Code-Level Design

Martin Kellogg

Code-level Design

Today's agenda:

- Why does code-level design matter?
- Some general principles, with examples
- Break
- Automation and linting
- Our course style guide

Reading quiz: code-level design

Q1: The Joel Test has:

A. 12 yes/no questions
B. 6 multiple choice questions
C. one yes/no question
D. 30 true/false questions

Q2: **TRUE** or **FALSE**: Prettier is an opinionated JavaScript formatter with few options, because each option is a possible point about which engineers might disagree.

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Why does code-level design matter?

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- Software systems need to be understandable to humans

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- Software systems need to be understandable to humans
  - Maintenance is the largest part of the software lifecycle - estimated to be **50-80%** of total development cost
  - **Reading** code is one of the most time-consuming tasks that software engineers engage in regularly

Coupling makes code hard to understand

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- names
- order of arguments
- algorithms
- meaning of data
- types

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Two pieces of code might be coupled for many reasons:

- names
- order of arguments
- algorithms
- meaning of data
- types

If two pieces of code are coupled, one must understand both to modify either. Therefore, **more coupling = harder to understand**.

Surprises make code hard to understand

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  - varies by language and by codebase
  - do as others do
  - this includes **bad** conventions that otherwise violate the rules I'm about to show you!

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  - also avoid **premature optimization**

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- avoid "clever" implementations unless you really need them
  - also avoid **premature optimization**
- try to make code as "**greppable**" as you can
  - ask yourself if someone using this code in the future will be able to find the location you're editing

Greppability

Suppose you have two database tables named `shipping_addresses` and `billing_addresses`. You could get them this way:

```
const getTableName = (addressType: 'shipping' | 'billing') => {
    return `${addressType}_addresses`
}
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Now suppose further that I'm **debugging** something to do with the `shipping_addresses` table, so I search the codebase for "shipping_addresses". Will I find this code? **NO**

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Some general code-level design principles

- use good names
- make your data meaningful
- one job per method
- don’t repeat yourself (DRY)
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Use good names

- names are the only part of the documentation that’s actually required :)
- follow naming conventions (avoid surprises)
- applies to everything that you name, including:
  - methods
  - variables
  - types/classes
  - files
  - constants


parseDBMXML means:
A: parse DBM XML
B: parse DB MXML
C: parse DB Mx Markup Language
D: parse DB Mx Machine Learning

Use good names: example 1

```
var t : number

var l : number
```

Use good names: example 1

```
var temp : number

var loc : number
```

Use good names: example 1

```
var temp : Temperature

var loc : SensorLocation
```

Use good names: example 1

```
var temperature : Temperature

var location : SensorLocation
```

Use good names: example 2

```
function checkLine (line : string) : boolean
```

Use good names: example 2

```
function lineIsTooLong (line : string) : boolean
```

Naming principles

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```
function printDiameter (c : Circle) : void
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Make your data meaningful

Three decisions:

- Decide **what part** of the information in the "real world" needs to be represented as data
- Decide **how** that information needs to be represented as data
- Document how to **interpret** the data in your computer as information about the real world

Make your data meaningful: shirt example

- Suppose that I am wearing a red shirt, and I've decided I need to represent that fact in my program.
- How should I represent that in my program?
- We need to decide:

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- How should I represent that in my program?
- We need to decide:
  - how to represent shirts (including their color)
  - how to represent colors
  - how to represent my shirt

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```
type Shirt = {
  /** the color of the shirt */
  color: Color
}

type Color = { ... }

/** My shirt */
const myShirt: Shirt

myShirt.color = red
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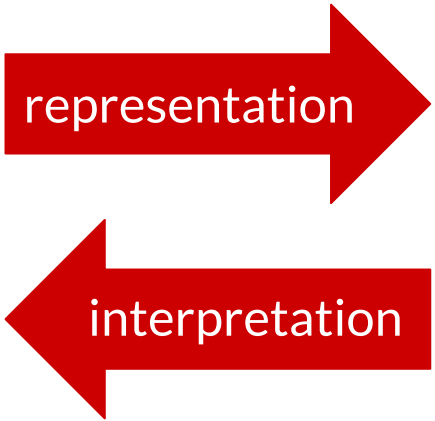
Make your data meaningful: shirt example

my shirt is red

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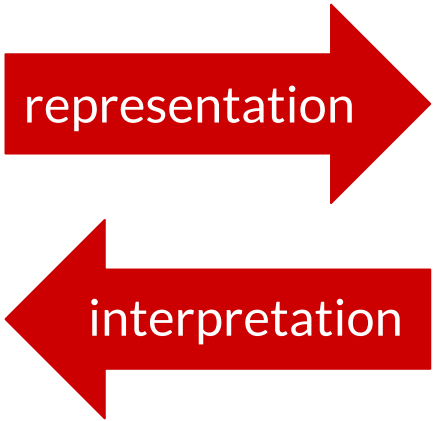


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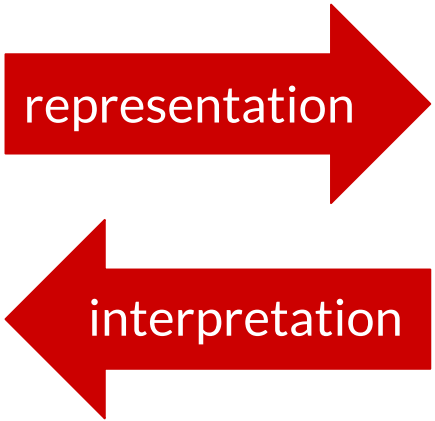


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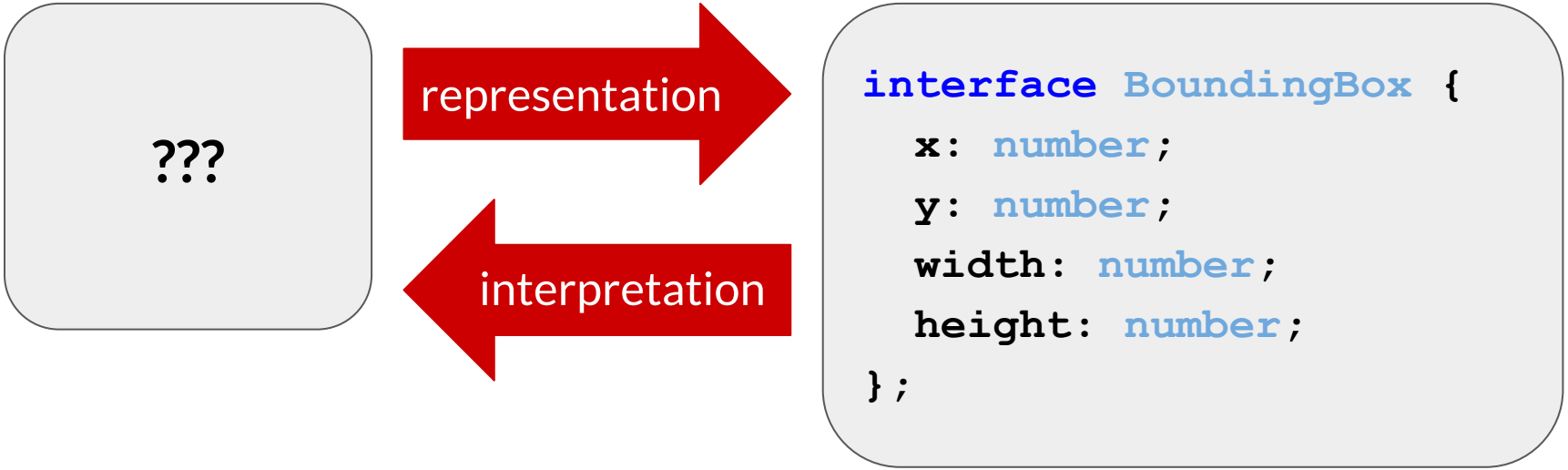
We have to **write it down**!

Make your data meaningful: xy example



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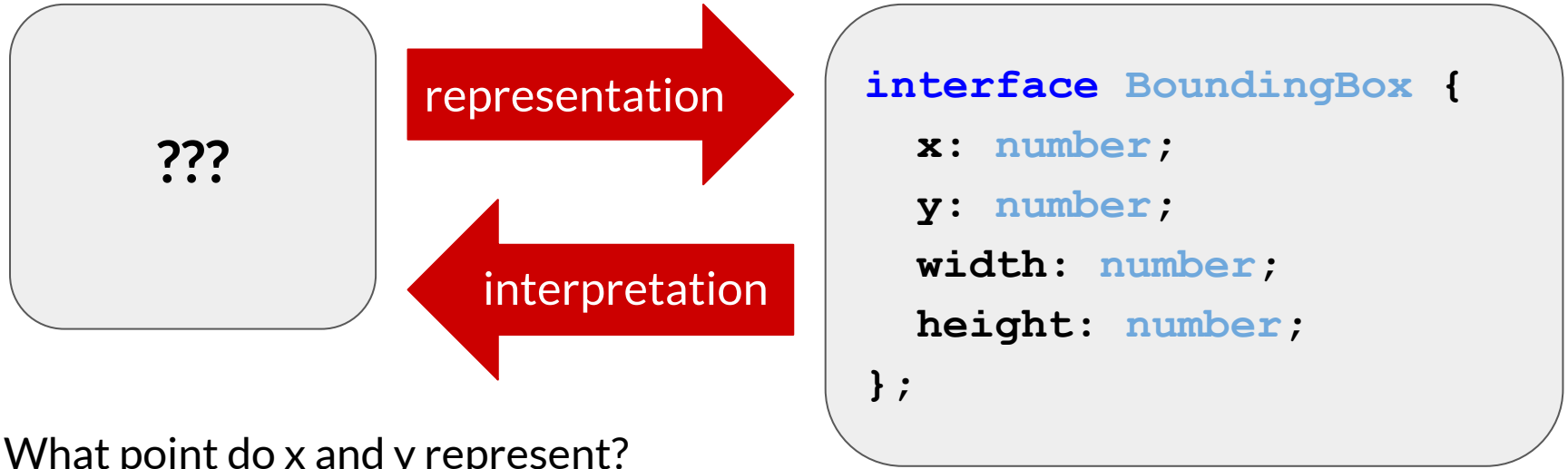

- What point do x and y represent?
- What units are these values in (pixels? feet?)
- Does y grow moving up or down?
- What is this “bounding”? How close is the box to the “bound” thing?

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> Make sure you write all of this down!
> This is what **comments** are for.

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- **one job per method**
- don’t repeat yourself (DRY)
- avoid magic numbers/strings (don’t hardcode)

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- You call both of them if you need to (or write a method that does)

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- Same principle applies for classes

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- If you need something more than once, give it a name and use that name everywhere
- Applies to:
  - constants/variables
  - methods (turn any differences between almost-clones into parameters!)
  - code blocks (turn them into methods)
  - classes (use a superclass)

My project's codebase when I paste another copy of the same lines I already have in few other files

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Don’t be this person!

Don’t repeat yourself: example

```
function testequal (testname: string, actualVal: T, correctVal: T) {
  test(testname, function () {
    expect(actualVal).toBe(correctVal) })
}

describe('tests for countOfLocalMorks', function () {
  testequal('empty crew',countOfLocalMorks(ship1),0)
  testequal('just Mork',countOfLocalMorks(ship2),1)
  testequal('just Mindy',countOfLocalMorks(ship3),0)
  testequal('two Morks',countOfLocalMorks(ship4),2)
  testequal('drone has no Morks',countOfLocalMorks(drone1),0)
})
```

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```

```
function testship (testname: string, ship : Ship, correctVal: number) {
   testequal(testname, countOfLocalMorks(ship), correctVal);
}
```

```
  })
```

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Avoid magic numbers

- integer and float literals should usually not appear in complex expressions (exception: `x = x + 1` is always okay)
- same applies to string literals

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Give them names!

Avoid magic numbers: examples

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```
const salesTaxRate = 1.06
let salesprice = netPrice * salesTaxRate
```

Avoid magic numbers: another example

- Suppose we are computing income tax in a state with four rates:
  - No tax on incomes less than $10,000
  - 10% on incomes between $10,000 and $20,000
  - 20% on incomes between $20,000 and $50,000
  - 25% on incomes greater than $50,000

Avoid magic numbers: another example

```
function grossTax(income : number): number {
  if ((0 <= income) && (income <= 10000)) {
    return 0
  } else if ((10000 < income) && (income <= 20000)) {
    return 0.10 * (income - 10000)
  } else if ((20000 < income) && (income <= 50000)) {
    return 1000 + 0.20 * (income - 20000)
  } else {
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What might change?

- boundaries of the tax brackets
- number of brackets

In-class exercise: rewrite to avoid magic numbers

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In-class exercise: my solution, part 1

```
// defines the tax bracket for income lower < income <= upper.
// if upper is null, then lower < income (no upper bound)
type TaxBracket = {
  lower: number,
  upper: number | null,
  base : number,
  rate : number
}
let brackets : TaxBracket[] = [
  {lower:0, upper:10000, base:0, rate:0},
  {lower:10000, upper:20000, base:0, rate:0.10},
  {lower:20000, upper:50000, base:1000, rate:0.20},
  {lower:50000, upper: null, base:7000, rate:0.25} ]
```

In-class exercise: my solution, part 2

```
// defines the incomes covered by a bracket function
function isInBracket(income : number, bracket : TaxBracket) : boolean {
  return (bracket.upper == null) ?
    (bracket.lower <= income) :
    ((bracket.lower <= income) && (income < bracket.upper))
}
function income2bracket(income : number,
                        brackets : TaxBracket[]) : TaxBracket {
  return brackets.find(b0 => isInBracket(income, b0))
}
function taxByBracket(income : number, bracket : TaxBracket) : number {
  return bracket.base + bracket.rate * (income - bracket.lower)
}
function grossTax(income:number, brackets: TaxBracket[]) : number {
  return taxByBracket(income, income2bracket(income, brackets))
}
```

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  Example: simple bash script to accomplish a specific, one-off task

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DANGER: premature optimization via over-engineering
don't sacrifice readability or usability for maintainability!

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A surprise: non-standard formatting

What's wrong with the following (Java) code?

```
public abstract class racecar {

private final int Number_of_gears = 6;

        public abstract void DRIVE();

 public int GetNumberOfGears(){return Number_of_gears;}

}
```

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- How do we decide which format is best?

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Solution to both problems: use an **automatic** formatting tool

- avoids flamewars about e.g., tabs vs spaces
- automatically enforced = we don't have to think about it
- reduces surprises when reading code

Automated formatters

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- E.g.,:
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  - Go has gofmt
  - JavaScript has prettier (which we’ll use in this class)

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  - Go has gofmt
  - JavaScript has prettier (which we'll use in this class)
- **Lesson**: always use an automated formatter

Aside: “opinionated”

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Automated formatters vs linters

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You'll see both terms, and some linters also look for other mistakes.

We'll use both `prettier` (an automated formatter) and `ESLint` (a linter) in this course.

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Course style guide

https://web.njit.edu/~mjk76/teaching/cs490-au24/policies/style/

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I expect you to follow this style guide for all assignments in this course (including IP0!).

Advertising

- I’m coaching the ICPC team this year, and I’d love to have any/all of you participate
  - info session on Wednesday next week at 4pm, GITC 3600
  - ICPC is a team programming contest
    - excellent prep for LeetCode-style technical interviews!
  - we’ll run weekly practices until the real contest in November (?)

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  - we’ll run weekly practices until the real contest in November (?)
- YWCC advising asked me to advertise their senior day
  - starts at 11:30am today in the GITC lobby
  - stop by if you plan to graduate in Spring 2025

Action items before next class

- Finish Individual Project 0 by Monday AoE
- Mandatory readings for next class (see course calendar)
- Remaining OH for IP0 questions:
  - Lauren: today 4-5pm, Monday 6-7pm (GITC 4324)
  - Peter: Monday 10-11am (GITC 4403)
  - or ask your questions on Discord