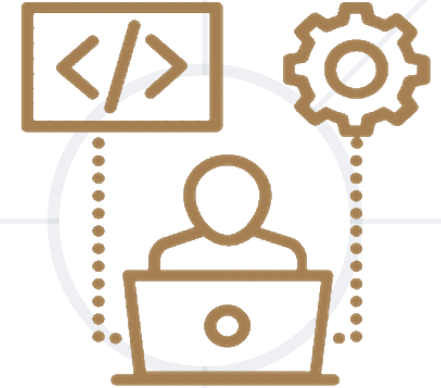
Skill #2: Algorithmic Thinking (30%)

- **Algorithmic** (engineering, mathematical) **thinking**
 - The ability to analyze problems and find solutions
 - Breaking the problem down to steps (algorithm)
- **How** to develop algorithmic thinking?
 - Solve **1000+** programming **problems**
 - It takes 6 to 12 months of coding every day
- **Courses** in **SoftUni**: Programming Basics, Fundamentals and Advanced Modules
- The programming language doesn't matter!



Skill #3: Fundamental Concepts (25%)

- **Fundamental software development concepts**
 - **Object-oriented programming (OOP)**
 - **Functional programming (FP)**
 - **Asynchronous programming and parallel execution**
 - **Databases:** relational DB, SQL, document DB, key-value model
 - **Web technologies:** HTTP, JS, DOM, AJAX, REST, ...
 - **Software engineering:** source control, agile, ...
- **SoftUni Curriculum:** Professional Modules
- The programming language doesn't matter!



Skill #4: Languages & Technologies (25%)

- **Programming language and technologies**
 - They only form **25% of the skills** of a programmer!
- The programming languages and technologies come always together (as a **technology stack**)!
- Example of skills required for a **Junior C# / .NET Developer**:
 - C# + .NET Core + Visual Studio + databases + SQL Server + SQL + EF + ASP.NET MVC + HTML + CSS + JS + AJAX + REST + JSON + OOP + FP + algorithmic thinking + Git + software engineering + English + teamwork skills
- Software technologies **change very fast!**
- **SoftUni Curriculum:** Professional Modules



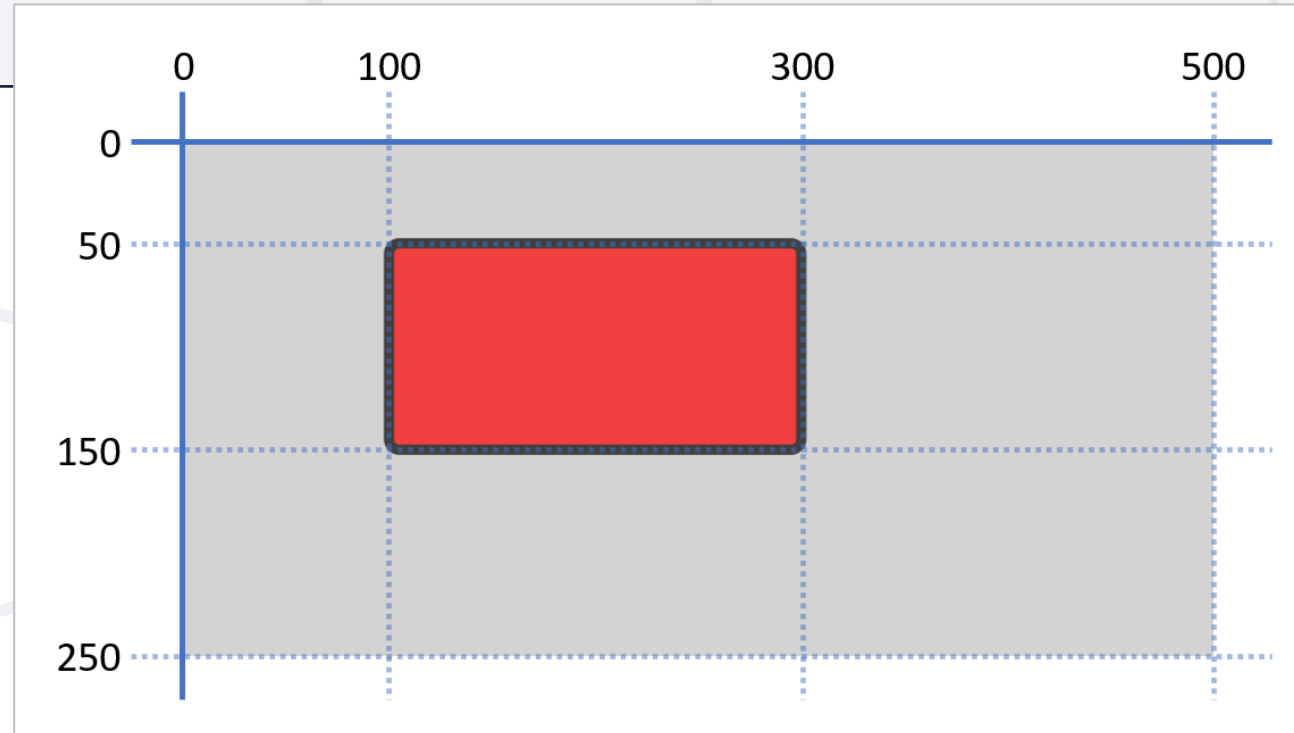


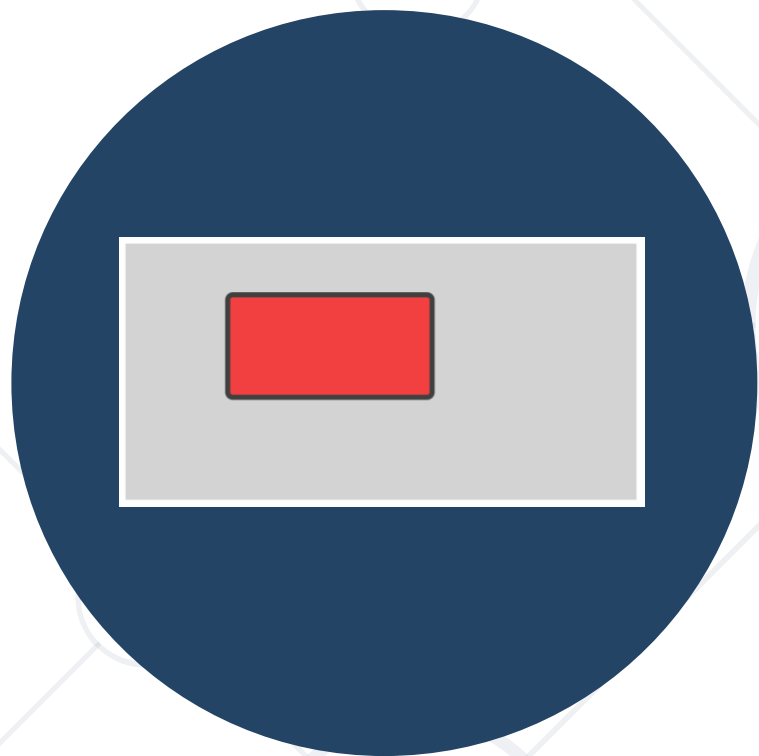
Fundamental Software Engineering Concepts

- Basic **mathematical concepts** related to programming
 - **Coordinate systems** (used in computer graphics)
 - **Mathematical functions** (lambda calculus, discrete functions, ...)
 - **Vectors** and **matrices** (used in graphics, machine learning, ...)
 - Finite state **automata** and **state machines** (used in parsers)
 - **Statistics** concepts (used in machine learning)
 - **Algorithm complexity** (estimate the speed)
 - **Mathematical modeling**

Coordinate System and SVG – Example

```
<svg width="500" height="250" style="background:lightgray">  
  <rect x="100" y="50" width="200" height="100" rx="5" ry="5"  
  style="fill:red;stroke:black;stroke-width:5;opacity:0.7" />  
</svg>
```



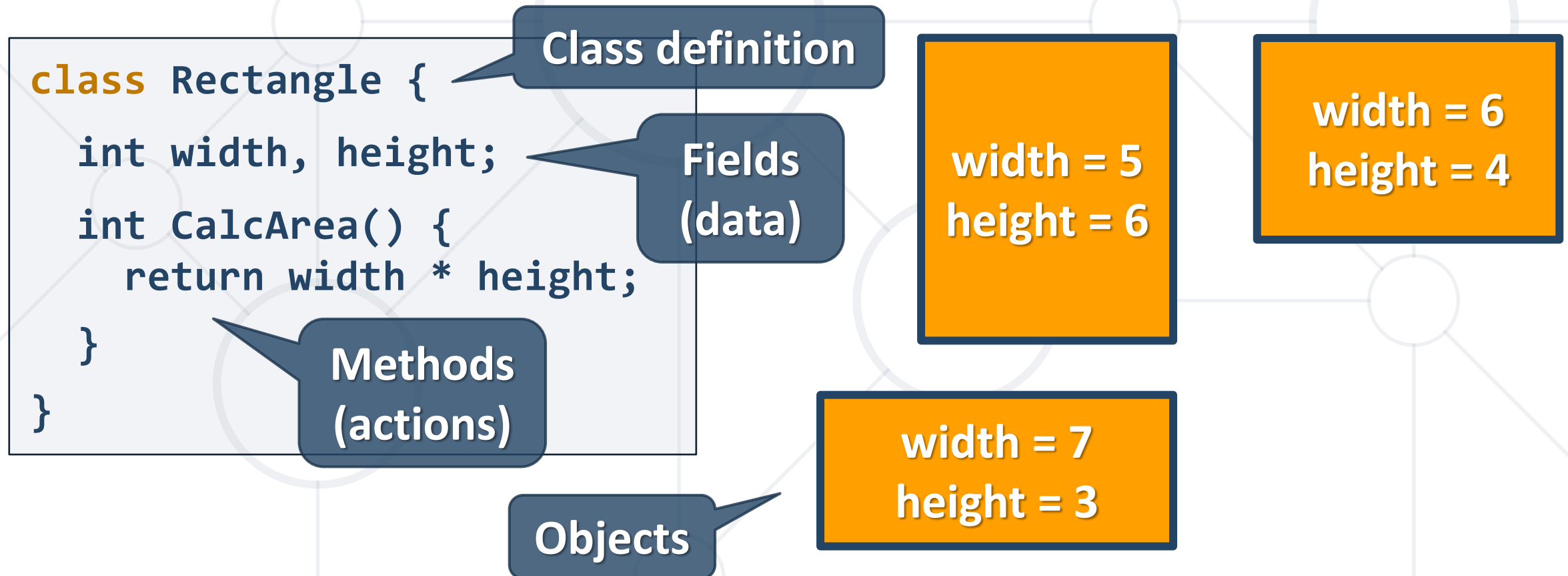


SVG and the Coordinate System

Live Demo

<https://repl.it/@nakov/SVG-example>

- **Object-Oriented Programming (OOP)** is the concept of using **classes** and **objects** (class instances) to model the real world





Object-Oriented Programming (OOP)

Live Demo

<https://repl.it/@nakov/rectangle-oop-js>
<https://repl.it/@nakov/rectangle-oop-cs>

- **Inheritance** allows classes to **inherit data and functionality** from a **parent class** (base class)
 - **Interface** – defines abstract actions
 - Actions to be implemented in descendent classes
 - **Abstract class** – abstraction, e.g. **Figure**
 - Defines data + actions + abstract actions
 - **Concrete class** – e.g. **Circle, Rectangle**
 - Defines data + concrete functionality



Inheritance and Interfaces – Example

```
abstract class Figure {  
    int x, y;  
    abstract int calcArea();  
}
```

Base abstract class

Abstract
method

Child class

```
class Circle extends Figure {  
    int radius;  
    override int calcArea() =>  
        PI * radius * radius;  
}
```

```
class Rectangle extends Figure {  
    int width, height;  
    override int calcArea() =>  
        width * height;  
}
```



Inheritance in OOP

Live Demo

<https://repl.it/@nakov/inheritance-oop-js>

<https://repl.it/@nakov/inheritance-oop-cs>

- **Functional programming (FP)**
 - Programming by composing **pure functions**, avoiding **shared state**, **mutable data**, and **side-effects**
 - **Declarative** programming approach (not **imperative**)
 - Program state flows through pure functions
- **Pure function** == function, which returns value only determined by its input, without side effects
 - Examples: *sqrt(x)*, *sort(list)* → sorted list
 - Pure function == consistent result



- **Purely functional languages** are **unpractical** and rarely used
 - The program is **pure function** without side effects, e.g. **Haskell**
- **Impure functional languages**
 - Emphasize functional style, but allow side effects, e.g. **Clojure**
- **Multi-paradigm languages**
 - Combine multiple programming paradigms: **functional, structured, object-oriented, ...**
 - Examples: **JavaScript, C#, Python, Java**

- Read several numbers and **find the biggest** of them (in C#)

- **Functional style**

```
Console.WriteLine(  
    Console.ReadLine()  
        .Split(" ")  
        .Select(int.Parse)  
        .Max()  
);
```

- **Imperative style**

```
var input = Console.ReadLine();  
var items = input.Split(" ");  
var nums = items.Select(int.Parse);  
var maxNum = nums.Max();  
Console.WriteLine(maxNum);
```



Functional Programming (FP)

Live Demo

<https://repl.it/@nakov/functional-max-num-cs>

<https://repl.it/@nakov/imperative-max-num-cs>

- **Lambda functions:** anonymous function (formula)

```
x => 2 * x
```

C#

```
x => 2 * x
```

JS

```
lambda x: 2 * x
```

Python

- JS, Python, C# and Java and support **first-class functions** (functions can be stored in variables and passed as arguments)

```
let twice = x => 2 * x;  
let d = twice(5); // 10
```

JS

```
twice = lambda x: 2 * x  
d = twice(5) # 10
```

Python

```
Func<int, int> twice =  
    x => 2 * x;  
var d = twice(5); // 10
```

C#

```
Function<Integer, Integer>  
    twice = x -> 2 * x;  
var d = twice.apply(5);
```

Java



First-Class Functions

Live Demo

<https://repl.it/@nakov/first-class-function-js>

- Higher-order functions take other functions as arguments

```
function aggregate(start, end, func) {  
  for (var result = start, i = start+1; i <= end; i++)  
    result = func(result, i);  
  return result;  
}
```

```
aggregate(1, 10, (a, b) => a + b) // 55
```

```
aggregate(1, 10, (a, b) => a * b) // 3628800
```

```
aggregate(1, 10, (a, b) => '' + a + b) // "12345678910"
```



Higher-Order Functions

Live Demo

<https://repl.it/@nakov/higher-order-functions-js>

- **Data structures** are representations of data in the computer memory, which allow efficient access and modification
- **Linear data types:** arrays, lists, stacks, queues



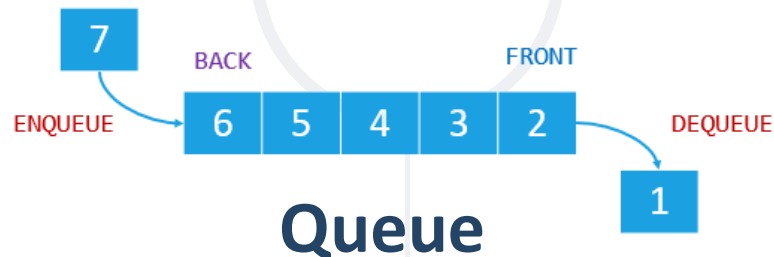
Array / list

(indexed group of elements)



Linked list

(sequence of linked elements)



Queue

List of Numbers – Example

- **List of numbers**, representing a sequence of income amounts:

```
var incomes = [  
    150, 200, 70.50, 120  
];
```



Element	Value
incomes[0]	150
incomes[1]	200
incomes[2]	70.50
incomes[3]	120
incomes[4]	300



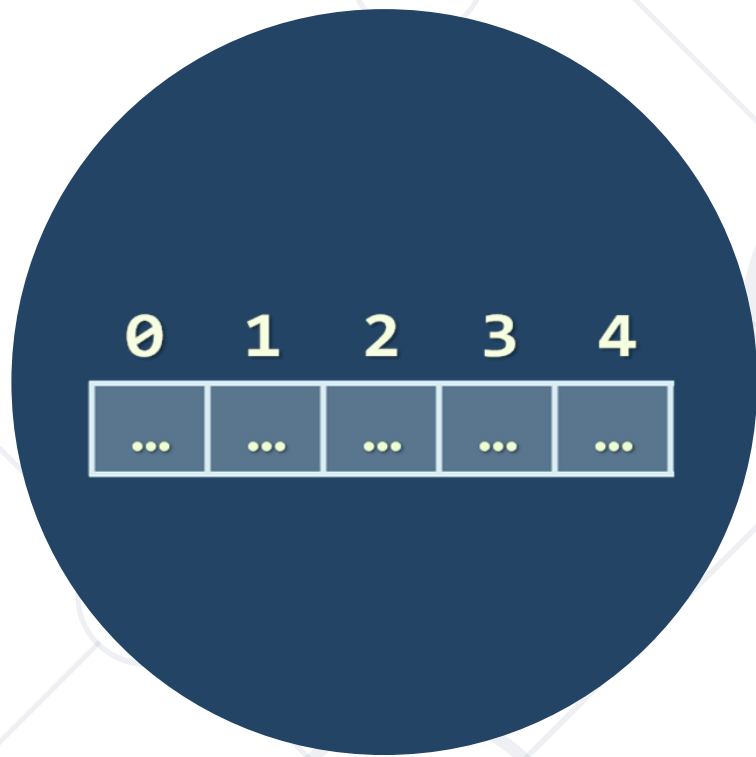
250

- **Adding a new income:**

```
incomes.push(300);
```

- **Modifying an existing income:**

```
incomes[1] = 250;
```

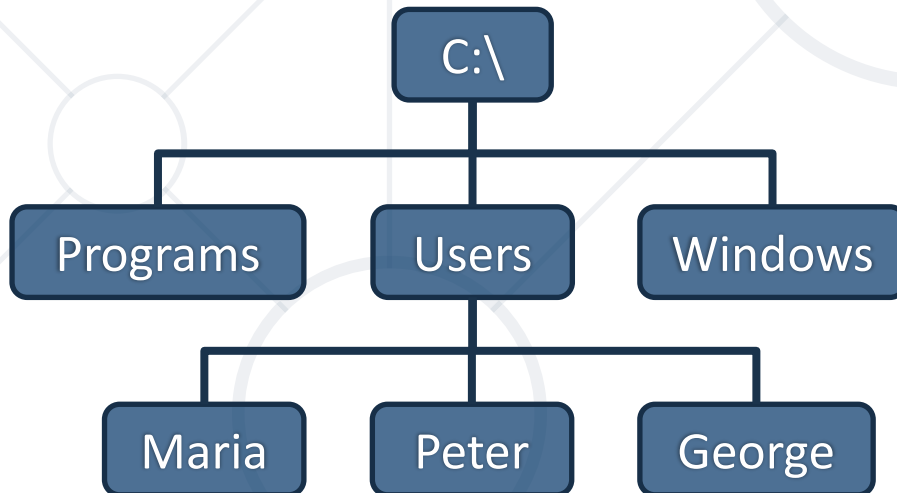


List of Numbers

Live Demo

<https://repl.it/@nakov/list-example-js>

- **Trees and tree-like data structures**
 - Each **node** holds data + list of **child nodes** + **parent node**
- **Tree traversal algorithms**
 - Depth-First Search (DFS)
 - Breadth-First Search (BFS)



```
DepthFirstSearch(node) {  
    print(node);  
    for each ch in node.childNodes  
        DepthFirstSearch(ch)  
}
```

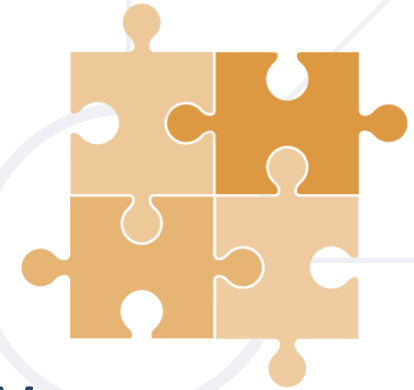


Recursive Traversal of the File System

Live Demo

<https://repl.it/@nakov/traverse-folders-cs>

- **Component-based software development**
 - A **programming paradigm** in which applications are composed of re-usable **components**
- **Components** are self-contained pieces of functionality
 - E.g. PDF generator, email sender, date picker UI control
- User interface (UI) components are also known as **UI controls**, **visual components** or **widgets**
- Components are distributed in **libraries**
 - E.g. the UI control library [jQuery UI](#)



Example of Software Component

← → ↻ 🔒 jquery-ui-datepicker-example.nakov.repl.co

Date:

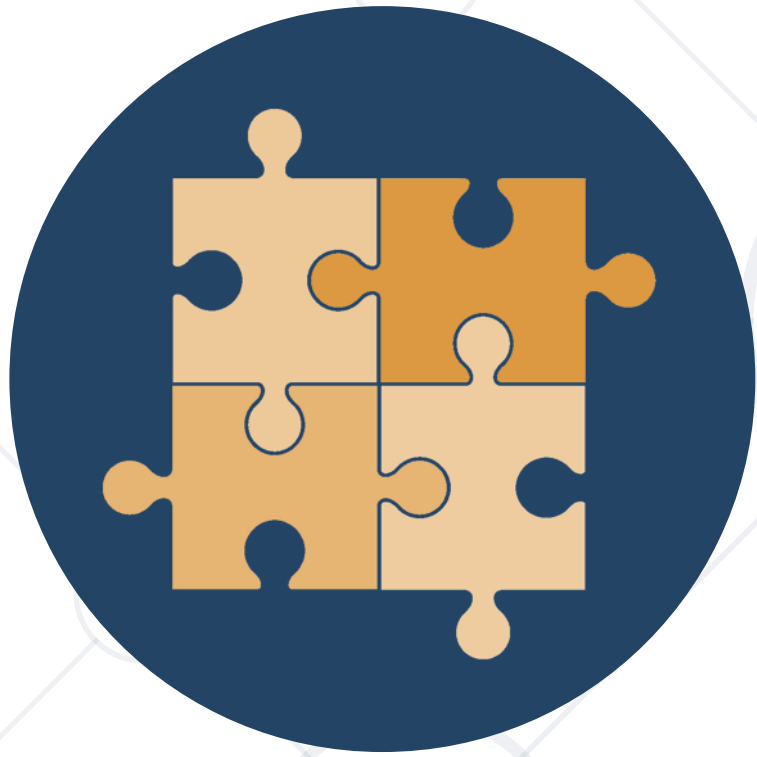
🕒

February 2021

🕒

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

UI component
"date picker"



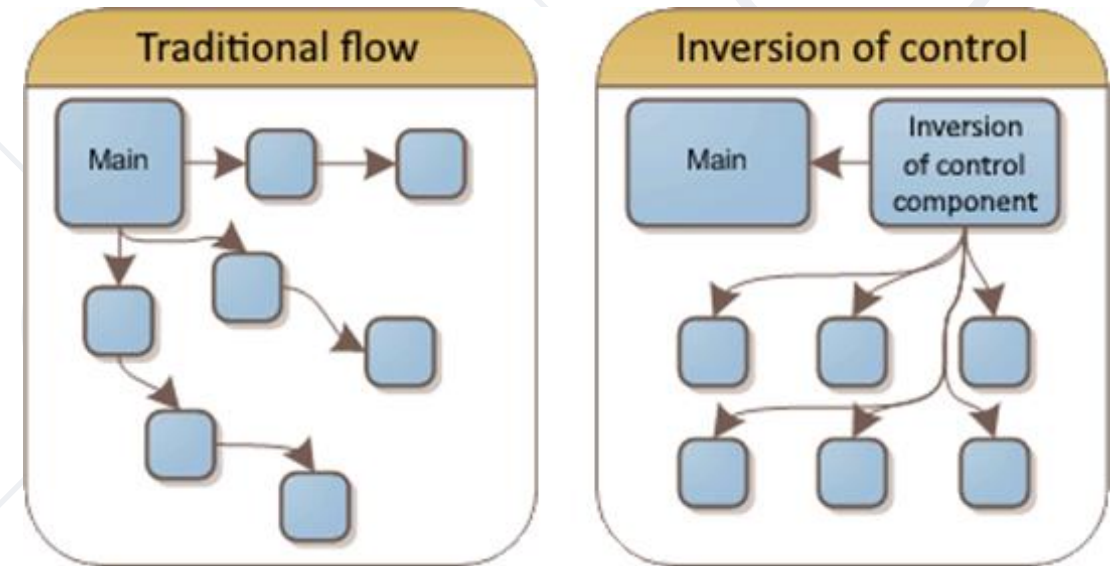
jQuery UI Date Picker

Live Demo

<https://repl.it/@nakov/jquery-ui-datepicker-example>

- **Event-driven programming**
 - A **programming paradigm** in which the flow of the program is determined by **events**, e.g. mouse clicks, key presses, etc.
- Event **source** (event emitter)
 - Produces events, e.g. when the mouse is clicked
- Event **handler** (event consumer, callback)
 - Processes events, e.g. show a message

- **Inversion of control (IoC) principle**
 - A function / component / framework does the processing and calls pieces of your code for certain tasks
- **Examples of IoC behavior:**
 - A **parser** processes a document and calls **events** when it finds certain tokens
 - A **GUI app** manages the UI and calls **events** for the user input



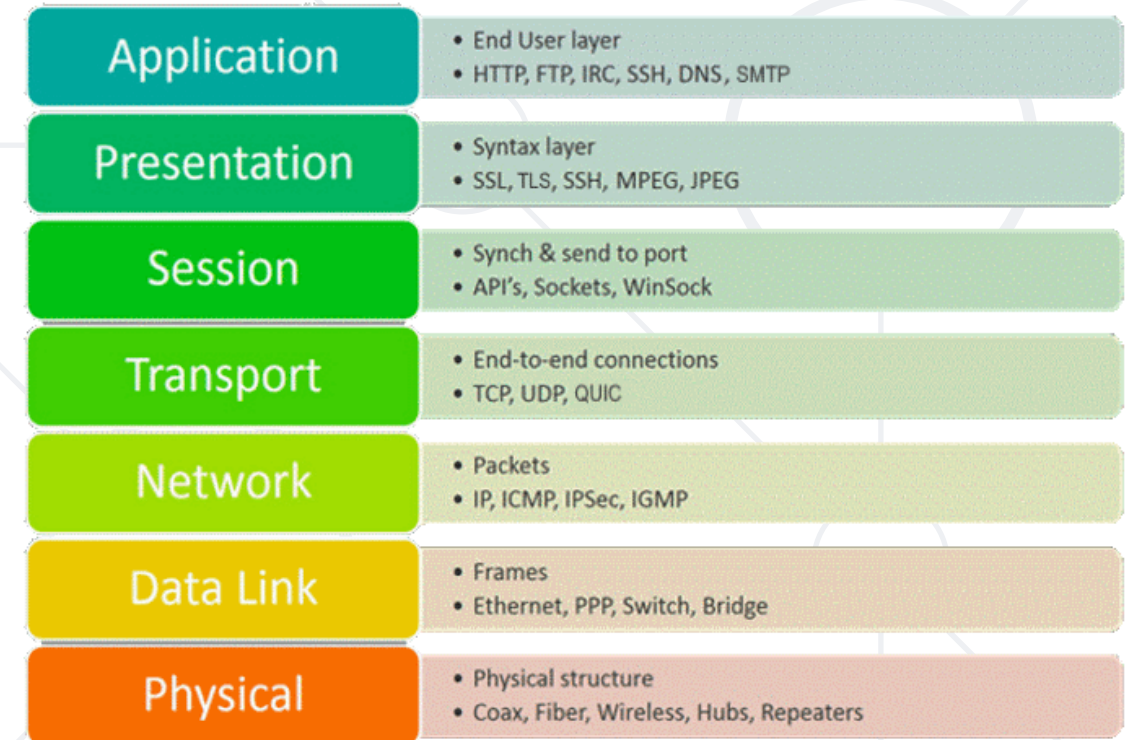
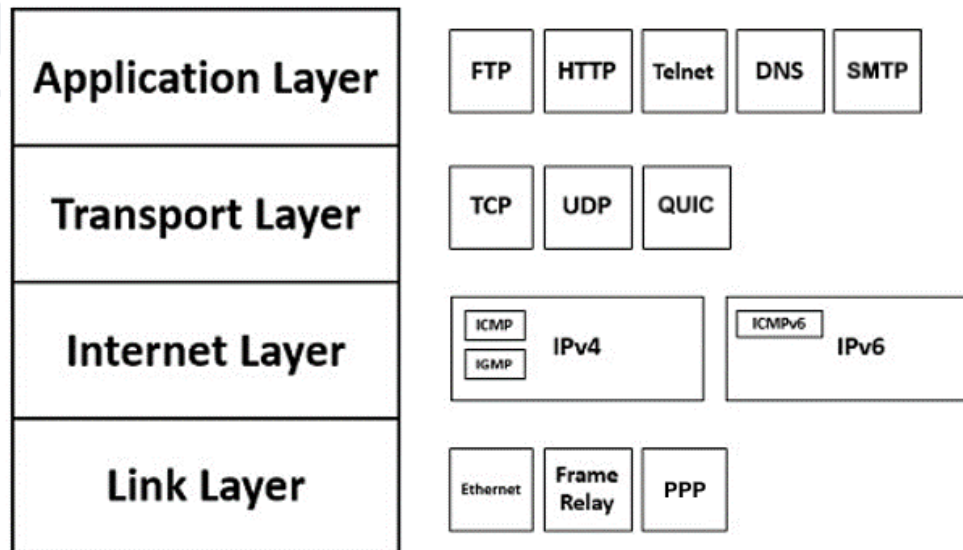
Example of IoC and Event-Driven Programming

The **UI framework** draws the UI and check for events in a loop (event loop)



Clicking a button **emits an event**, which is **handled** by the calculator's engine

- Communication in Internet uses **networking protocols**
 - The **OSI model** defines 7 layers of networking protocols
 - The **TCP/IP** protocol suite



- Most applications communicate through **HTTP** or **sockets**
- **HTTP** is "request / response" based protocol for the Web
 - Clients request resources (GET / POST / PUT / DELETE **request**)
 - The Web server provides the resource (**HTTP response**)
- **Sockets** are bidirectional communication streams
- **Web sockets** are sockets that run over HTTP
 - Allow JavaScript client to communicate with the Web server bidirectionally




Real-World Example of Socket Communication

The screenshot shows an iPad interface. In the background, a Telegram chat with 'Tim Yount' is visible. Overlaid on top is a web browser displaying the Investing.com 'Top Cryptocurrencies' page. The browser's address bar shows 'investing.com/crypto/'. The page features a table of cryptocurrency data.

Name	Symbol	Price (USD)	Market Cap	Vol (24H)
Bitcoin	BTC	9,319.8	\$171.87B	\$19.07B
Ethereum	ETH	234.89	\$26.26B	\$8.71B
Tether	USDT	0.9999	\$9.19B	\$25.67B
XRP	XRP	0.18370	\$8.14B	\$1.15B
Bitcoin Cash	BCH	233.36	\$4.31B	\$1.32B
Bitcoin SV	BSV	173.56	\$3.20B	\$982.12M
Litecoin	LTC	42.673	\$2.79B	\$1.47B
Binance Coin	BNB	16.0780	\$2.50B	\$169.03M
EOS	EOS	2.5014	\$2.33B	\$1.35B
Cardano	ADA	0.082560	\$2.14B	\$302.99M

- Telegram Messenger
 - The "Brawl Stars" Game
 - The Live Crypto Prices Dashboard @ Investing.com

Example of Web Socket Communication



This browser supports WebSocket.

Location:

wss://echo.websocket.org

Connect

Disconnect

Message:

Rock it with HTML5 WebSocket

Send

Log:

CONNECTED

SENT: Rock it with HTML5 WebSocket

RECEIVED: Rock it with HTML5 WebSocket

Elements

Console

Network

Application

Preserve log

Disable cache

Online

Name

☐ ?encoding=text

☐ mem6YaGs126MiZpBA-...

☐ mem6YaGs126MiZpBA-...

☐ mem6YaGs126MiZpBA-...

☐ mem6YaGs126MiZpBA-...

☐ mem6YaGs126MiZpBA-...

☐ mem6YaGs126MiZpBA-...

☐ mem6YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem5YaGs126MiZpBA-...

☐ mem8YaGs126MiZpBA-...

801 requests0 B transferred

Headers

Messages

Initiator

Timing

All

Enter regex, for example: (wel

Data	Length	Time
↑ Rock it with HTML5 WebSocket	28	16:03:46.865
↓ Rock it with HTML5 WebSocket	28	16:03:46.981

Select message to browse its content.

WEBSOCKETS



WebSocket

Live Demo

<https://www.websocket.org/echo.html>

<https://repl.it/@nakov/websocket-server-js>

<https://repl.it/@nakov/websocket-client-js>

- **Asynchronous programming** and **concurrent execution** allow multiple pieces of code to run simultaneously
 - **Multithreading** in Java and C# (several threads run concurrently)
 - Accessing common data from concurrent threads may need **synchronization** (mutexes, semaphores, atomic operations)
 - Background **tasks** (C#) and **promises** (JS) with **async / await**
 - **Web Workers** and **Service Workers** in HTML5
 - Multiple parallel **processes** in Windows / Linux



Concurrent Execution using Web Workers

Live Demo

<https://repl.it/@nakov/webworker-js>

- A **promise** in JS holds an **operation** that runs **asynchronously**
 - After **completion** or **failure** an **event** is called

```
let request = fetch('https://blog.softuni.org/wp-json/wp/v2/posts');  
request.then(function(response) {  
  response.json().then(function(posts) {  
    console.log(JSON.stringify(posts));  
  });  
});  
request.catch((err) => console.log(err));
```



Fetching Resources Asynchronously

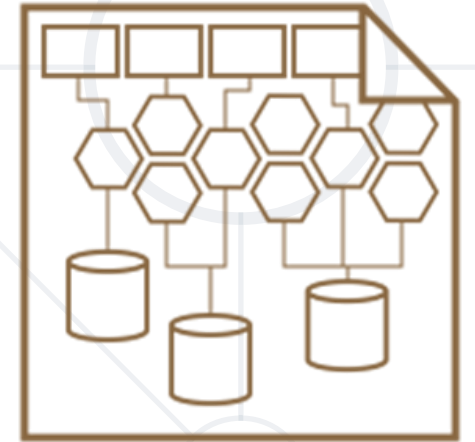
Live Demo

<https://repl.it/@nakov/fetch-example-js>

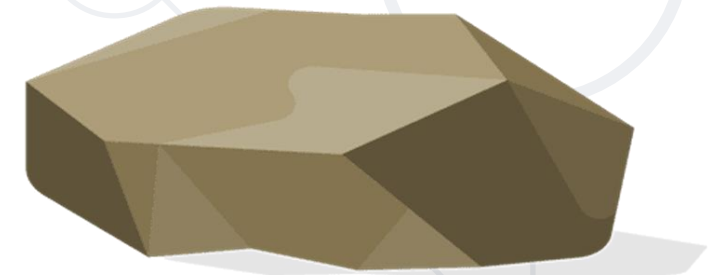


Software Architectures

- Software systems consist of **interconnected components** organized in certain structure called **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

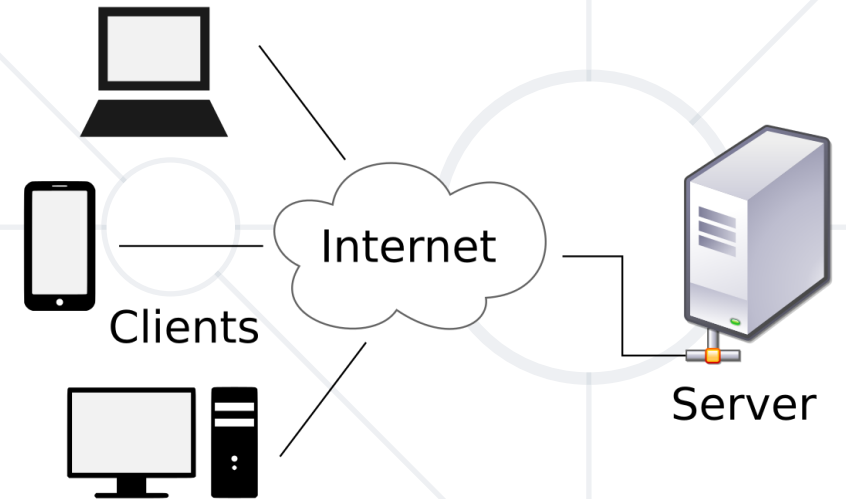


- **Monolith apps**
 - A **single application** holds its data, logic and user interface (UI)
 - **Single user** (no shared data access)
 - **Disconnected** from Internet
 - App data is stored on the **local machine**
 - Examples:
 - A simple smartphone **game**
 - The **Notepad** text editor

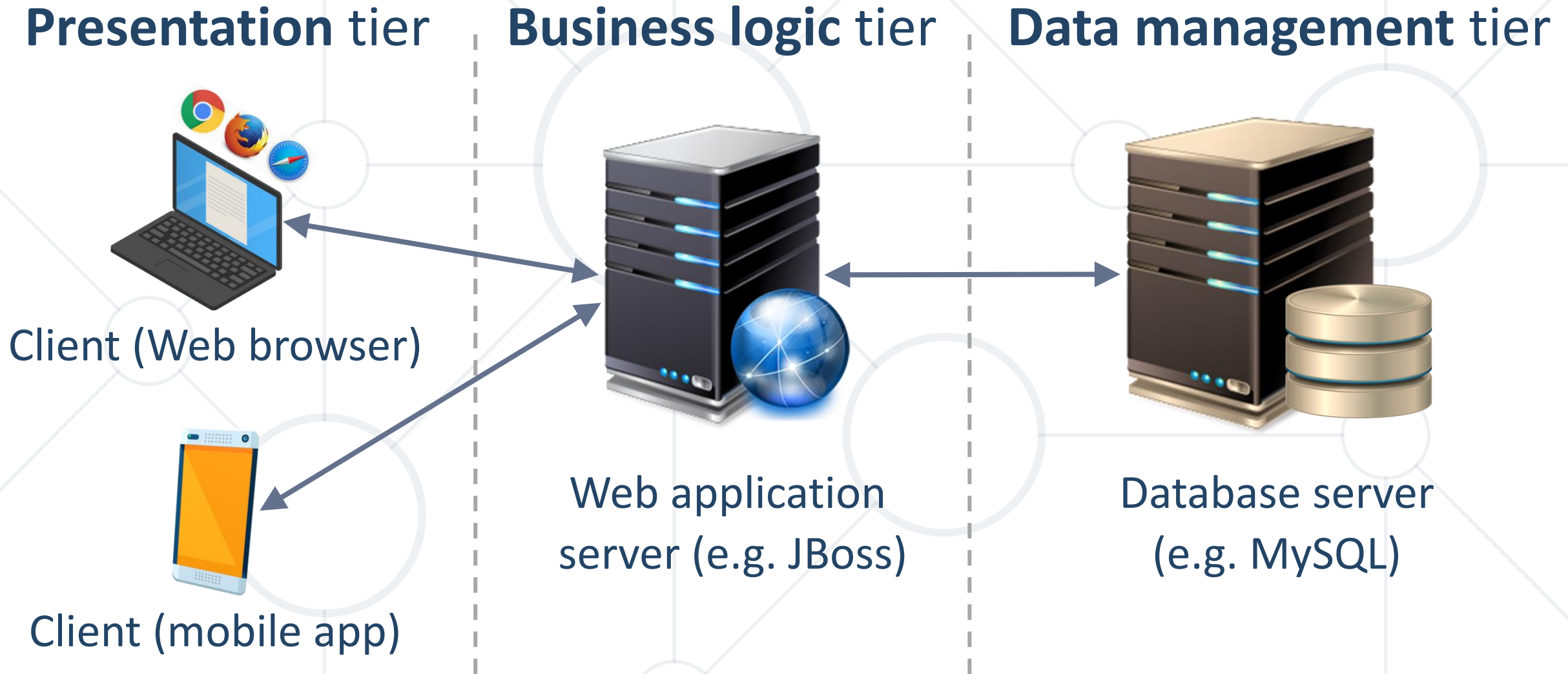


The "Client-Server" Model

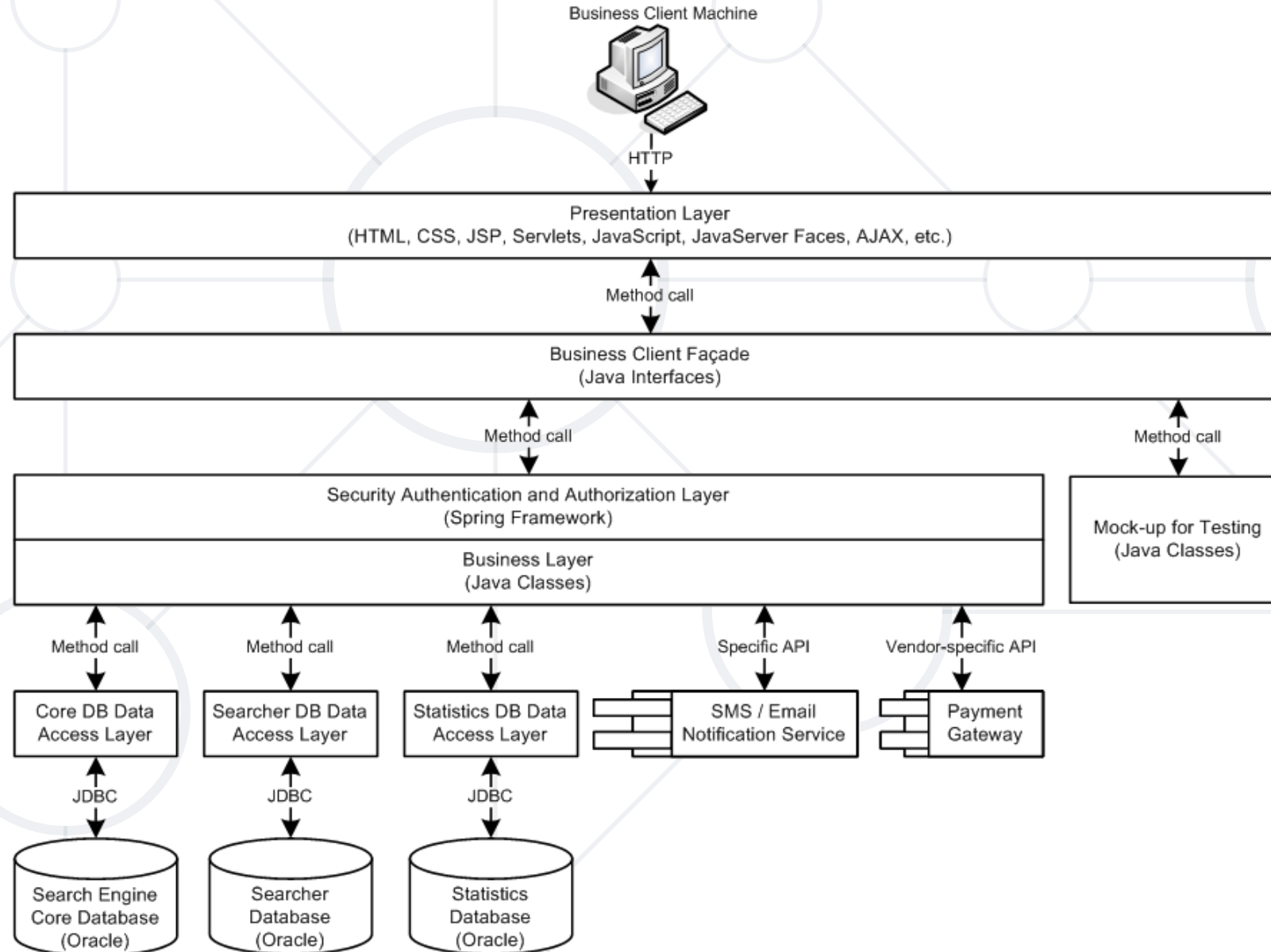
- The **client-server** architectural model
 - The **server** holds app data and logic and provides APIs to clients
 - The **clients** implement the UI (the **user interface**) and consume the server APIs
- Examples:
 - Web browser ↔ Web site
 - Email client ↔ Email server
 - Chat client ↔ Chat server



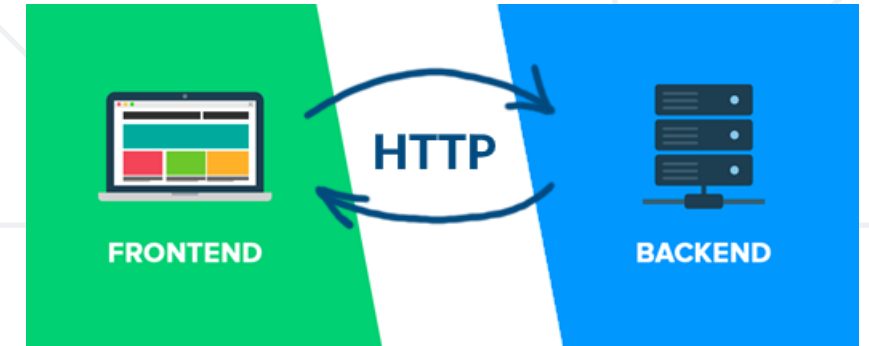
3-Tier Architecture / Multi Tier Architecture



Software Architecture – Example



- **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

- **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



- **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, ...
- **Back-end developers** deal with the business logic, data processing, data storage, APIs

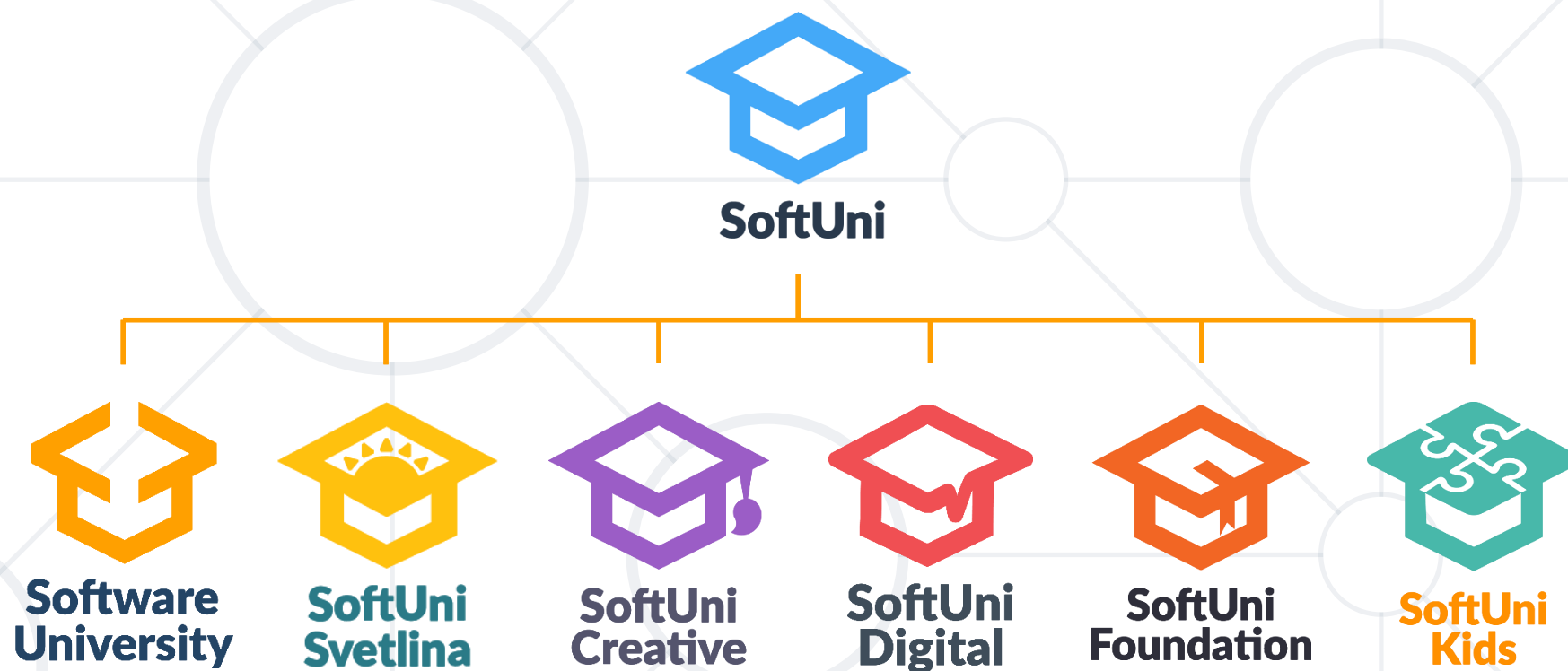


- Full stack development
 - Combines **back end + front-end**
 - Requires end-to-end **architecture, design and implementation**
- **Full stack developers**
 - Build **back-end services**: business logic, data processing, data storage, databases, server-side APIs, containers and cloud
 - Build **front-end apps**: Web, mobile and desktop UI
 - Connect and **integrate** the **front-end** with the **back-end**

- The 4 skills of the software engineers:
 - Coding
 - Problem Solving
 - Development Concepts
 - Software Technologies
- OOP, FP, Async, Event-Driven Programming
- Software Architectures
 - Front-End and Back-End



Questions?



Trainings @ Software University (SoftUni)



- Software University – High-Quality Education, Profession and Job for Software Developers

- softuni.bg, softuni.org

- Software University Foundation

- softuni.foundation

- Software University @ Facebook

- facebook.com/SoftwareUniversity

- Software University Forums

- forum.softuni.bg



- This course (slides, examples, demos, exercises, homework, documents, videos and other assets) is **copyrighted content**
- Unauthorized copy, reproduction or use is illegal
- © SoftUni – <https://softuni.org>
- © Software University – <https://softuni.bg>

