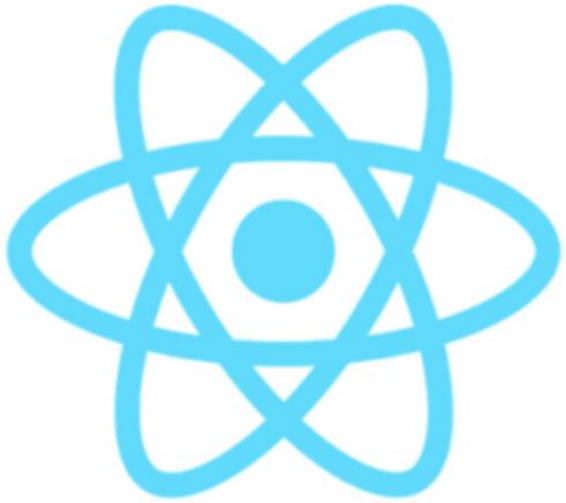
Full-stack Application Development

Functional and Object Oriented JavaScript. Design Patterns. Event-Driven Programming

Where to Find The Code and Materials?

https://github.com/iproduct/fullstack-typescript-react



Brief History of JavaScript™

- JavaScript™ created by Brendan Eich from Netscape for less then 10 days!
- Initially was called Mocha, later LiveScript – Netscape Navigator 2.0 - 1995
- December 1995 Netscape® и Sun® agree to call the new language JavaScript™
- "JS had to 'look like Java' only less so, be Java's dumb kid brother or boy-hostage sidekick. Plus, I had to be done in ten days or something worse than JS would have happened."

B. E. (http://www.jwz.org/blog/2010/10/every-day-i-learn-something-new-and-stupid/#comment-1021)

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The Language of Web

- JavaScript™ success comes fast. Microsoft® create own implementation called JScript to overcome trademark problems. JScript was included in Internet Explorer 3.0, in August 1996.
- In November 1996 Netscape announced their proposal to Ecma International to standardize JavaScript → ECMAScript
- JavaScript – most popular client-side (in the browser) web programming language („de facto“ standard) and one of most popular programming languages in general.
- Highly efficient server-side platform called Node.js based on Google V8 JS engine, compiles JS to executable code Just In Time (JIT) during execution (used at the client-side also).

Object-Oriented JavaScript

Three standard ways to create objects in JavaScript:

- Using object literal:

  var newObject = { };

- Using Object.create(prototype[, propertiesObject]) (prototypal)

  var newObject = Object.create(Object.prototype);

- Using constructor function (pseudo-classical)

  var newObject = new Object();

Object Properties

- Object-Oriented (OO) – object literals and constructor functions
- Objects can have named properites

Ex.:
```
myObject.name = 'Scene 1';
    myObject ['num-elements'] = 5;
    MyObject.protopype.toString = function() {
        return “Name: “ + this.name + “: “ + this['num-elements'] }
```

- Configurable object properties – e.g. read only, get/set, etc.

Ex.:
```
Object.defineProperty( newObject, "someKey", {
        value: "fine grained control on property's behavior",
        writable: true,  enumerable: true,  configurable: true
    });
```

Property Getters and Setters

Ex.:

```
function PositionLogger() {
    var position = null,   positionsLog = [];
    Object.defineProperty(this, 'position', {
        get: function() {
            console.log('get position called');
            return position;
        },
        set: function(val) {
            position = val;
            positionsLog.push({ val: position });
        }
    });
    this.getLog = function() { return positionsLog; };
}
```

JavaScript Features

- The state of objects could be changed using JS functions stored in object's **prototype**, called **methods**.
- Actually in JavaScript **there were no real classes**, - only objects and constructor functions before ES6 (ES 2015, Harmony).
- JS is **dynamically typed language** – new properties and methods can be added runtime.
- JS supports object inheritance using prototypes and mixins (adding dynamically new properies and methods).
- **Prototypes** are objects (which also can have their prototypes) → inhreritance = traversing prototype chain
- Main resource: **Introduction to OO JS YouTube video** https://www.youtube.com/watch?v=PMfcsYzj-9M

JavaScript Features

- Supports **for ... in** operator for iterating object's properties, including inherited ones from the prototype chain.
- Provides a number of predefined datatypes such as: **Object, Number, String, Array, Function, Date** etc.
- Dynamically typed – variables are universal containers, no variable type declaration.
- Allows dynamic script evaluation, parsing and execution using **eval()** – **discouraged as a bad practice**.

Datatypes in JavaScript

- Primitive datatypes:
  - **boolean** – values **true** и **false**
  - **number** – floating point numbers (no real integers in JS)
  - **string** – strings (no char type –> string of 1 character)
- Abstract datatypes:
  - **Object** – predefined, used as default prototype for other objects (defines some common properties and methods for all objects: **constructor, prototype**; methods: **toString(), valueOf(), hasOwnProperty(), propertyIsEnumerable(), isPrototypeOf()**;)
  - **Array** – array of data (really dictionary type, resizable)
  - **Function** – function or object method (defines some common properties: **length, arguments, caller, callee, prototype**)

Datatypes in JavaScript

- Special datatypes:
  - **null** – special values of object type that does not point anywhere
  - **undefined** – a value of variable or argument that have not been initialized
  - **NaN** – Not-a-Number – when the arithmetic operation should return numeric value, but result is not valid number
  - **Infinity** – special numeric value designating infinity ∞
- Operator **typeOf**

  Example: **typeOf myObject.toString** //-->'function'

Problem 1: OOP in JavaScript

Create a JS file **employees.js** that implements the following functionality:

- Create constructor **Employee(name, experienceInYears, qualifications)**. The **qualifications** should be an **array of strings**.
- Override the method **toString()** from base class Object in order to return as string all provided employee object attributes.
- Create **two employees** using the implemented constructor, and print their state to the **console** (using **console.log()**)

New Array Methods in ECMAScript 5 (1)

- Introduces in JavaScript 1.6 (ECMAScript Language Specification 5.1th Edition - ECMA-262) – November 2005
- **indexOf (searchElement[, fromIndex])** – returns the index of **first** occurrence of the *searchEleement* element in the array
- **lastIndexOf (searchElement[, fromIndex])** – returns the index of **last** occurrence of the *searchEleement* element in the array
- **every(callback[, thisObject]))** – calls the boolean result ***callback function*** for each element in the array till callback returns false, if callback returns true for each element => every returns true
- *Ex:* **function isYoung(value, index, array) { return value < 45; }**

  var areAllYoung = [41, 20, 17, 52, 39].every(isYoung);

New Array Methods in ECMAScript 5 (2)

- **some(callback[, thisObject]))** – calls the boolean result *callback function* for each element in the array till callback returns true, if callback returns false for each element => some returns false
- *Ex:* **function isYoung(value, index, array) { return value < 45; }**

  var isSomebodyYoung = [41, 20, 17, 52, 39].some(isYoung);
- **filter(callback[, thisObject])** – calls the boolean result *callback function* for each element in the array, and returns new array of **only** these elements, for which the predicate (callback) is true
- *Ex:* **function isYoung(value, index, array) { return value < 45; }**

  var young = = [41, 20, 17, 52, 39].filter(isYoung);

  // returns [41, 20, 17, 39]

New Array Methods in ECMAScript 5 (3)

- **map(callback[, thisObject]))** – calls the *callback function* for **each** element of the array, and returns new array with containing the **results** returned by *callback function*
- *Ex:* **function nextYear(value, index, array) { return value + 1;}**

  var newYearAges = [41, 20, 17, 52, 39].map(nextYear);

  // returns [42, 21, 18, 53, 40]
- **forEach(callback[, thisObject])** – executes the *callback function* for each element in the array
- *Ex:* **function print(value, index, array) { console.log(value) }**

  [41, 20, 17, 52, 39].filter(isYoung).map(ageNextYear).forEach(print);

  // prints in console: 42, 21, 18 и 40

New Array Methods in ECMAScript 5 (4)

- **reduce(callback[, initialValue])** – applies *callback function* for an *accumulator variable* and for *each of the array elements* (left-to-right) – reducing this way the array to a *single value (the final accumulator value)*, returned as a result.
- **reduceRight(callback[, initialValue])** – the same but right-to-left
- *Ex:* **function sum(previousValue, currentValue, index, array) {**

```
        return previousValue + currentValue; }
var result = [41, 20, 17, 52, 39]
    .filter(isYoung).map(ageNextYear).reduce(sum, 0);
console.log("Sum = ", result); //  prints: Sum =  121
```

Functional JavaScript

- Functional language – functions are "first class citizens"
- Functions can have own properties and methods, can be assigned to variables, pass as arguments and returned as a result of other function's execution.
- Can be called by reference using operator **()**.
- Functions can have embedded inner functions at arbitrary depth
- All arguments and variables of outer function are accessible to inner functions – even after call of outer function completes
- Outer function = enclosing context (Scope) for inner functions → **Closure**

Closures

Example:

```
function countWithClosure() {
        var count = 0;
        return function() {
                return count ++;
        }
}

var count = countWithClosure(); <-- Function call – returns innner
        function wich keeps reference to count variable from the outer scope
console.log( count() );         <-- Prints 0;
console.log( count() );         <-- Prints 1;
console.log( count() );         <-- Prints 2;
```

Default Values & RegEx

- Functions can be called with different number of arguments. It is possible to define default values – Example:

```
function Polygon(strokeColor, fillColor) {
        this.strokeColor = strokeColor || "#000000";
        this.fillColor = fillColor || "#ff0000";
        this.points = [];
        for (i=2;i < arguments.length; i++) {
            this.points[i] = arguments[i];
}
```

- Regullar expressions – Example: **/a*/**.match(str)

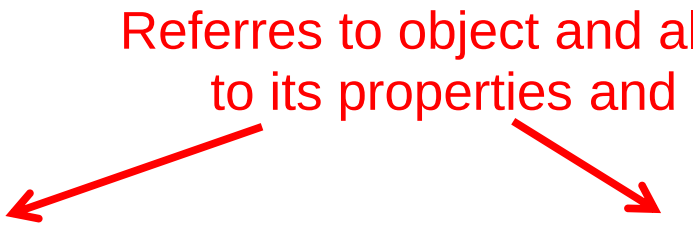
Object Literals. Using this

- Object literals – example:

```
var point1 = { x: 50, y: 100 }
var rectangle1 = { x: 200, y: 100, width: 300, height: 200 }
```

- Using **this** calling a function /D. Crockford/ - „Method Call“:

```
var scene1 = {
    name: 'Scene 1',
    numElements: 5,
    toString: function() {
        return “Name: “ + this.name + “, Elements: “ + this['numElements'] }
}
console.log(scene1.toString())   // --> 'Name: Scene 1, Elements: 5'
```



Accessing this in Inner Functions

- Using **this** calling a function /D. Crockford/ - „Function Call“:

```
var scene1 = {
    ...
    log: function(str) {
        var self = this;
        var createMessage = function(message) {
            return “Log for '“ + self.name +“' („ + Date() + “): “
    + message;
        }
        console.log( createMessage(str) );
}
```

It's necessary to use additional variable,
because ***this*** points to global object (window)
undefined in strict mode

„Classical“ Inheritance, call() apply() & bind()

- Pattern „Calling a function using special method“
  Function.prototype.apply(thisArg, [argsArray])
  Function.prototype.call(thisArg[, arg1, arg2, ...])
  Function.prototype.bind(thisArg[, arg1, arg2, ...])

```
function Point(x, y, color){
    Shape.apply(this, [x, y, 1, 1, color, color]);
}
extend(Point, Shape);
function extend(Child, Parent) {
    Child.prototype = new Parent;
    Child.prototype.constructor = Child;
    Child.prototype.supper = Parent.prototype;
}
```

„Classical“ Inheritance. Using call() & apply()

```
Point.prototype.toString = function() {
    return "Point [" + this.supper.toString.call( this ) + "]";
}
Point.prototype.draw = function(ctx) {
    ctx.fillStyle = this.fillColor;
    ctx.fillRect(this.x, this.y, 1, 1);
}
point1 = new Point(200,150, „blue“);
console.log(point1.toString() );
```

„Classical“ Inheritance. Using call() & apply()

```
Point.prototype.toString = function() {
    return "Point [" + this.supper.toString.apply( this, [] ) + "]";
}
Point.prototype.draw = function(ctx) {
    ctx.fillStyle = this.fillColor;
    ctx.fillRect(this.x, this.y, 1, 1);
}
point1 = new Point(200,150, „blue“);
console.log(point1.toString() );
```

JavaScript Design Patterns

- **Software design patterns** gained popularity after the book Design Patterns: Elements of Reusable Object-Oriented Software [1994], GoF: Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides
- **Def: Software design pattern** is a general reusable solution to a commonly occurring problem within a given context in software design
- **Proven solutions** – proven techniques that reflect the experience and insights the developers
- **Easily reused** – out of the box solutions to common problems
- **Expressiveness** – define common vocabulary and structure

JavaScript Design Patterns

- Prototype (Object.create() / Object.clone())
- Constructor (using prototypes)
- Singleton (literals, lazy instantiation)
- Module
- Observer (publish/subscribe events)
- Dynamic loading of JS modules
- DRY (Don't Repeat Yourself)
- Command
- Facade
- Factory
- Mixin
- Decorator
- Function Chaining

Examples Using JavaScript Design Patterns

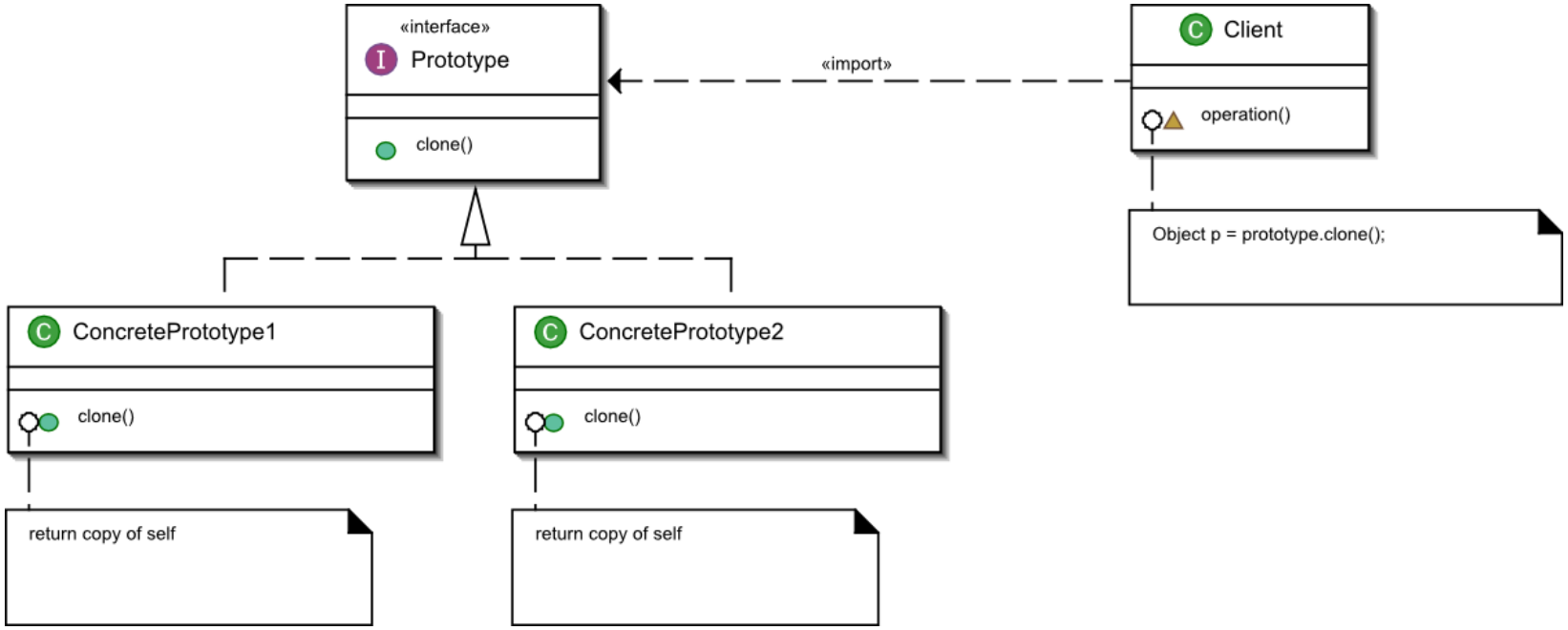
Learning JavaScript Design Patterns

A book by Addy Osmani:

https://addyosmani.com/resources/essentialjsdesignpatterns/book/

JS Design Patterns: Prototype

- Intent: creates objects based on a template of an existing object through cloning: Object.create(prototype[, propertiesObject])



JS Design Patterns: Constructor

- Intent: **constructor** is a special function used to initialize properties of a new object once memory allocated

```
function Vehicle( model, year, kilometers ) {
  this.model = model;
  this.year = year;
  this.kilometers = kilometers;
  this.toString = function () {
    return this.model + " (" + this.year + ") has travelled "
            + this.kilometers + " kilometers";
  };
}
var focus = new Vehicle( "Ford Focus", 2010, 90000 );
var jazz = new Vehicle( "Honda Jazz", 2005, 170000 );
```

Better solution is to place the object methods in the prototype instead of making copies for each instance

JS Design Patterns: Module

- Intent: Group several related elements, such as singletons, properties and methods, into a single conceptual entity.
- A portion of the code must have global or public access and be designed for use as global/public code. Additional private or protected code can be executed by the main public code.
- A module must have an initializer/finalizer functions that are equivalents to, or complementary to object constructor/ destructor methods
- In JavaScript, there are several options for implementing modules: Module pattern, as Object literal, AMD modules, CommonJS modules, ECMAScript Harmony modules (ES Modules)

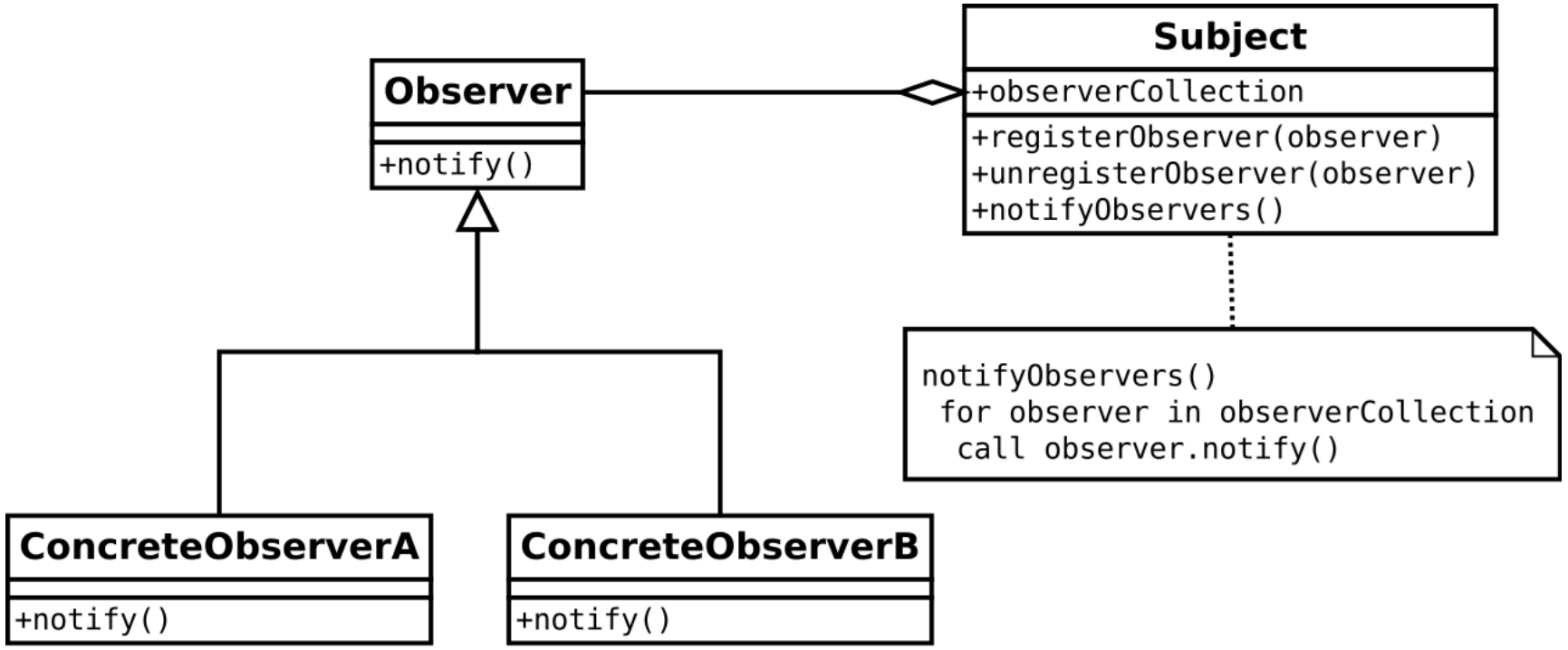
JS Design Patterns: Singleton

- Intent: Ensure a class has only one instance, and provide a global point of access to it.
- Object literals **{ }** in JavaScript are a natural way to implement Singletons
- Often Singletons are lazily initialized, like:

```
getInstance: function( myOptions ) {
    if( instance === undefined ) {
        instance = new MySingleton( myOptions );
    }
    return instance;
}
```

JS Design Patterns: Observer (Publish/Subscribe)

- Intent: Define a one-to-many dependency between objects where a state change in one object results in all its dependents being notified and updated automatically.



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JS Design Patterns: Mixin

- Intent: Mixins as a means of collecting functionality through extension – simple alternative to multiple inheritance
- Example:

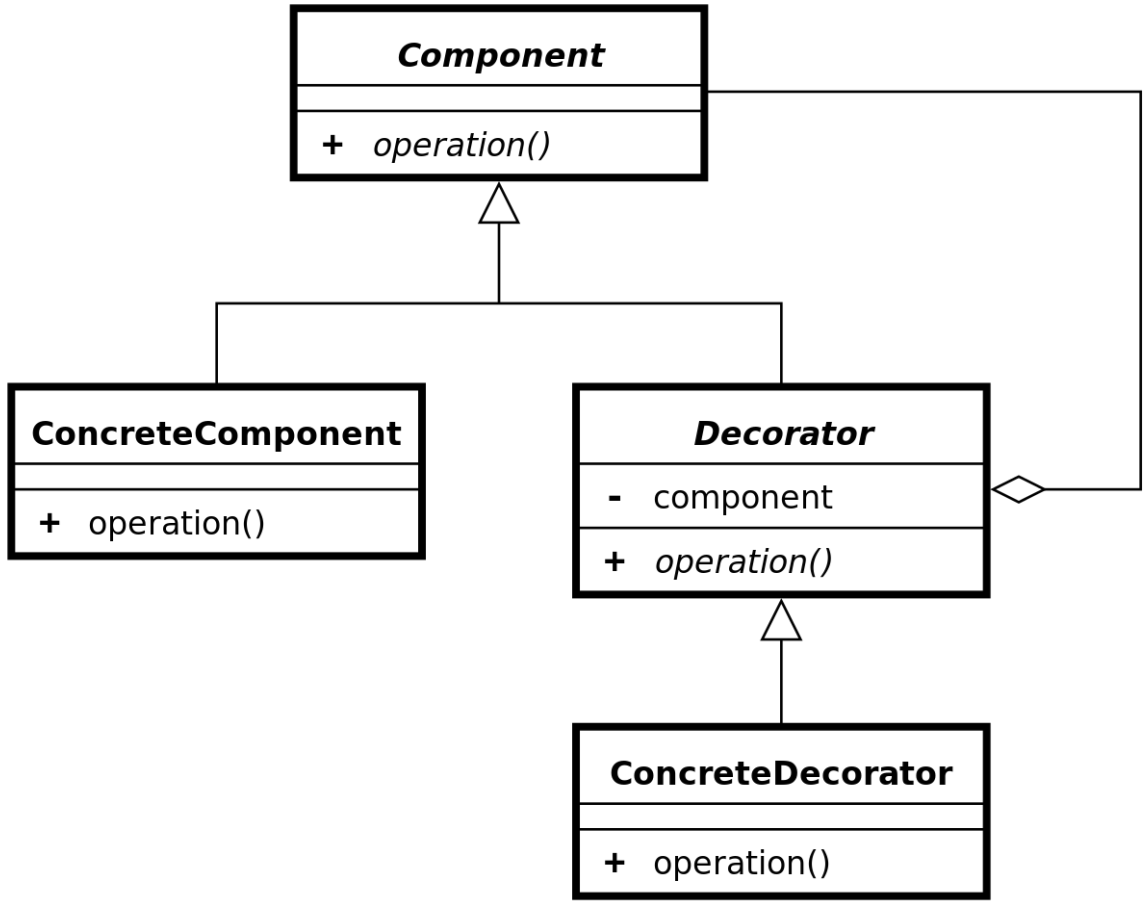
```
var o1 = { a: 1, b: 1, c: 1 };

var o2 = { b: 2, c: 2 };

var o3 = { c: 3 };

var obj = Object.assign({}, o1, o2, o3);

console.log(obj); // { a: 1, b: 2, c: 3 }
```

- In ECMAScript 6 there is **Object.assign(target, ...sources)**

JS Design Patterns: Decorator

- Intent: Attach additional responsibilities to an object dynamically keeping the same interface.

- Decorators provide a flexible alternative to subclassing for extending functionality.



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Conclusions – OO JavaScript Development

JavaScript™ provides everything needed for contemporary object-oriented and functional software development. JavaScript supports:

- **Data encapsulation** (separation of public and private parts) – How**?**: Using design patterns **Module**
- **Inheritance** – before ES 6 there were no classes but several choices for constructing new objects using object templates ("pseudo-classical" using **new**, OR **using functions**, OR **Object.create(baseObject)**, OR **Mixin**)
- **Polimorphism** supported – there are methods with the same name and different implementations – **duck typing**

Event Handling Models in JavaScript

- DOM Level 0 (original Netscape model)

```
<a href="#" onclick= "alert('I\'m clicked!'); return false;" />
```

- Traditional model (as properties)

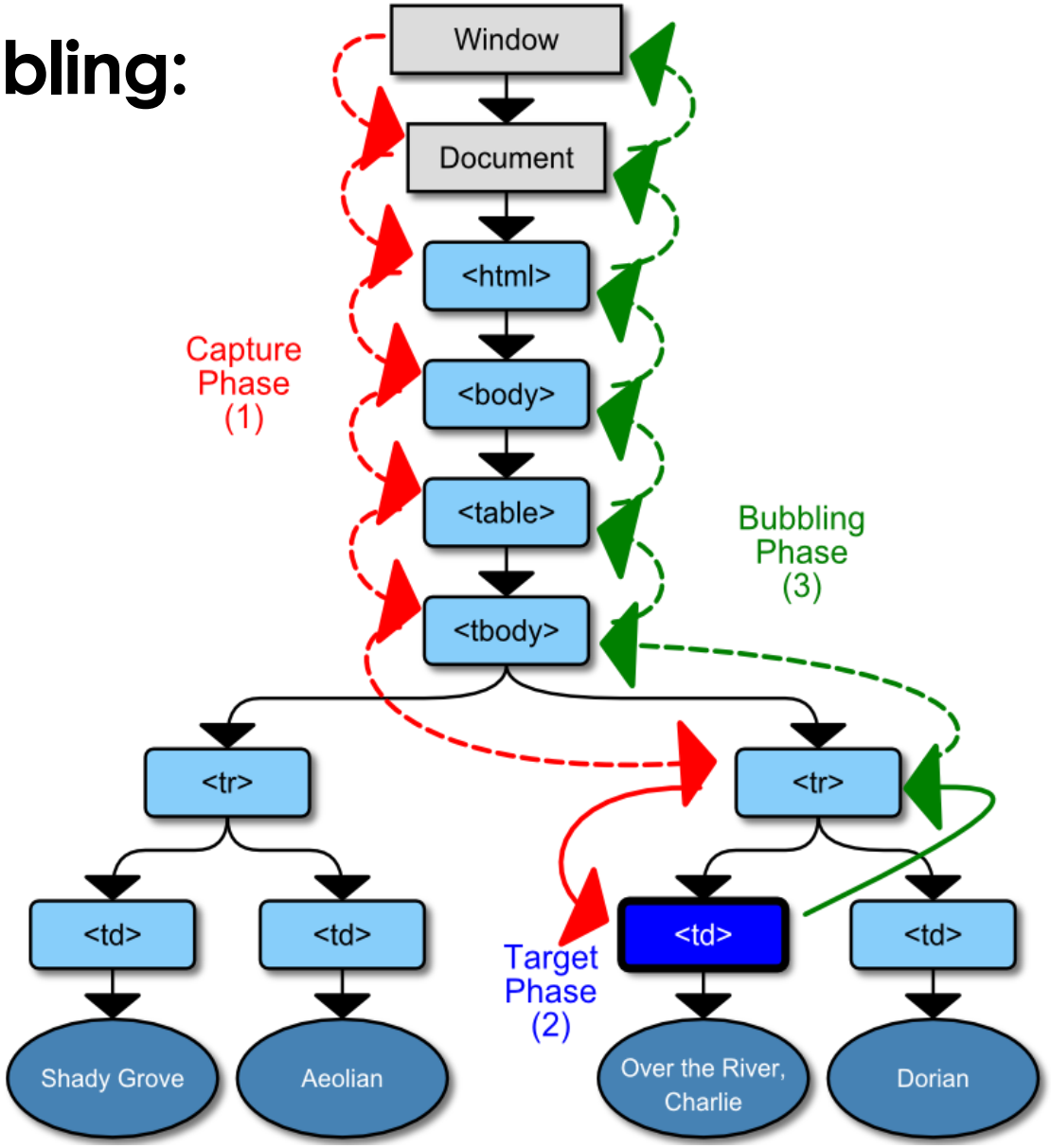
```
anElem.onclick = function() { this.style.color = 'red'; }
```

- can register multiple event handlers:

```
var oldHandler = (anElem.onclick) ? anElem.onclick : function (){ };
anElem.onclick = function () {oldHandler(); this.style.color = 'red'; };
```

- Microsoft Event Handling Model
- DOM Level 2 Event Handling Model
- DOM Level 3 Event Handling Model

Events Capturing and Bubbling:



W3C DOM Level 2 Event Handling Model

- Three phases in event handling life-cycle:
  - **Capturing** phase – from document to target element
  - **At Target** phase – processsing in the target element
  - **Bubbling** phase – returns back from target to document
- All events go through Capturing phase, but not all through Bubbling phase – only low level (raw) events
- **event.stopPropagation()** - stops further processing
- **event.preventDefault()** - prevents standards event processing
- Register/deregister event handlers:

anElement.addEventListener('click', eventListener, false)

anElement.removeEventListener('click', eventListener, false)

Microsoft Event Handling Model (Older IE)

- Register/deregister event handlers:

```
anElement.attachEvent('onclick', eventListener)
anElement.detachEvent('onclick', eventListener)
```

- Callback function *eventListener* does not receive *event* object:

```
function crossBrowserEventHandler(event) {
  if(!event) event = window.event;  ... // processing follows ... }
```

- No Capturing phase – every element has methods **setCapture()** and **releaseCapture()**
- from document towards target element
- **window.event.cancelBubble = true;** // stops bubbling -a
- **window.event.returnValue=false;** // prevents default action

W3C DOM Level 2 Events and APIs – Sample Events

Interface Name	Events
Event	abort, blur, change, error, focus, load, reset, resize, scroll, select, submit, unload
MouseEvent	click, mousedown, mousemove, mouseout, mouseover, mouseup
UIEvent	DOMActivate, DOMFocusIn, DOMFocusOut

Resources

- Crockford, D., JavaScript: The Good Parts. O'Reilly, 2008.
- Douglas Crockford: JavaScript: The Good Parts video at YouTube – http://www.youtube.com/watch?v=_DKkVvOt6dk
- Douglas Crockford: JavaScript: The Good Parts presentation at http://crockford.com/onjs/2.pptx
- Koss, M., Object Oriented Programming in JavaScript – http://mckoss.com/jscript/object.htm
- Osmani, A., Essential JavaScript Design Patterns for Beginners http://addyosmani.com/resources/essentialjsdesignpatterns/book/
- Fielding's REST blog – http://roy.gbiv.com/untangled/2008/rest-apis-must-be-hypertext-driven

Thank's for Your Attention!

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