Software Development Concepts

Fundamental Concepts and Paradigms in the Software Engineering Profession

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The 4 Skills of Software Engineers

Skills of the 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%)

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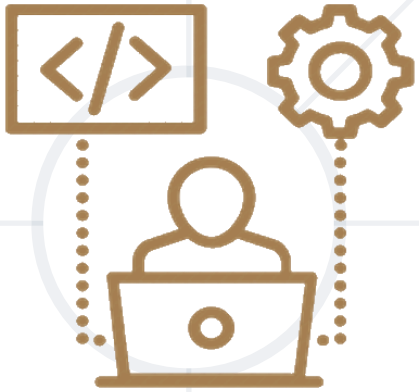
- **Algorithmic** (engineering, mathematical) **thinking**
  - The ability to analyze problems and find solutions
  - Breaking the problem down to steps (algorithm)
- How to develop algorithmic thinking?
  - Solve **1000+** programming **problems**
  - It takes 6 to 12 months of coding every day
- Courses 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%)

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- **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

Math Concepts in Software Development

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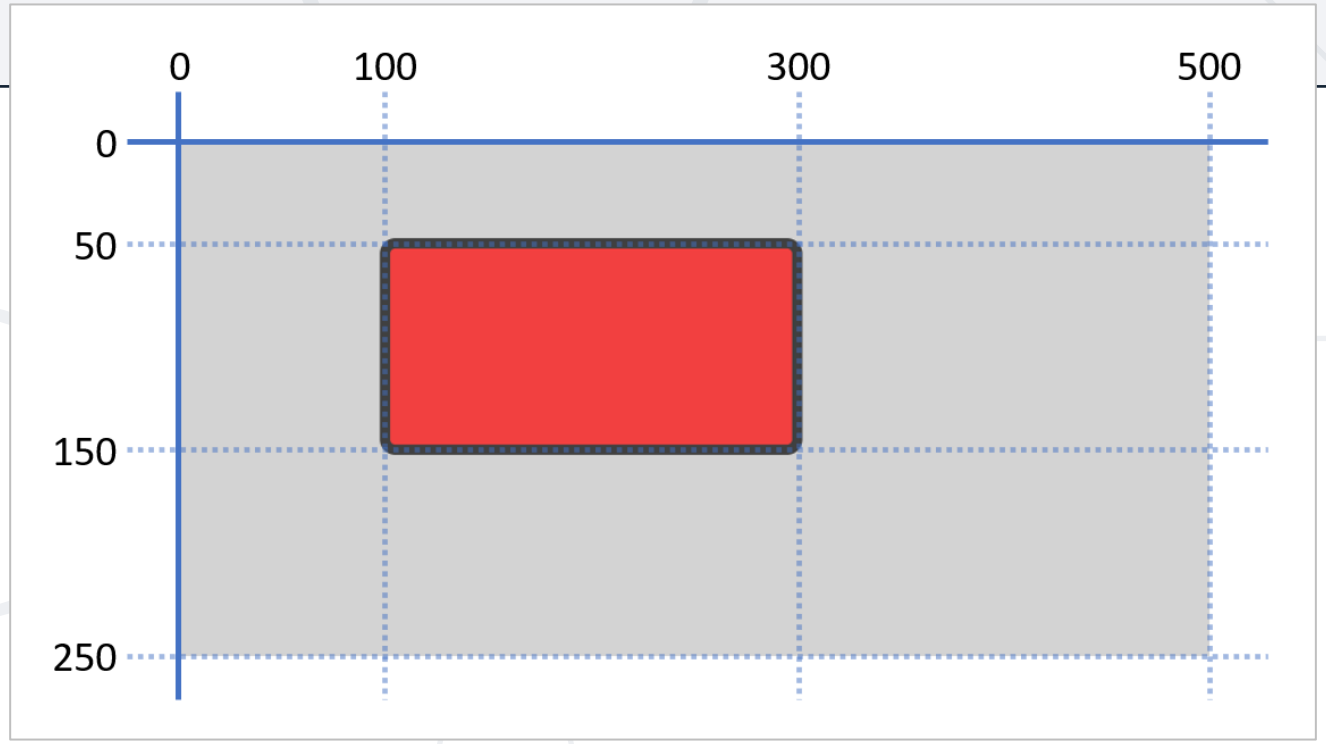
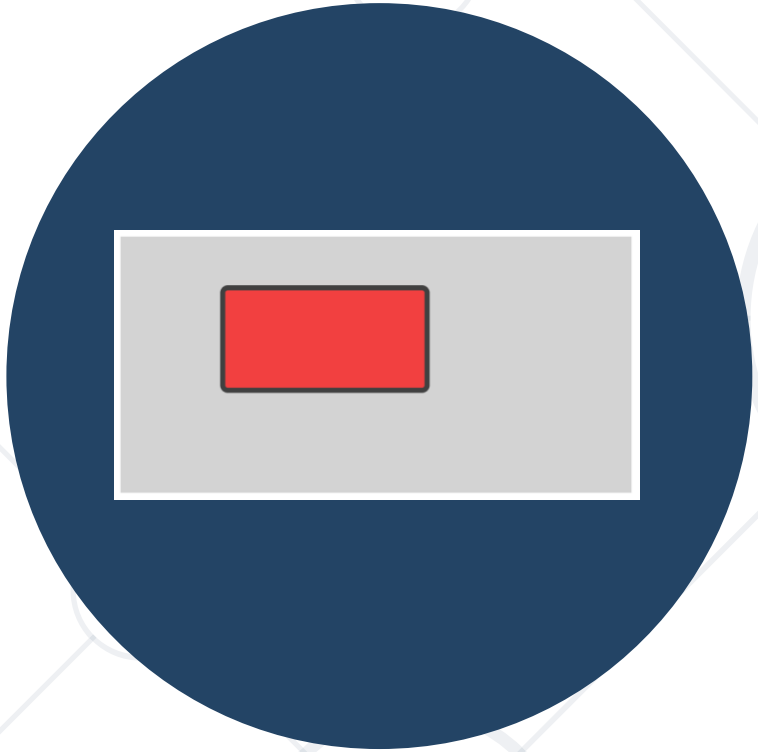
- Basic **mathematical concepts** related to programming
  - **Coordinate systems** (used in computer graphics)
  - Mathematical **functions** (lambda calculus, discrete functions, …)
  - **Vectors** and **matrices** (used in graphics, machine learning, …)
  - Finite state **automata** and **state machines** (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)

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

```
class Rectangle {
  int width, height;
  int CalcArea() {
    return width * height;
  }
}
```

Class definition

Fields (data)

Methods (actions)

Objects

width = 5
height = 6

width = 6
height = 4

width = 7
height = 3

Object-Oriented Programming (OOP)

Live Demo

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

Inheritance and Interfaces

- **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

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```
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

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- **Functional programming** (FP)
  - Programming by composing **pure functions**, avoiding **shared state**, **mutable data**, and **side-effects**
  - **Declarative** programing 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

Functional Programming Languages

- **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 programing paradigms: **functional**, **structured**, **object-oriented**, …
  - Examples: **JavaScript**, **C#**, **Python**, **Java**

Functional Programming – Examples

- 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 and First-Class Functions

- **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 – Examples

- **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"
```

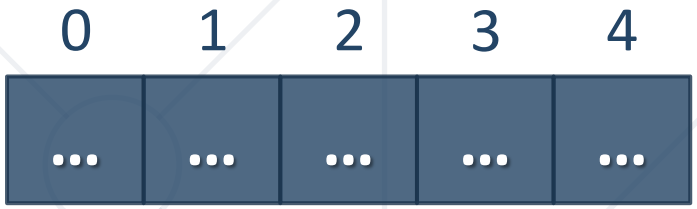
Higher-Order Functions

Live Demo

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

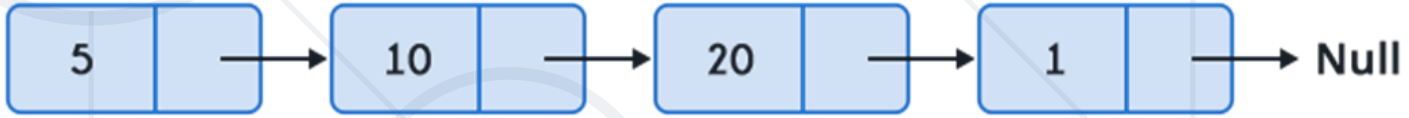
Data Structures

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



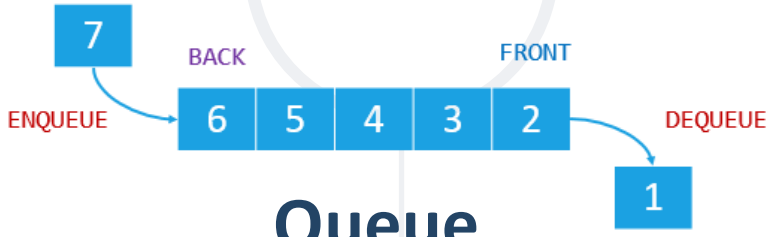
Array / list

(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

250

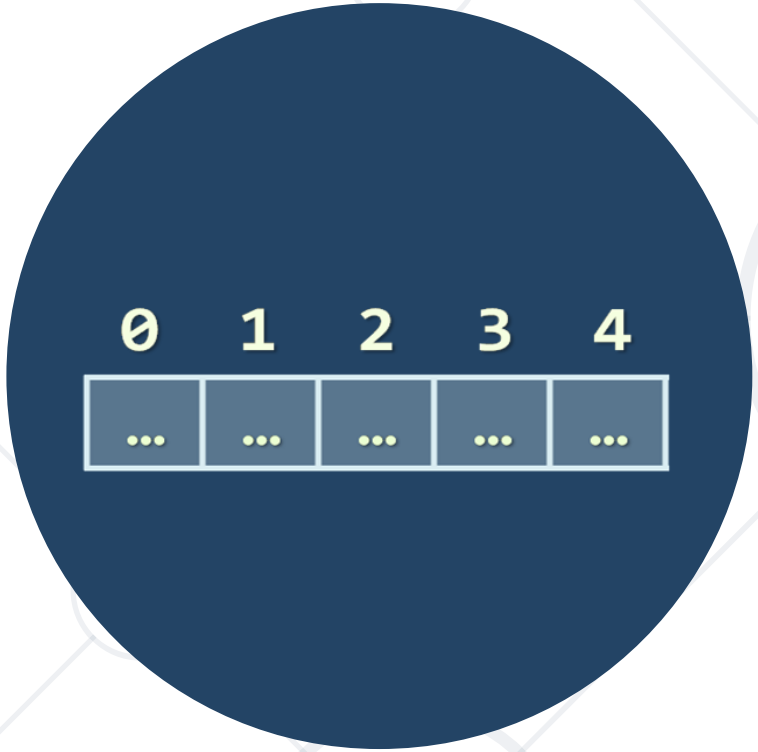
- **Adding** a new income

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

Element	Value
incomes[4]	300

- **Modifying** an existing income

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

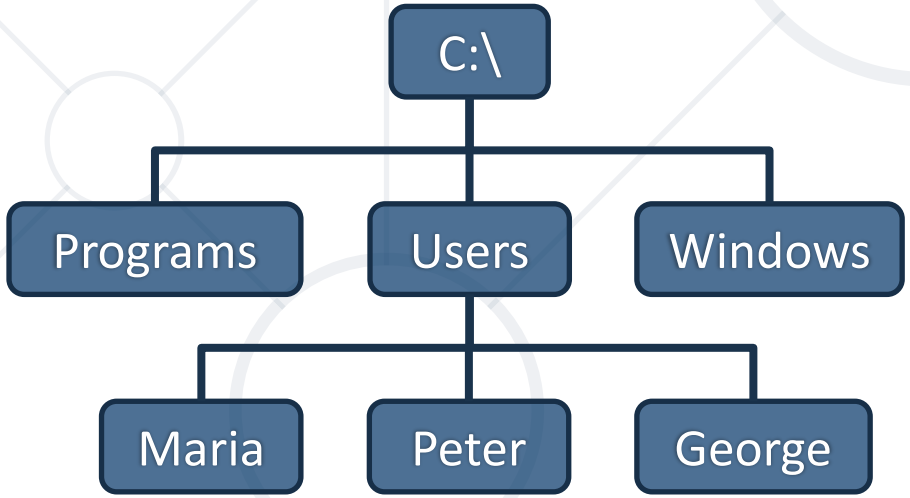


List of Numbers

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**

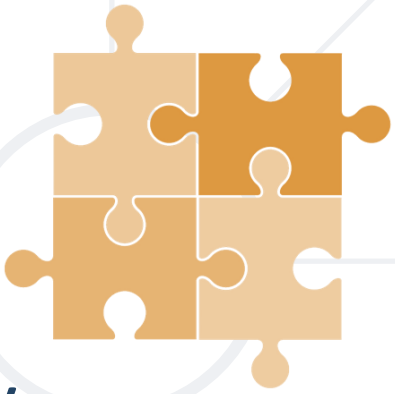


- **Tree traversal algorithms**
  - Depth-First Search (DFS)
  - Breadth-First Search (BFS)

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

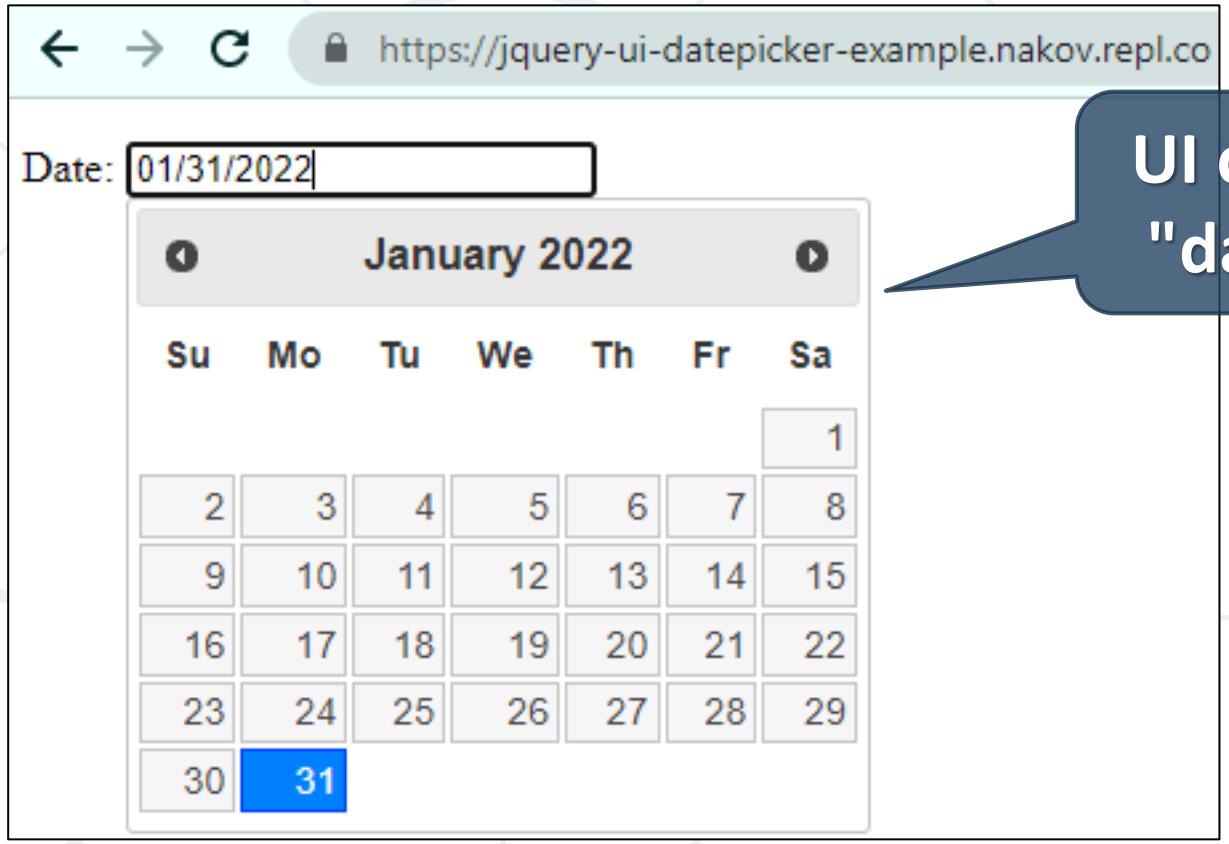
Component-Based Software Development

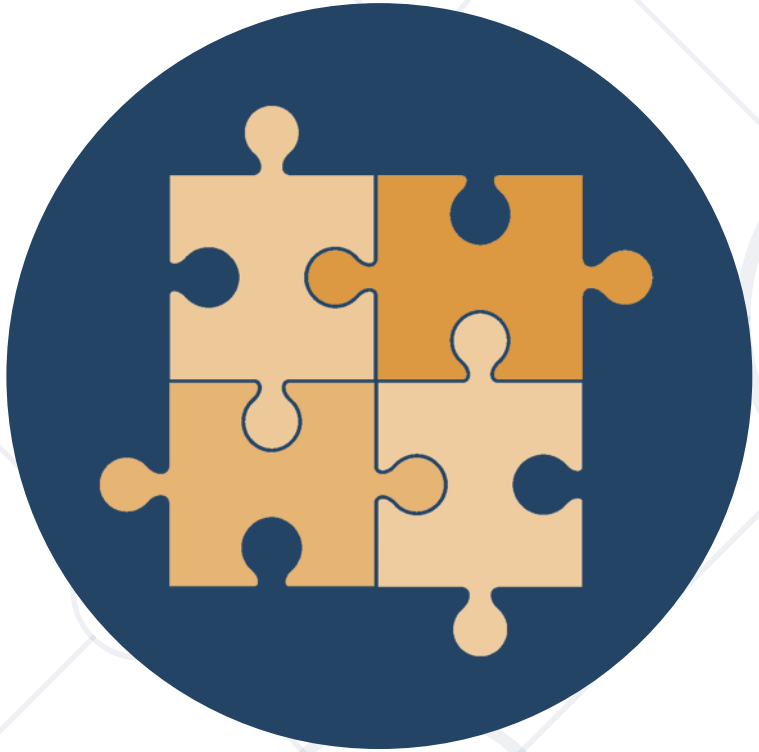
- **Component-based software development**
  - A **programming paradigm** in which applications are composed of re-usable **components**



- **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 Date Picker

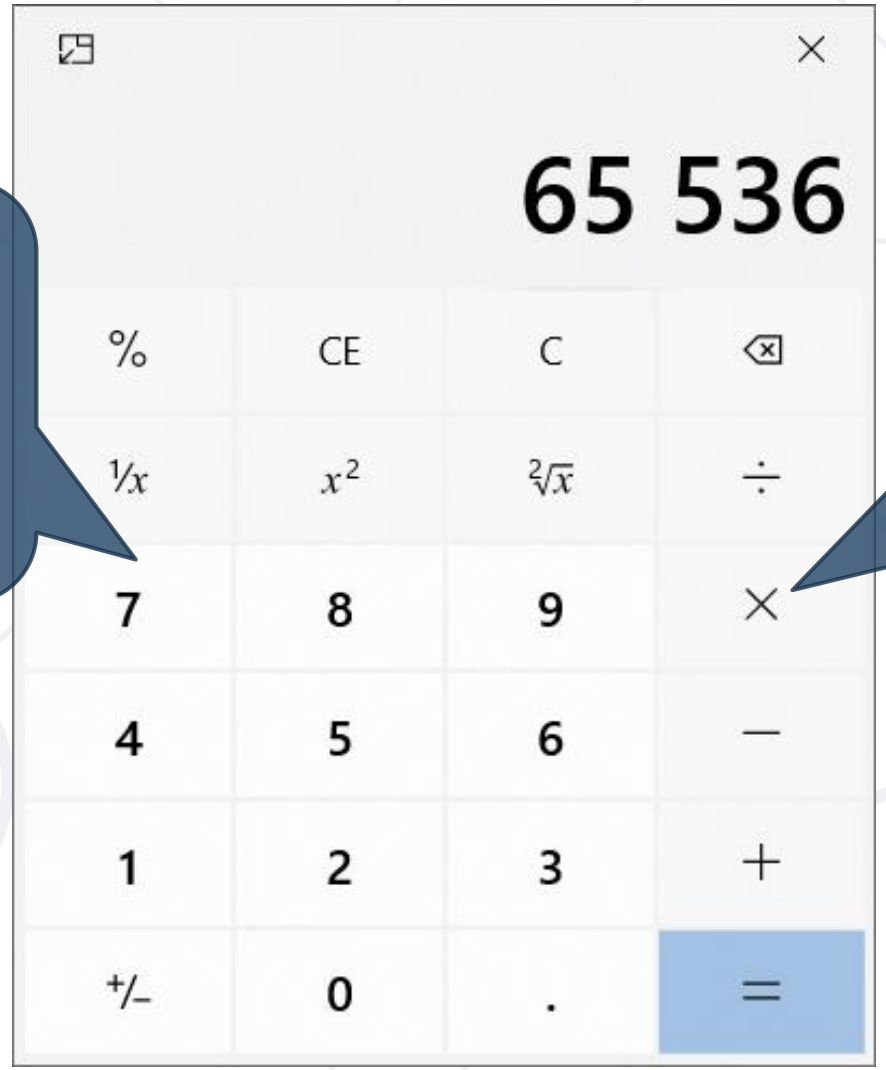
Live Demo

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

Event-Driven Programming

- **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

Example of Event-Driven Programming



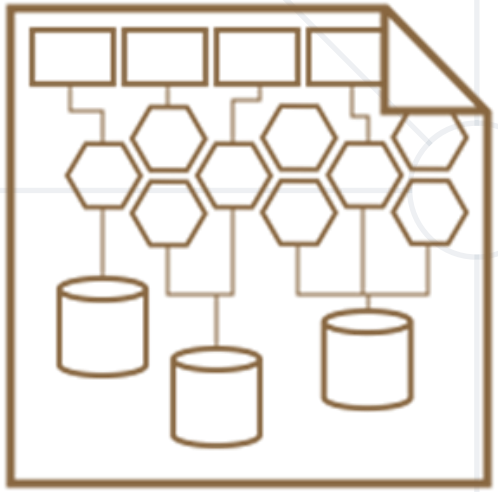
The UI framework draws the UI and check for events in a loop (event loop)

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

Software Architectures

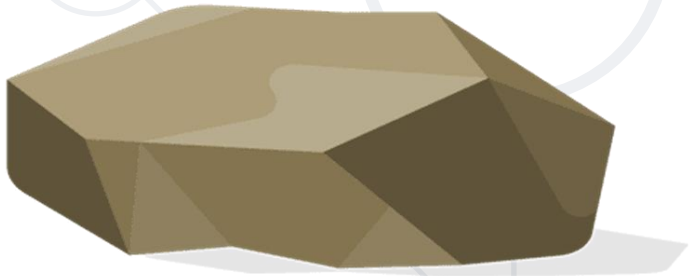
Software Architectures

- 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



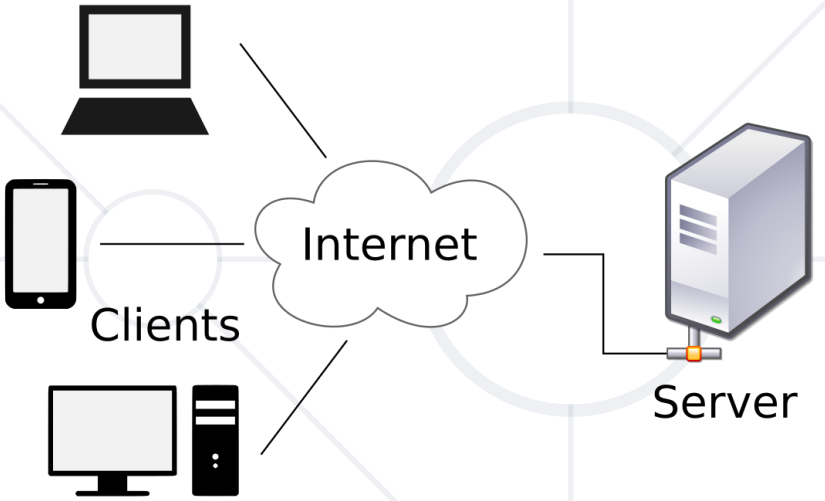
Monolith Apps

- **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

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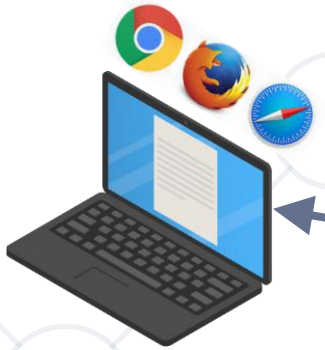
Presentation tier

Business logic tier

Data management tier



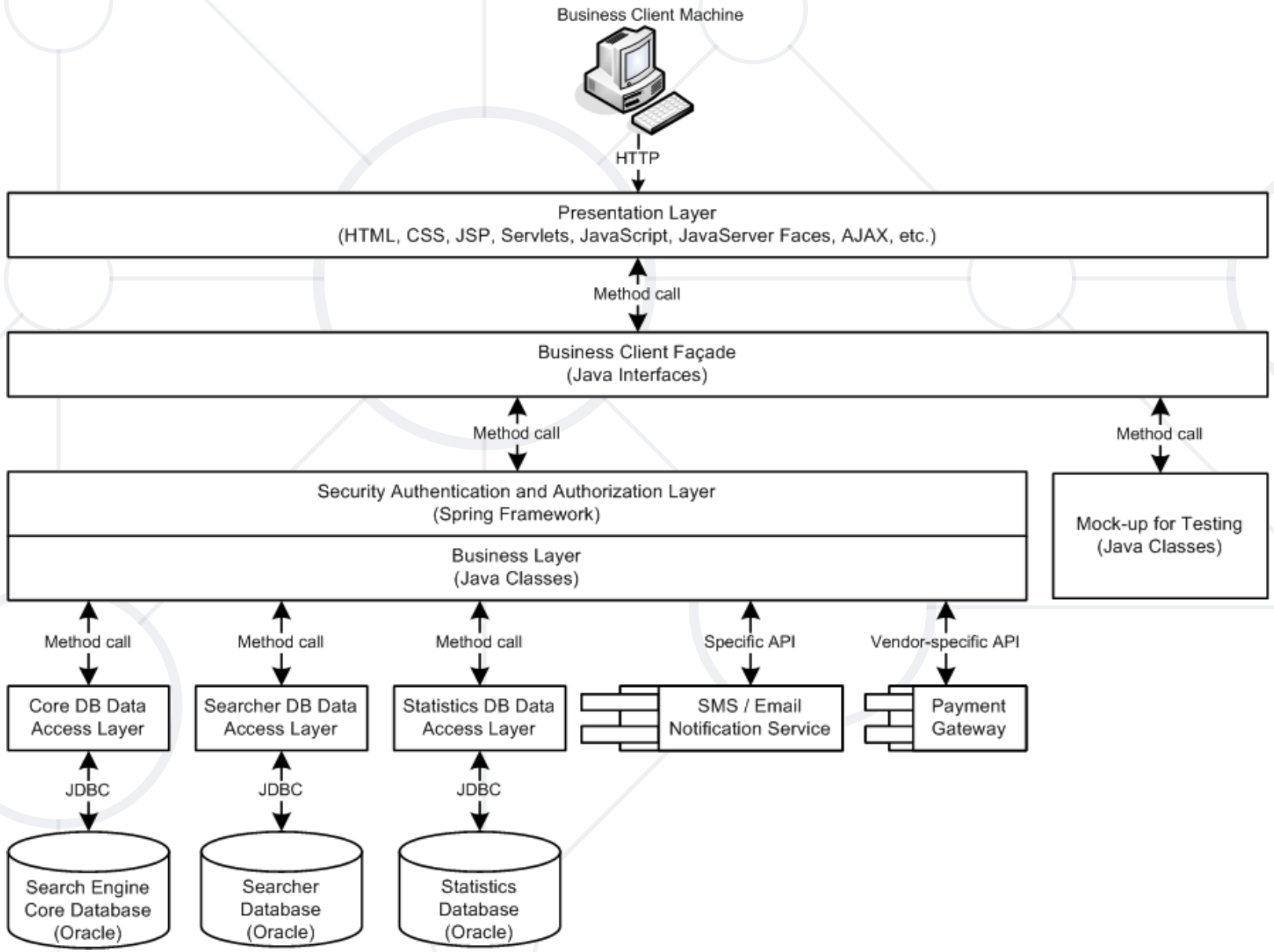
Client (Web browser)

Client (mobile app)

Web application server (e.g. JBoss)

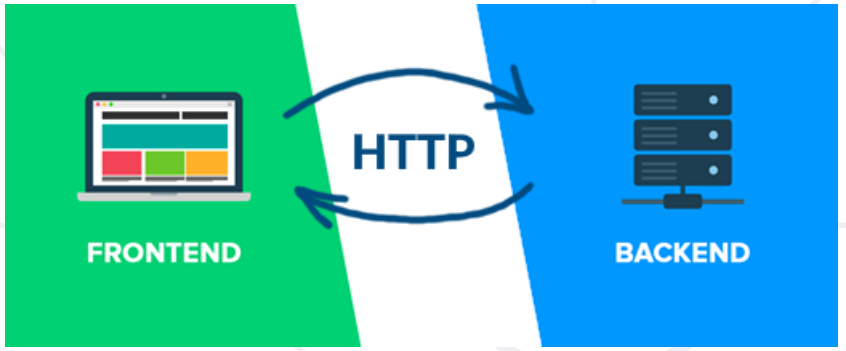
Database server (e.g. MySQL)

Software Architecture – Example



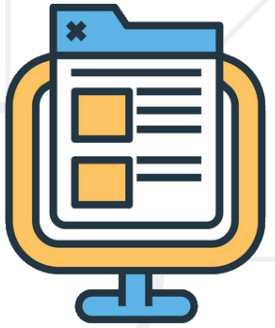
Front-End and Back-End

- **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

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

Back-End Technologies

- 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

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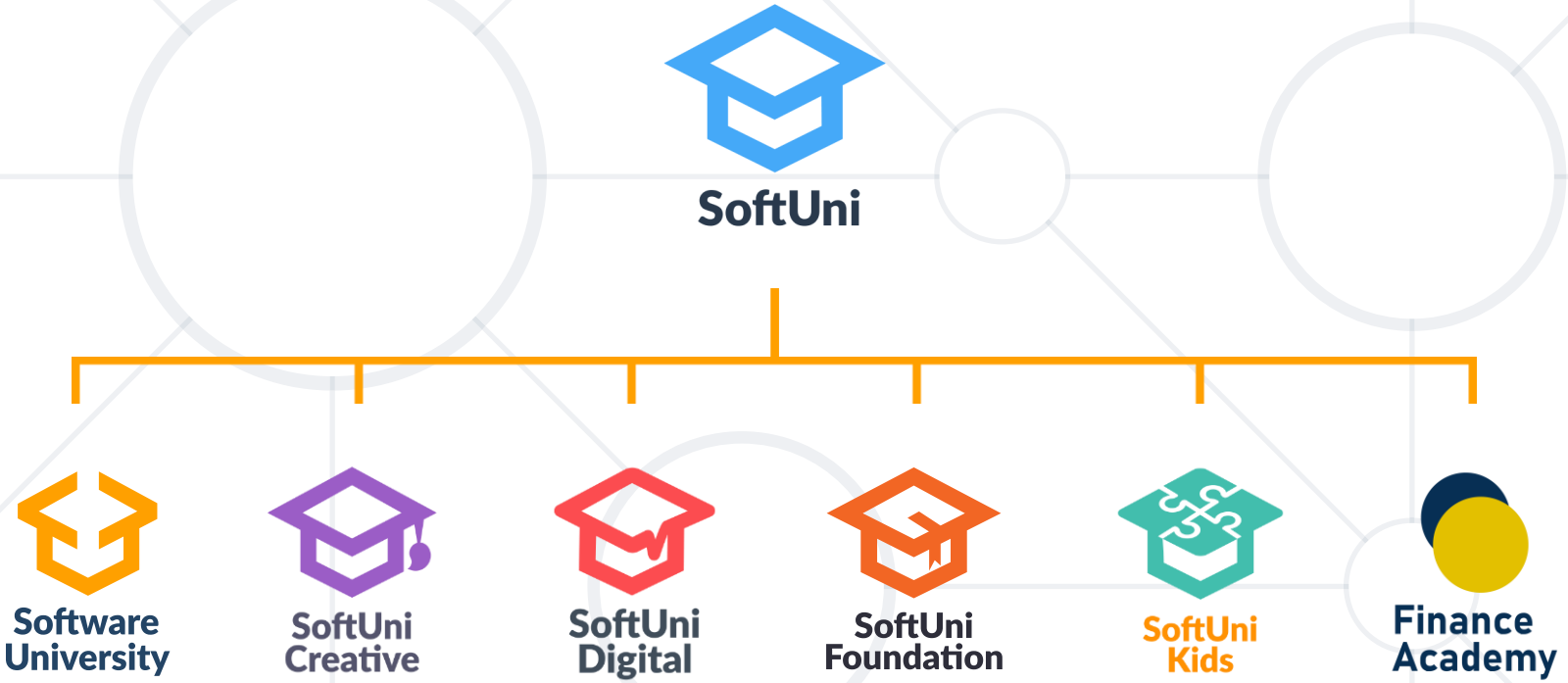
- Full stack development
  - Combines **back end + front-end**
  - Requires end-to-end **architecture**, **design** and **implementation**
- **Full stack developers**
  - Build **back-end services**: business logic, data processing, data storage, databases, server-side APIs, containers and cloud
  -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

Summary

- 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?



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