

CS 4530: Fundamentals of Software Engineering

Lesson 1.2 General Program Design Principles

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Outline of this lesson

1. The purposes of the principles
2. Difficulties the principles should help with
3. Five general-purpose principles
 - usable for all programming, not just object-oriented

In the next lesson, we'll present five more principles that are specific to object-oriented programming

Learning Objectives for this Lesson

- By the end of this lesson you should be able to:
 - Describe the purpose of our design principles
 - List 5 general design principles and illustrate their expression in code
 - Identify some violations of the principles and suggest ways to mitigate them

The Challenge: Controlling Complexity

- Software systems must be comprehensible by humans
- Why? Software needs to be maintainable
 - continuously adapted to a changing environment
 - Maintenance takes 50–80% of the cost
- Why? Software needs to be reusable
 - Economics: cheaper to reuse than rewrite!

The biggest obstacle: coupling

- Two pieces of code are *coupled* if a change in one demands a change in the other.
- A coupling represents an agreement between the two pieces of code.
 - They may agree on:
 - names
 - order (e.g. of arguments)
 - meaning (e.g. meaning of data)
 - algorithms
- The more two pieces of code are coupled, the harder they are to understand and modify: you have to understand both to understand either of them.

There's a fancy word for this:
connascence
(meaning "born together")

More coupling means less readability, less modifiability

Five general-purpose principles

Five General Principles

1. Use Good Names
2. Make Your Data Mean Something
3. One Method/One Job
4. Don't Repeat Yourself
5. Don't Hardcode Things That Are Likely To Change

Principle 1. Use Good Names

- The name of a thing is a first clue to the reader about what the thing means.
 - often, it's the only clue 😞
- Use good names for
 - constants
 - variables
 - functions/methods
 - data types

Good Names for Variables and Types

```
var t : number  
var l : number
```



```
var temp : number  
var loc  : number
```



```
var temp : Temperature  
var loc  : SensorLocation
```


Good Names for Functions and Methods

```
function checkLine () : boolean
```



```
function LineIsTooLong () : boolean
```

Good Names for Functions and Methods

- Use noun-like names for functions or methods that return values, e.g.

```
let c = new Circle(initRadius)
let a = c.diameter()
```

- not:

```
let a = c.calculateDiameter()
```

- Reserve verb-like names for functions or methods that perform actions, like

```
table1.addItem(student1, grade1)
```

Principle 2. Make Your Data Mean Something

- You need to do three things:
 1. Decide **what part** of the information in the "real world" needs to be represented as data
 2. Decide **how** that information needs to be represented as data
 3. Document how to **interpret** the data in your computer as information about the real world

Example 1:

- Right now 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:
 - how to represent shirts (including their color)
 - how to represent colors
 - how to represent **my** shirt

Example 1 (cont'd)

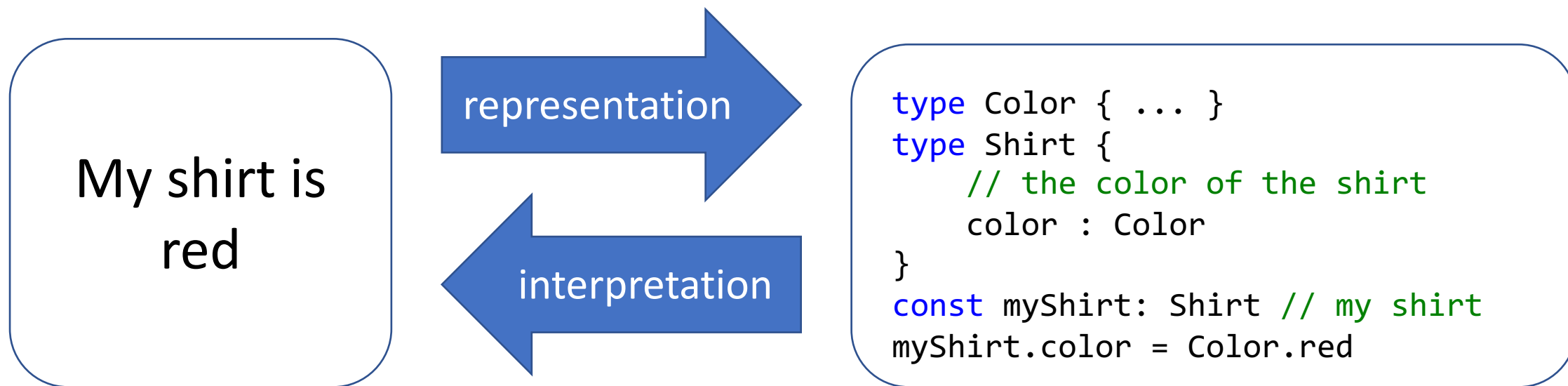
- So we need to write something like this:

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

```
type Color { ... }
```

```
const myShirt: Shirt // my shirt
```

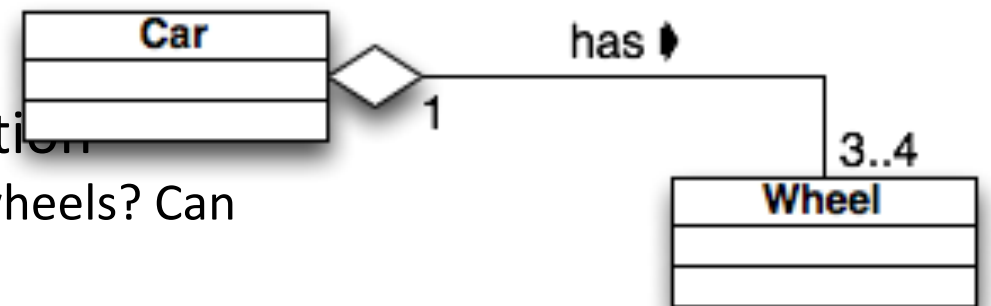
The Big Picture



- How do we know that these are connected?
- Answer: we have to **write down** the interpretation
- In our Typescript infrastructure, we do that with the comments.

Example 2: What does an object represent?

- What does an object of class Car represent?
 - a model of car (e.g. Dodge, Ford, Toyota)?
 - a particular car (my 2019 Toyota, VIN = 456789)?
- What does an object of class Wheel represent?
 - a model of tire? (Goodyear GoodGrips14)
 - a particular tire? (Goodyear GoodGrips14 SN = 345678)
- What does "has" represent?
 - depends on what Car and Wheel represent
 - this may affect the navigability of the association
 - (can you get from a car object to the associated wheels? Can you get from a wheel to the car that it's on?)



Principle 3: One Method/One Job

- Each class, and each method of that class, should have one job, and only one job
- If your method has more than one job, split it into 2 methods. Why?
 - You might want one part but not the other
 - It's easier to test a method that has only one job
- You call both of them if you need to.
 - or write a single method that calls them both
- Same thing for classes.

Principle 4: Don't Repeat Yourself

- If you have some quantity that you use more than once, give it a name and use the name.
- That way you only need to change it in one place!
- And of course you should use a good name
- If you have some task that you do in many places, make it into a procedure.
- If the tasks are slightly different, turn the differences into parameters.

A real example

```
function testequal <T> (testname: string, actualVal: T, correctVal: T) {  
    it(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)  
})
```

Principle 5: Don't Hardcode Things That Are Likely To Change

- "No magic numbers" and "Don't Repeat Yourself" are already examples of this.
- General strategy: If there something that might change, give it a name
 - if it's not already a "thing", refactor to make it a "thing"
- Let's look at a couple of examples.

Replace magic numbers with good names

- Replace magic numbers with good names

```
let salesprice = netPrice * 1.06
```



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

But use **good** names!

```
int a[100]; for (int i = 0; i <= 99; i++)  
a[i] = 0;
```

```
int ONE_HUNDRED = 100;  
int a[ONE_HUNDRED]; ...
```



```
int ARRAYSIZE = 100;  
int a[ARRAYSIZE]; for (int i = 0; i <=  
ARRAYSIZE-1; i++) a[i] = 0;
```

Example

- Imagine we are computing income tax in a state where there are four rates:
 - One on incomes less than \$10,000
 - One on incomes between \$10,000 and \$20,000
 - One on incomes between \$20,000 and \$50,000
 - One on incomes greater than \$50,000
- You might write something like

You might write something like

```
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 { return 7000 + 0.25 * (income - 50000) }  
}
```

- What might change?
 - The boundaries of the tax brackets might change
 - The number of brackets might change

So let's represent our data differently

```
// 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}  
]
```


And now it's easy to rewrite our function

```
// defines the incomes covered by a bracket
function isInBracket(income:number, bracket:TaxBracket) : boolean {
    if (bracket.upper == null)
    { return (bracket.lower <= income) }
    else
    { return ((bracket.lower <= income) && (income < bracket.upper))}
}

function taxByBracket(income:number, bracket:TaxBracket) : number {
    return bracket.base + bracket.rate * (income - bracket.lower)
}

function grossTax2 (income:number, brackets: TaxBracket[] ) : number {
    return taxByBracket(income, income2bracket(income, brackets))
}
```

Review: Learning Objectives for this Lesson

- You should now be able to:
 - Describe the purpose of our design principles
 - List 5 general design principles and illustrate their expression in code
 - Identify some violations of the principles and suggest ways to mitigate them

Next...

- In our next lesson, we'll learn about five more basic principles that are specific to an object-oriented setting.