Web programming

Introdução Engenharia Informática

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JavaScript (JS) is often misunderstood as a “scripting toy,” but it is a sophisticated, high-level language.

1. **Dynamic Typing & Weak Typing**
    - Variables are not bound to a specific *data type.*
    - *Why this matters:* You can assign a Number to a variable, and later assign a String to the same variable. This offers flexibility but increases the risk of runtime errors (e.g., trying to multiply a string).

```
let x = 42;
x = "hello";
console.log(x)
```

JavaScript: Detailed Overview ii

2. **Prototype-based Object Orientation**
   - *How it works:* Unlike Class-based languages (Java/C++) where objects are instantiated from “blueprints” (classes), JS objects inherit directly from other objects (prototypes).
   - *Implication:* Memory efficiency involves cloning existing structures rather than defining rigid hierarchies.

JavaScript: Detailed Overview iii

```
let person  = {
  eats: true,
  hasLegs: 2,
  walks(){ console.log('I can walk')}
}
//define another object
let man = {
  hasBreast: false,
  hasBeard : true,
}
//set the prototype of man to person object
man.__proto__ = person;
//define a third object
let samuel = {
```

```
    age: 23
}
//set the prototype of samuel to man
samuel.__proto__ = man;
//access walk method from samuel
console.log(samuel.walks())
//access hasBeard from samuel
console.log(samuel.hasBeard)
```

3. Single-Threaded Execution

- *The Constraint:* JS has a **single Call Stack**. It can only do *one thing at a time*.

JavaScript: Detailed Overview v

- *The Risk:* If you run a heavy mathematical loop (e.g., calculating Pi to a billion digits), the entire browser tab freezes (UI blocking) because the thread is busy.

Sequential Programming (Procedural) i

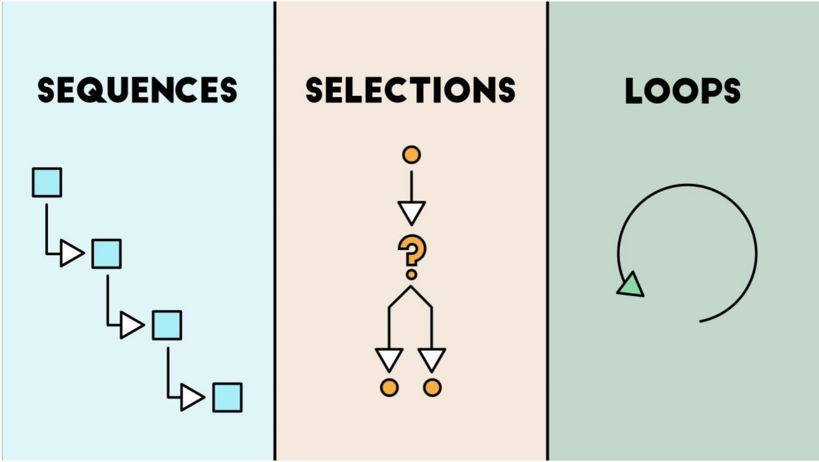
This is the model used in basic C, Fortran, or simple Python scripts.

The Logic:

1. The program starts.
2. Line 1 executes.
3. Line 2 executes.
4. **Line 3 asks for input (`scanf`, `input()`).**
5. The program **HALTS** (blocks) and waits for the user. Nothing else happens until the user hits Enter.

Sequential Programming (Procedural) ii

Why this fails for UI: In a web interface, we cannot **“halt”** the rendering engine to wait for a mouse click. If we did, buttons wouldn’t animate, and gifs wouldn’t play.



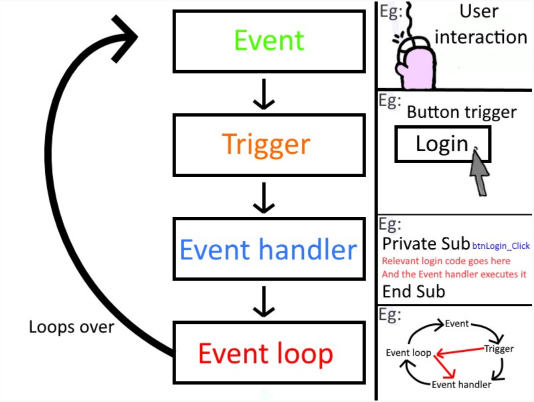
Event-Driven Programming i

Modern interfaces (Web, Windows, macOS) use an **Event-Driven** architecture.

The Logic: 1. The program starts (Initialization). 2. It defines "Handlers" (functions waiting for specific triggers). 3. It enters the **Event Loop**. 4. The program sits in a **Listening State**.

Event-Driven Programming ii

The "Hollywood Principle": ** Don't call us, we'll call you. **
The code doesn't ask "Did the user click?". Instead, the browser interrupts the code saying "A click just happened, run the Click Function."



The Chain of Events i

How does a physical action become code execution?

1. **Hardware Level:** User moves the mouse. The mouse hardware sends an electrical signal (interrupt) to the CPU.
2. **OS Level:** The Operating System (Windows/Linux) interprets this signal as a coordinate change and paints the cursor moving.
3. **Browser Level:** The browser window sees the cursor is over a specific HTML button and the mouse button was pressed.

The Chain of Events ii

4. **The Event:** The browser creates a JavaScript `Event` Object containing details (X/Y coordinates, which button, timestamps).
5. **The Listener:** The browser checks: *Does this HTML element have a listener attached?*
6. **Execution:** If yes, the registered JS function is pushed to the execution stack.

The Document Object Model (DOM)

The Concept: When you write an HTML file, it is just a text string. The browser parses this string into a structure in memory called the DOM.

- **HTML:** `<div id="app"></div>` (Text on hard drive)
- **DOM:** `HTMLDivElement` (Object in RAM)

Why JS uses the DOM: JavaScript cannot edit the text file on the server. It edits the **Object in RAM**. The browser's rendering engine constantly watches the DOM; when JS updates the DOM object, the browser repaints the screen.

Execution & Loading Strategies i

HTML is parsed sequentially (top to bottom). When the parser sees a `<script>` tag, it pauses HTML parsing to download and run the script. This creates issues:

1. **The "Bottom of Body" Hack**
   - *Technique:* Putting `<script>` just before `</body>`.
   - *Reasoning:* Ensures all HTML elements exist in the DOM before the script tries to find them.
2. **The `defer` Attribute (Modern Standard)**

```html
<script src="app.js" defer></script>
```

Execution & Loading Strategies ii

- *Behavior:* The script downloads in the background (parallel) while HTML parses.
- *Execution:* The browser guarantees the script will only run **after** the HTML is fully parsed but **before** the `DOMContentLoaded` event.
- *Benefit:* Faster page load times and safe DOM access.

The Event Loop (Technical Detail) i

How does single-threaded JS handle asynchronous tasks (like fetching data) without freezing?

1. **Call Stack:** Runs synchronous code (LIFO).
2. **Web APIs:** When you call `setTimeout` or `fetch`, the "work" is offloaded to the Browser's C++ threads (not the JS thread).
3. **Callback Queue:** When the Web API is done, it puts your callback function into a Queue.
4. **The Loop:** The Event Loop checks: *"Is the Stack empty?"*
    - If **NO**: Wait.
    - If **YES**: Move the first item from the Queue to the Stack.

The Event Loop (Technical Detail) ii

This is why `setTimeout(fn, 0)` *doesn't run immediately—it waits for the stack to clear.*

1. Handling Mouse Events i

We use `addEventListener`. This is the registration phase of Event-Driven programming.

```
const box = document.querySelector('#box');
// The 'event' object is automatically passed by the br
function handleMove(event) {
    // Update text with mouse coordinates
    box.textContent = `X: ${event.clientX}, Y: ${event.
    // Dynamic styling based on logic
    if (event.clientX > 500) {
        box.style.backgroundColor = 'red';
    } else {
        box.style.backgroundColor = 'blue';
```

1. Handling Mouse Events ii

```
    }
}
// Subscribe to the 'mousemove' event
box.addEventListener('mousemove', handleMove);
```

2. Dynamic Content (Photo Library) i

We can create the interface programmatically. This is how React/Vue work under the hood (Imperative approach).

```
const urls = ['img1.jpg', 'img2.jpg'];
const container = document.getElementById('gallery');

urls.forEach(url => {
    // 1. Create Element: Creates an orphan object in m
    const img = document.createElement('img');
    // 2. Configure Object: Set properties
    img.src = url;
    img.className = 'thumbnail';
    // 3. Attach Event: Make it interactive immediately
```

2. Dynamic Content (Photo Library) ii

```
    img.addEventListener('click', () ⇒ {
        console.log("You clicked " + url);
    });
    // 4. Mount: Insert into the live DOM tree.
    container.appendChild(img);
});
```

3. Asynchronous Data (Fetch API) i

Fetching data from an API takes time (latency). We use **Promises** (`async/await`) to prevent blocking.

```
async function getData() {
    try {
        // 'await' yields the thread until the Promise
        // The UI remains responsive during this pause.
        const response = await fetch('[https://api.data
        // Parsing JSON is also asynchronous (it handle
        const data = await response.json();
        console.log(data); // Runs only after network f
    } catch (error) {
        // Handles network failures (404, 500, Offline)
```

3. Asynchronous Data (Fetch API) ii

```
        console.error("Fetch failed:", error);
    }
}
```

4. Real-Time Communication (WebSockets) i

HTTP vs. WebSockets:

- **HTTP:** Client asks, Server answers, Connection closes. (Stateless).
- **WebSocket:** Client performs a “Handshake”, Connection upgrades to TCP socket, Connection stays open.

```
const socket = new WebSocket('ws://localhost:8080');
// Event: Connection Established
socket.onopen = () => {
    console.log("Connected to Chat Server");
    socket.send("User joined");
};
```

4. Real-Time Communication (WebSockets) ii

```
// Event: Server pushed data to us
socket.onmessage = (event) => {
    // This fires whenever the server sends data. No po
    const message = JSON.parse(event.data);
    displayMessage(message);
};
```

The Challenge of Interpreted Languages i

Unlike C, C++, or Rust, JavaScript is an **Interpreted** (or JIT compiled) language.

Compiled Languages (C/C++):

- The compiler scans the entire code **before** execution.
- Syntax errors and type mismatches are caught at **Compile Time**.
- *Result:* You cannot run the program until these errors are fixed.

Interpreted Languages (JavaScript):

The Challenge of Interpreted Languages ii

- The browser reads and executes code line-by-line (or block-by-block) at **Runtime**.
- *Result:* The application might load perfectly and run for minutes.
- **The Crash:** The error only occurs when the execution flow hits the specific buggy line (e.g., when a user clicks a specific button).

Consequence: "It works on my machine" is common. You might not encounter the error because you didn't trigger the specific execution path that contains the bug.

The Environment Gap: Editor vs. Browser i

Debugging Web Applications introduces a disconnect between where you **write** code and where you **run** code.

1. The Context Switch: * You write code in an **IDE** (VS Code), which has static analysis and linting. * You run code in the **Browser** (Chrome/Firefox). * When an error occurs, it appears in the Browser’s Console, not immediately in your text editor.

The Environment Gap: Editor vs. Browser ii

2. The "Black Box" Problem: * The browser often runs "minified" or "bundled" code (to save bandwidth). * An error on line 1 of `bundle.js` is useless to the developer. * *Solution:* We rely on **Source Maps**, which tell the browser how to map the running code back to your original files.

Debugging Strategies

1. “Printf” Debugging (`console.log`) * The oldest method. You print variables to the browser console to inspect the state. * *Pros:* Fast, simple. * *Cons:* Clutters code, requires cleanup, doesn’t pause execution.

2. The `debugger;` Keyword * Placing the statement `debugger;` in your code forces the browser to **pause execution** (breakpoint) at that line. * You can then step through code line-by-line.

3. Browser DevTools (The Sources Tab) * Modern browsers (Chrome/Firefox) have built-in debuggers that rival desktop IDEs. * You can set breakpoints, watch variables, and inspect the Call Stack directly in the browser.

The “State vs. View” Problem i

In complex apps (e.g., Facebook, Spotify), keeping the UI (View) in sync with the data (State) using Vanilla JS is error-prone.

Frameworks solve this by:

1. **Declarative Programming:** You define *what* the UI should look like for a given state, not *how* to update it.
2. **Componentization:** Breaking the UI into reusable, isolated chunks.

React: The Library i

Developed by Facebook (Meta). React is technically a **Library**, not a Framework, focused solely on the View layer.

Key Concepts:

1. **Virtual DOM:** React keeps a lightweight copy of the DOM in memory. When state changes, it calculates the “diff” and updates only the changed parts of the real DOM.
2. **JSX (JavaScript XML):** Syntax extension allowing HTML to be written inside JS.
3. **Unidirectional Data Flow:** Data flows down (Parent -> Child).

React Example i

Note the **Declarative** nature. We don't call `appendChild`. We return the structure we want.

```
import React, { useState } from 'react';
function ImageGallery() {
  // State Hook: When 'images' changes, the UI auto-upd
  const [images, setImages] = useState([
    { id: 1, url: 'img1.jpg' }
  ]);
  return (
    <div id="gallery">
      {/* Loop inside JSX */}
      {images.map(img => (
```

React Example ii

```
        <img key={img.id} src={img.url}
        className="thumbnail" />
      ))}
    </div>
  );
}
```

Angular: The Framework i

Developed by Google. Angular is a full-fledged **Framework**. It includes routing, HTTP clients, and form handling out of the box.

Key Concepts:

1. **TypeScript:** Mandatory. Adds static typing (Interfaces, Classes) to JS for safety.
2. **Dependency Injection (DI):** Built-in system to manage services and state.
3. **Two-Way Data Binding:** Changes in UI update State; Changes in State update UI (automatically).

Angular: The Framework ii

4. **Real DOM:** Angular operates directly on the DOM but uses a sophisticated Change Detection mechanism (Zones).

Angular Example i

Angular separates the Logic (Typescript) from the View (HTML Template).

Component Logic (`gallery.component.ts`)

```typescript
import { Component } from '@angular/core';
@Component({
  selector: 'app-gallery',
  templateUrl: './gallery.component.html'
})
export class GalleryComponent {
  // Typed Array
  images: Array<{url: string}> = [{ url: 'img1.jpg' }];
}
```

Angular Example ii

Template (`gallery.component.html`)

```html
<div id="gallery">
  <!-- Structural Directive (*ngFor) -->
  <img *ngFor="let img of images"
       [src]="img.url"
       class="thumbnail">
</div>
```

Summary Comparison i

Feature	**Vanilla JS**	**React**	**Angular**
Paradigm	Imperative	Declarative	Declarative
Language	JavaScript	JS + JSX	TypeScript
DOM	Direct Access	Virtual DOM	Real DOM + Zones
Scale	Small scripts	Medium/Large Apps	Enterprise Apps
Learning Curve	Low	Medium	High

Node.js & NPM i

Node.js is not a language; it is a **Runtime Environment**. It takes Chrome's V8 Engine and adds C++ bindings for File System (FS) and Networking, allowing JS to run on servers.

NPM (Node Package Manager):

- Manages dependencies (libraries).
- `package.json`: The project manifest. Lists what libraries are needed (`dependencies`) and how to run the project (`scripts`).

Simple Express Server i

Express is the standard framework for Node. It simplifies routing.

```
// Import express library
const express = require('express');
const cors = require('cors'); // Middleware for Securit
const app = express();
// Enable CORS: Allows our browser-based JS (from a dif
// to fetch data from this server. Without this, the br
app.use(cors());
// Define a Route (Endpoint)
app.get('/api/hello', (req, res) => {
    // Send JSON response
```

Simple Express Server ii

```
    res.json({
        msg: "Hello World",
        serverTime: Date.now()
    });
});
app.listen(3000, () => console.log("Running on port 300
```

Python for Web Services i

While Node.js shares a language with the frontend, **Python** is dominant in Data Science and AI.

FastAPI Features:

1. **Asynchronous:** Uses Python's `async def` (ASGI standard), making it much faster than Flask/Django.
2. **Type Hints:** Validates data automatically.
3. **Swagger UI:** Generates a documentation website (`/docs`) for your API automatically.

FastAPI Example i

```
from fastapi import FastAPI
from fastapi.middleware.cors import CORSMiddleware

app = FastAPI()

# CORS Configuration
# Explicitly allowing the frontend container/origin
app.add_middleware(
    CORSMiddleware,
    allow_origins=["*"], # In prod, replace * with spec
    allow_methods=["*"],
)
```

FastAPI Example ii

```python
@app.get("/api/items")
async def read_items():
    # Python Dictionary is automatically converted to J
    return [
        {"name": "Item 1", "price": 10.5},
        {"name": "Item 2", "price": 20.0}
    ]
```

The Architecture i

We have two separate applications:

1. **Frontend:** Static HTML/JS served by Nginx (or a built React/Angular app).
2. **Backend:** Python/Node API processing data.

We need to run them together and ensure they can communicate.

Docker Compose Configuration i

`docker-compose.yml` orchestrates multi-container applications.

```yaml
services:
  # --- THE BACKEND ---
  backend-api:
    build: ./backend_folder       # Build image from Do
    container_name: py_api
    ports:
      - "8000:8000"               # Expose port 8000 to
    volumes:
      - ./backend_folder:/app     # Hot-reload code cha
```

Docker Compose Configuration ii

```yaml
# --- THE FRONTEND ---
frontend-web:
  image: nginx:alpine           # Use pre-built Nginx
  container_name: my_website
  ports:
    - "8080:80"                 # Browser hits localh
  volumes:
    # Inject our HTML/JS (or React build) into Nginx
    - ./frontend_folder:/usr/share/nginx/html
  depends_on:
    - backend-api               # Wait for API to sta
```

Critical Networking Concept:

Docker Compose Configuration iii

- **Browser to Backend:** When your JavaScript runs in the *browser*, it is running on the *User's Machine*. Therefore, the JS `fetch` URL must point to `http://localhost:8000` (the port exposed by Docker to the host machine), not the internal container name.

Additional Resources i

JavaScript & The Web * MDN Web Docs (Mozilla) - The bible of web development. * JavaScript.info - Deep dive into the modern language. * What the heck is the event loop anyway? (Philip Roberts) - Essential visualization of the JS runtime.

Frameworks * React Documentation - Official docs (newly rewritten). * Angular University - Comprehensive tutorials for Angular.

Backend & DevOps * Node.js Best Practices - Architecture patterns. * FastAPI User Guide - Excellent documentation with interactive examples. * Docker Curriculum - A hands-on guide for beginners.