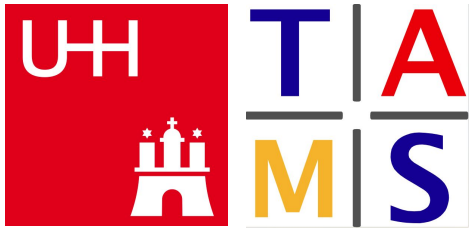


A JavaScript Framework for Presentations and Animations on Computer Science

Laszlo Korte

Bachelor Thesis
Technical Aspects of Multimodal Systems
Department of Informatics
University of Hamburg

Outline

1. Introduction
2. Web Platform
   - The Browser
   - NodeJS
   - Workflow
   - Graphical User Interface
3. Components
   - Demos
4. Architecture

Introduction

Motivation

Motivation

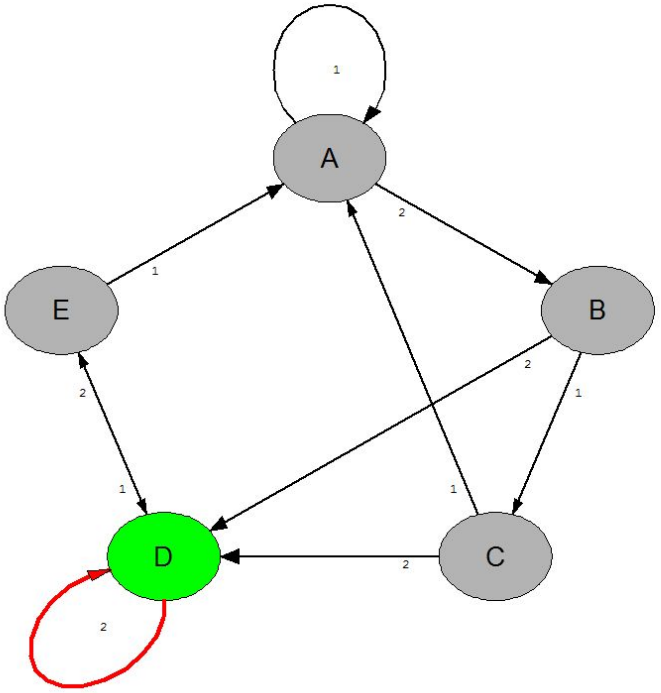
- Computer Science deals with abstract topics
- Hard to grasp without trying
- Short feedback cycle for building intuition

➔ **Interactive learning experience**

Matlab Components

- **Boolean expression** parsing and evaluation
- **Binary number** encoding and decoding
- **Finate-state machine** simulation
- **Algorithm** visualisation
- …

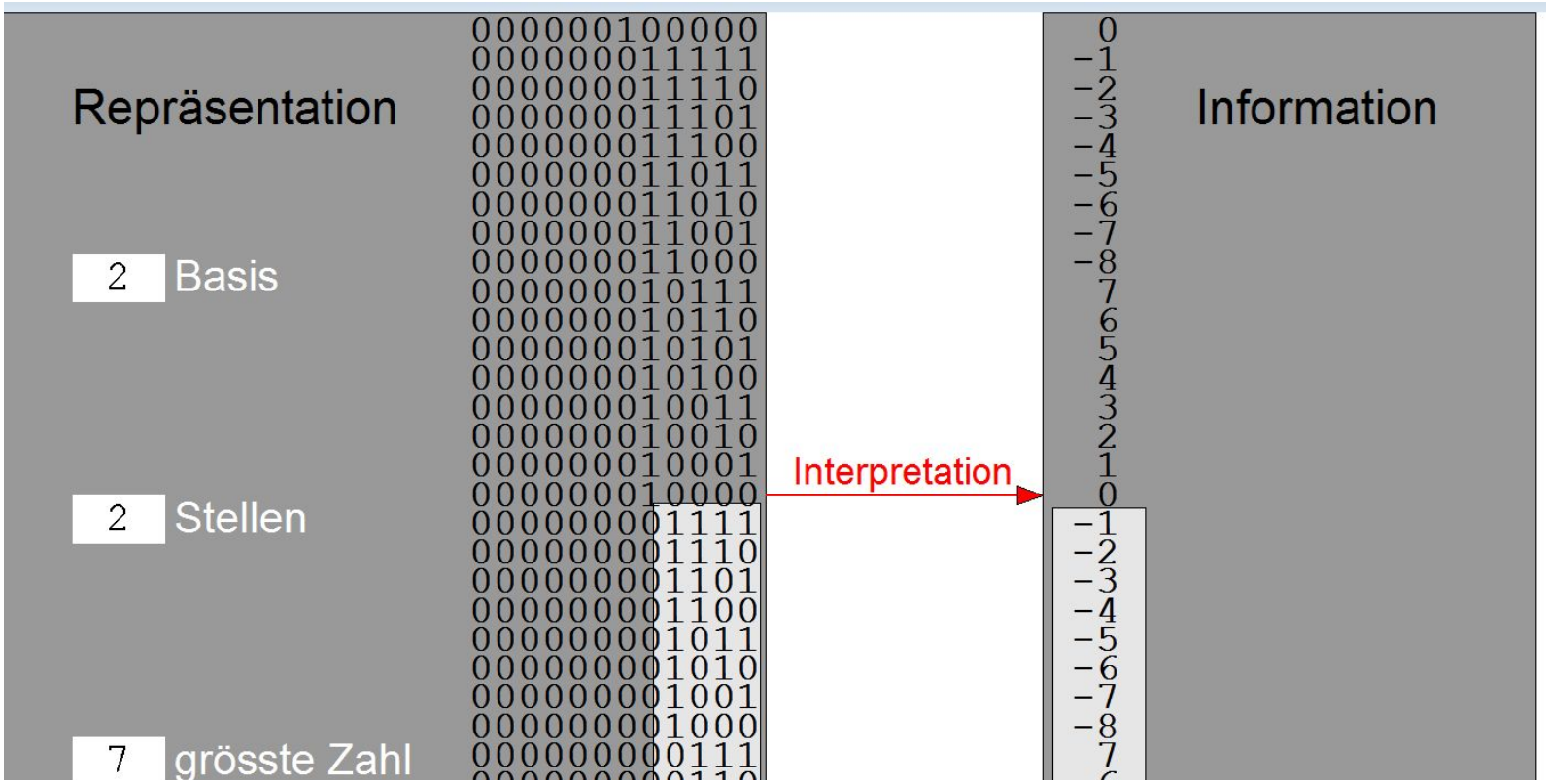
Matlab Components - FSM



Zustand	Index der Eingabe 1	2
A	A	B
B	C	D
C	A	D
D	E	D

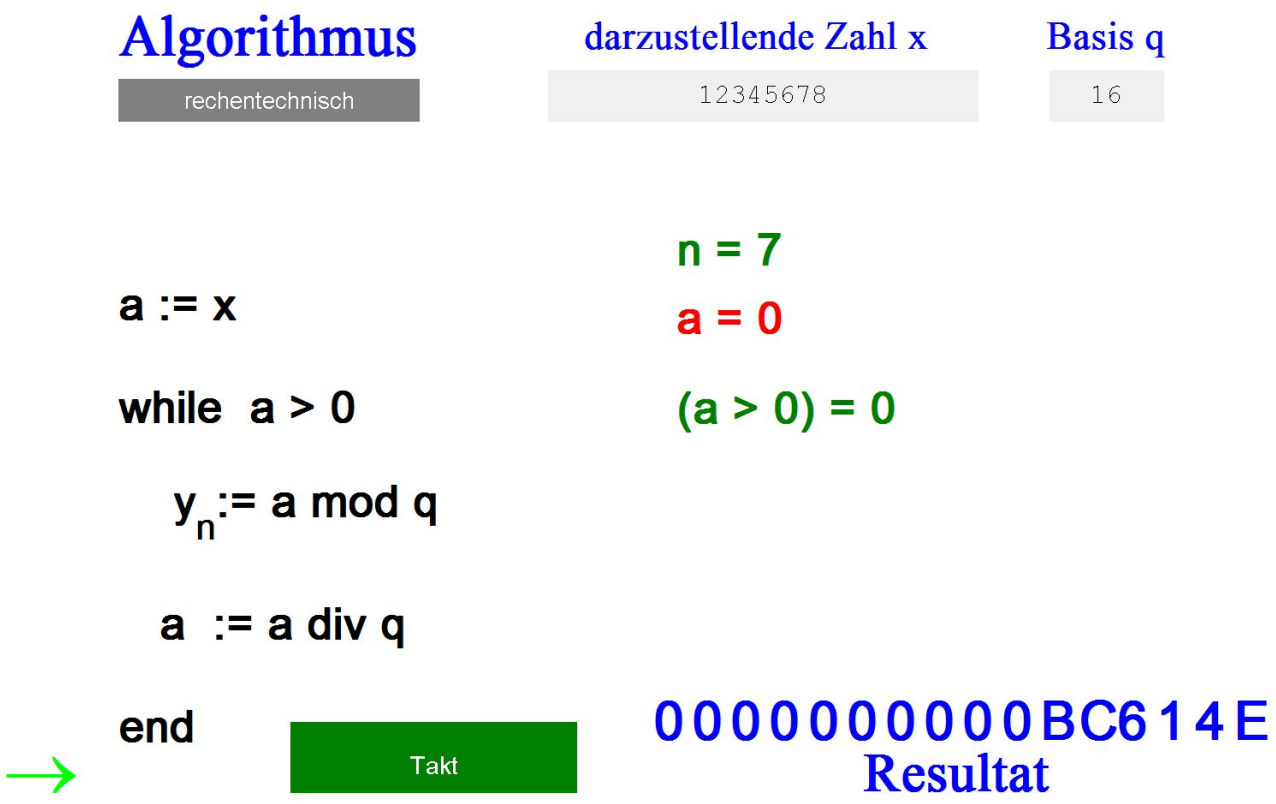
finite-state machine simulator

Matlab Components - number encoding



number “circle”

Matlab Components - base conversion



visualisation of an algorithm for base conversion

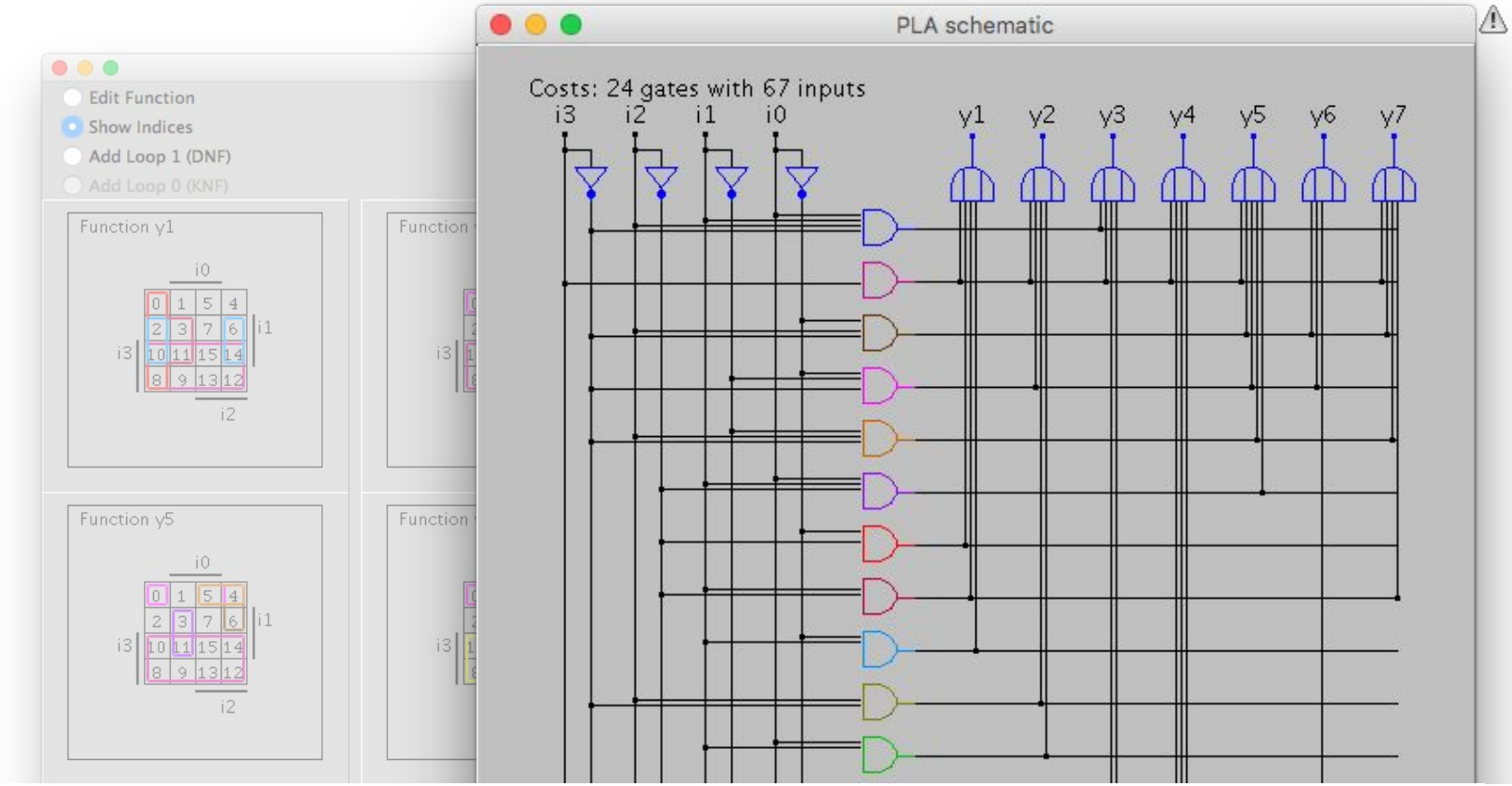
Java Applets

- Karnaugh map editor
- Advanced FSM editor

Java Applets - Karnaugh map

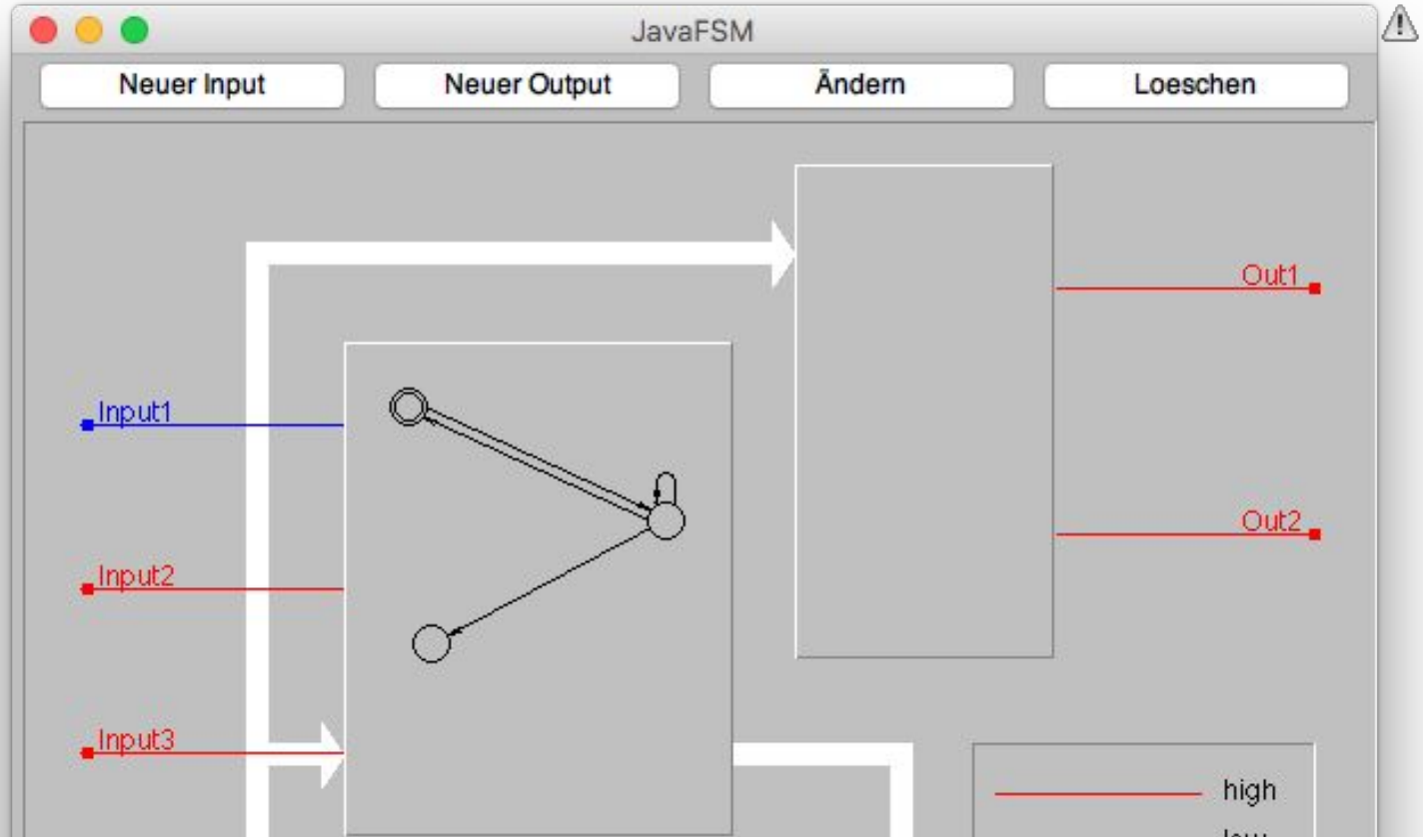
Karnaugh map editor

Java Applets - Karnaugh map



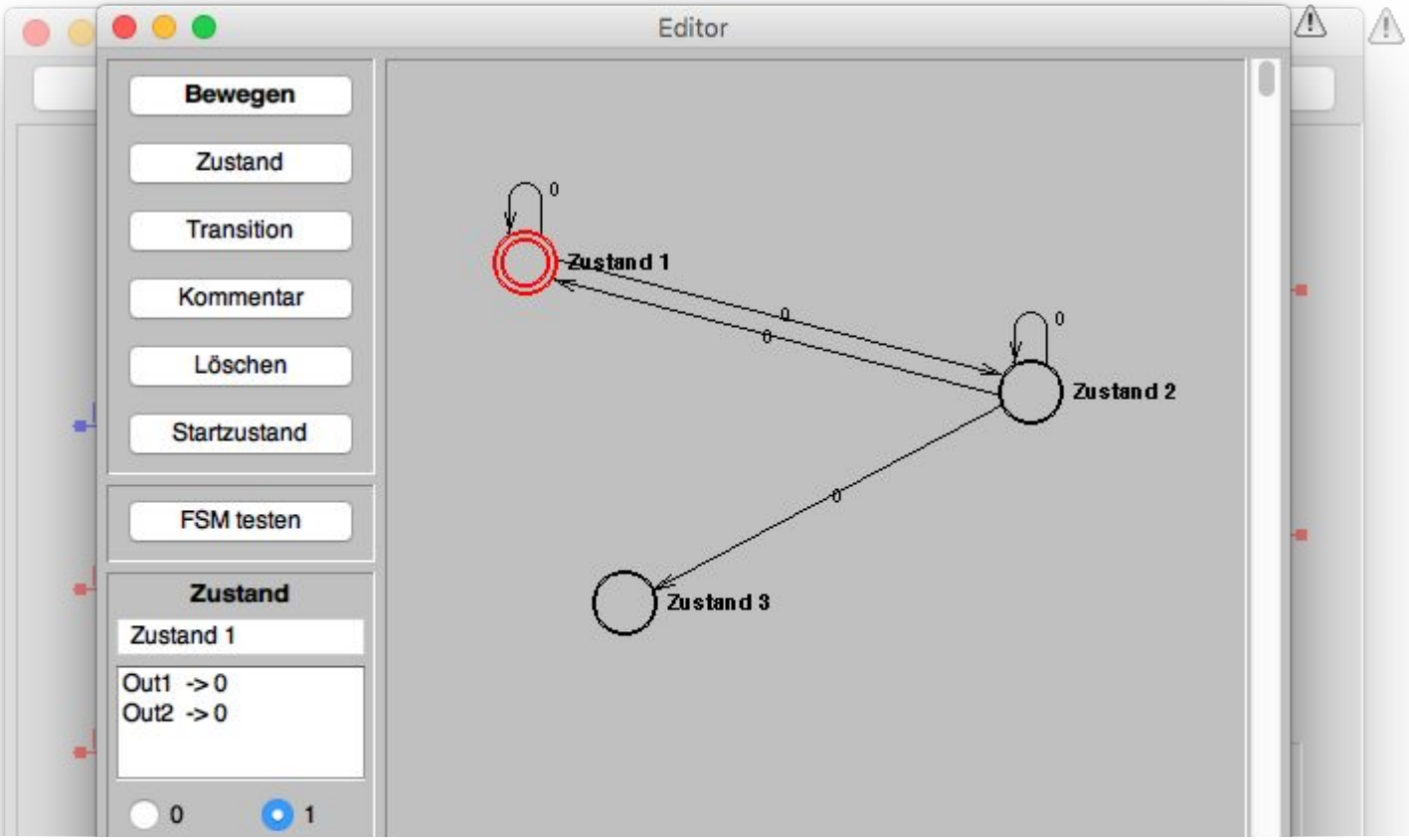
Karnaugh map editor

Java Applets - FSM



Finite-state machine editor

Java Applets - FSM



Finite-state machine editor

Issues

- Matlab
  - Not free, licensing restrictions
  - Not trouble-free with current Matlab version
  - Not on mobile devices

Issues

- Matlab
  - Not free, licensing restrictions
  - Not trouble-free with current Matlab version
  - Not on mobile devices
- Java Applets
  - Not on iOS (iPad, iPhone)
  - Not usable on touch screens

Introduction

Objective

Objective

- A new collection of components
  - no licensing issues
  - not limitted to a small set of devices

➔ The web as **free** and **open** platform

➔ **Touch screen** support

➔ Support a wide range of **screen sizes**

Objective - components

- Karnaugh map editor
- Finite-state machine editor
- Boolean expression editor
- Number circle
- ...

➔ **Expandable later on**

Web Platform

The Browser

The Browser

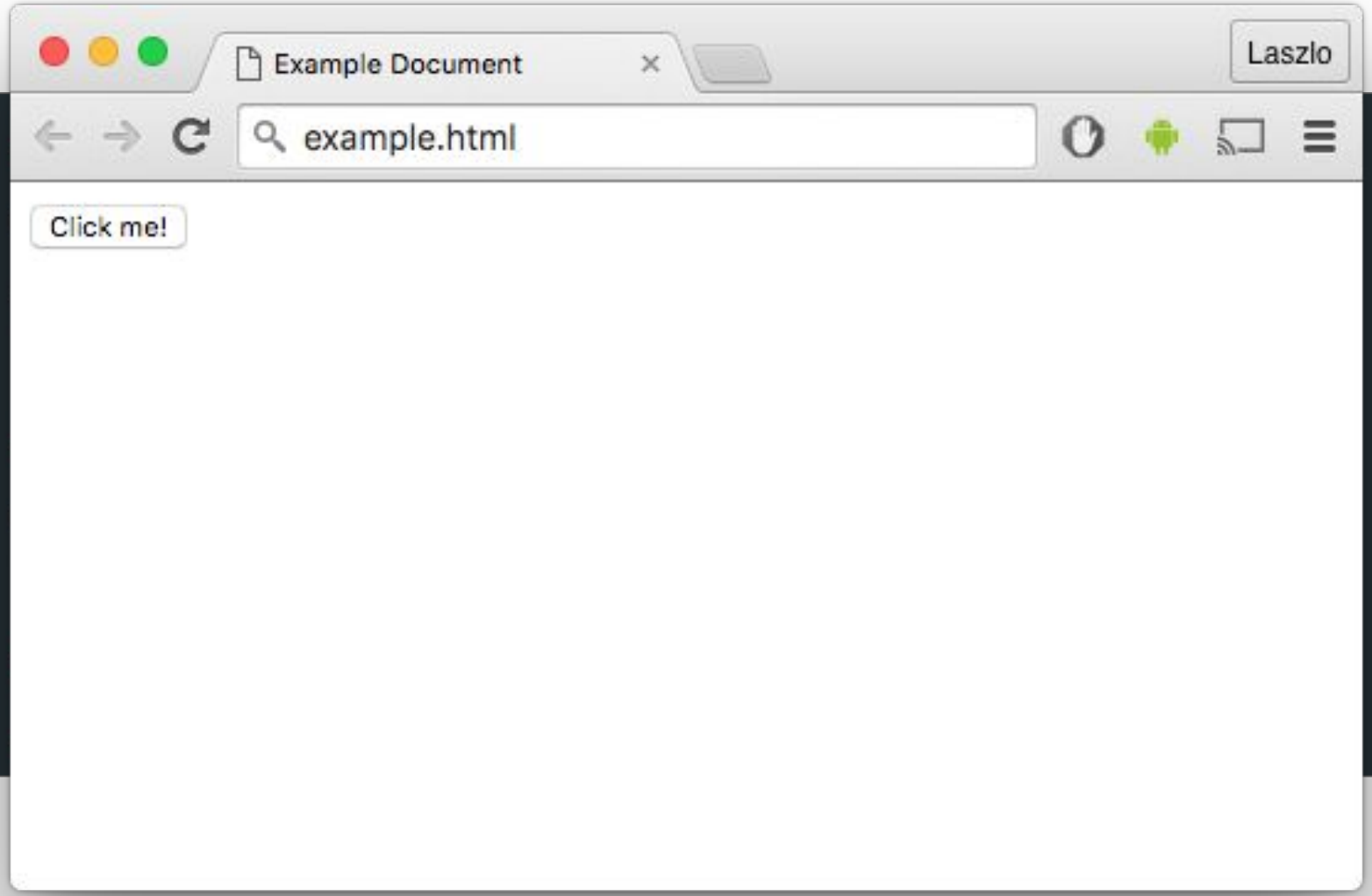
- Display **HyperText Markup Language** Documents (HTML)
- Documents can be styled via Stylehsheets (CSS)
- Documents may contain code to execute (JavaScript)

The Browser - example HTML document

```
1 <!DOCTYPE html>
2 <html>
3 <head>
4     <title>Example Document</title>
5 </head>
6 <body>
7     <button>Click me!</button>
8 </body>
9 </html>
```

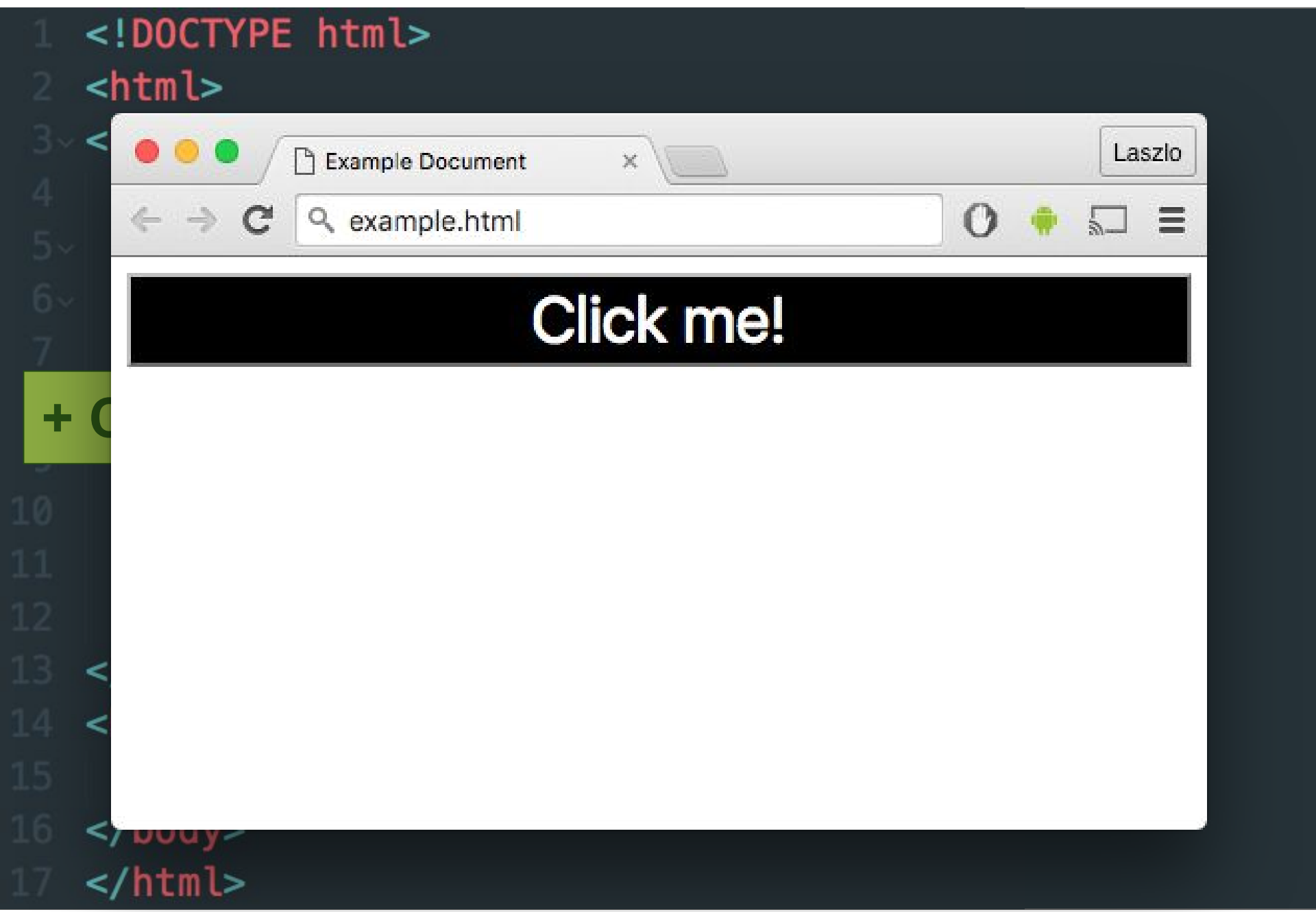
index.html

The Browser - example HTML document

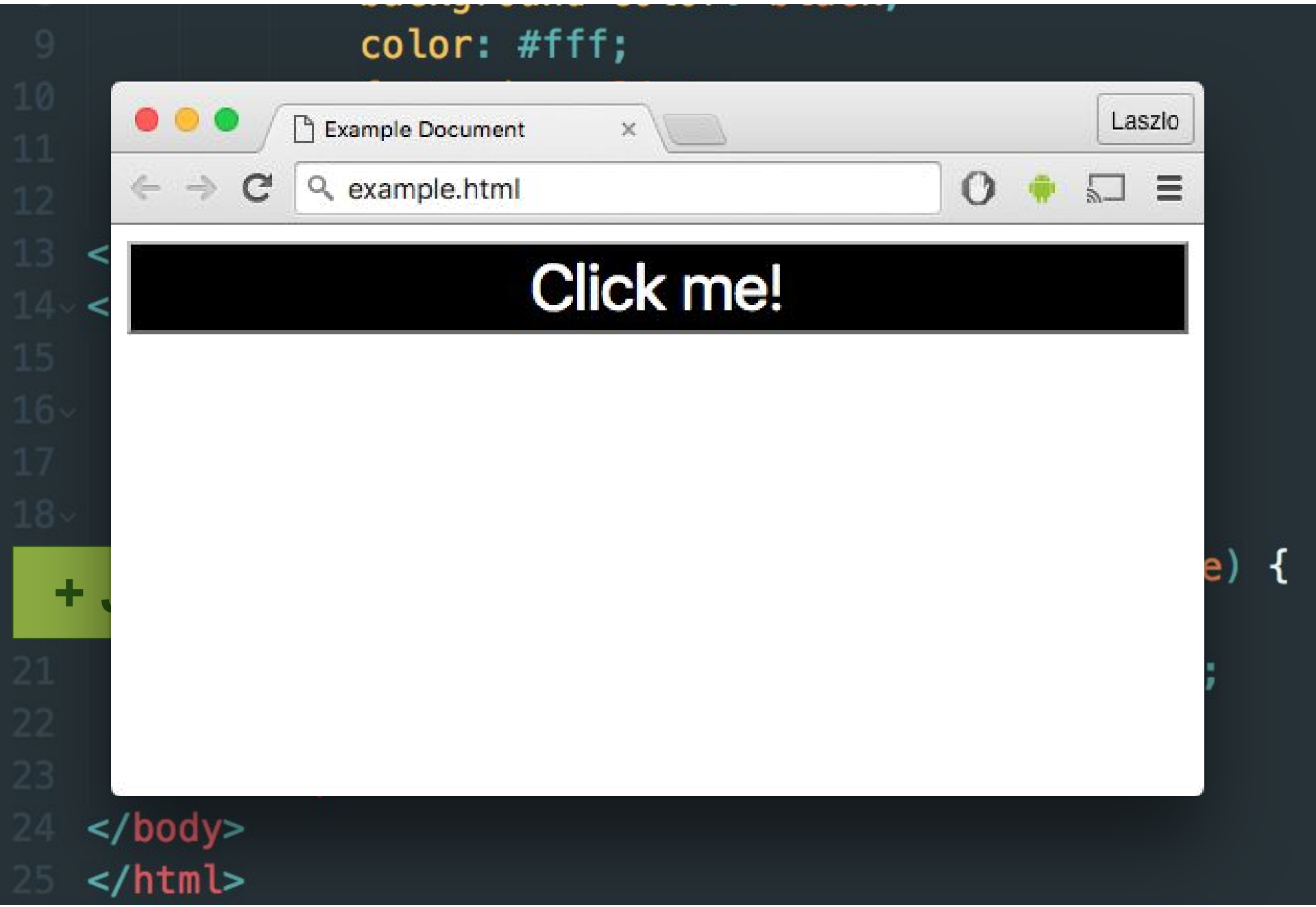


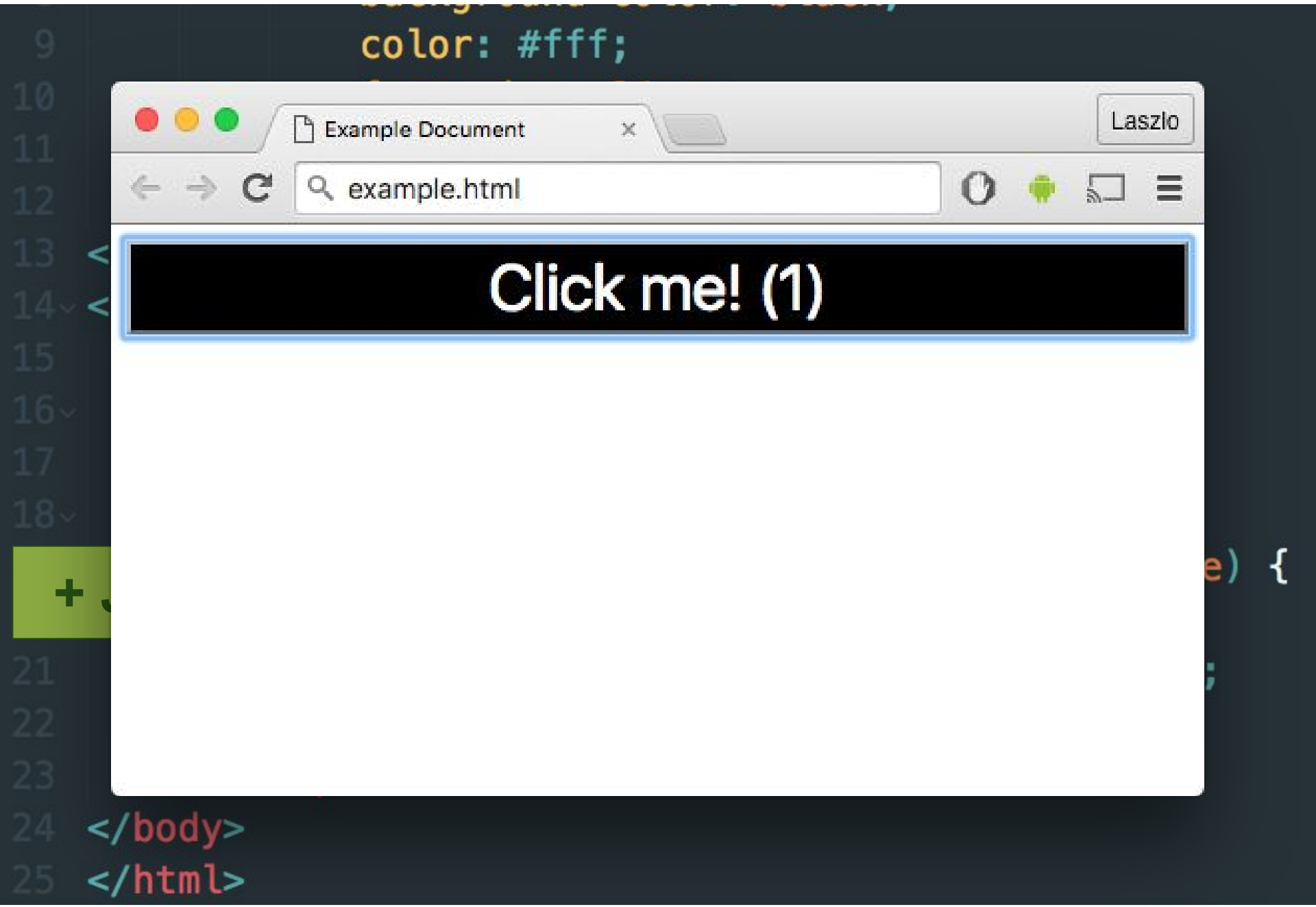
```
<!DOCTYPE html>
<html>
<head>
    <title>Example Document</title>
    <style>
        button {
            width: 100%;
            background-color: black;
            color: #fff;
            font-size: 24pt;
        }
    </style>
</head>
<body>
    <button>Click me!</button>
</body>
</html>
```

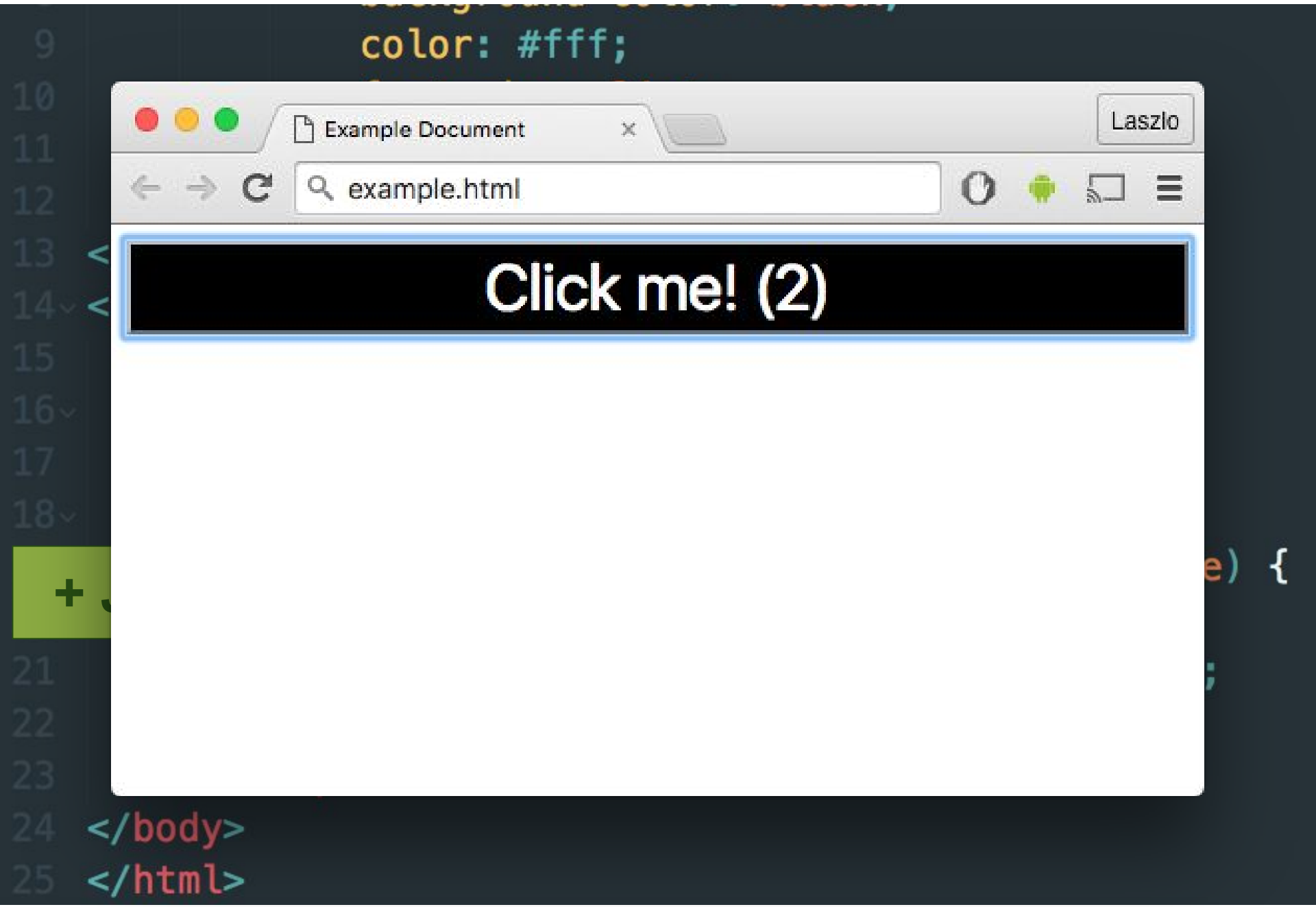
+ CSS

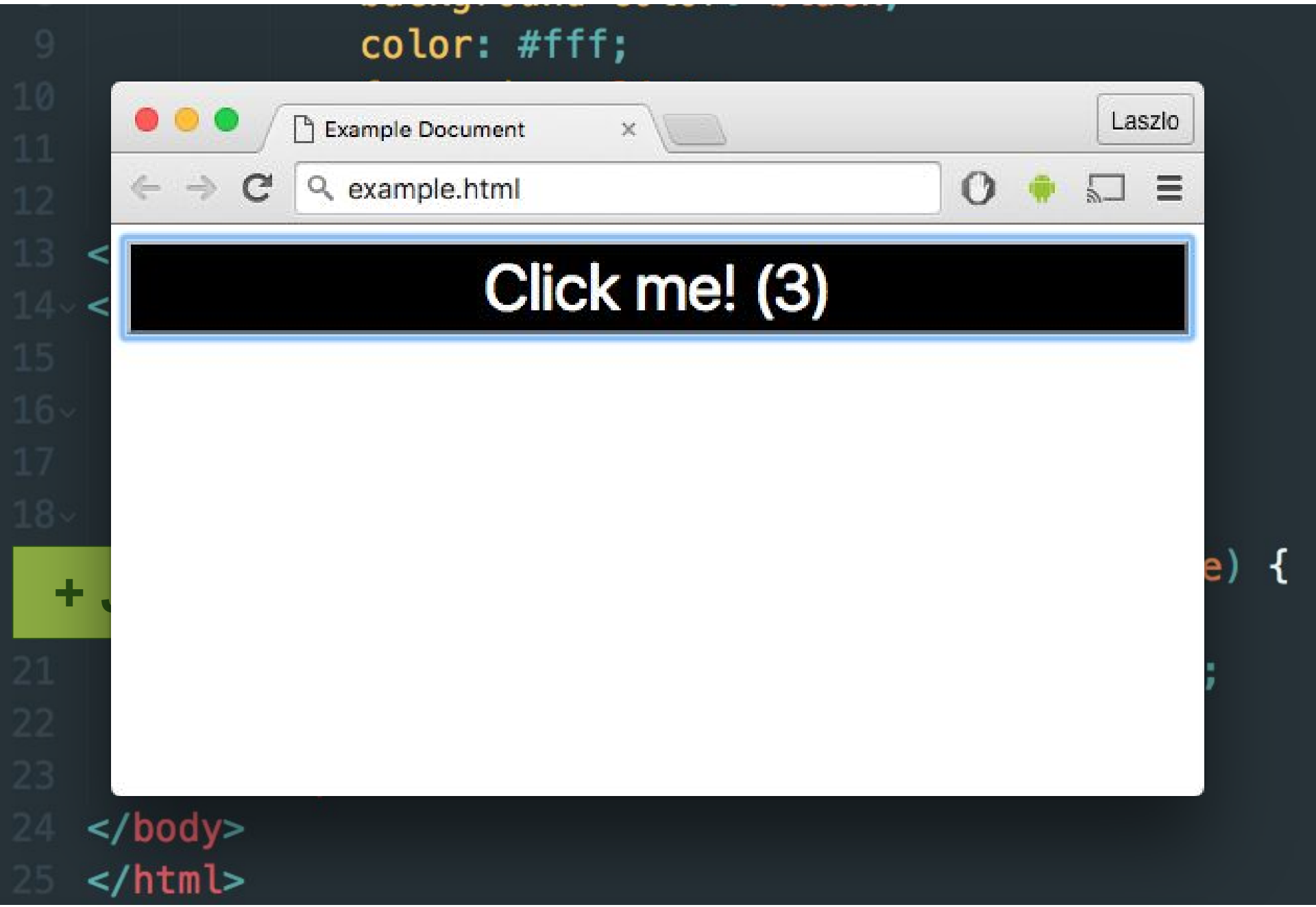

1 <!DOCTYPE html>
2 <html>
Example Document
Laszlo
example.html
Click me!
16 </body>
17 </html>

```
            color: #fff;
            font-size: 24pt;
        }
    </style>
</head>
<body>
    <button>Click me!</button>
    <script>
        var count = 0;
        document.querySelector('button')
            .addEventListener('click', function (e) {
                e.target.innerHTML =
                    'Click me! ('+ (++count) +')';
            })
    </script>
</body>
</html>
```


color: #fff;
Example Document
Laszlo
example.html
Click me!
</body>
</html>


color: #fff;
Example Document
Laszlo
example.html
Click me! (1)
</body>
</html>


color: #fff;
Example Document
Laszlo
example.html
Click me! (2)
</body>
</html>


color: #fff;
Example Document
Laszlo
example.html
Click me! (3)
</body>
</html>

The Browser - example document

```
<!DOCTYPE html>
<html>
<head>
    <title>Example Document</title>
    <link rel="stylesheet" href="./layout.css">
</head>
<body>
    <button>Click me!</button>
    <script src="./main.js"></script>
</body>
</html>
```

index.html

The Browser

- HTML Document is the **entry point**
  - links to/embeds stylesheets
  - links to/embeds javascripts

- Most of the application is defined in JavaScript (JS)

➔ start with an almost empty document, **build everything in JS**

The Browser - Document Object Model

- DOM API allows querying and modifying the whole document

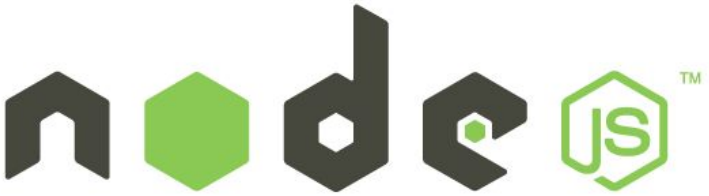
The Browser - JavaScript

- No module system
  - difficult to split application into modules
- No static type system
- Weird semantics
  - `5 + "5" === "55"`
  - `5 * "5" === 25`
- API differences across browsers

Web Platform

NodeJS

NodeJS



Source: https://nodejs.org/en/about/resources/

- JavaScript runtime environment
  - Based on Chrome's JavaScript engine V8
  - Run JavaScript outside the browser

➔ Large ecosystem of open source libraries and tools

NodeJS - Package Manager

Source: https://www.npmjs.com/

- Command line tool for managing dependencies
  - Like maven for Java or easy_install for python

- Access to **>250.000** libraries

Web Platform

Workflow

Babel Logo: https://github.com/babel/babel
ESLint Logo: http://eslint.org/
Webpack Logo: https://webpack.github.io/

Workflow - Tools

- BabelJS 
  - Access to future JS features (eg. module system)
- ESLint 
  - Check source code for common errors
- Webpack 
  - Module bundler
  - combine multiple JS files and libraries into one file

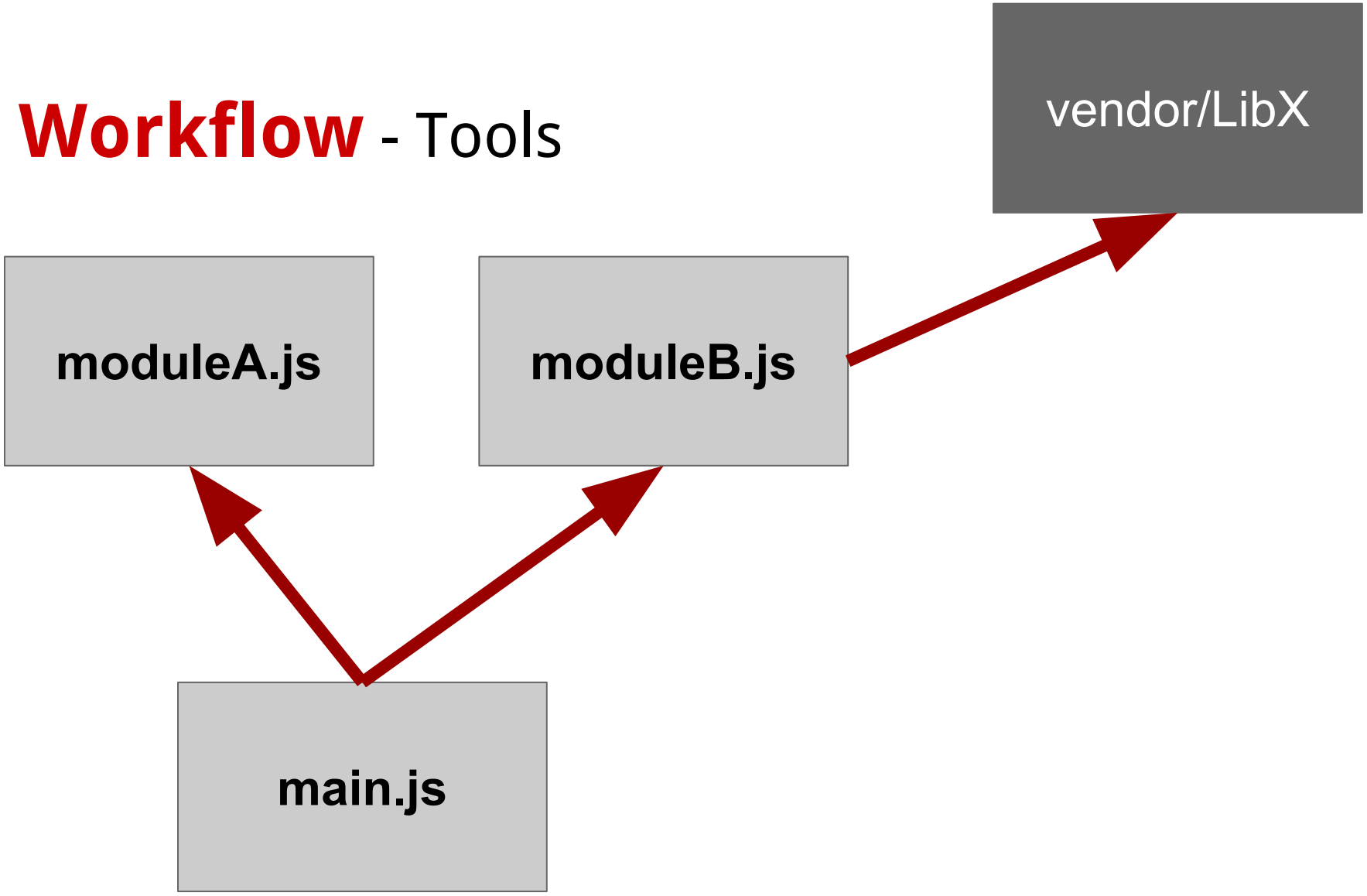
Workflow - Babel

Source: https://github.com/babel/babel

```
1 import doStuff from './moduleA.js';
2 import someFunction from './moduleB.js';
3
4 // ...
```

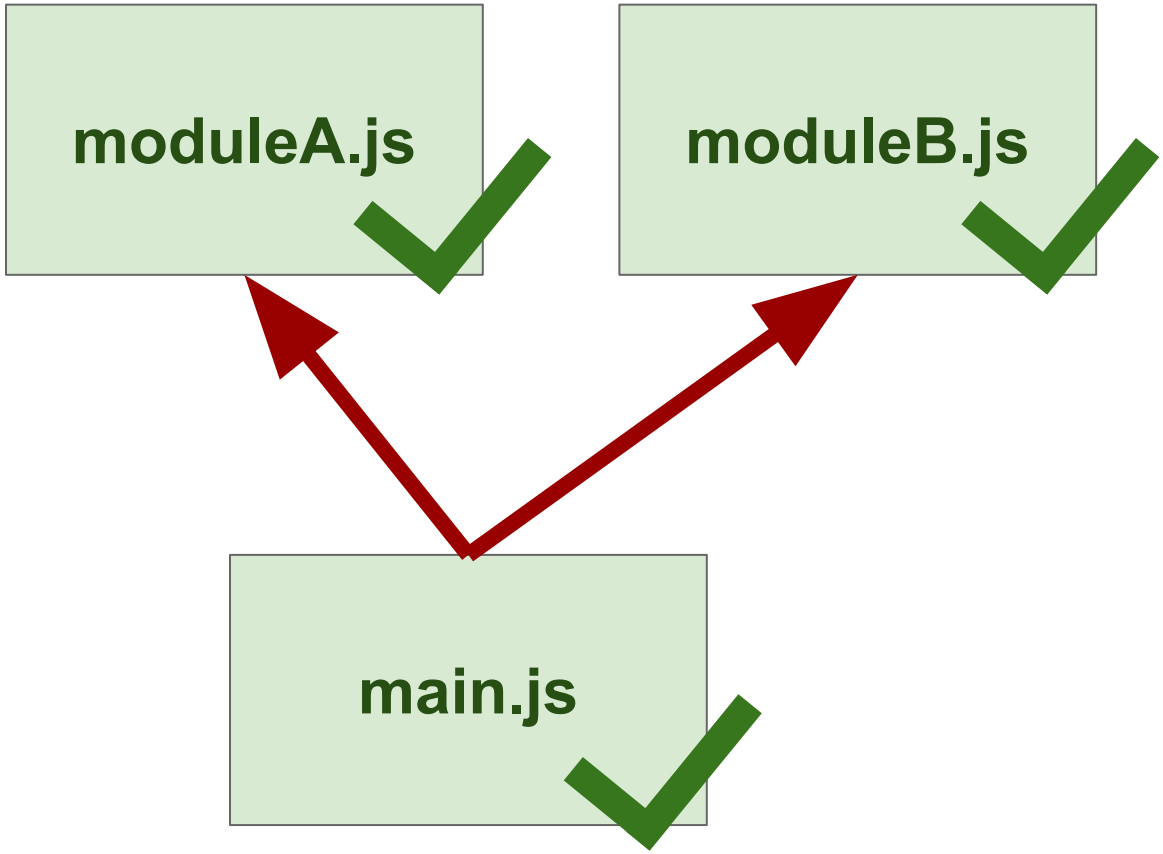
ES6 module import syntax

Workflow - Tools



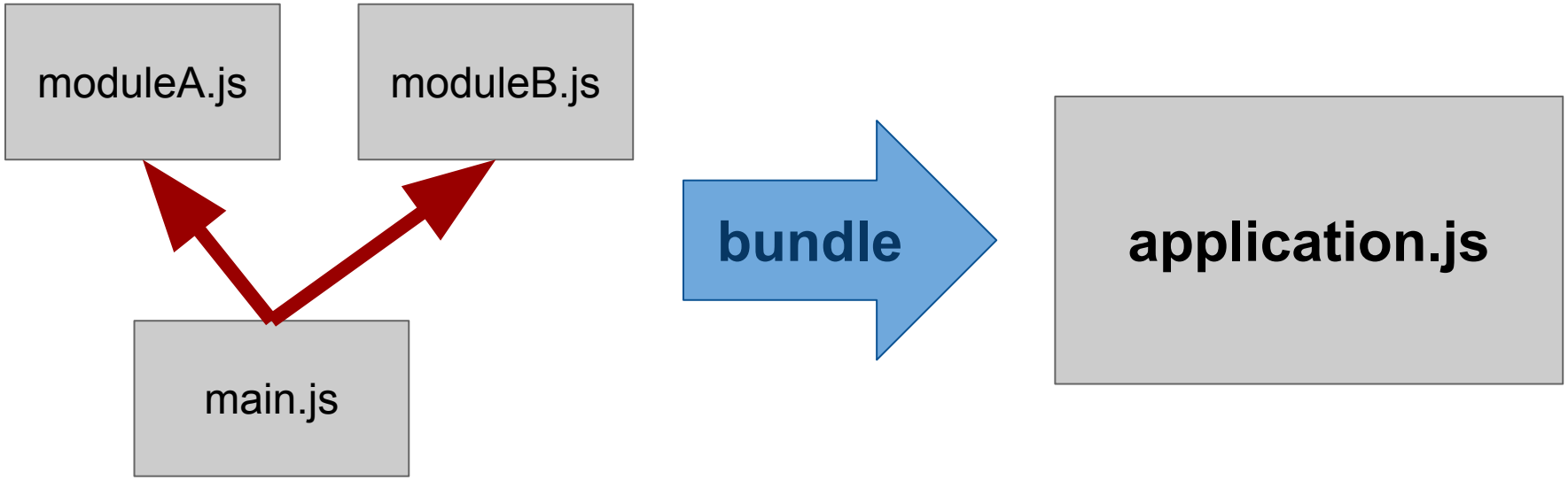
Workflow - ESLint

Source: http://eslint.org/

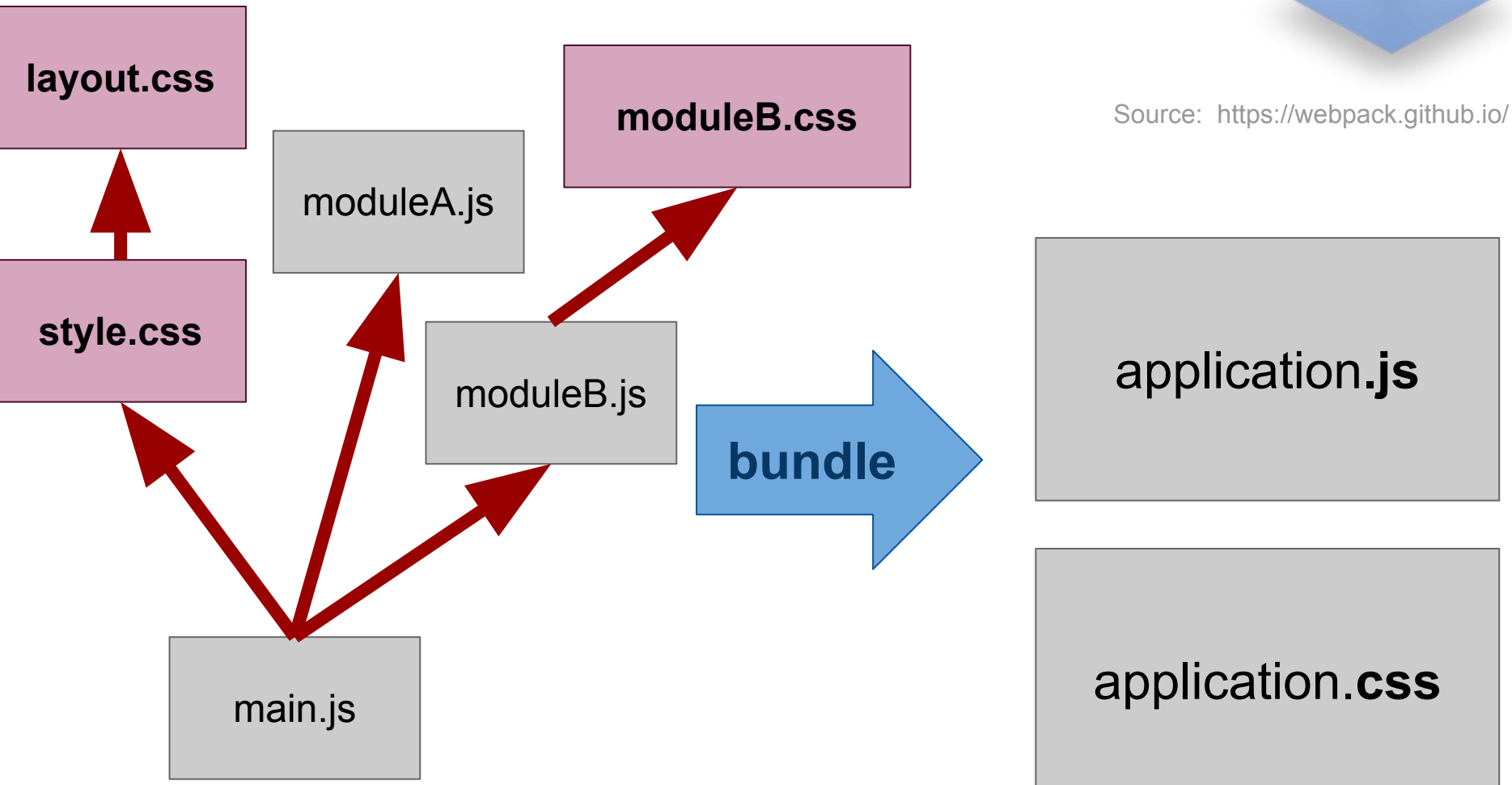


Workflow - Webpack

Source: https://webpack.github.io/



Workflow - Webpack



Source: https://webpack.github.io/

Workflow - Webpack Dev Server

Workflow - Webpack Dev Server

- No manual recompile
- Watches the file system for changes
- Pushes changes to browser (via websocket)

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Web Platform

Graphical User Interface

GUI - Graphical User Interface

- JavaScript provides multiple APIs for building GUIs

➔ HTML / CSS

➔ Canvas (2D bitmap)

➔ Scalable Vector Graphics (SVG)

GUI - HTML / CSS

- Layout calculations are done by the browser
  - text wrapping, adjusting height of elements
- Native support for responsive layouts
- API for user interactions

- Only rectangular shapes

GUI - Canvas (2D Bitmap)

- Fine grained control on a pixel level
- All kinds of shapes (arcs, bézier curves…)

- Hard to support multiple screen sizes
- Hittesting needs to be done manually

GUI - Scalable Vector Graphics (SVG)

- XML based format for vector graphics
- Embeddable into HTML
- All kinds of shapes (arcs, bézier curves…)
- Support for Stylesheets
- API for user interactions (event handling)
- sharp on all display sizes
- Manual layout (text wrapping, element height)

GUI

- HTML / CSS for base layout
- SVG for advanced visualisations and icons
- no Canvas

Components

Demo

- Logic expression editor
- Logic expression checker
- Karnaugh map editor
- LED editor
- Number circle
- FSM editor

https://**thesis.laszlokorte.de**/

Demo - Logic expression editor

- Parse boolean expression
  - In various dialects
- Generate a function table
- Generate an operator tree
  - Color branches
- Enter multiple expressions

thesis.laszlokorte.de/demo/logic-editor.html

Demo - **Logic expression editor** - Details

- Expressions are parsed by PEG.js via parsing expression grammar
- Tree is drawn via Buchheim algorithm

  (C. Buchheim, M. J Unger, and S. Leipert. Improving Walker's algorithm to run in linear time.)
- Labelled expressions are sorted topologically

Demo - Logic expression checker

- Simplified GUI for comparing two expressions
- Highlight differences in function table

thesis.laszlokorte.de/demo/logic-checker.html

Demo - Karnaugh map editor

- Create Karnaugh maps of various sizes
- Creating loops on a touch screen
- Show Programmable Logic Array
- Import and export expressions

thesis.laszlokorte.de/demo/kvd-editor.html

Demo - Karnaugh map editor - details

- PLA view is it's own component

Demo - LED editor

- Build function tables for 7-segment display…
- … or other displays

thesis.laszlokorte.de/demo/led-editor.html

Demo - Number circle

- Arrange binary numbers in a circle
- Adjusting the circle size
- Compare various encodings
- Highlight overflows

thesis.laszlokorte.de/demo/number-circle.html

Demo - Finite-state machine editor

- Edit Moore and Mealy machines
- Edit transition graph

- Not yet implemented:
  - Accept logic expressions as transition conditions
  - simulating the machine

thesis.laszlokorte.de/demo/fsm-editor.html

Architecture

Architecture

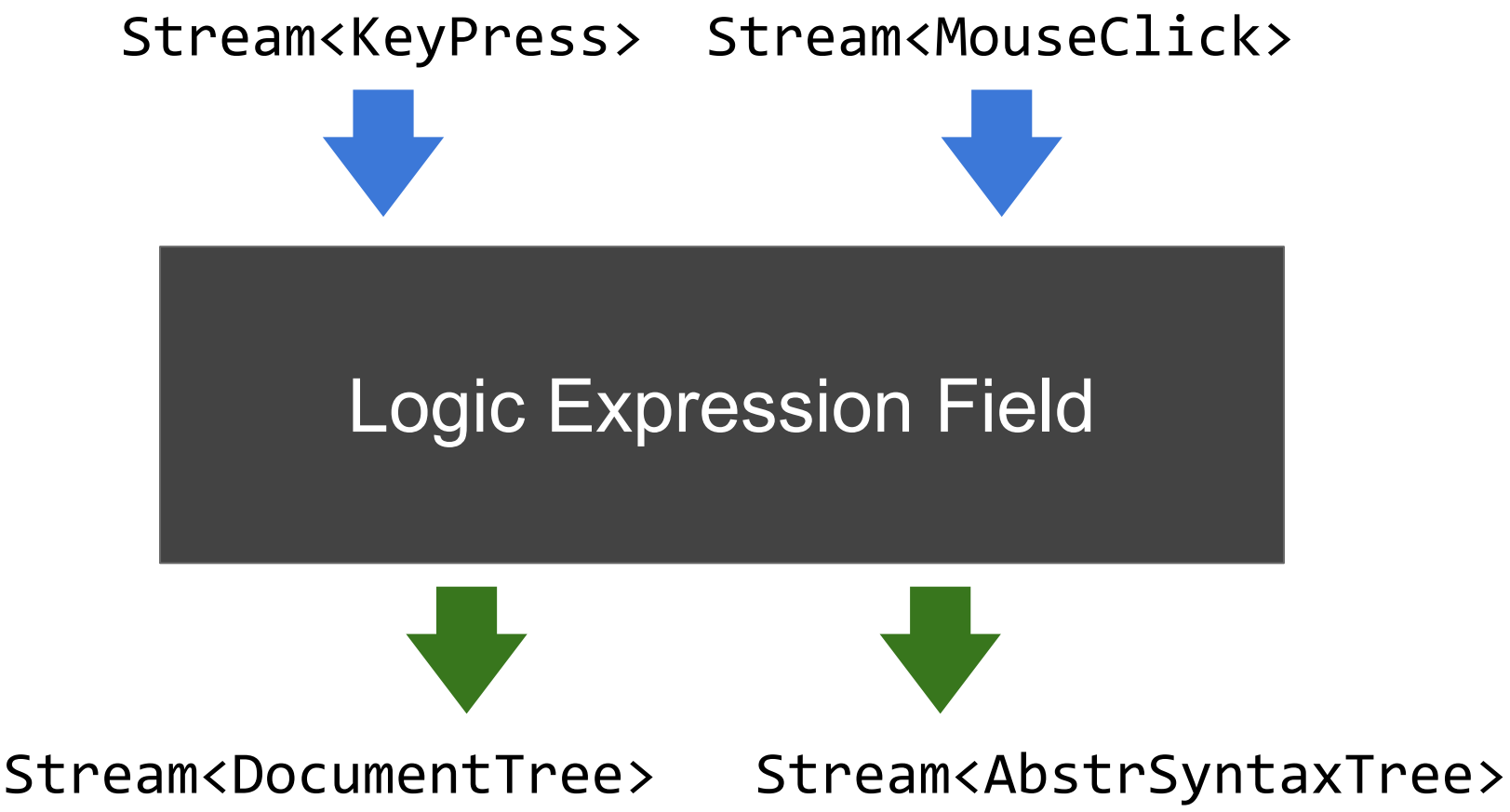
- Based on Functional Reactive Programming
- Each component is a pure function, that transforms input to output
- Components do not modify any outside state
- inspired by Cycle.js library

Source: http://cycle.js.org

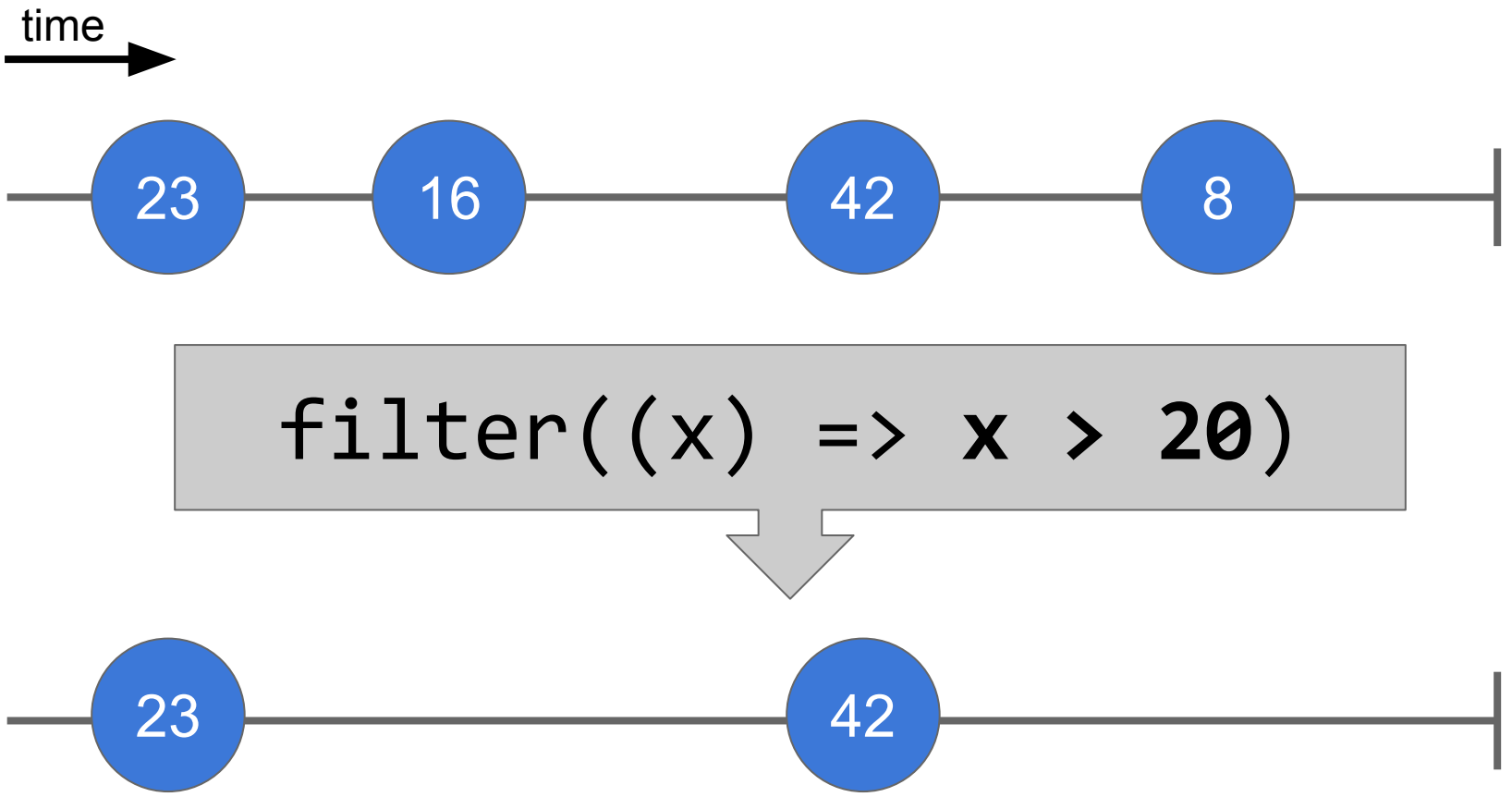
Architecture - Functional Reactive Programming

- **Events** and **state** are modelled as streams
- Streams represent data over time
- A component takes stream of events (clicks, key presses…) as input
- A component produces a stream of state (document state) as output

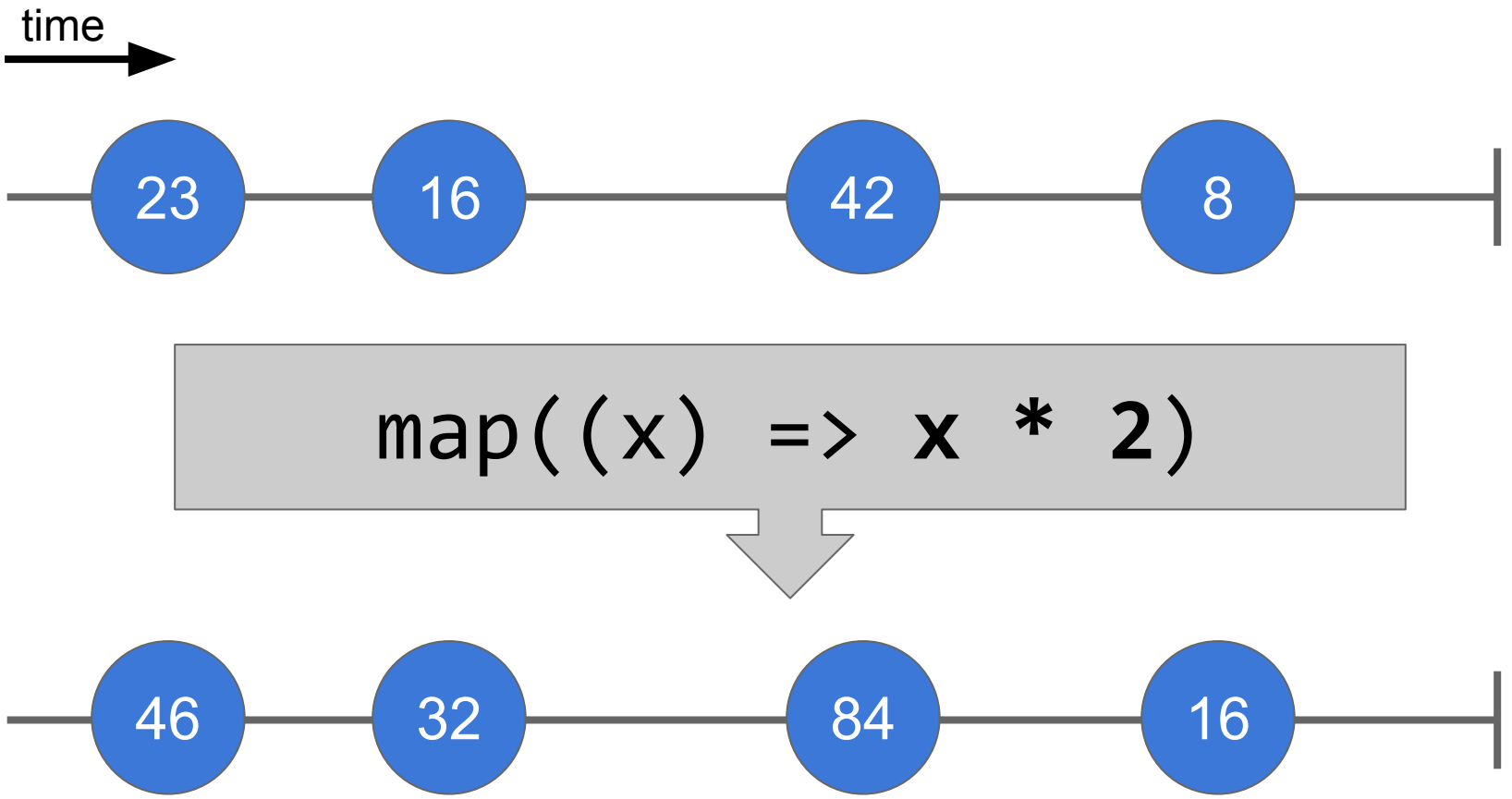
Architecture - Functional Reactive Programming



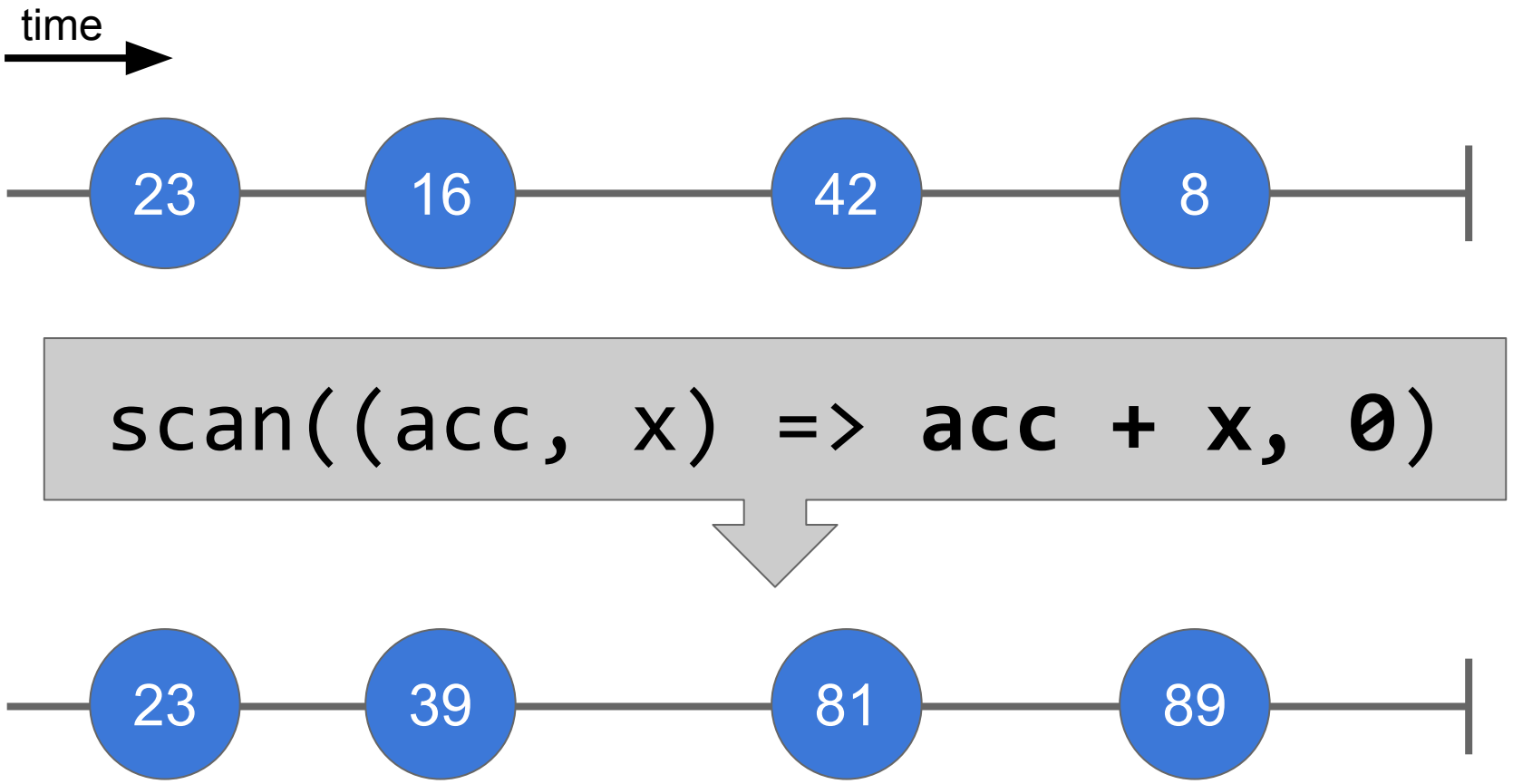
Architecture - Functional Reactive Programming



Architecture - Functional Reactive Programming



Architecture - Functional Reactive Programming



Architecture - Functional Reactive Programming

- many more operators available (reactivex.io)
- The whole GUI is built via stream transformation
- especially drag-drop and touch gestures are easy to build on top of event streams

Conclusion

Conclusion

- Componenents work across all major browsers:
  - Chrome, Firefox, Opera, Safari, IE11, Edge
- usable on various screen sizes
  - (sharp on retina screens)
- usable on touch screens

Conclusion

Stats:

- ~12.000 lines of JavaScript
- 217 JavaScript files
- 610 Git Commits

Conclusion

Potential improvements:

- Performance could be improved
- Printing support would be nice
  - eg. export expression tree or function table as PDF
- Expression parser via command line
- Splitting component into separate projects

Conclusion

Potential improvements (Cont.):

- Output file size could be further reduced
  - by tree shaking vendor libraries
  - currently ~500KB for Karnaugh maps
- For long term maintanance use a stronger language than JavaScript
  - eg. PureScript or TypeScript

Conclusion

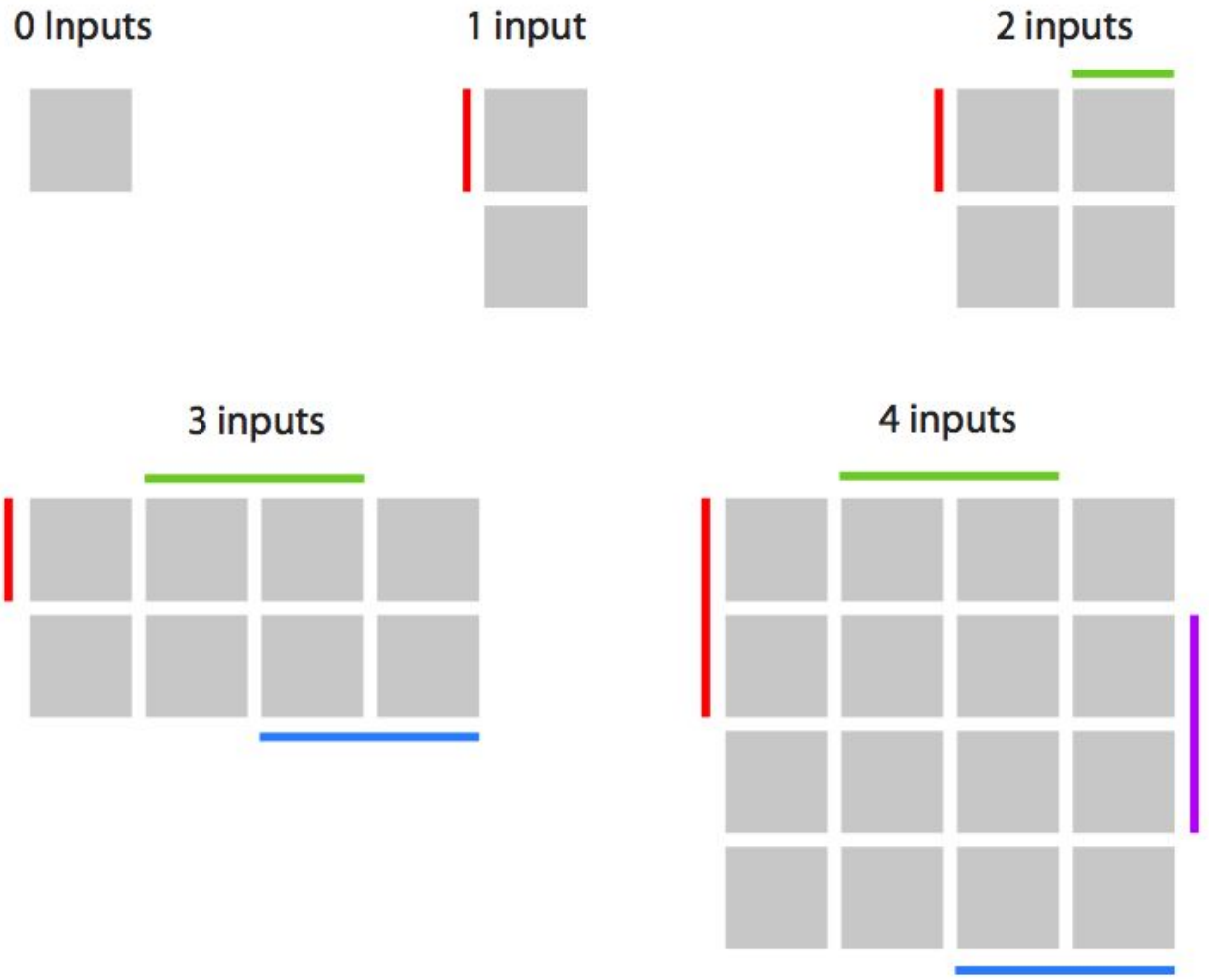
Potential improvements (Cont.):

- No animations yet!
  - easy to built via stream transformation…
  - … or CSS animations

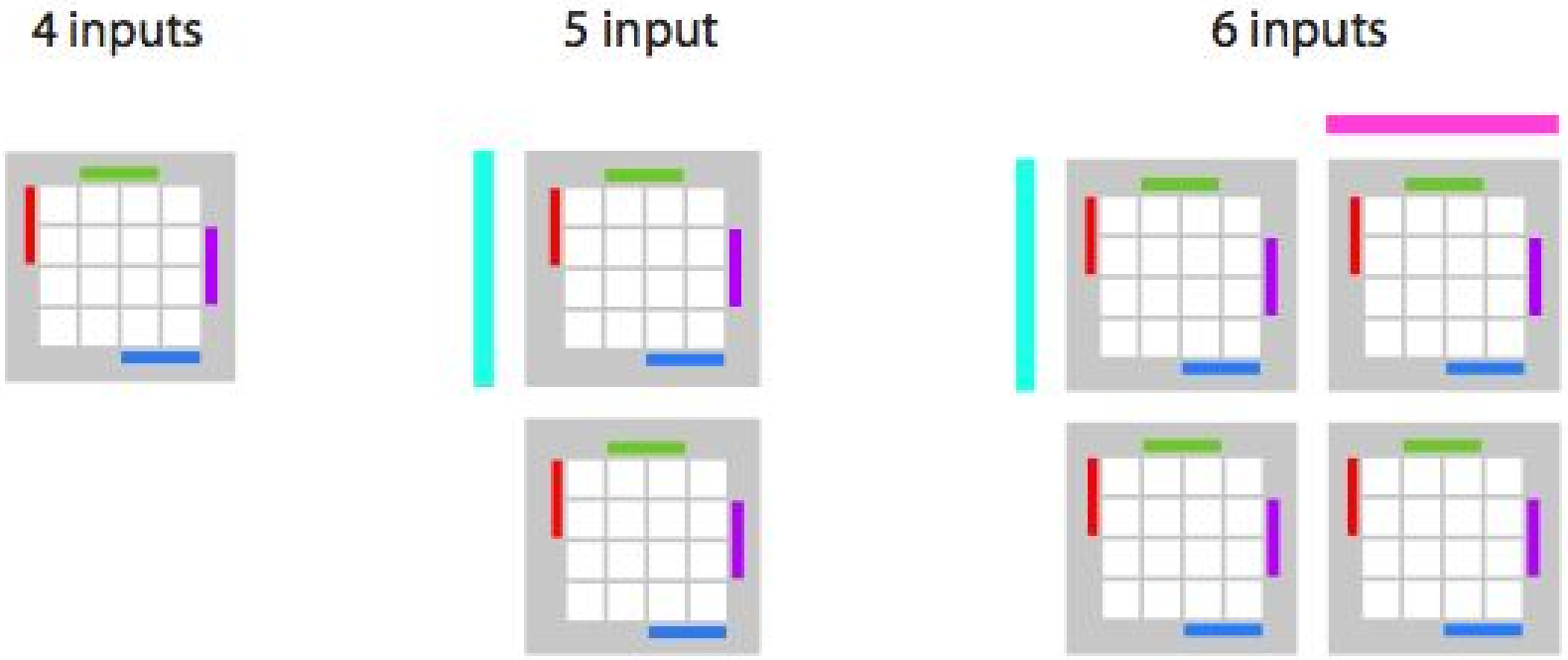
Thank you for your attention! Questions?

- **Web Platform**
  - The Browser
  - NodeJS, NPM
  - Workflow (Babel, ESLint, Webpack)
  - Graphical User Interface (HTML, Canvas, SVG)
- **Components**
  - Logic Expression editor/checker
  - Karnaugh Maps
  - LED editor
  - Number Circle
  - FSM editor
- **Architecture**

Bonus - Karnaugh map recursion

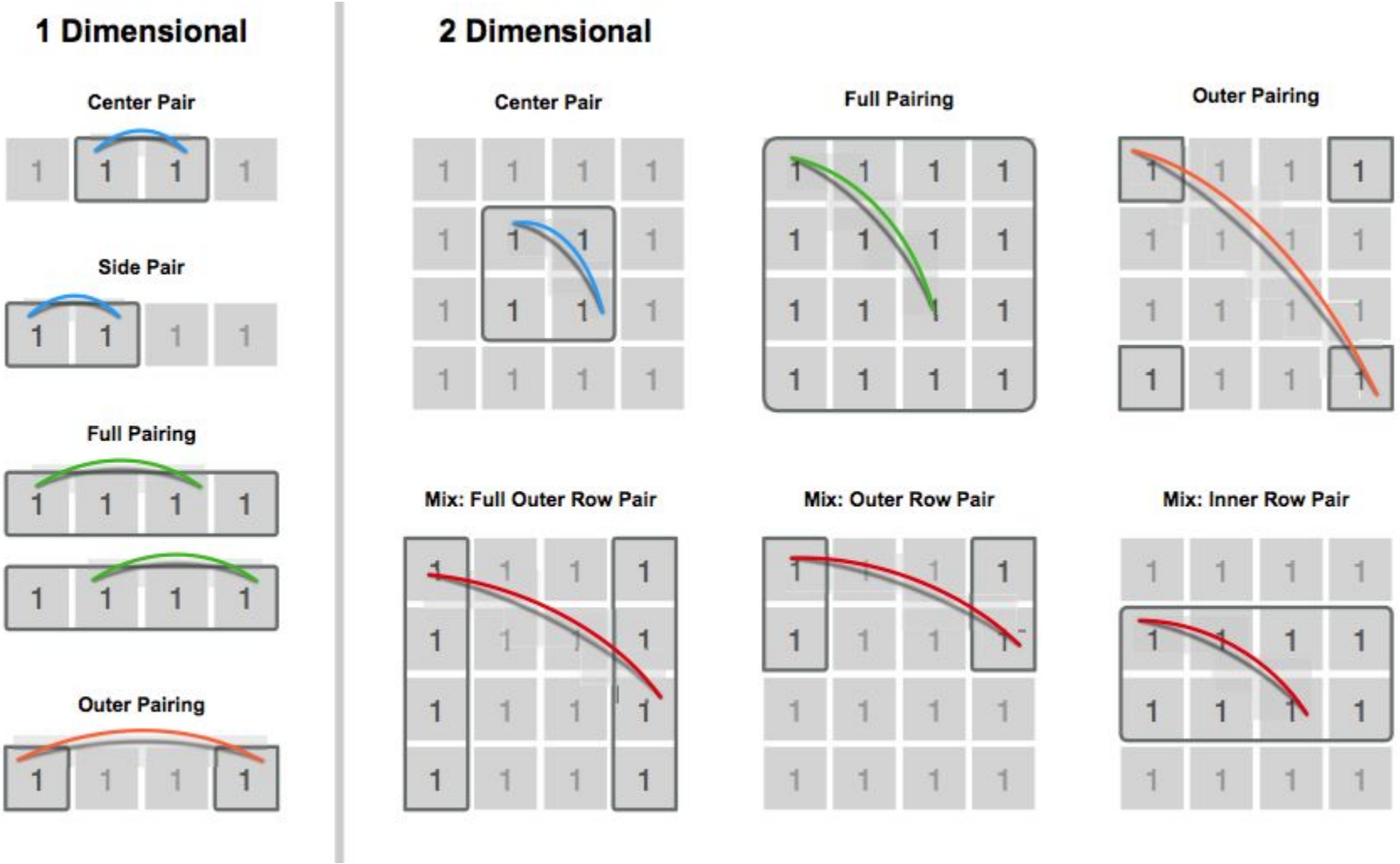


Bonus - Karnaugh map recursion (Cont.)

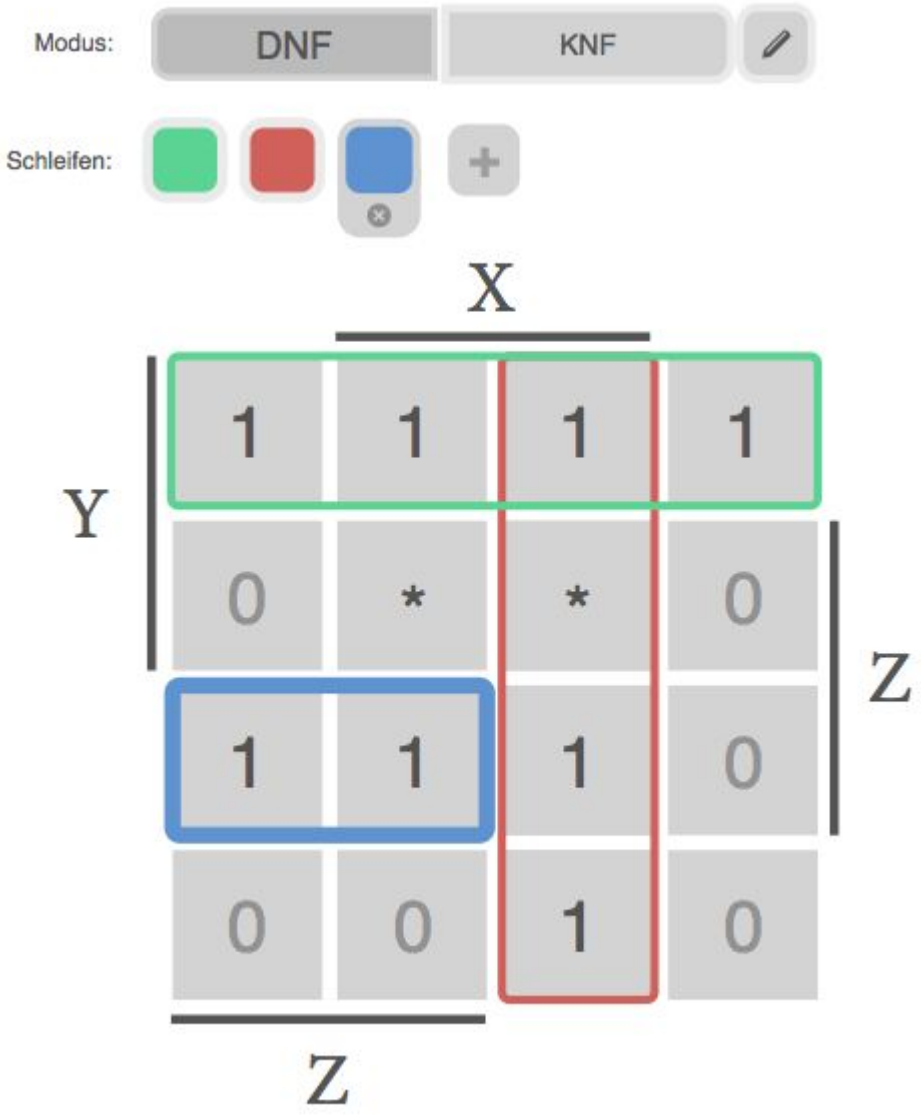


Bonus - Karnaugh map recursion (Cont. 2)

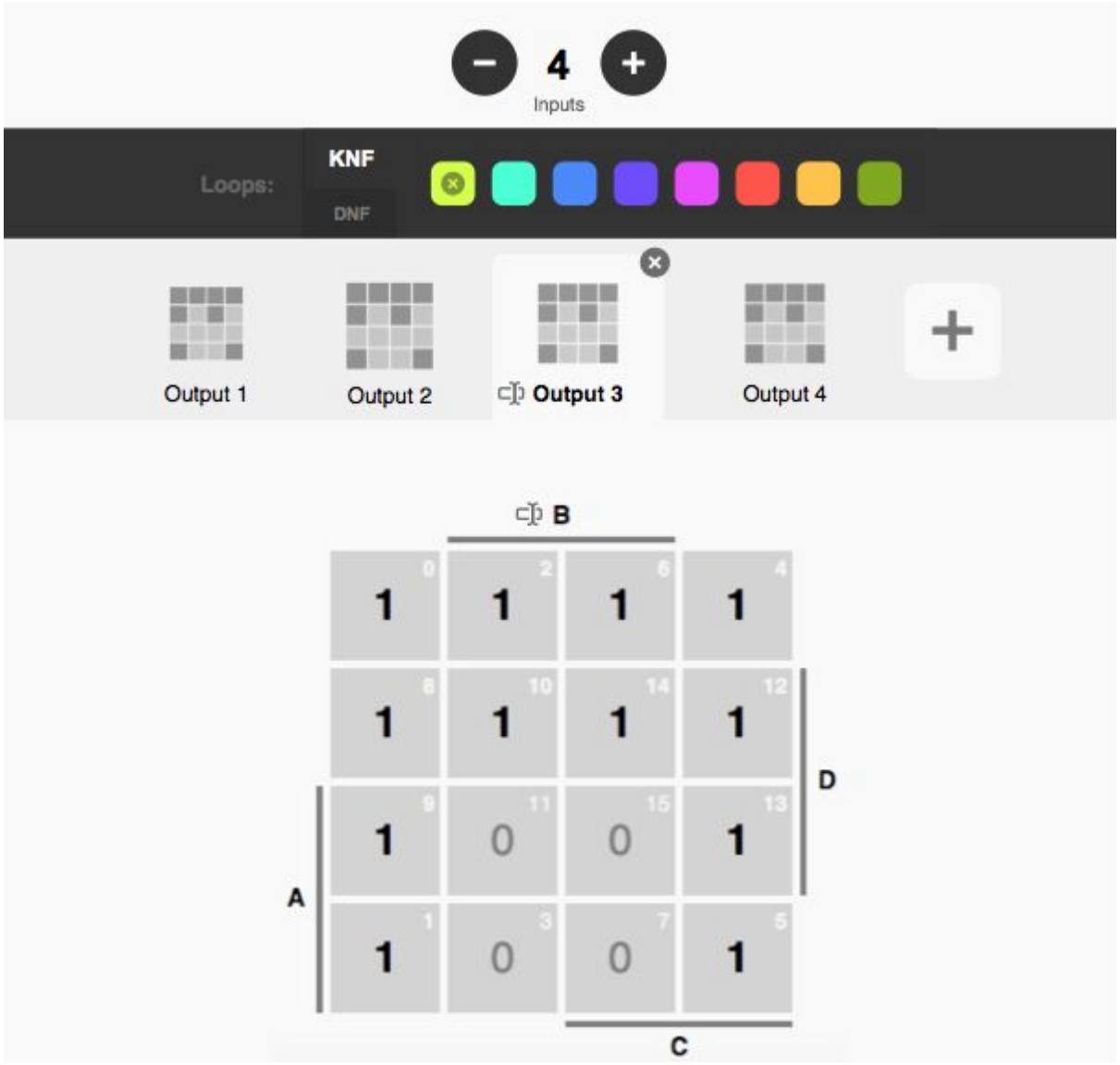
Bonus - Karnaugh map drag-’n-drop



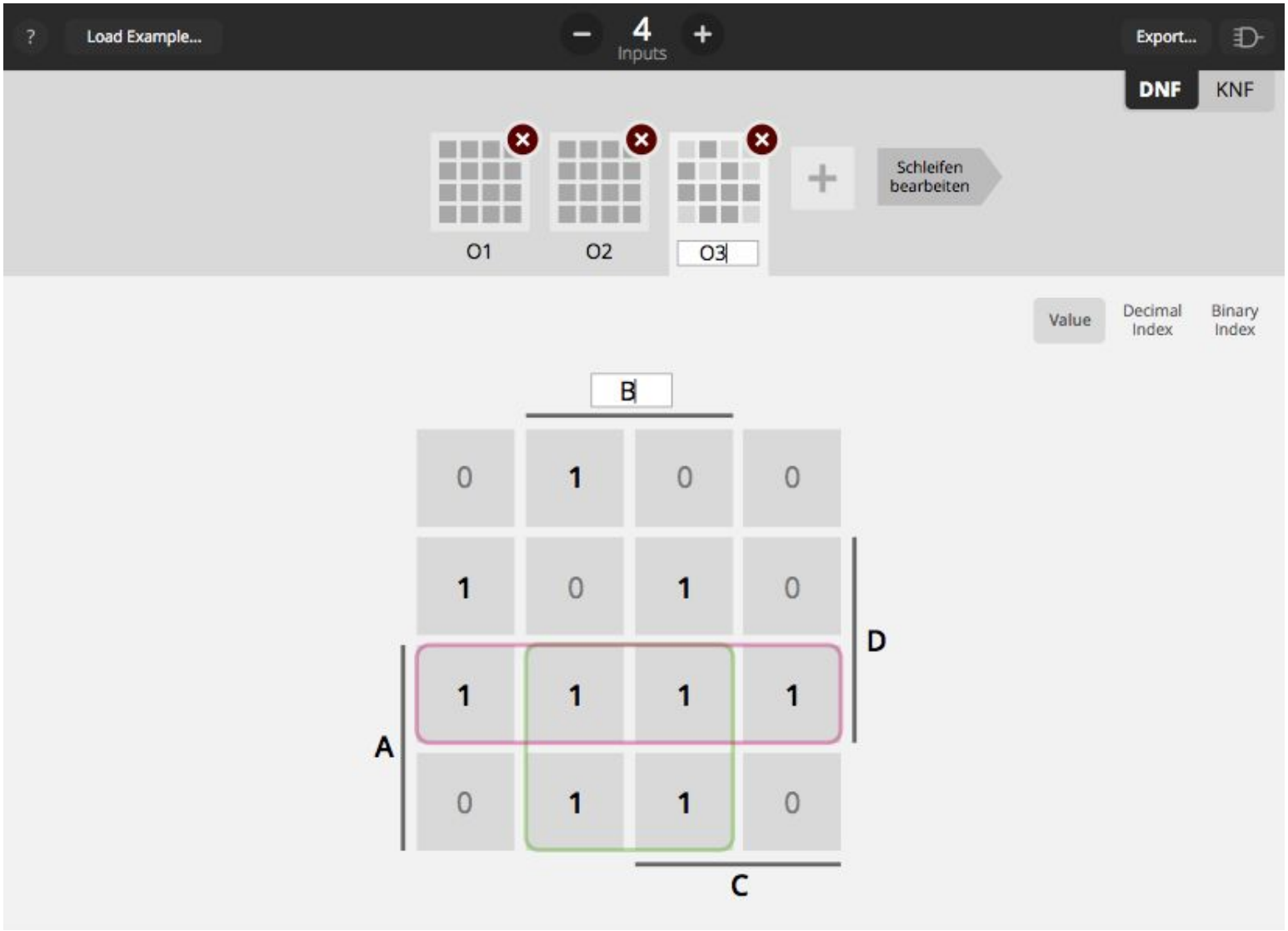
Bonus - Karnaugh map layout #1



Bonus - Karnaugh map layout #2



Bonus - Karnaugh map layout #3 a



Bonus - Karnaugh map layout #3 b