

JavaScript and high-order functions



Why JavaScript?

- Lingua franca of the Internet
 - Used in the browsers, used server-side, used for IoT
 - Still evolving to address growing needs (EcmaScript)
- Interesting goals and design trade-offs
- Illustrates many core concepts of CSE 130

Week 1

- A little bit of JavaScript history
- Concepts from JavaScript
 - First-class functions
 - Objects
 - Language flexibility

May 1995

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for the browser!

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How about Scheme?



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How about Scheme?

Ha? No! Make it look like Java!



One week later...

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Here is a hacked up prototype!



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Great! Let's ship it!

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(It really took another year to embed it in the browser)

JavaScript's design goals [Eich, ICFP 2005]

- Make it easy to copy/paste snippets of code
 - Tolerate “minor” errors — e.g., missing semicolons
- Simplify event handling (inspired by HyperCard)
- Pick a few hard-working, powerful primitives
 - First-class functions (based off Scheme/Lisp)
 - Objects everywhere (based off Self/Smalltalk)
- Leave all else out!

JavaScript has evolved

- EcmaScript 5 and 6 introduced many new features
 - block scoping
 - new types (Map, Set, Symbols, Uint8Array, etc.)
 - strict mode
 - module system
 - classes
- How could JavaScript have been useful without these?

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 - can be passed as arguments to a function
 - can be returned as result of function call

Function as scoping primitive

- Today: JavaScript has block scoping
- But, until recently, JavaScript only had function-level scoping
 - What does this mean?
 - How did people survive?

goto: scoping examples

Function as scoping primitive

- Whenever you want a new scope:
 - declare a new function
 - immediately call it
- Key requirement from language design:
 - being able to declare function in any scope

Okay! But...

- Why do we want to pass functions as arguments?
- Or return functions as results?

Functions as args

- Original reason: simple way to do event handling
 - E.g., `onclick(function() { alert("button clicked!"); })`
- Still true today. But many other reasons, including:
 - performance: asynchronous callbacks
 - expressiveness: filter, map-reduce, etc.

Performance?

- Don't need to block when reading file
- Can tell runtime system to call your "callback" function once it's read the file
 - This allows runtime to schedule other IO concurrently

goto: performance examples

Expressive power of passing functions

- Say more with less!
 - E.g., filter all positive elements from array
 - E.g., add 42 to every element of the array
- In both cases: we are expressing the computation we care about without telling the computer what to do
 - Don't need to clutter code with low-level mechanisms!

Why return functions?

- With the other 2 properties: let's you compose functions from other functions
 - Functions that do this are called “high-order”
- E.g., function composition: $(f \circ g)(x) = f(g(x))$
 - Here \circ is a function that takes 2 functions: f and g
 - How is this useful?

goto: expressive example

Are these just function pointers?

A: yes, B: no
discuss with peers!

No! JavaScript functions are closures!

- Closure = function code + environment
 - Function pointers don't keep track of environment
 - We'll see this in more detail in a few lectures

goto: closure examples

What else can functions be used for?

- Modules! EcmaScript now has notion of modules, but most implementations still use functions
- How can we use functions to implement modules?
 - Closures are good for information hiding
 - Locally declared variables are scoped to the function ("module")
 - Function called with `exports` object which is used to expose public variables/functions

goto: module examples

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 - e.g., `obj.f = function (y) { return this.x + y; }`

What is “this”?

- this is called the receiver
 - Comes from Self (Smalltalk dialect)
 - Will see more of this in objects lecture
- Intuitively: this points to the object which has the function as a method
 - Really: this is bound when the function is called

goto: receiver example

I thought JavaScript had classes

- Now it does! But it didn't always
- How did people program before?
 - Used to use functions as constructors!

What is a function constructor?

- Just a function!
 - When you call function with new the runtime binds the `this` keyword to newly created object
 - You can set properties on the receiver to populate object
 - One property of the object is special: `__proto__`
 - This is automatically set to the constructor prototype field (that's right! functions treated as objects)

goto: class examples

Why are objects powerful?

- Useful for organizing programs
 - Can hide details about the actual implementation and present clean interface that others can rely on
 - I.e., they provide a way to build reliable software
- Enable reuse
 - E.g., may want to add new kind of vehicle to the pipeline, can reuse lots of code that deals with assembling it
 - E.g., in JavaScript an array is just an object!

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Language flexibility

- Does not require lines end in ';'
 - Automatic ';' insertion not always what you expect
- Casts implicitly to avoid “failures”
 - Useful in some case, usually source of errors (see notes)
- Hoisting
 - Sometimes useful, but, variable declarations (though not definitions) are also hoisted

Language flexibility

- Evaluate string as code with eval
 - Need access to full scope at point of call
 - Scope depends on whether call is direct or not
- Can alter almost every object (“monkey patch”)
 - Even built-in objects like window and fs
 - What’s the problem with this?

Language flexibility

See site notes for example of what can go wrong

Takeaways

- First-class functions are extremely powerful
 - We'll see this over and over
- Language “flexibility” is not free
 - Think about features before shipping them!